




ERJU SYSTEM PILLAR

# D2 Migration Planning Guideline



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Abstract	(b) What functional packages (CCS trackside) shall be mandatory for SPRA to simplify migration (e.g. just ETPS, or always ETPS+PES together, or even ETPS+PES+ATO GoA2 functions together)?(i) Each deployment of mandatory functional packages (subsystems) needs to be self-sufficient concerning functions and user interfaces (e.g. TMS does perhaps not exist).(ii) Each deployment of mandatory functional packages (subsystems) needs to be integrateable – offer interconnection possibilities for adjacent legacy systemsHow do i. and ii. influence the optimal functional allocation for CCS/TMS(c) What are recommended decision criteria for national migration steps that help to decide an optimal migration plan.
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# 1 Introduction

## 1.1 Purpose of this document

**The purpose of this document is to offer guidance on how to develop an optimal strategy and plan to migrate the entire railway network of a country from the current, national control and command systems and operating rules to the harmonised systems and operating rules defined for the Single European Railway Area SERA ( SPT2TRAFFIC-5767 - SERA Development targets).**

**The document provides on the one hand guidance for CCS migration planning in general and on the other hand specific possible Migration Scenarios how to migrate to the Traffic CS target architecture (as described in the Traffic CS System Concept).**

There is no general "optimal" migration strategy, as many factors need to be considered, which might change from case to case.. What might be optimal in one application might be sub-optimal, or even a poor choice in another one.

This document therefore only provides guidance on how to develop optimal migration strategies and plans, which are however specific for a selected country, respectively for the network operated by an infrastructure manager. This guidance is provided in the form of issues to be considered, covering all relevant issues, including technical and operational aspects on a general level, the timing of a roll out and also the business case, but excluding specific national conditions or any cost figures.

The document does however contain examples from already developed migration strategies, which might be helpful for other cases.

Migration strategies and plans can also not be developed only from a specific stakeholder's point of view, specifically the infrastructure manager, as the needs of and impacts on all relevant stakeholders must be considered to gain their acceptance. This is specifically relevant for the non-mandatory elements of a migration, which cannot be enforced through a TSI.

This document therefore also identifies all stakeholders with their needs, respectively the impacts the migration will have on them, which must also be considered.

When developing an optimal migration strategy, a fair balance between the needs of, the benefits for and the impacts on the different stakeholders has to be found.

This balance might also be impacted by external effects, such as political decisions, available funding etc., which also need to be identified and considered.

## 1.2 Context of this document

This document (**Deliverable D2**) is part of three deliverables of the Traffic CS CCS Trackside Migration Group, as defined by Europe's Rail remit SC 2.4.

<b>Europe's Rail System Pillar - Domain Traffic CS</b> <b>CCS Trackside Migration Group</b> <b>Overview of the Deliverables D1, D2, D3 of the Specific Contract SC 2.4 (10/2024-10/2025)</b>		
<b>Recommendations for current rollouts</b> <b>Link to Deliverable D1</b>	<b>Migration Planning Guideline</b> <i>Guiding document for all deliverables</i> <b>Link to Deliverable D2</b>	<b>CCS Trackside Integration Strategy</b> <b>Link to Deliverable D3</b>
<ul style="list-style-type: none"> <li>General recommendations for upcoming contracts in</li> </ul>	<ul style="list-style-type: none"> <li>Guidance on how to develop a strategy and a plan to migrate to the harmonised operations and systems</li> </ul>	<ul style="list-style-type: none"> <li>Analysis of typical adaptor solutions and efforts to adapt legacy</li> </ul>

<p>existing or planned upcoming rollouts</p> <ul style="list-style-type: none"> <li>• List of potential candidates and evaluation criteria for an early integration (in the SERA pre-phase before 2030)</li> <li>• Analysis, which features and/or interfaces can be fully or partly recommended for an early integration</li> </ul>	<p>defined for the Single European Railway Area SERA +(e.g., considerations on migration steps, maintaining operation etc.)</p> <ul style="list-style-type: none"> <li>• Guidance on how to migrate to Traffic CS by analyzing several Migration Scenarios and Adaptor solutions</li> <li>• Definition of functional packages for CCS to simplify migration (e.g., PES+ETPS, ATO-TS etc.)</li> </ul>	<p>systems to the new harmonised interfaces</p> <ul style="list-style-type: none"> <li>• Analysis of connecting Traffic CS to legacy TMS</li> <li>• Analysis of handing over a train from Traffic CS to adjacent legacy CCS systems and vice versa</li> </ul> <p><b>Annex of CCS Trackside Integration Strategy</b></p> <p><b>Link to the Annex of Deliverable D3</b></p> <ul style="list-style-type: none"> <li>• Detailed analysis of national legacy CCS architectures in the migration context and comparison to the Traffic CS Target architecture</li> </ul>
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### 1.3 Scope of this document

#### 1.3.1 Deliverable description according to the remit of SC 2.4

##### Description according to the remit


**b) What functional packages (CCS trackside) shall be mandatory for SPRA to simplify migration (e.g. just ETPS, or always ETPS+PES together, or even ETPS+PES+ATO GoA2 functions together)?**

- (i) Each deployment of mandatory functional packages (subsystems) needs to be self-sufficient concerning functions and user interfaces (e.g. TMS does perhaps not exist).
- (ii) Each deployment of mandatory functional packages (subsystems) needs to be integrateable – offer interconnection possibilities for adjacent legacy systems
- How do i. and ii. influence the optimal functional allocation for CCS/TMS

**c) What are recommended decision criteria for national migration steps that help to decide an optimal migration plan?**

#### 1.3.2 Interpretation of the Deliverable description

The deliverable description shown above is interpreted as described in the following:

This D2 Migration Planning Guideline consists of two main parts, one generic part (chapter 2) about aspects and **"recommended decision criteria"** that **"help to decide an optimal migration plan" (c)** and one specific part (chapter 3), where the SERA target and specific possible Migration Scenarios about how to migrate to this SERA target (described in the  Traffic CS System Concept) are presented and evaluated **(b)**.



In the context of the Migration Scenarios, the integration of **"several functional packages (CCS trackside)"** of the Traffic CS target architecture in a legacy environment are discussed. It will be investigated, e.g., if it is recommended to deploy only ETPS or only ATO-TS or even always the whole Traffic CS target architecture (ETPS, PES, ATO-TS) for **"simplifying migration"**.

The statement, that each deployment of functional packages **"(i)...needs to be self-sufficient concerning functions and user interfaces"** is tackled by analyzing the dependencies between the Traffic CS systems ETPS, PES and ATO-TS as well as the need of these systems to interact with operator workbenches and especially central services as the digital register, configuration and diagnostic data storages.

Special attention is paid to the **"(ii)...interconnection possibilities for adjacent legacy systems"**. For connecting Traffic CS systems to existing legacy systems (e.g., legacy TMS or adjacent interlockings), the need for adaptations is identified and possible adaptor solutions are discussed.




Based on discussions in the Traffic CS domain, the **"optimal functional allocation for CCS/TMS"** is considered as stable and agreed and will therefore not be further analyzed in this document.



## 1.4 Document structure


This document is structured as follows:

- **1 - Introduction** Describes the purpose of the document, as well as its limitations
- **2 - General Aspects of the Migration Process** Lists and analyses the major aspects, which need to be considered when developing a migration plan. It also lists the major stakeholders with their needs, and analyses the impacts the migration to the SERA has.
- **3 - Migration towards SERA Traffic CS Target Architecture:** This chapter describes possible migration paths to introduce the trackside SERA Traffic CS Architecture.
- **4 - Summary**
- **5 - Annex**

## 1.5 General input documents and references

Id	Description	Reference
[  SPP-28723 - SPT2MIG-1625 - MIG SC 2.3 D1 CCS Features Indivisible for deployment]	Relationships between those (candidate) CCS features which make up the packages indivisible for deployment.	Link
[  SPP-28721 - SPT2MIG-2121 - MIG SC 2.3 D2 Scope for System Pillar Reference Architecture B1R1 and further releases]	Assessments and recommendations for a scope for SPRA B1R1 (first release of the System Pillar Reference Architecture) and succeeding releases according to the STIP (Standardisation and Input Plan)	Link
[  SPP-28722 - SPT2MIG-2151 - MIG SC 2.3 D3 Migration Requirements for the Target System (main document)]	List of key migration	Link

Id	Description	Reference
	challenges and resulting concepts and requirements for the CCS target system and regarding the (to be defined) targets that need to be considered for deployment of the CCS target system, while interfacing with existing systems. Onboard and Trackside Migration is discussed in more detail in the following two reports:	
 SPP-28720 - SPT2MIG-2207 - MIG SC 2.3 D5 Special Trackside Signals and Boards]	Decision base for the question: Will the support of standardized special trackside signals be needed inside of SPRA (not as national migration solution) for migration or integration reasons? These could be, for example, shunting signals, border signals, or fall back signals.	Link
 SPP-28719 - SPT2MIG-3427 - MIG SC 2.3 D3 Trackside Migration]	As the harmonized CCS trackside system can't be modified to connect to the neighbouring non-harmonized legacy CCS trackside systems, adapter solutions have to be realized. Based on the analysis of 5 examples from legacy CCS systems the complexity of such adapters	Link

Id	Description	Reference
	were analysed, resulting in concepts and requirements for the Traffic CS interface connecting to the neighbouring trackside CCS system.	
[  SPP-28724 - SPT2MIG-3428 - MIG SC 2.3 D3 Onboard Migration]	Uptake of features for onboard migration that support progress that is achievable rapidly, i.e before radio-based ETCS L2 trackside will be available (e.g. C-DAS, RTO, modularity), up to and including the migration towards ETCS and FRMCS and features as described in the (to be defined) targets.	Link

## 1.6 Glossary

### 1.6.1 Abbreviations

Abbreviation	Definition
ASTP	Advanced Safe Train Positioning (ASTP)
ATO	Automatic Train Operation
ATO-TS	ERTMS/ATO Trackside
C-DAS	Connected Driver Advisory System
CCS	Control-Command and Signalling
DR-I	Digital Register - Infrastructure
ERJU	Europe's Rail Joint Undertaking
ETCS	European Train Control System
ETPS	European Trackside Protection System
IXL	Interlocking
PER	Perception
PES	Plan Execution System
RTO	Remote Train Operations
SDI	Standard Diagnostic Interface
SERA	Single European Railway Area
SMI	Standard Maintenance Interface
SPRA	System Pillar Reference Architecture
SSI	Standard Security Interface

Abbreviation	Definition
STIP	Standardisation and TSI Input Plan
TMS	Traffic Management System
TSI	Technical Specifications for Interoperability

### 1.6.2 Relevant terms and definitions

Term	Definition
Advanced Safe Train Positioning (ASTP)	<p>Advanced Safe Train Positioning (ASTP) is a CCS onboard interoperability constituent, separated from the ERTMS/ETCS on-board equipment by fully standardized interfaces with all connected systems. ASTP shall perform functions for safety relevant applications and be the only source of odometry information in the CCS-OB.</p> <p>The main ASTP functionalities interfacing with other onboard systems, are:</p> <ul style="list-style-type: none"> <li>• provision of <b>Odometry</b> information</li> <li>• identification of all potential virtual <b>Reference Location(s)</b></li> <li>• provision of 3D kinematic information</li> </ul>
Automatic Train Operation	<p>Automatic Train Operation is technology for automating the operation of trains. The degree of the automatisation is shown by the Grade of Automation (GoA). GoA0: train operating on-sight, no automation GoA1: train operating manual, train driver controls starting, stopping, passenger service functions as opening and closing doors and handling emergency. Train protection systems like ETCS L1 in place. GoA2: train operating semi-automatic. Starting and stopping automated using advanced train protection systems like ETCS L2 or 3, driver operates passenger service functions and handles emergencies GoA3: driverless train operation. Starting and stopping automated, service staff operates passenger service functions and handles emergencies GoA4: unattended train operation. All operations are fully automated without any on-train staff</p>
BASELINE	A baseline is defined by a stable kernel in terms of system functionality, performance and other non-functional characteristics.
BASELINE RELEASE	A baseline release is defined by a specific version of each of the CCS TSI annex A documents that are relevant for the system
Class A / B system	ERTMS is considered being a class A system whereas national legacy non-ERTMS systems are known as class B systems. In the frame of the migration to the future, harmonised CCS architecture based on harmonised operating rules, ERTMS systems based on earlier baselines are also treated as a kind of Class B system.
Connected Driver Advisory System	Realizes a communications link to the Control Centre (or Traffic Management Centre) in each controlled area in which the train operates. This enables the provision of schedule, routing and speed restriction updates to trains in near real time, and also

Term	Definition
	receipt of information from trains to the IM control centre to improve regulation decisions.
Digital Register - Infrastructure	The Digital Register Infrastructure (DR-I) is a database managing and providing static infrastructure data as central service. The data exchange between Traffic CS and this database is based on the Standard Maintenance Interface SMI-xx (e.g. prepared by EULYNX) via the subsystem Configuration.
ERTMS/ATO Trackside	ERTMS/ATO Trackside (ATO-TS) is the ERTMS/ATO trackside subsystem. ERTMS/ATO provides a set of non-safety functions related to speed control, accurate stopping, door opening and closing, and other functions traditionally assigned to a driver, while the safety of operation is still ensured by ETCS with regards to the speed and distance limits and also by other safe systems.
European Trackside Protection System	The Trackside Protection System is the core system of Traffic CS, implementing the safety critical functions. The Trackside Protection System controls all Trackside Assets Control and Supervision (TACS) connected to ETCS, for example points, level crossings, and manages Movement Permissions for trains, whilst maintaining the safety of the railway.
European Train Control System	European Train Control System (ETCS) is a cab-signalling system that incorporates automatic train protection (ERA definition). ETCS in the frame of SERA will support the following Levels: * L2 with fixed train detection (classic L2 with trackside detection (track circuits, axle-counters, ...)) * L2 with hybrid train detection (virtual fixed or moving blocks with trackside detection (axle-counters, ...)) – formerly known as Hybrid L3 * L2 with virtual fixed or moving blocks and train integrity (no trackside detection) – formerly known as pure L3
Interlocking	Interlocking is a set of signaling devices which physically materializes, in the area of action of a switch post (junction, crossing of tracks, etc.) through mechanical, and / or electrical solutions. It allows train movement if the safety conditions have been met regarding train maneuver and signal control devices.
Migration	Migration is the national or company specific process of converting existing CCS/TMS systems including operational processes to corresponding systems and processes of the harmonized System Pillar Reference Architecture (SPRA).
Perception	PER - Perception

Term	Definition
Plan Execution System	<p>The Plan Execution System is a subsystem of Traffic CS which is responsible for:</p> <ul style="list-style-type: none"> <li>• processing the Operational Plans provided by the TMS, which are based on the Operating State of the railway within the Area of Control and</li> <li>• providing the Operating State within the Area of Control received from Trackside Protection System towards the TMS.</li> </ul>
Radio Block Centre (RBC)	ETCS trackside centralised unit controlling ETCS train movements in level 2.
Repository	<p>A repository is similar to a database and data dictionary; however, it usually encompasses a comprehensive information management system environment. It must include not only descriptions of data structures (i.e. entities and elements), but also metadata of interest to the enterprise, data screens, reports, programs, and systems. Typically, it includes and internal set of software tools, a DBMS, a metamodel, populated metadata, and loading and retrieval software for accessing repository data.</p>
SERA Enablers	<p>The development of the SERA Target functionality is a long-term process. In this process standalone functional units so-called "SERA Enablers" are developed belonging to the SERA Target system. Individual SERA Enablers might be suitable for early rollout in legacy projects, which still use national specifications and legacy systems. Therefore, SERA Enablers are standalone subsystems having standardized interfaces, which are specified, developed, tested and approved according to the needs of the SERA Target. If needed, adapters can be used to integrate them in legacy systems (part of migration strategy).</p> <p>Currently identified SERA Enablers are:</p> <ul style="list-style-type: none"> <li>• Object controllers with SP Standard interfaces (partially based on EULYNX)</li> <li>• PES and ETPS with SP Standard interfaces (i.e. SCI process interfaces and service interfaces SDI, SMI and SSI)</li> <li>• Central services with SP Standard interfaces (i.e. service interfaces SDI, SMI and SSI), which provide supporting functions for operation of SERA systems: configuration, maintenance and digital register-infrastructure, security, communication.</li> <li>• TMS with SP Standard interfaces (i.e. SCI-OP process interface and service interfaces SDI, SMI and SSI)</li> <li>• FRMCS for radio communication, replacing GSM-R</li> <li>• Safe train integrity and train length information of rolling stock, enabling safe traffic control for mixed traffic</li> <li>• ATO-TS ( for ATO GoA1/2) with SP Standard interfaces (i.e. SCI process interfaces and service interfaces SDI, SMI and SSI), based on harmonized operation concept and related rules</li> </ul>
SERA Phase	<p>The SERA Phase is a deployment phase, which starts when the SERA Target - comprising all SERA Enablers (refer to SERA Enablers list in Glossary) - is ready (i.e. tested and approved) for implementation (rollout) in projects. The key</p>

Term	Definition
	<p>SERA Enabler will be the moving block with the DTCC safety principle (either implemented with GSL or CBTC based solutions) based on the harmonized operation concept and related rule set.</p> <p>In this context the trackside infrastructure is equipped for moving block (allowing TDD reduction) enabling degraded modes and mixed fleet operation (i.e. parallel movement of equipped and non-equipped trains with or w/o safe train length and integrity).</p> <p>Core elements for rollout of the SERA Target are the subsystems ETPS and PES (ATO-TS optional) plus the related process interfaces SCI between them and to the adjacent systems like:</p> <ul style="list-style-type: none"> <li>• TMS</li> <li>• Operators Workplace</li> <li>• Object Controllers.</li> </ul> <p>Additionally, also adjacent auxiliary systems and related interfaces SDI, SMI, SSI plus related tools (e.g. for engineering, testing, simulation) must be available as well. For example, these auxiliary systems are:</p> <ul style="list-style-type: none"> <li>• Central services, which provide supporting functions for operation of the core systems: configuration, maintenance and digital register-infrastructure, security, communication.</li> </ul>
SERA Pre-Phase	<p>The SERA Pre-Phase is a deployment phase, which starts when the first SERA Enablers (belonging to the SERA Target; see SERA Enablers list in Glossary) are ready for implementation (rollout) in projects, where legacy subsystems can be replaced already by equivalent SERA Subsystems. Such projects still use national specifications and legacy systems. This approach forms a significant part of the overall migration strategy towards SERA.</p> <p>As a sample this might comprise the early introduction of certain SERA Enablers like object controllers having SP Standard interfaces (based on EULYNX) in combination with legacy system components (supporting legacy L2/FB/FVB principles; optional ATO GoA2).</p> <p>This allows early benefitting - during the long-term SERA Development process - from their advantages (e.g. performance increase and cost reduction) and ensures protection of investment</p> <p>The gradual rollout of those SERA Enablers is part of the migration path towards the later SERA Phase and its target system. SERA Enablers in this pre-phase must be functional</p>



Term	Definition
	units of reasonable size and standalone testable and approved - e.g. like an SERA ready object controller unit. Related migration use cases and concepts are specified in separate SP Documents.
Single European Railway Area	Defining the fundamental design principles and process for adopting a functional architecture for rail as a system, with a focus on CCS, CMS and TMS supporting the implementation of the SERA (Single European Railway Area)
Standard Diagnostic Interface	Standard Diagnostic Interface as defined by EULYNX / System Pillar
Standard Maintenance Interface	Standard Maintenance Interface as defined by EULYNX / System Pillar
Standard Security Interface	Standard Security Interface as defined by EULYNX / System Pillar
Standardisation and TSI Input Plan	The Europe's Rail (EU-Rail) Standardisation and TSI Input Plan (STIP) is a collection of all outputs from EU-Rail (Innovation and System Pillar) which contribute to the goal of harmonisation of the railway system. The harmonisation topics are categorised in technical domains and described by the foreseen harmonisation channel (TSI, EN standards, SP document), the time horizon as well as dependencies with existing regulations, standards, and R&I activities.
Traffic Management System	Ensemble of applications providing permanent control across the network, automatically sets routes for trains and logs train movements as well as detects and maybe solves potential conflicts.
target picture	<p>The following are considered minimum characteristics (baseline) for the targeted solution:</p> <ul style="list-style-type: none"> <li>Operational production processes directly related to the railway traffic commercial production are harmonised. This includes ETCS related processes, processes for securing and releasing railway lines/areas to/from maintenance and commissioning, operating through and recovering from degraded (non-regular) operations, reacting to and managing emergency situations (from operational perspective).</li> <li>Railway system operates ETCS L2, without signals.</li> <li>Railway system operates EULYNX type equipment.</li> </ul>

### 1.6.3 Additional terms used in this document

Several terms need to be defined or clarified to properly understand this document. For some of them, definitions have been produced elsewhere, but they don't reflect the purpose of this document. These following definitions have therefore been retained, but an attempt might be made at a later stage harmonise the different definitions. The document therefore defines it's own definition for the following terms:

#### Migration:

Migration in the sense of this document is the transformation of existing, national signalling systems, including related infrastructure, operating rules, operating concepts, national regulations etc. to a



harmonised, European signalling system, using harmonised operating rules and harmonised operating concepts based on European legislation, and possibly harmonised products based on industry standards.

**Target:**

The harmonised, European signalling system shall be based on ETCS Level 2 without lineside signals, with the exception of possibly harmonised shunting signals. The System shall support the harmonised ATO GoA 2.

**National Targets:**

There cannot be national targets only. Where a migration is not possible in a reasonable time due to e.g., financial constraints, intermediate national targets might however be defined to reach the European target at a later stage.

**Perimeter:**

Migration is largely a national issue, even where there are multiple infrastructure managers in a country, as the starting point is to a large extent country specific due to national regulations, national operating rules, country specific products etc.. The perimeter of a migration plan is therefore always a country, or the network of an infrastructure manager within a country.

**Functional Package:**

This term, which is used in the remit, is interpreted as combining Traffic CS systems into packets, which shall be implemented together, rather than individually with different schedules.

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## 2 General Aspects of the Migration Process

### 2.1 Overview

There are many aspects which need to be considered when developing an optimal migration strategy for the transition from a national signalling infrastructure to SERA compliant systems and SERA operating rules. Some of these aspects are relevant for all infrastructures, and some might only be relevant for specific cases. The following list contains the most relevant ones identified during the development of this guideline:

- The railway network as a whole always must remain operational throughout the migration.
- Network access shall be as open as possible, and restrictions shall be known long in advance to take preparation measures. This includes the mandatory implementation of specific ETCS baselines / system versions in train onboards. Multiple upgrades of onboard systems shall be avoided, unless upgrades are only related to optional features the RU might, or might not want to use.
- The starting point from which a migration concept shall be developed needs to be identified per infrastructure manager, and might even be different for different regions, lines or stations on a network of an infrastructure manager.
- The target state to be reached needs to be defined to the level necessary, and shall be only one across Europe.
- Intermediate steps might be planned for the migration from starting point to target, e.g., to generate early benefits or to prepare for major migration steps, e.g., the introduction of harmonised operating rules.
- It must be clear which functionalities, baselines, features etc. are mandatory for both infrastructure managers and railway undertakings, and which ones are optional for each of them.
- The introduction of non-mandatory features, or of features which are introduced with subsequent TSI releases must also be coordinated between infrastructure managers and railway undertakings, so that they can be used.
- Dependencies must also be considered between features which either need to be introduced at the same time, or at least in a specific sequence.
- The number of changes to operating rules shall be kept as small as reasonably possible, in the best case to only one step from current, national operating rules to SERA rules. Existing and new operating rules will however coexist during the migration phase.
- It must also always be clear which operating rules are valid where, and the frequency of rule changes along journeys shall be kept small.
- Systems and products must be available in time.
- Resources must be available in time at all involved stakeholders.
- Target dates must be defined and possibly legal deadlines considered.
- The focus must be on overall cost - benefit for the entire sector, possibly supported by measures to balance benefits between stakeholders.
- Protection of investments (e.g., should specific systems be retained when transition to SERA) will have to be considered in detail, as it might impact operation, require national features in SERA systems etc.

These aspects are individually described in more detail in section [2.2 - Detailed description of each aspect of a migration plan](#).

There are also many stakeholders impacted by the migration from current CCS systems and operation to those standardised for the SERA. The needs, and also the impacts on at least following stakeholders must be considered to develop a balanced migration strategy:

- Infrastructure Managers
- Railway Undertakings
- Vehicle Owners
- Legislators
- Supervisory authorities
- Suppliers
- End customers

These needs and impacts on these stakeholders are individually described in more detail in section [2.3 - Detailed needs of and impacts on stakeholders](#).

## 2.2 Detailed description of each aspect of a migration plan

### 2.2.1 Definition of the starting point

As migration is a transition from a starting point to a target, a relatively detailed documentation of the starting point is required. The following items should be documented as starting point, as they might have a significant impact on selecting an optimal migration concept:

- The main reasons why a migration to the harmonised SERA architecture and operating rules is needed, shall be identified, such as e.g.,:
  - the need to replace obsolete trackside infrastructure (traffic management systems, interlockings, object controllers, Class B train control systems), or also onboard systems (Class B train control systems)
  - the need to increase train speeds beyond what currently installed Class B systems permit
  - the need to increase track capacity
  - the wish to simplify cross border traffic by eliminating national requirements
  - legal requirements from either the EU or national authorities
- An overview of the existing infrastructure, including:
  - Interlocking types, including object controllers, with their functionalities and interfaces
  - Traffic Management systems
  - Operational control / plan execution systems
  - Class B train control systems
  - Existing non-SERA compliant ETCS installations
- The currently applicable operating rules must be identified, including the areas or lines, on which they are applicable, and also including specific rules for certain areas, lines or even stations
- Areas need to be identified, e.g. some commuter networks, where captive rolling stock is used, including whether these areas are also used by trains operating elsewhere, or whether open access might not even be possible, but where SERA compliance is still required
- Connections to other networks must be identified, with the currently used transition schemes
- The current operators must be identified, as they will be impacted by the introduction of SERA compliant CCS systems and operating rules
- Significant functional differences between national systems and SERA systems must be identified, as e.g., they might make the concept of stepwise introduction of systems not feasible
- The goals of the different impacted stakeholders must be identified, especially where they differ from each other
- National legislation must be identified, which will have to be changed

### 2.2.2 Definition of the target

The target of the migration discussed in this document is a harmonised, SERA compliant CCS system based on ETCS L2 without signals, except harmonised shunting signals, based on harmonised operating rules, and with optionally ATO GoA2.

In the frame of SERA / ERJU, many new features (also called functions or items) are being discussed to extend harmonisation to operation, and to introduce new functionalities. The features under discussion are being collected in the STIP list. These features are currently not part of the target, as it is neither sure whether they will finally be standardised, or when they will become available. Some aspects of a later introduction of such features are however discussed in this document, as this might have an impact on the migration strategy already for the current target.

The harmonised SERA compliant CCS system includes both trackside and onboard assets, covering all aspects from traffic management to object controllers, communication etc.

Not part of the target are Class B systems, they however need to be considered when developing a migration plan.

Once the harmonised SERA systems are fully specified, a commitment is needed from the IMs to actually roll out these systems to motivate the market to develop them. In a second step, migration strategies need to be developed for each country, including a target date, to identify the need for migration-specific features or interfaces.

The same applies to migration strategies and plans which require changes to currently applied, or even legacy systems, respectively products.

Where it is already clear that completing the roll out of a SERA compliant CCS system by the European target date is not possible, intermediate goals shall be defined, which:

- are stepping stones toward the goal of full SERA compliant architecture
- could include a full roll-out on e.g., corridors, but only preparations on lines still equipped with Class B systems

It is assumed (which must be confirmed) that backward compatibility with Baseline 3 equipped trains is part of the SERA target.

### 2.2.3 Consideration of the evolution of the harmonised SERA compliant CCS system

A significant challenge of migration planning is to consider future evolutions of the SERA compliant CCS system, specifically as many features of the STIP list will have a significant impact on operation, interfaces and systems.

A balance has to be found between stability on one side and the evolution of SERA systems and products on the other side, especially regarding safeguarding interoperability and investments by all stakeholders.

A stepwise inclusion of new functions or features into the target system will either have to be done in a way which does not impact network access by vehicles not equipped accordingly, which might significantly reduce expected benefits, or require upgrading of already equipped rolling stock.

A stepwise inclusion of new functions or features into the target system will also require multiple updates to products, which will either significantly increase the number of variants which need to be maintained, or require mandatory updates.

### 2.2.4 Optional and mandatory features

So far, migration plans have largely been produced as national replacement strategy for obsolete Class B systems, for the introduction of Level 2 for e.g., high speed lines, or to achieve technical interoperability, e.g., on Trans European corridors. The scope of harmonisation has been limited to what is published in the TSI as technical requirements, and has e.g., not included harmonised operating rules. The current TSI also does not include a significant number of features which are considered as "optional".

One feature which was in the past considered optional when equipping trains with ETCS was the support of ETCS Level 2 on top of ETCS Level 1. This has however been clarified, as equipping trains only for Level 1 is not anymore permitted.

Another feature, which is still considered "optional", but whose onboard implementation is mandatory to operate on certain infrastructures is the Euroloop reader. With only ETCS Level 2 being part of the future SERA compliant CCS system, Euroloop will however disappear.

One feature of the currently specified CCS system listed in the TSI which is still considered as "optional", is ATO GoA 2. So far it seems to be assumed that infrastructure managers can decide whether they want

to support ATO GoA 2, and the railway undertakings can decide whether they want to implement it on their trains.

In the frame of SERA / ERJU, many new features (also called functions or items) are being discussed to extend interoperability to operation, and to introduce new functionalities.

Many of these new features are expected to generate significant benefits, both operationally and economically, but not necessarily for all stakeholders.

Many of these new features will probably also not be listed in a TSI, but published as standards through other channels, as their implementation is neither considered necessary for safety and interoperability, and are therefore not covered by the mandate of ERA.

When these new features will be standardised, whether they will be part of a TSI or of a non-mandatory standard, whether their implementation will be, or can be declared "mandatory" and whether backward compatibility with Baseline 3 equipped trains will be retained is therefore currently unclear.

As the topic of optional functions, and the resulting consequences heavily impact migration strategies, this needs to be clarified on a European level with high priority.

### 2.2.5 Dependencies between features

Dependencies exist between certain new features listed independently in the STIP, e.g., between ATO GoA 3/4 and Perception, between Perception and ASTP, between ASTP and the Onboard Repository and between the Onboard Repository and the Digital Register. While these features are currently not part of the target, they should already be considered when making long term plans beyond the current target which rely on these features.

A list of these dependencies will have to be produced, including the TSI release, in which they shall be introduced, which must then be considered for all new items considered for application.

As dependencies between features will heavily impact migration strategies, this topic needs to be clarified on a European level with high priority

### 2.2.6 Operation during migration

A railway has to remain fully operational during the migration from national / Class B operation and systems to harmonised SERA operation and systems.

SERA compliant systems with harmonised SERA operating rules will have to be introduced gradually on a network, as a conversion of an entire network from a Class B system and national operating rules to ETCS Level 2 based on SERA operating rules in one step will not be possible. This will result in transitions between areas operated with the Class B systems and national operating rules to areas where ETCS Level 2 based on SERA operating rules are applied, and vice versa.

The number of such transition locations should be kept small, as they always result in a change of applicable operating rules. Too frequent changes might be confusing to the drivers and signaller, with the risk that incorrect rules are applied. ETCS Level 2 based on SERA operating rules should therefore be introduced in clearly defined areas, with only few transition points. These areas can then be expanded in steps.

The gradual introduction of ETCS Level 2 based on SERA operating rules should also consider the requirement to equip rolling stock, as this might also be a gradual process. The trackside rollout of ETCS Level 2 based on SERA operating rules should therefore focus on creating either ETCS corridors, e.g the TEN corridors, or ETCS areas, such as the commuter networks of an area or large city. Introducing ETCS Level 2 based on SERA operating rules just based on the obsolescence of individual trackside infrastructure, such as a single interlocking, might result in operators having to install ETCS on large fleets within a very short time, which then still operate mostly with the Class B system.

Currently, Class B systems and ETCS are not only applied exclusively on respective lines, but are often installed in parallel, with trains operating to different rules depending on their equipment, to avoid the above problem. This however has several disadvantages:

- Constraints of national operating rules and Class B systems need to be considered in the design of ETCS, preventing optimisation (e.g. most class B systems require longer overlaps than ETCS does, with its SIL 4 braking curve supervision, or marker boards don't have to be placed with the same, restrictive sighting rules than optical signals).
- Handling of various operating cases, and especially degraded operations, might be difficult as the signaller has to apply different rules depending on the system used by an individual train.
- Even the qualification of the driver might have to be considered, as a driver only qualified for ETCS, but not for the Class B system, might operate a train which is equipped with both systems. This train would then have to apply the rules for trains only equipped with ETCS, even though the Class B system is available.

Overlaying ETCS and Class B systems should therefore be avoided.

Specific operating procedures / interfaces might be required to handle transitions between Class B systems and ETCS / SERA areas. These Class B system specific measures shall be designed in a way that they only impact the national operation / Class B systems, to keep the harmonised SERA operation and systems free of national requirements.

### 2.2.7 Network access during migration

Network access during the migration to the ERJU / SERA system architecture and operating rules will be impacted by many aspects, such as:

- the time during which Class B systems are still required
- the applied ETCS system version
- the selected features, as many are "optional", with no clarity however on what that means
- the sequencing of the rollout across a network
- backward, and possibly even forward compatibility

These aspects are being discussed in more detail in the following sections.

#### 2.2.7.1 Class B systems

The need to equip rolling stock with Class B systems is today a significant stumbling block for cross border traffic, but also for national traffic, where Class B systems will still be required during the migration.

The main issues with Class B systems are:

- they are cost drivers for new rolling stock, as both ETCS and national systems need to be installed
- if rolling stock shall operated in multiple countries, there is also an issue with space onboard the trains, with installing the multitude of antennas
- many Class B systems are difficult to procure, as they are reaching their end of life
- in some cases, new Class B systems need to be developed due to obsolescence
- some Class B systems are not available as STMs, making their integration with ETCS difficult and expensive
- non STM Class B systems also often require their own DMI, odometry sensors, brake valves etc.

A migration plan could consider this by rolling out SERA systems with priority on e.g., transit corridors or in specific areas with significant cross border traffic. The need for Class B onboard systems could then be eliminated for a significant portion of rolling stock.

#### 2.2.7.2 ETCS System version

The system version required by the trackside has a significant impact on the network access by railway undertakings, as their rolling stock needs to be equipped accordingly.

Key question is, whether the requirement stipulated by the railway undertakings, that Baseline 3 equipped trains shall be permitted to operate, shall be fulfilled.

Higher baselines might allow trackside to use additional features, but this must be balanced against the impact this choice has on the operator.

The selection of the system version is therefore a very important aspect when defining a migration concept, and the choice needs to be based on an analysis of the advantages, as well as the impact it has on the different stakeholder. It therefore likely requires more than a cost-benefit analysis.

### 2.2.7.3 Geographical sequencing of SERA migration within a network

On most railway networks, certain types of traffic, and also rolling stock, are limited in their operation to specific area or corridors. Examples are suburban networks around larger cities, or also regional trains.

A migration plan could consider this by e.g., prioritising certain high speed or transit corridors, thus delaying the need to retrofit the typically larger fleets of commuter networks.

Prioritising such parts of the network could also eliminate the need for e.g., freight or high speed trains to still be fitted with Class B systems, if properly planned. This might even eliminate the need for drivers operating these trains to be certified to operate under national operating rules.

This might however require changes to existing, national legislation, as some countries currently don't support certification limited to specific lines or areas

The proper sequencing of the rollout of the ERJU / SERA harmonised system across a national network will therefore be critical for the railway undertakings. It shall consider both international and national traffic patterns.

### 2.2.7.4 Backward / forward compatibility

ETCS specifications are released in so called **baselines**, with each baseline consisting of a full set of documents required to develop, install and operate ETCS trackside and onboard. Some documents might remain stable from one baseline to the next one, but they are none-the-less listed as being part of a newer baseline.

Each baseline introduces new features, and possibly also error corrections for a previous baseline.

ETCS also knows so called **system versions**, which indicate whether trains equipped with ETCS of an earlier baseline can still operate on a track equipped with a newer baseline. The system version has the following format: X.Y, where the number X distinguishes incompatible versions, and the number Y indicates compatibility within a version X.

The picture below (source: <https://www.era.europa.eu/content/backwards-and-forwards-compatibility-etcs-baselines>) shows as example that a train equipped with a baseline 2 OBU, operating with system version 1.0, can run on a track equipped to baseline 3, operating under system version 1, but cannot run on a track equipped to baseline 3, operating under system version 2.



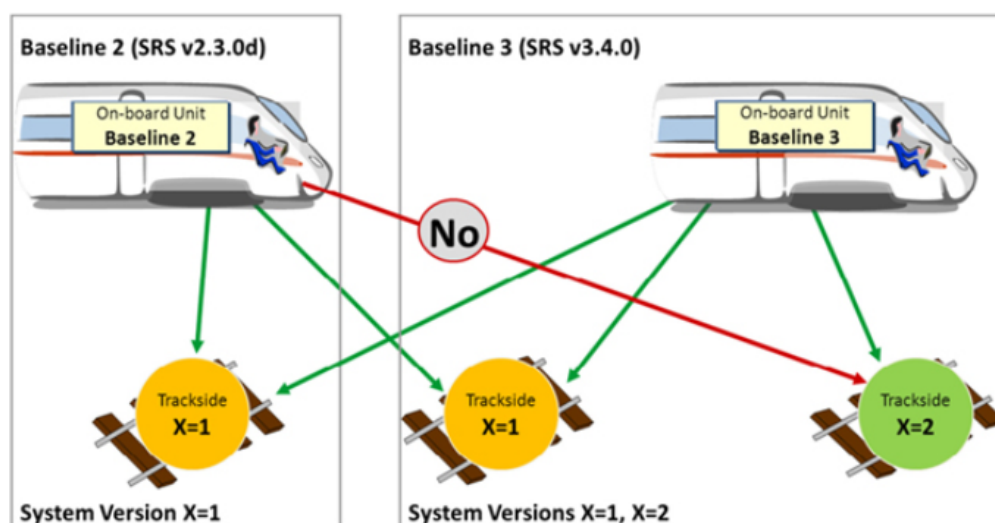


Figure 1 - B3MR1 example for backwards and forwards compatibility of ETCS baselines

The compatibility, respectively incompatibility between two ETCS system versions is assessed by analysing the relationship between an ETCS on-board equipment operating one system version and an ETCS trackside infrastructure operated with another one. The analysis considers if there is "normal" operation and service possible ("normal" means here that a train is not penalised because of a reduction of performance or safety) or if there is a technical, operational or safety related obstacle preventing train operation.

The system version specified by the trackside will depend on which new features of the new baseline it is using.

The trackside / on-board compatibility Matrix according to the TSI 2023 is as follows:

		OBU Compatibility		
		Reduced envelope #1 B4 OBU supporting up to system version 2.1	Reduced envelope #2 B4 OBU supporting up to system version 2.2	Full envelope B4 OBU supporting up to system version 3.0
Trackside B4 System Version (X.Y)	1.0	Fully compatible	Fully compatible	Fully compatible
	1.1	Fully compatible	Fully compatible	Fully compatible
	2.0	Fully compatible	Fully compatible	Fully compatible
	2.1	Fully compatible	Fully compatible	Fully compatible
	2.2	Compatible, but OBU cannot use the new features in the higher Y version.	Fully compatible	Fully compatible
	2.3	Compatible, but OBU cannot use the new features in the higher Y version.	Compatible, but OBU cannot use the new features in the higher Y version.	Fully compatible
	3.0	Not compatible. OBU cannot run on the line due to higher X version.	Not compatible. OBU cannot run on the line due to higher X version.	Fully compatible

**Fully compatible**

Compatible, but OBU cannot use the new features in the higher Y version.

Not compatible. OBU cannot run on the line due to higher X version.

Figure 2 - Trackside / OBU Compatibility Matrix according to CCS TSI 2023

The system version management will get more complex with the introduction of new features, as the compatibility will often depend on how they are being used.



The exact handling of baselines and system versions can be found in "SUBSET-104 - ETCS System Version Management", which defines unambiguously the ETCS system version, and clarifies what does affect and what does not affect the ETCS system version.

### 2.2.7.5 Evolution of ERTMS

In a similar way as ETCS, also the harmonised ERJU / SERA CCS systems will continue to evolve as new features will be added.

Such an evolution might however have a huge impact on existing installations, as well as operating rules, and might therefore also result in significant cost for upgrading of installed systems, as well as staff training. The impact will not only be on e.g., onboard units, but might also require changes to any other of the harmonised ERJU / SERA CCS systems, such as e.g., the TMS, PES or ETPS.

The introduction of new features, regardless of whether they are part of new TSI releases or also introduced as ERJU standards, must therefore consider the need to upgrade existing systems.

### 2.2.8 Operating rules during migration

Key element of any railway operation are the applicable operating rules. While these are relatively clear when operating with national systems, due to the different look of signals, the case is more complex with ETCS.

During migration, different rules will apply on different sections of a railway network. Depending on the chosen migration strategy, different rules might even apply on the same line, if e.g., lines are double equipped with ETCS and Class B systems. Whether such overlay solutions make sense should therefore be analysed in detail.

Today, national operating rules exist also for lines equipped with ETCS Level 2, despite the harmonised functionality. These differences reflect different functionalities of underlying interlockings, of different national practices or even legislation. This could also be a safety issue, as a driver who operates cross border traffic might apply the wrong rules.

Once ERJU / SERA compliant products are introduced, also the related, harmonised operating rules have to be introduced. If this is done gradually, different ETCS Level 2 operating rules might exist even within a country. This would be especially critical where ETCS Level 2 lines are connected.

To avoid this, it might have to be considered to migrate existing ETCS Level 2 lines to SERA first, before rolling out ETCS Level 2 on additional lines of a network. This is especially relevant where only a limited number of such lines exist, and where also only part of the staff is currently certified to operate on ETCS Level 2 lines with national operating rules.

### 2.2.9 Availability of harmonised products

One of the goals of ERJU / SERA is to extend harmonisation to a point where products result, which can be used in identical form in multiple countries. This shall result in e.g., lower prices due to scale or increased competition, but also to quicker availability of systems as no national variants need to be developed by suppliers.

Standardisation beyond what is necessary for interoperability and safety can however not be regulated and enforced by ERA through a TSI.

The standardisation of such subsystems, and their availability from multiple suppliers will however only materialise if a number of conditions are met. These include e.g.:

- The relevant standards are developed, implemented into prototypes, tested between multiple suppliers for compatibility, finalised and published in a form so that they can be used by suppliers free of IP rights.
- The harmonisation is done to a level where an open market for products which are compliant with the SP architecture and specification is generated. If however e.g., mechanical aspects,

connectors, power supply characteristics, EMC and IP ratings of required enclosures etc. are not part of the standardisation, but are specified differently by customer, this can not be achieved.

- A certain commitment is given by users to then procure products developed according to these standards in a pure form, free of national or user specific additions or deviations.

Assuming that such products will be available in a migration plan must therefore consider these conditions.

#### 2.2.10 Availability of human resources

Human resources are more and more scarce, especially highly qualified staff with railway specific know-how is missing across the sector. All stakeholders are impacted by this problem.

Especially for highly qualified staff, a stable workload must also be ensured, as otherwise a loss of human resources will result which can only be corrected with high effort and over a long time-span, if at all.

A migration strategy has to consider this aspect, ensuring that the project scope is in line with available human resources, or that a buildup of resources is planned over a realistic time span, and to a reasonable level.

Migration strategies which rely on significant changes to existing legacy systems, or require development of a multitude of adapters, must also consider these aspects.

#### 2.2.11 Deadlines / target dates for migration

Signalling systems have typically a lifespan of decades, rather than years. This is possible only due to slow and minimal changes being introduced, especially regarding operating rules.

With ERJU / SERA, huge changes are being introduced. Unfortunately, current planning (e.g., STIP list) indicates that these changes will not be introduced in a single step, but with many steps, which will most likely not only impact systems, respectively products, but also operating rules. This might also result in additional cost.

This will likely lead to a much higher variety of systems / products in use, and of applicable rule-sets, which will be difficult to manage, and make achieving many of the SERA goals difficult.

Care must therefore be taken that both future developments of system functionalities, as well as of the European operating rules, are only done by adding / expanding functions and rules without impacting already installed systems and rules, and with backward compatibility possible.

To keep the variety of systems and rule-sets in use small, the transition to ERJU / SERA should be as fast as reasonably possible, with the goal to eliminate national systems and rules by a defined time.

#### 2.2.12 Financial Aspects

Key element of each migration is the financing. An accelerated rollout of SERA compliant systems and operation likely exceeds existing, regular budgets of most involved stakeholders. This is especially relevant for the infrastructure managers, as well as the railway undertakings, respectively vehicle owners.

Political entities are also impacted, as most infrastructure managers, as well as many railway undertakings depend to a significant portion on public funding.

Many activities in ERJU are focusing on the high level goal of SERA to make railways more efficient, and thus less dependent on public funding. This might however only be achieved with an accelerated replacement of legacy systems, as well as the quick introduction of harmonised operating rules, as both national and SERA compliant products will otherwise have to be manufactured and supported in parallel for a very long timespan, which rather increases cost.

The development of a migration strategy shall therefore consider the overall cost and financing, including every intermediate step which is being considered. This includes e.g., the need for changes in legacy systems, the development of products specifically required for migration such as adapters, the need for training, engineering etc. Migration shall therefore evaluate:

- technical solutions which permit smooth migration
- modularity where cost savings can be demonstrated

- steps which help preserve existing investments
- steps which quickly result in standardised systems
- compensation of financially impacted actors to allow cost saving measures at other actors
- how systems can be used for a long timespan without the need for regular upgrades
- how specific, and often cost driving requirements from individual customers can be eliminated
- how new features truly result in cost savings

### 2.2.12.1 Cost for Infrastructure Managers vs. Railway Undertakings / Vehicle Owners

Many of the changes proposed in ERJU / SERA will result in a non-balanced distribution of cost and benefits between different stakeholders, and specifically between the Infrastructure Managers and the Railway Undertakings.

In order to make changes acceptable to all stakeholders, migration strategies might have to evaluate and introduce mechanisms of compensation to eliminate this effect.

### 2.2.12.2 Protection of investments

Protection of investments is an important aspect of any migration strategy. It must however always be viewed with the whole railway system in mind.


A balance must therefore be found between protecting investments of one stakeholder and the impact this might have on other stakeholders. Keeping e.g., a short section on a line in operation with legacy systems, as e.g., systems on that section can still be used for another decade or two, might result in requiring operators to keep Class B systems on their trains, and even install them on new trains. It will also result in drivers having to be trained accordingly.

Also for this aspect, migration strategies might have to evaluate and introduce mechanisms of compensation to compensate stakeholders who must consider early replacement of systems.

## 2.3 Detailed needs of and impacts on stakeholders

This section lists generic needs of the different stakeholder groups.

### 2.3.1 Infrastructure Managers

A survey was produced to identify the needs of infrastructure managers and railway undertakings in regard to migration (Details can be found in the:  SPT2MIG Questionnaire Report\_V14).

Unfortunately, this survey revealed significant differences in needs between infrastructure managers and railway undertakings, and even between different infrastructure managers, who will have different migration strategies.

However, common needs of the highest importance are stated:

- **Operational harmonization, compatibility and continuity:** systems must remain compatible over migration, including the interoperability of existing Class B and ETCS systems, and operational continuity must be ensured.
- **Standardization of specifications and products:** their simplification and also the harmonization of rules will bring a positive financial balance, despite some high initial costs during the transition phases
- **Coordination between infrastructure migration and on-board systems:** fleet and infrastructure migration must be aligned to limit disruption and maximize efficiency. A particular attention is required for the deployment of the various functionalities to ensure consistency between trackside and on-board equipment.
- **Stable specifications:** To ensure high migration efficiency, specifications should remain as stable as possible, with a minimum number of versions for the different migration steps.

### 2.3.2 Railway Undertakings

An EU-survey was produced to identify the needs of infrastructure managers and railway undertakings in regard to migration (Details can be found here: [SPT2MIG Questionnaire Report\\_V14](#)).

Railways Undertakings have difficulties establishing their own migration strategies to ERJU / SERA compliant systems, due to their dependence on decisions taken by the infrastructure managers. Most of their decisions are therefore influenced by the migration strategies of the infrastructure managers regarding their networks. As long as the infrastructure managers do not publish clear and binding migration strategies, decisions taken by the railway undertakings will be limited to short term needs.

### 2.3.3 Vehicle Owners

In general, the high-level needs of vehicle owners are consistent with those of the IMs and RUs: Clear and consistent specifications, plannable constant workload during migration steps, fair balance between costs and benefits for each stakeholder, real benefits for each migration step, coordination of migration within EU, maturity of new features, protection of investments with an overall migration funding. It is difficult to set up independent migration strategies due to their dependency on the infrastructure.

As the vehicle owners are mostly Leasing Companies and incumbent RU's, there are some specific needs for migration and integration of new features (authorization, certification, operations, training, etc.):

For the leasing companies:

- Need to run anywhere, often cross border
- Low margin operations, hence investments in CCS need to fulfil 30-year lifecycle
- Invested heavily in Baseline 3.4 compliant systems; backward compatibility with this Baseline is expected even if new trackside functions are implemented with future baselines
- introduction of FRMCS should support B3.4 onboard units
- low authorisation effort, automated cross border authorisation. Particular attention must be paid to the capacity of ERA regarding vehicle authorization

For the incumbent RU's

- Need of predictability of migration targets
- Reduction of down time most important

Both leasing companies and RUs need accurate information about migration to have a clear vision of the compatibility check for the envisaged routes or operating areas, as transport plans and contracts are negotiated over the medium term.

In addition to these considerations, the SC2.1 Survey ([SPT2MIG Questionnaire Report\\_V14](#)) highlighted some particular aspects to be taken into account:

- Dual onboard architecture is important in the migration situation (Class B and ETCS trackside), as some leasing companies mention that there is currently no alternative for leasing locomotives without Class B. Of course, this is not an ideal approach, some responded that they would like to avoid such investments.
- A better overall migration coordination could avoid their worst case, having dual onboard combined with dual trackside. This would also reduce lower performance as well as safety during migration phases.

### 2.3.4 Legislators

Certain aspects of harmonised ERJU / SERA compliant systems and operating procedures might be in conflict with current national laws and regulations. Some of these conflicts are reflected in the so called Notified National Technical Rules (NNTRs), which are published by most Countries. Switzerland for example require testing of onboard systems in test labs of the trackside suppliers, or Euroloop capability.

Migrating to these systems and operating procedures can however only be performed if they are covered by applicable laws and regulations. Where conflicts exist, the respective laws and regulations must be adapted to the new systems and operating procedures, which might take some time.

Legislators will typically not identify conflicts themselves, they must therefore be informed by other stakeholders about identified conflicts.

As part of the development of a migration plan, conflicts with national laws and regulations must be identified. As ERJU / SERA compliant systems and operating procedures shall not contain national or customer specific deviations or add-ons, these conflicts can only be solved by adjusting conflicting national laws and regulations.

### 2.3.5 Supervisory Authorities

Supervisory authorities ensure that organisations under their control comply with all applicable legal requirements and regulations. Many aspects, which shall be harmonised with the introduction of ERJU / SERA systems and operating procedures, will potentially be in conflict with current regulations.

As supervisory authorities typically only have limited possibilities to approve deviations from legal requirements and regulations, they can only continue their oversight if these legal requirements and regulations are adapted to cover the harmonised systems and operating procedures.

Supervisory authorities must therefore be involved in the development of migration plans, in order to identify potential conflicts with current regulations, so that they can be highlighted to the legislators.

### 2.3.6 Suppliers

With the introduction of SERA, a more open and competitive market shall be generated for harmonised CCS systems without country specific add-ons. It is envisaged that this will lead to lower prices, both due to scale effects and competition, and might even bring new suppliers into the CCS market. A key element of creating such an open market is the proposal to break down systems into a number of exchangeable modules with interoperable interfaces.

Most of the standardisation proposed in ERJU, e.g., introducing modularity or harmonising diagnostics, is not justified by creating interoperability, nor improving safety, and can therefore not be legally enforced. There is therefore a risk that systems not designed with the proposed modularity (e.g., ASTP or ATO as separate modules) are still being procured if they are cheaper, require less space etc., splitting an already small market in numbers into even smaller numbers of modular and non-modular product variants.

Whether procuring products from multiple suppliers reduces life cycle cost or not needs to be investigated, especially where low volumes are procured. Firstly, splitting a system into modules requires individual enclosures, computing modules (potentially with a SIL level), power supplies, wiring etc. per module. Then, each module has to individually go through the full testing and certification process. And even if interfaces are being standardised between modules, there is still a need for integration testing, for certifying each combination to be used etc. And finally, if systems are being procured as modules from different suppliers, a potentially costly system integration role will be necessary.

To create a truly open market, and to achieve envisaged cost savings, various conditions must therefore be met from suppliers' perspectives:

- Harmonised products shall be free of national features or requirements, so that they can truly be supplied to multiple customers in identical form.
- Respective standards must therefore be specified, and either legally enforced, where possible, or supported by customer commitments.
- Volumes must increase per supplier, which requires a significant growth of the market if additional suppliers shall be attracted.
- The functionality of products must be stable over a long time to avoid having to continuously spend significant R&D resources for redesigns, cross-testing and re-certification.
- It should be possible to supply certain types of documents, e.g., for certification and second / third level of maintenance in English, rather than in national language.

Attracting additional suppliers into the CCS market would reduce volumes per supplier to even lower levels than what they currently are, unless the market grows significantly.

While some of these issues can be resolved by the customers themselves, some might require changes to national laws and regulations.

### 2.3.7 Customers

Customers in this context are the end users of rail services, which are typically passengers as well as freight shippers.

Passengers have many requirements which are not directly related to CCS systems, such e.g., sufficient seating, clean trains and working air conditioners.

Passengers and shippers however also have requirements which are expected to improve by the introduction of the ERJU / SERA CCS system architecture, including harmonised operation, such as:

- Punctuality and stability of services
- Accurate information and quick reaction in case of unforeseen events
- Easy access to tickets, respectively freight services for national and international services
- Competitive pricing

These aspects are part of the common business objective of SERA.

Regarding migration, both customer groups expect that no degradations of current service levels occur. They probably also expect that services improve stepwise during migration.

Migration planning shall therefore focus on maintain current service levels during the whole process, which might take decades. Impacts, which should be avoided except for short durations are:


- temporary reduction of services,
- re-routing of traffic,
- extended travel times,
- need for frequent changes of trains,
- use of legacy equipment with less comfort etc.




### 3 Migration towards SERA Traffic CS Target Architecture

This chapter provides guidance on how migration towards the SERA Target for the trackside architecture can be achieved by providing an overview of the main Traffic CS systems, SERA enablers and their possible Migration Scenarios.

#### 3.1 - SERA Target | Traffic CS System Architecture

In this section the three basic systems of the Traffic CS target architecture **PES, ETPS and ATO-TS** are shortly introduced as well as their interfaces with each other and with operator work benches and central services as Digital Register, Diagnostics and Configuration. Further detailed descriptions can be found in the  Traffic CS System Concept.

#### 3.2 - SERA Enablers | Recommendations for current rollouts

In this section, **enablers for the SERA pre-phase** going hand in hand with recommendations for current rollouts are explained as prior knowledge for the upcoming sections. This section contains a short summary of the outcome of  D1 Recommendations for current rollouts.


#### 3.3 - Migration Scenarios

In this section a number of possible **Migration Scenarios** for a stepwise integration of Traffic CS systems (building functional packages) are introduced and evaluated regarding self-sufficiency of functions and user interfaces as well as interconnection possibilities for adjacent legacy systems and needs for adaption (see 1.3.2 - Interpretation of the Deliverable description)

#### 3.4 - Geographical dimension

In this section the deployment of the before mentioned Migration Scenarios are discussed on a **geographical scale** for a station wise integration, a line wise integration or a renewal of a part of a network.

#### 3.1 SERA Target | Traffic CS System Architecture

The  Traffic CS System Concept summarizes the most important system requirements for Traffic CS and explains in its solution concept how it is foreseen to fulfil these requirements. Furthermore, assumptions and expectations to external systems outside of Traffic CS are stated and a roadmap towards the SERA target is presented.

## Traffic CS System Architecture

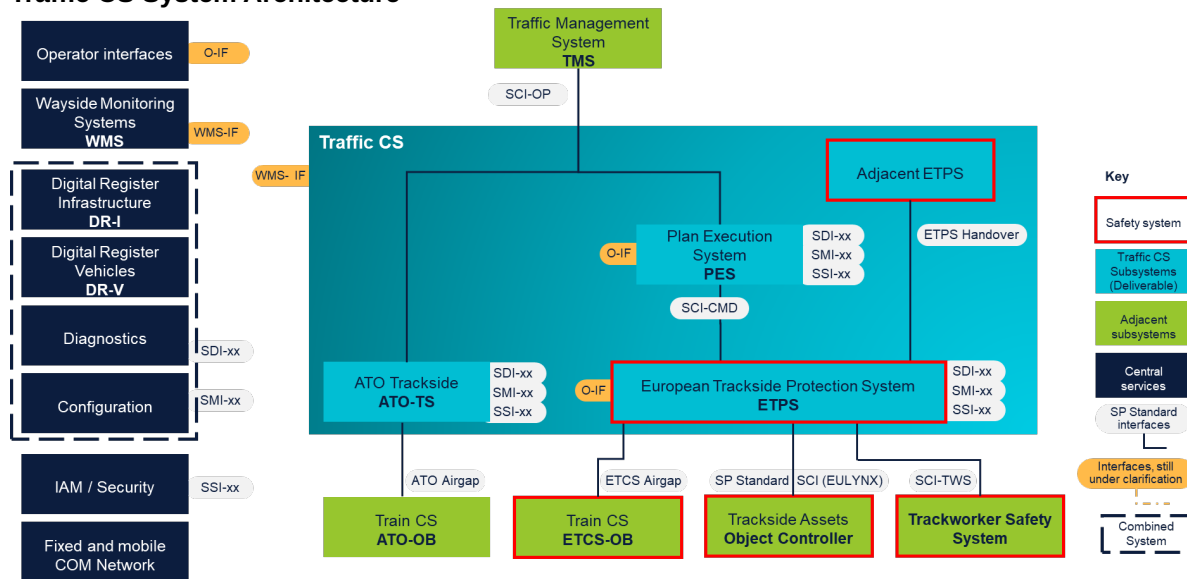


Figure 3 - Traffic CS System Architecture

[SPT2TRAFFIC-8897]

**Main sub-systems in the Traffic CS System Architecture are:**

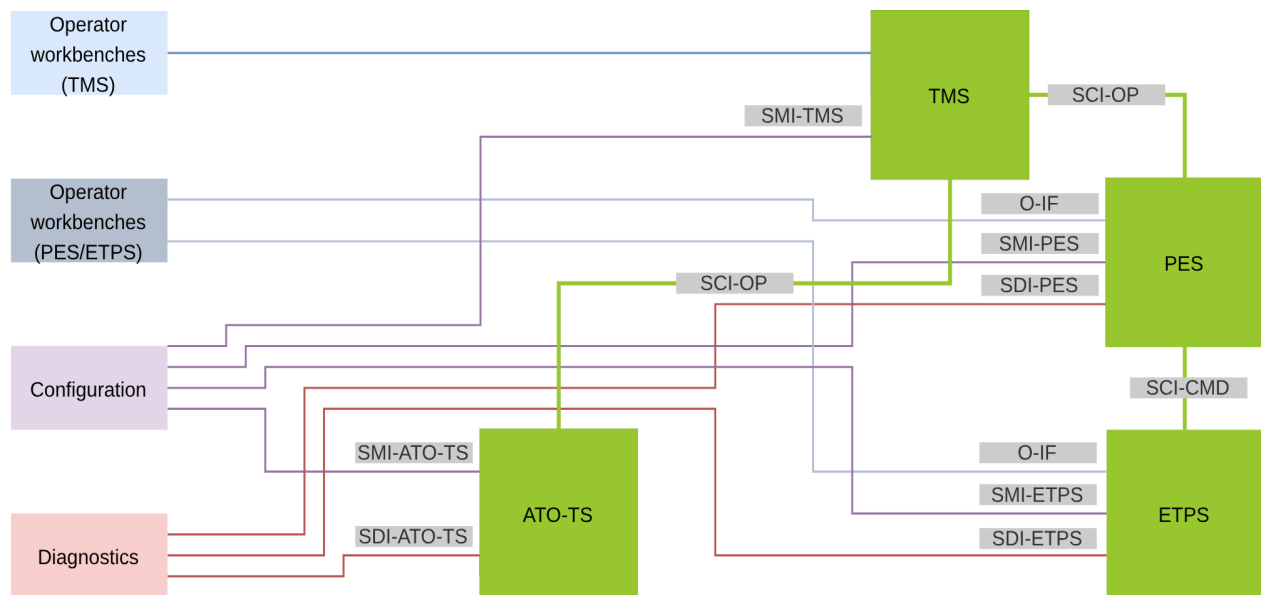
**Plan Execution System (PES):** The main functions of PES are: processing the Operational Plans provided by the TMS, which are based on the Operating State of the railway within the Area of Control and the provision of the Operating State within the Area of Control received from ETPS towards the TMS. These are from current perspective considered as non safety critical functions.

**European Trackside Protection System (ETPS):** The main functions of ETPS are: Maintain an up-to-date Operating State of the railway within the Area of Control, process requests from PES for movements of trackside infrastructure Process requests from PES for Movement Permissions, process requests from Operator relating to manual operations (for example for Usage Restrictions, including TSRs, Release Movement Permissions based on the movement of trains), detect and react to unsafe situations, manage communications to Trackside Assets, Trains and adjacent ETPSs. These are from current perspective considered as safety critical functions.

**ATO Trackside (ATO-TS):** this subsystem implements the adaptation function between TMS and ATO OBU; i.e. it receives the Operational Plan and translates it to the Journey Profile which is sent by ATO-TS to ATO-OB, it translates the infrastructure topology from Digital Register Infrastructure to Segment Profiles which are sent by ATO-TS to ATO-OB on request of the ATO-OB. In addition, for each train within the area, the ATO Trackside subsystem will manage communications to ATO-OB and process ATO status information sent by the train. These are all non safety critical functions.

### Foreseen harmonised interfaces between SERA systems





### Foreseen harmonised interfaces between SERA systems and exchanged information

**Notice: Interfaces to Trackside Assets Object Controllers are not taken into account here!**

**(for justification see [Disclaimer on Migration Scenarios](#) and [SERA enablers](#))**

#	Name (if existent)	Interface between Systems	Exchanged information (short description)	Link to TCS System Concept
I 1	SCI-OP	TMS < PES	<ul style="list-style-type: none"> <li>TMS sends Operational Plans to PES</li> <li>PES reports to TMS on progress of Operational Plans based on information from ETPS.</li> <li>PES provides current Operating State to TMS</li> </ul>	SCI-OP
I 2	SCI-OP	TMS < ATO-TS	<ul style="list-style-type: none"> <li>TMS sends Operational Plans to ATO-TS with detailed information about passing and stopping points</li> <li>ATO-TS translates Operational Plans to Journey Profiles which are sent by ATO-TS to ATO-OB</li> <li>ATO-TS sends Status Report to TMS</li> </ul>	SCI-OP
I 3	-	TMS < Operator workbenches (TMS)	<ul style="list-style-type: none"> <li>Interface I3 is out of scope of the Traffic CS Domain; just mentioned here for a better understanding of <u>Migration Scenario M01</u>, where TMS is involved</li> </ul>	-
I 4	SMI-TMS	TMS < Configuration	<ul style="list-style-type: none"> <li>Interface I4 is out of scope of the Traffic CS Domain; just mentioned here for a better understanding of <u>Migration Scenario M01</u>, where TMS is involved</li> </ul>	-

#	Name (if existent)	Interface between Systems			Exchanged information (short description)	Link to TCS System Concept
I 5	SCI-CMD	PE S	< >	ETPS	<ul style="list-style-type: none"> <li>• PES sends requests to ETPS for movements of trackside infrastructure and for Movement Permissions.</li> <li>• PES receives the Operating State of the railway within the Area of Control from ETPS</li> </ul>	SCI-CMD
I 6	O-IF	PE S	< >	Operator workbenches (PES/ETPS)	<ul style="list-style-type: none"> <li>• PES provides current Operating State to the Operator workbenches</li> <li>• PES receives Operator Requests from the Operator workbenches (e.g., to move points, or to reserve a path for a train in some degraded situations)</li> <li>• For these, the safety checks will still be performed within ETPS</li> </ul>	O-IF
I 7	SDI-PES	PE S	< >	Diagnostics	<ul style="list-style-type: none"> <li>• PES provides diagnostic information via SDI-PES</li> </ul>	SDI-XX
I 8	SMI-PES	PE S	< >	Configuration	<ul style="list-style-type: none"> <li>• PES receives System Configuration data via SMI-PES</li> <li>• PES receives Infrastructure topology from Digital Register Infrastructure via Configuration SMI-xx interface</li> </ul>	SMI-XX
I 9	O-IF	ET PS	< >	Operator workbenches (PES/ETPS)	<ul style="list-style-type: none"> <li>• Requests from the Operator via the O-IF related to manual operations for a specific train(s) in a specific area or related to usage restrictions (e.g. override points, Axle counter resets, TSR management)</li> <li>• Some safety checks might be done by the Operator</li> <li>• Operator Emergency Commands, for example to stop a train or all trains within an area.</li> <li>• ETPS will be required to provide the complete Operating State to the Operator Interface.</li> </ul>	O-IF
I 10	SDI-ETPS	ET PS	< >	Diagnostics	<ul style="list-style-type: none"> <li>• ETPS provides diagnostic information via SDI-ETPS</li> </ul>	SDI-XX
I 11	SMI-ETPS	ET PS	< >	Configuration	<ul style="list-style-type: none"> <li>• ETPS receives System Configuration data via SMI-ETPS</li> <li>• Infrastructure topology from Digital Register Infrastructure via Configuration SMI-xx Interface</li> </ul>	SMI-XX

#	Name (if existent)	Interface between Systems			Exchanged information (short description)	Link to TCS System Concept
I 1 2	SDI-ATO-TS	AT O- TS	< >	Diagn ostics	<ul style="list-style-type: none"> <li>• ATO-TS provides diagnostic information</li> </ul>	SDI-XX
I 1 3	SMI-ATO-TS	AT O- TS	< >	Config uratio n	<ul style="list-style-type: none"> <li>• ATO-TS receives System Configuration data</li> <li>• ATO-TS receives Infrastructure topology from Digital Register Infrastructure via Configuration SMI-xx to be able to provide Segment Profiles to ATO-OB</li> <li>• it translates the infrastructure topology from Digital Register Infrastructure to Segment Profiles which are sent by ATO-TS to ATO-OB on request of the ATO-OB</li> </ul>	SMI-XX

### 3.2 SERA Enablers | Recommendations for current rollouts

This sections contains a short summary of the results of the already reviewed document "D1 Recommendations for current rollouts" representing an important part of the storyline "how to migrate stepwise to the Traffic CS target architecture".

In  D1 Recommendations for current rollouts **two main questions** are assessed:

1. What can be recommended for existing and/or planned upcoming roll-outs before 2030 (in the SERA pre-phase)?
2. Which System Pillar specifications for features, components and/or interfaces are ready for use or shall be taken into account for developing migration strategies?

From this assessment the following **general recommendations** are derived:

- Apply for signalling deployments based on ETCS L2 without signals
- Follow the specific recommendations elaborated in this deliverable (regarding the candidates listed below)

and the following **potential System Pillar Specification candidates for current rollouts** are evaluated:

- SCI-OP Interface (1)
- CCS/TMS Data Model (2)
- Cybersecurity Requirements (3)
- Object Controllers SCI (4)
- Object Controllers SDI (5)
- Object Controllers SMI (6)
- Traffic CS SDI/SMI (7)
- Computing Environment Specifications (8)


The above candidates have been assessed, weighed and awarded a traffic light accordingly:

- **Green:** There are already objects available, projected as stable and compatible to future harmonised Traffic CS products and their usage is recommended. There is a **high likelihood** that current versions will be **compatible** with future Traffic CS target architecture.
- **Yellow:** There are already objects available, partly stable, partly compatible and probably upgradable to future harmonised Traffic CS products and an alignment to these is recommended.

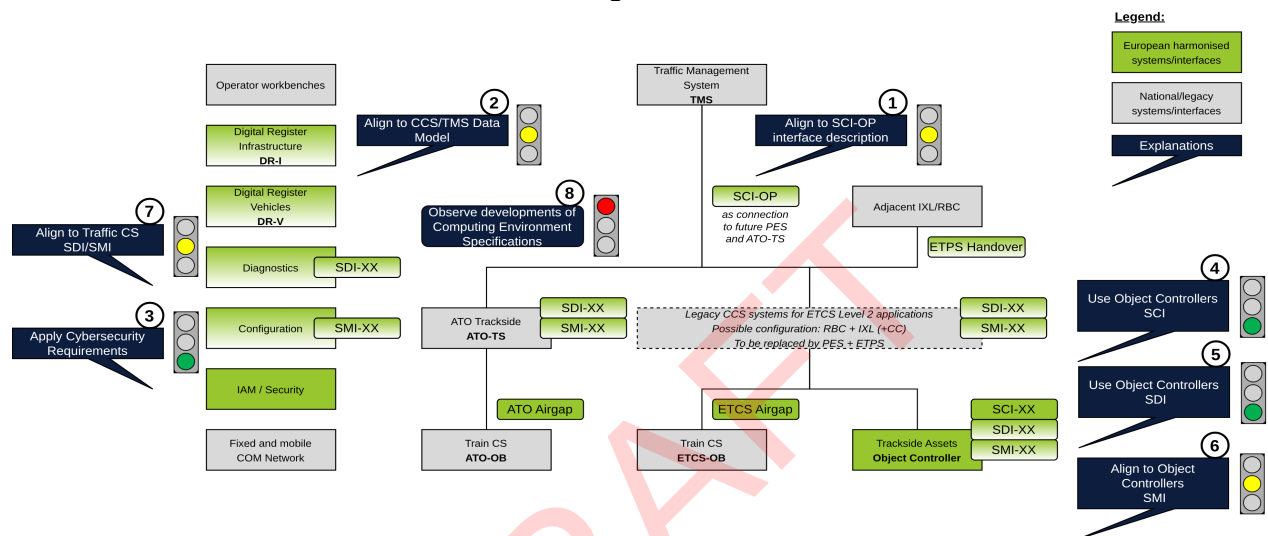
There is a **medium likelihood** that current versions will be **compatible** with future Traffic CS target architecture.

- **Red:** There are no objects available, or the usage of those objects is not recommended. Further developments shall be carefully observed. There is an **uncertainty** that current versions (if existent) will be compatible with the future Traffic CS target architecture.

With respect to above assessment it should also be understood that common but also partially diverging targets of the different stakeholders (e.g. Supplier, IM), in the context of early rollout of these SERA Candidates, exist. For instance, it might be beneficial to stick to proven legacy solutions in the rollout planning until a stable, mature SERA Candidate of reasonable size becomes available.


For further details, see:  D1 Recommendations for current rollouts

### Recommendations for current rollouts - drawing



### 3.3 Migration Scenarios

**General Disclaimer and Assumptions - Please read this carefully before diving into the Migration Scenarios!**

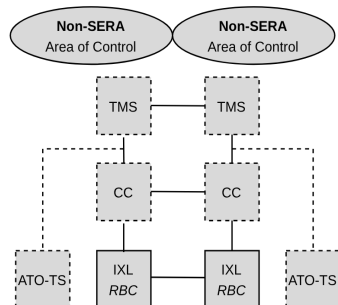
- For each Migration Scenario two ETPS/IXL (+RBC) Areas of Control are shown for visualising handovers and transitions to adjacent legacy systems (it is assumed, that ETPS, legacy IXL and legacy RBC use an Area of Control of similar scale)
- Operator workbenches, Digital Register, Diagnostics and Configuration are only shown for the harmonised SERA systems
- For simplification on legacy site, there is always shown a 1:1 relationship for CC : IXL(+RBC)
- A 1:1 relationship is also assumed for PES : ETPS (still to be evaluated)
- For the analysis in this document, it is assumed that there will be no handover between two PES in two Areas of Control, but this still has to be proven by the MIG Handover workgroup
- SERA enablers as Trackside Assets Object Controllers have not been taken into account here, as their deployment is partly independent of these scenarios. A recommendation regarding the deployment of these enablers in the SERA pre-phase can be found in section **3.2**
- At the level of abstraction shown, on legacy site, no difference has been made between IXL+ETCS L2, IXL + ETCS L1 or IXL + NTC. This will be further detailed in  **D3 CCS Trackside Integration Strategy**.
- The allocation of CCS functionalities to specific legacy systems differ from one Infrastructure Manager (IM) to the other, which is indicated by the remark "IM-specific functional scope" (adaptors are therefore named from the perspective of the harmonised SERA systems, e.g., adaptor "(PT)" for connecting PES to legacy TMS or adaptor "(EX)" for connecting ETPS to multiple "X" adjacent legacy systems (IXL, RBC)).
- For this analysis, it is assumed, that adaptations are done on legacy side, even though requirements for facilitating adaptations on legacy side might be addressed to the harmonised systems.
- The CCS onboard systems on the trainside are not shown as they are connected via the already harmonised interfaces SS-026 (ETCS airgap) and SS-126 (ATO airgap) to the trackside and CCS onboard migration is out of scope of this document

In the following figure, one typical simplified **legacy starting configuration** and the foreseen **harmonised SERA target configuration** according to the Traffic CS System concept are shown schematically with their basic components. The legacy systems are shown in grey color, while the harmonised systems are shown in green. For both cases, two areas of control are shown in order to analyze handover scenarios.

**Overview - SERA and Non-SERA systems**

### Full legacy configuration as starting point

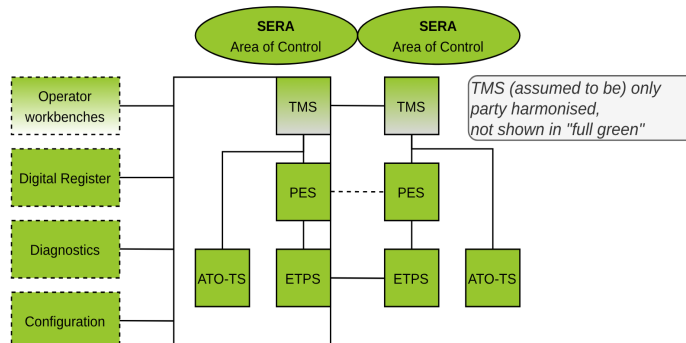
One possible and common legacy configuration. TMS, CC and/or ATO-TS may not exist. Various IM-specific functional allocations.



**ATO-TS:** Legacy ATO (if existent)  
**IXL:** Legacy Interlocking  
**RBC:** Legacy RBC (if existent)  
**CC:** Legacy Command-and-Control Center (if existent)  
**Non-SERA:** Non-Single European Railway Area  
 (Area of Control not equipped with harmonised systems of the System Pillar Reference Architecture)  
**TMS:** Legacy Traffic Management System (if existent)

### Harmonised SERA target configuration

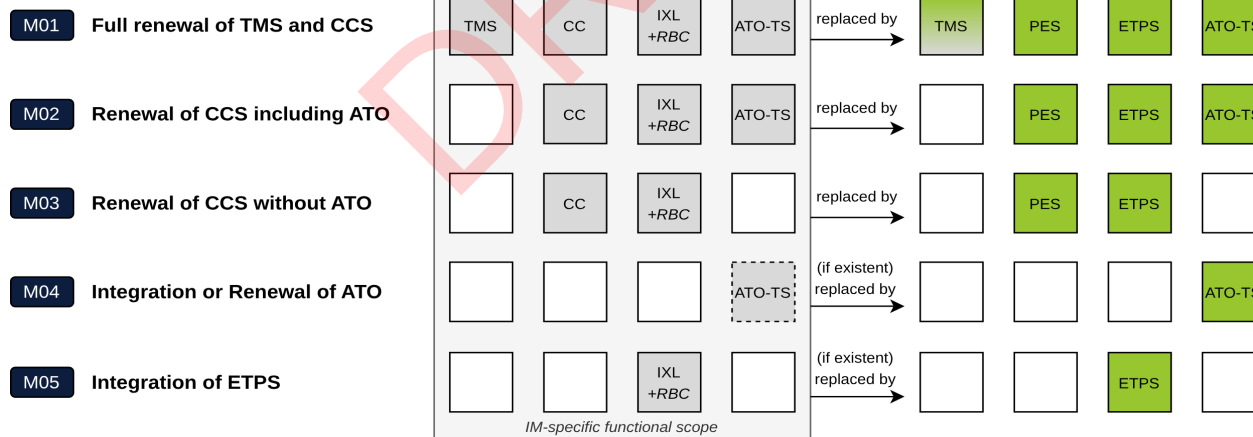
The currently foreseen SERA target configuration according to the Traffic CS System Concept (PES Handover possibly not needed)



**ATO-TS:** Harmonised ATO Trackside  
**ETPS:** Harmonised European Train Protection System  
**PES:** Harmonised Plan Execution System  
**SERA:** Single European Railway Area  
 (Area of Control fully equipped with harmonised systems of the System Pillar Reference Architecture)  
**TMS:** (Partly) harmonised Traffic Management System  
 (currently unclear in which extent TMS is going to be harmonised within ERJU System Pillar)

In the following, five possible **Migration Scenarios (M01-M05)** are analyzed, including their specific boundary conditions and need for adaptations for connecting to adjacent legacy systems. Depending on the individual starting situation of the specific Infrastructure Manager the first migration step can be the full renewal of TMS and CCS systems (M01), a renewal of CCS with or without ATO (M02, M03), a renewal respectively an integration of ATO-TS (M04) or a replacement of IXL/RBC by ETPS (M05). A scenario for a sole implementation of PES in a legacy environment is considered as not applicable (see 3.3.7).

### Overview - Migration Scenarios



The five Migration Scenarios presented in the figure above are analyzed in detail in the following four subchapters:

3.3.1 - M01 - Full renewal of TMS and CCS

3.3.2 - M02 - Renewal of CCS including ATO

3.3.3 - M03 - Renewal of CCS without ATO

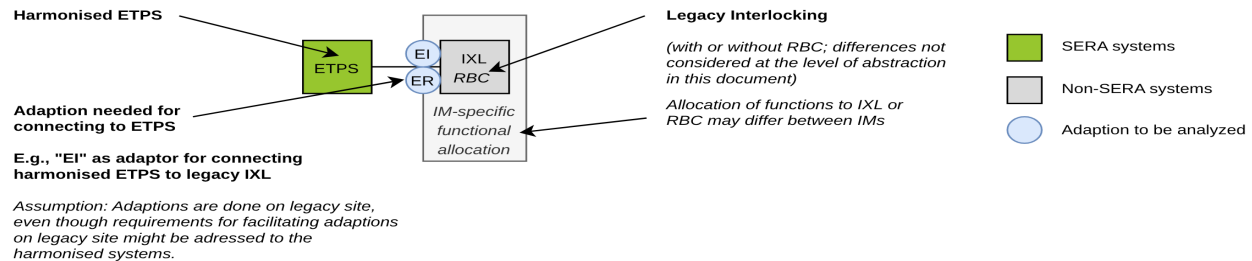
3.3.4 - M04 - Integration or Renewal of ATO

3.3.5 - M05 - Replacement of IXL/RBC by Integration of ETPS

Each analysis starts with the description of the motivation for getting into this scenario and the basic

integration steps (integrating harmonised SERA systems in an existing legacy environment). After the description and figure visualizing the possible integration steps, certain boundary conditions for the specific scenario as well as the need for adaptations (preferably on legacy site) are discussed (see exemplary figure below). The adaptor solutions in detail are discussed in the document [D3 CCS](#) Trackside Integration Strategy of the CCS Trackside Migration Group.

### Exemplary visualisation of adaptations



### 3.3.1 M01 - Full renewal of TMS and CCS

#### M01 Scenario description

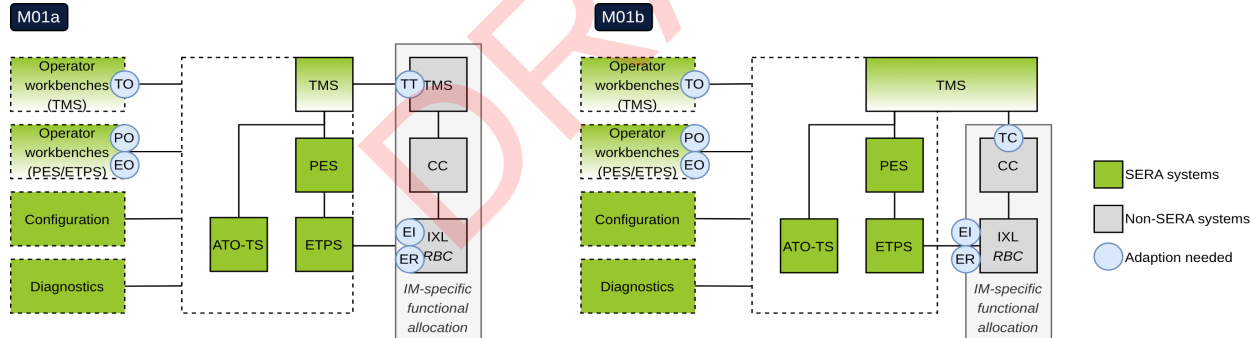
Motivation:

- Legacy TMS, IXL (and if existing, RBC and CC) need to be replaced

Integration steps:

- Harmonised TMS, PES, ATO-TS and ETPS shall be integrated in a legacy environment
- It might be the case, that the new harmonized TMS has to be connected not only to harmonized PES and ATO-TS but also to legacy IXL, RBC or CC (see M01b). In this case a second adaption is needed.

#### M01 Scenario visualization



#### M01 Boundary conditions

- If both IXL and RBC are existent, they have to be replaced together by ETPS, as the safety functions of IXL and RBC are merged into the safety component ETPS in the SERA phase.
- Harmonized operational rules have to be implemented for using PES, ETPS, ATO-TS and TMS

#### M01 Connections to adjacent legacy systems and central services

- TMS
  - For connecting TMS to legacy TMS an adaptor is needed (TT) (see M01a)
  - For connecting TMS to legacy CC an adaptor is needed (TC) (see M01b)
  - For connecting TMS to the (partly harmonised) Operator workbenches an adaptor is needed (TO)
  - TMS to be connected to harmonised Digital Register, Diagnostics and Configuration

#### • PES

- For connecting PES to the (partly harmonised) Operator workbenches an adaptor is needed (PO)
- PES to be connected to harmonised Digital Register, Diagnostics and Configuration

#### • ETPS

- For connecting ETPS to legacy IXL (and RBC) adaptors are needed (EI) (and (ER))
- For connecting ETPS to the (partly harmonised) Operator workbenches an adaptor is needed (EO)
- ETPS to be connected to harmonised Digital Register, Diagnostics and Configuration

#### • ATO-TS

- ATO-TS to be connected to harmonised Digital Register, Diagnostics and Configuration

### 3.3.2 M02 - Renewal of CCS including ATO

#### M02 Scenario description

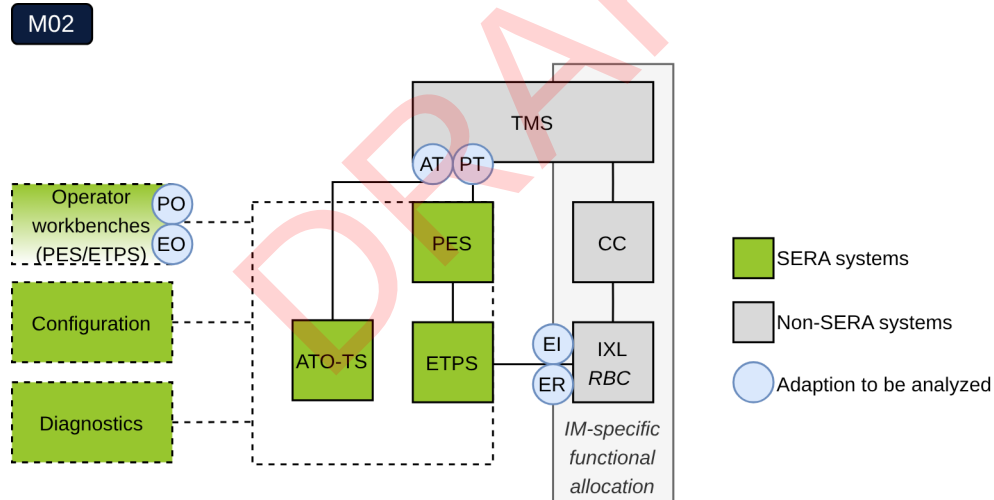
Motivation:

- Legacy IXL (and if existing, RBC and ATO) need(s) to be replaced

Integration steps:

- Integration of harmonised PES, ATO-TS and ETPS in a legacy environment.

#### M02 Scenario visualization



#### M02 Boundary conditions

- If both IXL and RBC are existent, they have to be replaced together by ETPS, as the safety functions of IXL and RBC are merged into the safety component ETPS in the SERA phase.
- Harmonized operational rules have to be implemented for using PES, ETPS and ATO-TS.

#### M02 Connections to adjacent legacy systems and central services

#### • PES

- For connecting PES to legacy TMS an adaptor is needed (PT)
- For connecting PES to the (partly harmonised) Operator workbenches an adaptor is needed (PO)
- PES to be connected to harmonised Digital Register, Diagnostics and Configuration



#### • ETPS

- For connecting ETPS to legacy IXL (and RBC) adaptors are needed (EI) (and (ER))
- For connecting ETPS to the (partly harmonised) Operator workbenches an adaptor is needed (EO)
- ETPS to be connected to harmonised Digital Register, Diagnostics and Configuration

#### • ATO-TS

- For connecting ATO-TS to legacy TMS an adaptor is needed (AT)
- ATO-TS to be connected to harmonised Digital Register, Diagnostics and Configuration

### 3.3.3 M03 - Renewal of CCS without ATO

#### M03 Scenario description

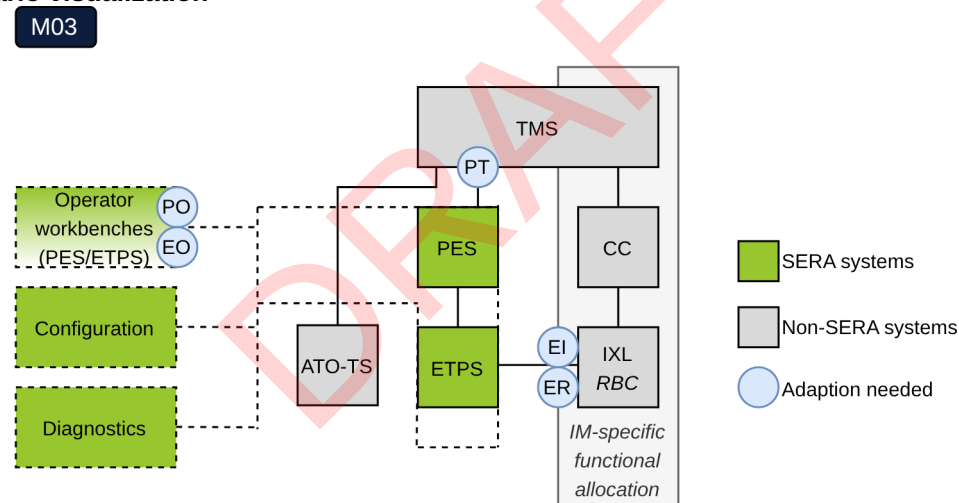
Motivation:

- Legacy IXL (and if existing, RBC) need to be replaced

Integration steps:

- Integration of harmonised PES and ETPS in a legacy environment. Legacy ATO-TS not existent or to be reused

#### M03 Scenario visualization



#### M03 Boundary conditions

- If both IXL and RBC are existent, they have to be replaced together by ETPS, as the safety functions of IXL and RBC are merged into the safety component ETPS in the SERA phase.
- Harmonized operational rules have to be implemented for using PES, ETPS.

#### M03 Connections to adjacent legacy systems and central services

##### • PES

- For connecting PES to legacy TMS an adaptor is needed (PT)
- For connecting PES to the (partly harmonised) Operator workbenches an adaptor is needed (PO)
- PES to be connected to harmonised Digital Register, Diagnostics and Configuration

##### • ETPS

- For connecting ETPS to legacy IXL (and RBC) adaptors are needed (EI) (and (ER))

- For connecting ETPS to the (partly harmonised) Operator workbenches an adaptor is needed (EO)
- ETPS to be connected to harmonised Digital Register, Diagnostics and Configuration

### 3.3.4 M04 - Integration or Renewal of ATO

#### M04 Scenario description

Motivation:

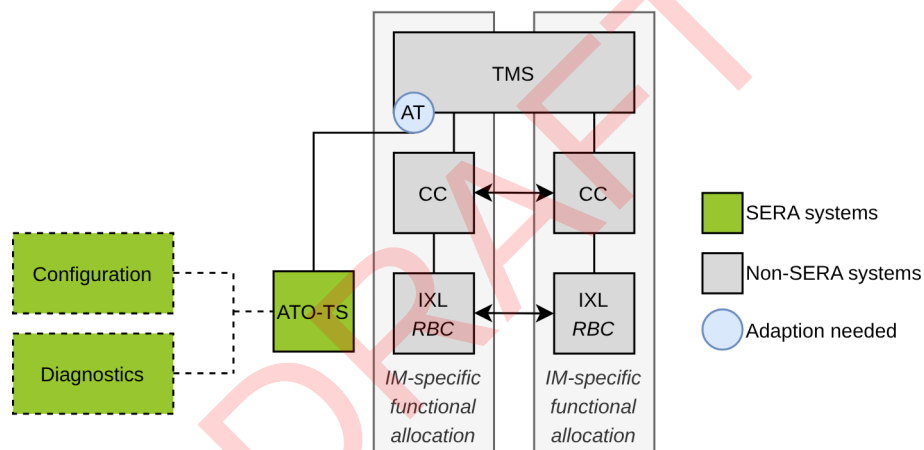
- ATO needs to be replaced or ATO shall be newly integrated.

Integration steps:

- Integration of harmonised ATO-TS in a legacy environment. Legacy IXL (+RBC) (+CC) to be reused.

#### M04 Scenario visualization

M04



#### M04 Boundary conditions

- ATO-TS functionality is independent from PES/ETPS (see 3.1-5)

#### M04 Connections to adjacent legacy systems and central services

##### • ATO-TS

- For connecting ATO-TS to legacy TMS an adaptor is needed (AT)
- ATO-TS to be connected to harmonised Digital Register, Diagnostics and Configuration

### 3.3.5 M05 - Replacement of IXL/RBC by Integration of ETPS

#### M05 Scenario description

Motivation:

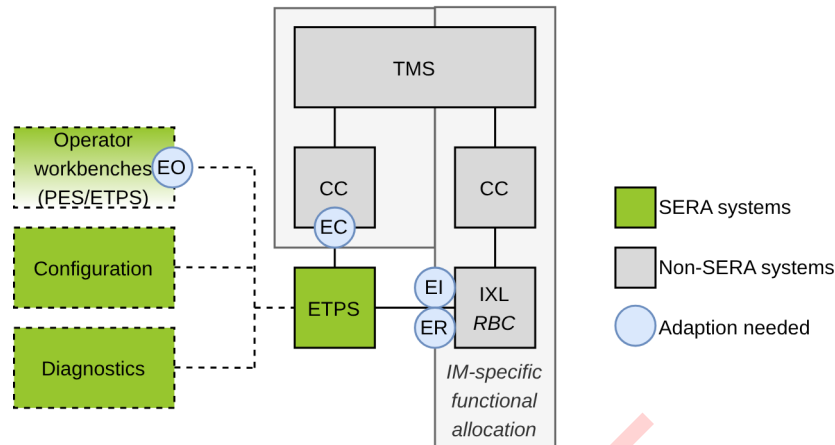
- Legacy IXL (and if existing, RBC) need to be replaced
- CC functionality shall be reused

Integration steps:

- Integration of harmonised ETPS in a legacy environment.

### M05 Scenario visualization

M05



### M05 Boundary conditions

- If both IXL and RBC are existent, they have to be replaced together by ETPS, as the safety functions of IXL and RBC are merged into the safety component ETPS in the SERA phase.
- Harmonized operational rules have to be implemented for using ETPS.
- This case seems might be only applicable, when the legacy CC is so close to PES that the legacy CC can be adapted or better upgraded with SERA functionalities.

### M05 Connections to adjacent legacy systems and central services

#### • ETPS

- For connecting ETPS to legacy CC an adaptor is needed (EC)
- For connecting ETPS to legacy IXL (and RBC) adaptors are needed (EI) (and (ER))
- For connecting ETPS to the (partly harmonised) Operator workbenches an adaptor is needed (EO)
- ETPS to be connected to harmonised Digital Register, Diagnostics and Configuration

### 3.3.6 Overview of Adaptors

Adaptor	Description	Scenarios	Comment
(AT)	Connecting ATO-TS to legacy TMS (information flow <b>I2</b> in <b>3.1-5</b> )	M02, M04	<ul style="list-style-type: none"> <li>• Adaptor based on the harmonised SCI-OP interface protocol (see <b>4</b> D3 CCS Trackside Integration Strategy)</li> </ul>
(EC)	Connecting ETPS to legacy CC (information flow <b>I5</b> in <b>3.1-5</b> )	M05	<ul style="list-style-type: none"> <li>• To be further analyzed</li> </ul>
(EO)	Connecting ETPS to the Operator workbenches (information flow <b>I9</b> in <b>3.1-5</b> )	M01, M02, M03, M05	<ul style="list-style-type: none"> <li>• To be further analyzed</li> </ul>
(EI) (ER))	Connecting ETPS to legacy IXL (and RBC)	M01, M02, M03, M05	

Adaptor	Description	Scenarios	Comment
			<ul style="list-style-type: none"> <li>ETPS handover likely to be defined based on RBC Handover (SS-039) (see <a href="#">D3 CCS Trackside Integration Strategy</a>)</li> </ul>
(PO)	Connecting PES to the Operator workbenches (information flow <a href="#">I6</a> in <a href="#">3.1-5</a> )	M01, M02, M03	<ul style="list-style-type: none"> <li>To be further analyzed</li> </ul>
(PT)	Connecting PES to legacy TMS (information flow <a href="#">I1</a> in <a href="#">3.1-5</a> )	M02, M03	<ul style="list-style-type: none"> <li>Adaptor based on the the harmonised SCI-OP interface protocol (see <a href="#">D3 CCS Trackside Integration Strategy</a>)</li> </ul>
(TC)	Connecting TMS to legacy CC	M01	<ul style="list-style-type: none"> <li>No further analysis within Traffic CS</li> </ul>
(TO)	Connecting TMS to the Operator workbenches (information flow <a href="#">I3</a> in <a href="#">3.1-5</a> )	M01	<ul style="list-style-type: none"> <li>No further analysis within Traffic CS</li> </ul>
(TT)	Connecting TMS to legacy TMS	M01	<ul style="list-style-type: none"> <li>No further analysis within Traffic CS</li> </ul>

### 3.3.7 Summarised Evaluation & Recommendation

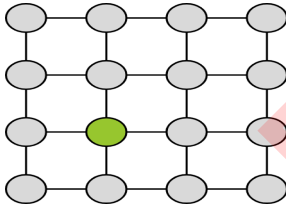
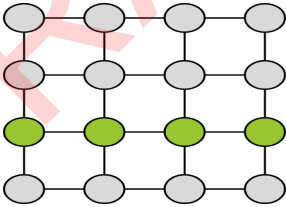
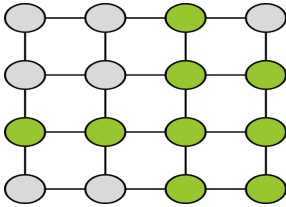
Migration Scenario	Integration of	Evaluation & Recommendation
<b>M01</b> Full renewal of TMS and CCS <a href="#">3.3.1</a>	TMS, PES, ETPS, ATO-TS in a legacy environment	<ul style="list-style-type: none"> <li>Recommended scenario, if TMS shall be (partly) renewed</li> <li>Integration of TMS and the whole Traffic CS functional package including Central services</li> <li>Full set of harmonised operational rules can be used</li> </ul>
<b>M02</b> Renewal of CCS including ATO <a href="#">3.3.2</a>	PES, ETPS, ATO-TS in a legacy environment	<ul style="list-style-type: none"> <li>Recommended scenario, if legacy TMS shall be reused</li> <li>Integration of the whole Traffic CS functional package including Central services</li> </ul>
<b>M03</b> Renewal of CCS without ATO <a href="#">3.3.3</a>	PES, ETPS in a legacy environment	<ul style="list-style-type: none"> <li>Feasible scenario, although the additional efforts for adding ATO-TS are considered as relatively low, so it should be considered, if M02 cannot be a better option.</li> </ul>
<b>M04</b> Integration or Renewal of ATO <a href="#">3.3.4</a>	ATO-TS in a legacy environment	<ul style="list-style-type: none"> <li>Feasible scenario as ATO-TS functionality is independent from PES/ETPS and ATO-TS is only connected to TMS via SCI-OP and to the Central services (<a href="#">3.1-5</a>)</li> </ul>
<b>M05</b> Replacement of		

Migration Scenario	Integration of	Evaluation & Recommendation
IXL/RBC by Integration ETPS <u>3.3.5</u>	ETPS in a legacy environment	<ul style="list-style-type: none"> <li>• A sole integration of ETPS without PES is in general not recommended, because of strong dependencies between both systems via the interface SCI-CMD (<u>I5</u> in <u>3.1-5</u>)</li> <li>• Central services only to be used for ETPS without PES involves questionable efforts</li> <li>• This scenario might only be a feasible option, if legacy CC shall not be replaced and includes already functionalities very similar to the ones of PES</li> </ul>
<b>Not applicable</b>	PES in a legacy environment	<ul style="list-style-type: none"> <li>• No benefits are seen for a sole implementation of PES, therefore this is not considered as a Migration Scenario</li> <li>• PES would have to be connected both to TMS as well as to IXL/RBC via specific adapters (<u>3.1-5</u>)</li> </ul>

### 3.4 Geographical dimension

Besides the technical aspects of integrating SERA systems in a legacy environment as discussed above, the geographical dimension of migration has to be taken into account. The technical TMS/CCS trackside integration in general can be done for one station, for one line or for a part of the network. The implications and boundary conditions of this three geographical dimensions (cases A, B, C) regarding the four Migration Scenarios discussed before (M01-M04) are elaborated in the table presented in the following.

General considerations regarding the geographical dimension of migration are discussed in chapter 2.

	A) Station wise integration	B) Line wise integration	C) Renewal of a part of the network
			
<b>General considerations for all Migration Scenarios</b>	Many connections and handovers to Non-SERA areas.	More connections to Non-SERA areas in comparison to case C.	Less connections to Non-SERA areas in comparison to case B.

<b>M01 Migration Scenario Full renewal of TMS and CCS</b>	Not useful, as operational rules will be affected. - Could be only a starting point for a pilot project in a border region.	To be considered, if the renewal of TMS for one line is beneficial. Change of operational rules to be taken into account.	Feasible scenario <i>(if new systems already considered as stable, mature and with sufficient functionality - see statement below this table)</i>
<b>M02 Migration Scenario Renewal of Traffic CS</b>	Not useful, as operational rules will be affected.	Change of operational rules to be taken into account.	Feasible scenario <i>(if new systems already considered as stable, mature and with sufficient functionality - see statment below this table)</i>
<b>M03 Migration Scenario Renewal of PES +ET PS</b>	Not useful, as operational rules will be affected.	Renewal without ATO-TS not recommended as additional efforts for adding ATO-TS considered as low.	Renewal without ATO-TS not recommended as additional efforts for adding ATO-TS considered as low.

<b>M04 Migration Scenario or Renewal of ATO-TS</b>	<p>New integration of ATO-TS feasible as unlikely to PES/ETPS no interfaces to adjacent areas of control are needed.</p> <p>Renewal of legacy ATO not useful in most of the cases, only in very special cases, when ATO equipment of only one station reaches end of life and operational rules are not affected.</p>	<p>New integration of ATO-TS feasible as unlikely to PES/ETPS no interfaces to adjacent areas of control are needed.</p> <p>Renewal of legacy ATO useful, if existing CCS components (IXL, RBC) have not yet reached end of life.</p>	<p>New integration of ATO-TS feasible as unlikely to PES/ETPS no interfaces to adjacent areas of control are needed.</p> <p>Renewal of legacy ATO useful, if existing CCS components (IXL, RBC) have not yet reached end of life.</p>
<b>M05 Integration of ETPS</b>	<p>Only applicable for very specific cases, to be evaluated</p>	<p>Not useful, to integrate only ETPS without PES on a larger scale.</p>	<p>Not useful, to integrate only ETPS without PES on a larger scale.</p>

It is not likely that the first baseline of the Traffic CS systems will be adequate to be used immediately for a relevant part of the network (case C)), because of limited functionality at the beginning. This is at least what was observed during ETCS rollout and there is no reason that this will be different for this more complex Traffic CS systems. So it seems logical that the availability and maturity of baselines of systems will affect the possibility to move gradually from case A to case C.

## 4 Summary

Developing a migration strategy and plan to convert existing rail networks from the current, largely national technical systems and operations towards the future, harmonised SERA systems and harmonised operating rules is a huge task, which:

- is largely a national issue, as the starting situations are different
- will impact most aspects of the existing networks
- will impact many stakeholders

Note that around 200'000 km of railway lines and 100'000 pieces of rolling stock are impacted by the migration.

Developing a migration strategy and plan requires:

- close cooperation between the impacted stakeholders in each country
- some coordination with neighbouring countries
- agreement on a common goal
- a commitment to work towards that goal
- a certain level of stability as the plan shall cover a timespan of possibly 20 years or more

While a migration strategy and plan toward the target defined in 2.2.2 - Definition of the target can be defined, some significant issues need to be clarified:

- the evolution of the migration target
- the handling of "optional" features, especially in regard to network access
- the standardisation of features which are not relevant for interoperability and safety, and thus require a certain voluntary commitment from the impacted stakeholders



## 5 Annex

### 5.1 Example of Existing Migration Strategies

A migration to a harmonised system architecture based on harmonised operating rules has not yet been done anywhere, as these harmonised rules do not exist yet, so no examples exist which cover all relevant aspects. In some countries, migration strategies to a pure ETCS Level 2 system have however been developed, and their execution started. These strategies already cover many relevant aspects of the migration to an all ERJU / SEMP system implementation, and might therefore be used for guidance.

#### 5.1.1 Example Switzerland

##### 5.1.1.1 Major Goals of migrating to a harmonised CCS system

A number of key goals were defined for the introduction of ETCS (without lineside signals, but with fixed blocks and conventional track vacancy proving) in Switzerland:

- There shall be no dual installations trackside with Class B systems, which will be both costly, and create operational issues, as trains will have to be operated according to different rules.
- The number of rule changes shall be limited to one, meaning trains shall either be operated according to already existing operating rules, which are based on lineside signals, or to new operating rules defined for operation with cab signalling.
- A cost reduction shall result for the infrastructure manager from the elimination of trackside signals and Class B systems.
- A cost reduction shall result for the railway undertakings from the elimination of Class B systems onboard trains as early as possible.
- Both trackside and onboard migration from Class B systems to ETCS Level 2 shall be spread over a reasonable time-frame, which considers the remaining usable life of installed systems, the available resources at the infrastructure manager, the railway undertakings and the supply industry.

##### 5.1.1.2 Pre-Conditions

- The Introduction of ETCS in Switzerland was started due to the need to introduce an ATP system for lines operated at speeds higher than 160 km/h, where national law requires a SIL 4 system which provides cab signalling and continuous supervision.
- This need resulted from a "high-speed" line being under construction between Olten and Berne, to be commissioned in 2004 and operated at 200 km/h. Alternative systems were also being considered, such as an improved version of ZUB 121, as well as LZB, but finally the decision was made to use the ETCS, which was still under development, despite the risks.
- The use of cab signalling was also considered necessary in long tunnels (above 25 km), even if they would be operated only at 160 km/h, as the observation of optical signals is considered difficult. Discussion were ongoing at that time whether a new base tunnel under the Gotthard pass should finally be built, which had been under discussion since 1947.
- Two legacy Class B systems were in use in Switzerland at that time, a basic warning / stop system called Signum and a system incorporating braking curve supervision called ZUB 121, both not providing cab signalling and both not designed to any SIL level. Both systems were considered obsolete both from safety and technology point of view.
- Finally, a significant part of the railway traffic in Switzerland is cross-border, where the use of ETCS can eliminate the need to install multiple Class B systems in the respective rolling stock.

##### 5.1.1.3 Key aspects of the migration concept

Seamless migration of any train control system to another one always requires either doubling installations trackside or onboard. The key aspect of the Swiss migration concept was to reduce this double equipment

to the minimum possible, and to avoid parallel operation of both Class B systems and ETCS on the same line for operational reasons.

It was therefore decided that any new high-speed line, as well as the new long tunnels for transit should be equipped only with ETCS Level 2. Any rolling stock to be operated over these lines therefore had to be equipped with ETCS L2, in addition to the legacy systems Signum and ZUB 121.

In order to avoid newly built vehicles having to be equipped with legacy systems, it was decided to replace the trackside legacy systems (Signum magnets and ZUB Coils) with ETCS Level 1 Limited Supervision, but also containing information for the Class B Systems in Packet 44. This however required all existing Class B systems to be equipped with a Eurobalise reader. Where both Signum and ZUB are installed on a vehicle, the Eurobalise reader together with ZUB also performs the Signum functionality. allowing removal of the Signum onboard system.

The gradual upgrade of existing, conventionally signalled lines to ETCS Level 2 was planned considering the following criteria:

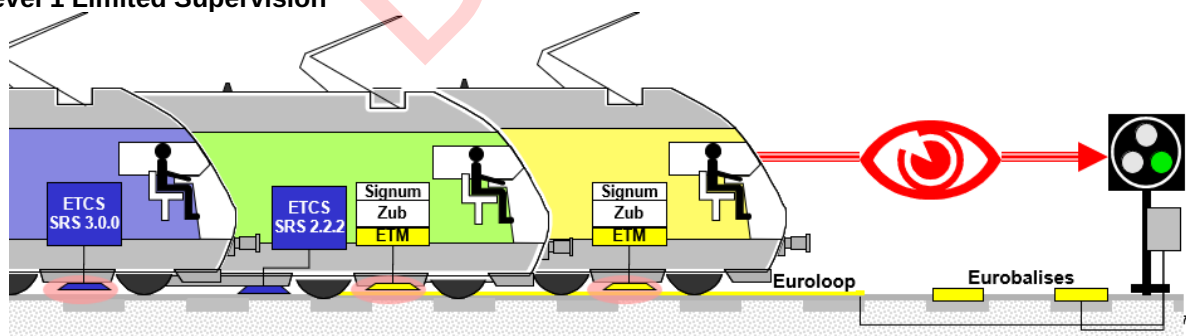
- If they are located where trains passing had to be equipped with ETCS due to the line leading to either the high-speed line or the transit corridors, then they could be equipped at any time.
- If installing ETCS would be done due to e.g., the need to increase capacity, then installing ETCS on trains operating over the line could be considered.
- If they are located where only a limited fleet operates, then installing ETCS on those trains could also be considered.
- Upgrade of other existing, conventionally signalled lines to ETCS Level 2 should be delayed until train fleets are due for replacement.

#### 5.1.1.4 Migration steps onboard

Onboard migration therefore depended on where the vehicle was to operate:

- Vehicles to operate on ETCS Level 2 lines had to be equipped with ETCS, as well as with a balise reader for the Class B systems.
- Vehicles to operate only on conventionally signalled lines had to be equipped with a balise reader for the Class B systems.
- New vehicles only require ETCS, if compliant with Baseline 3, which includes the Limited Supervision mode.

#### Compatibility of trains with various levels of onboard equipment with tracks equipped with ETCS Level 1 Limited Supervision



Once the trackside rollout of ETCS Level 1 Limited Supervision was completed, the onboard antennas of the Class B systems could be removed, as these systems only operated from balises.

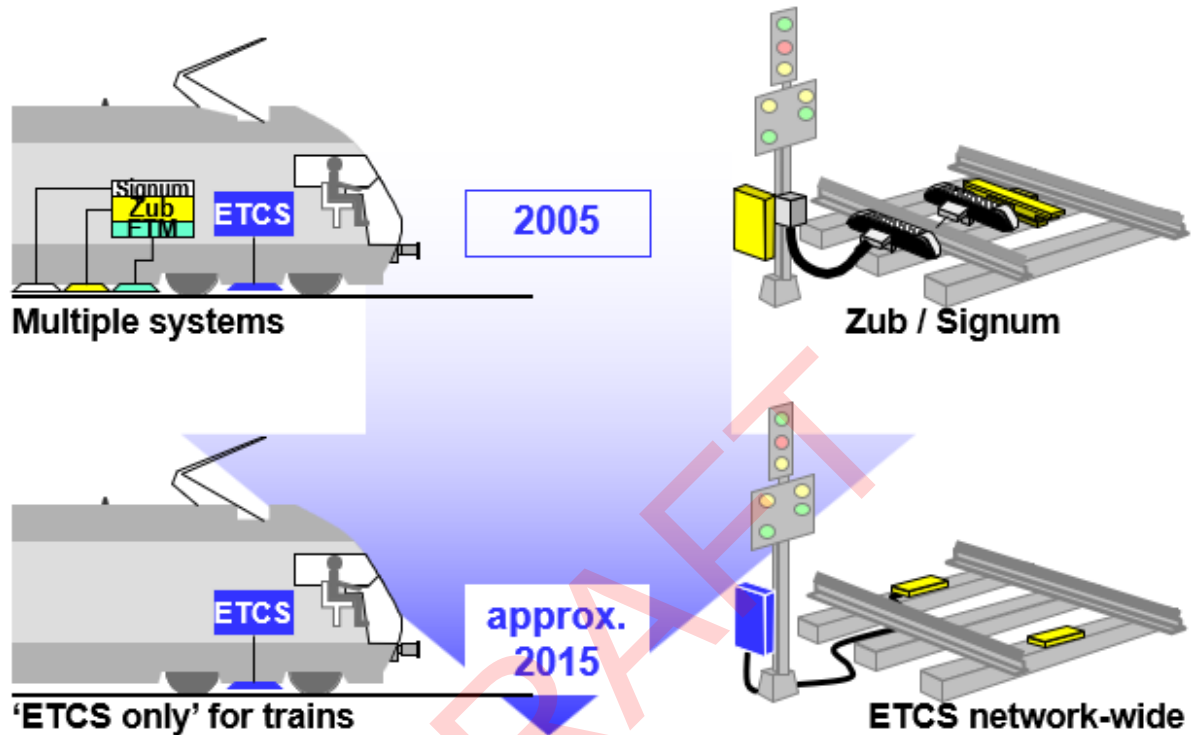
#### 5.1.1.5 Migration steps trackside

ETCS Level 2 was installed from the start as "pure" Level 2 without lineside signals, apart from shunting signals. This was the case for the initial high-speed line between Olten and Bern, for the Lötschberg- and

Gotthard-Tunnels, for the access lines to these tunnels and also for lines with stations, such as Pully-Villeneuve and Sion-Sierre, where the full spectrum of operation is performed.

On all other lines, the existing Signum magnets and ZUB Coils located at around 12'000 signals were replaced over only four years by Eurobalises. This was only started once all Class B onboard systems were equipped with balise readers, allowing direct replacement of magnets and coils. The direct replacement also permitted reusing certain existing interfaces.

**Trackside replacement of Class B systems with ETCS Level 1 Limite Supervision to eliminate the need for Class B systems onboard trains**



The quick roll-out was made possible by a "factory style" approach, based on a redefined work split between infrastructure managers, suppliers and authorities, applying optimised processes, and a high level of standardisation and automation.

#### 5.1.1.6 Sequencing of operating rule changes

Key aspect, as already mentioned, was to change rules only once. This has been achieved by using Level 1 Limit Supervision mode during transition, rather than Level 1 Full Supervision mode, as this would have required to significantly updated existing operating rules for lines with lineside signals.

It should also be noted that, due to phased rollout of ETCS in specific areas, a significant portion of the drivers is currently not operating in areas with ETCS Level 2 (e.g. the drives of the S-Bahn Zurich). They will only have to be trained / certified for Level 2 once the first lines are converted in their area.