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ERTMS - Third Work Plan of the European Coordinator Matthias Ruete

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ACRONYMS AND ABBREVIATIONS

ATL	Atlantic - European Transport Corridor
ATO	Automatic Train Operation
BSAS	Baltic Sea — Adriatic Sea - European Transport Corridor
BBA	Baltic Sea — Black Sea — Aegean Sea - European Transport Corridor
CBA	Cost-benefit analysis
CCS TSI	Control Command and Signalling Technical Specification for Interoperability
CEF	Connecting Europe Facility
CER	Community of European Railway and Infrastructure Companies
CF	Cohesion Fund
CINEA	European Climate, Infrastructure and Environment Executive Agency
CNC	Core Network Corridor
CTCS	Chinese Train Control System
DAC	Digital Automatic Coupling
DMT	ERTMS Deployment Management Team
EC	European Commission
EDP	European Deployment Plan
EECT	Extended ERA Core Team
EIB	European Investment Bank
EIF	European Investment Fund
ERA	European Union Agency for Railways
ERDF	European Regional Development Fund
ERTMS	European Rail Traffic Management System
ESC	ETCS System compatibility
ETC	European Transport Corridor
ETCS	European Train Control System
EU	European Union

EU-27	European Union 27 Member States
EU-RAIL	Europe's Rail Joint Undertaking
FRMCS	Future Radio Mobile Communication Systems
FS	Full Supervision mode of ERTMS
GoA	Grade of Automation
GSM-R	Global System for Mobile Communications – Railway
IM	Infrastructure Manager
IPCEI	Important Projects of Common European Interest
L1	Level 1 of ERTMS
L2	Level 2 of ERTMS
LS	Limited Supervision mode of ERTMS
MED	Mediterranean - European Transport Corridor
MFF	Multiannual Financial Framework
MNO	Mobile Network Operators
MS	Member State
NIP	National Implementation Plan
NSA	National Safety Authority
NSB	North Sea - Baltic - European Transport Corridor
NSRM	North Sea - Rhine - Mediterranean - European Transport Corridor
OB	On-board
OBU	On-board Unit
RBC	Radio Block Centre
RDB	Rhine – Danube - European Transport Corridor
RISC	Railway Interoperability and Safety Committee
RRF	Recovery and Resilience Facility
RRP	Recovery and Resilience Plans
RSC	Radio System Compatibility
SAFE	Security Action for Europe
SCM	Scandinavian — Mediterranean - European Transport Corridor

SERA	Single European Railway Area
STM	Specific Transmission Module
TEN-T	Trans-European Transport Network
TMS	Traffic Management System
UIC	Union Internationale des Chemins de Fer / International Union of Railways
UNIFE	Union des Industries Ferroviaires Européennes/ European Rail Supply Industry Association
WBEM	Western Balkans — Eastern Mediterranean - European Transport Corridor

Table 1: Acronyms and abbreviation

1. INTRODUCTION

My latest ERTMS workplan dates back to 2022. Obviously, the geopolitical and security environment has changed considerably since then. All the more reason to strengthen and modernise the EU rail sector which is still world leader.

Since 2022, ERTMS has been subject to numerous developments. Political, legal, technological and financial parameters have changed and reinforced the willingness and obligation to deploy ERTMS as the single European signalling system. There is now **broad political support** for the roll-out in the European Parliament, among EU transport ministers and among the relevant rail stakeholders at the European level. The debate is no longer about the 'if', but **the 'how' and 'when' ERTMS should be deployed**.

With this workplan[1], I nevertheless sound a warning as to the realities on the ground. **Progress is slow**, the mindset of many stakeholders is not yet sufficiently attuned to the momentous challenge this digital transformation brings. This must be better understood at the highest level of administrations, railway undertakings and infrastructure management whereas the responsibilities are often delegated downwards.

The present work plan takes stock of the – often slow – progress of development and deployment in the past years. It analyses accomplishments and challenges, proposes pragmatic solutions and defines priorities of future action. It contains an analysis of the **National Implementation Plans** (NIPs) for ERTMS submitted by Member States in 2024 and 2025. The overall purpose of my work plan is to identify the next steps for an accelerated deployment of ERTMS in a difficult geopolitical and economic environment. It may serve also as the basis for the next European Deployment Plan (EDP) for ERTMS and the work of my fellow TEN-T coordinators on the nine European Transport Corridors and the European Maritime Space.

ERTMS – more important than ever

ERTMS is essential for the **modernisation** of railways in Europe. It harmonises railway traffic management across the different national networks, eliminates barriers and streamlines operations. ERTMS plays a crucial role in the **digitalisation** of railways, enabling **innovations** such as Automatic Train Operation (ATO) and advanced radio communication (FRMCS). By integrating these digital technologies, ERTMS enhances the operational capacity and reliability of rail services.

A fundamental component of the vision for ERTMS is its contribution towards **achieving the Single European Rail Area**. This objective involves facilitating seamless cross-border traffic, a goal that is essential for enhancing the efficiency and fluidity of European railway networks. The significance of ERTMS has been explicitly confirmed by the reports authored by Mario Draghi and Enrico Letta in 2024. Their analyses underscore the necessity of modernisation and integration efforts driven by ERTMS to propel Europe's railway networks into a new era of advancement and connectivity. The importance of modern railways is also highlighted in relation to **military mobility** and the ambition of a **high-speed rail network** across Europe (see chapter 8 of this report).

As we continue to further develop and deploy ERTMS, it has become ever more evident that ERTMS is a pivotal solution in achieving a modernised, digitalised, safe and seamlessly interconnected railway system across the EU. It is also widely adopted in the rest of the world.

Recent progress in the development of the ERTMS framework

[1] This workplan has been developed on the basis of a considerable number of contributions and reactions from the EP, the Commission services, ERA, EU Rail and CINEA, the Member States as well as numerous stakeholders. I wish to thank all while assuming the responsibility for its content.

In recent years, ERTMS has made significant strides towards its goals through a **reinforced legal and regulatory framework**. The adoption of the revised Trans-European Transport Network (TEN-T) Regulation in 2024 is a critical step, as it has reinforced ERTMS's importance and sets forth ambitious objectives for its deployment up to 2050. Complementing this, the 2023 approval of the Technical Specifications for Interoperability for Command, Control, and Signalling System (TSI CCS) has strengthened and expanded the technical and implementation rules guiding ERTMS deployment. In this context, the role of the European Union Agency for Railways (ERA) as systems authority has been confirmed.

The further development of the **institutional framework** has been instrumental in advancing ERTMS. Initiatives such as the creation of the System Pillar and Deployment Group within the Joint Undertaking Europe's Rail have been vital in establishing a systematic process to help with the development and deployment of the technical rules for ERTMS. Moreover, the role of the European Coordinator for ERTMS has been bolstered under the revised TEN-T Regulation, formalising collaborative structures like the consultative ERTMS Forum and appointing national ERTMS representatives. However, this workplan identifies a persistent lack of governance and therefore proposes to reinforce the coordination and governance at European level (see chapter 9.3).

On the **technological front**, the work on developing the future radio communication standard for railways based on 5G (FRMCS) is continuing, albeit lagging considerably behind its initial timeline, as the necessary technical specifications are not yet available. Moreover, a major uncertainty exists as to the continuous availability of the present, 2G based technology beyond 2035. Both factors constitute a major risk. Railway undertakings and infrastructure managers are often not sure how to invest, and no satisfactory answers are given as to the continuity of railway communication systems. Efforts are also made to define interfaces that allow for modular development and the use of off-the-shelf products and the exchange of individual ERTMS components. This would move the system towards a more flexible and vehicle-based framework. Once these aspects are solved, these technological advancements should help to reap the full benefits of ERTMS and to promote its roll-out.

In terms of trackside deployment, ERTMS was in operation on **12 400 km of the TEN-T network** (i.e. 10% of EU 27) including **10 600 km on the core network alone** (i.e. 17%) at the end of 2024 (see chapter 3). Until 2030, approximately another 28 000 km of the TEN-T network are planned to be equipped with ERTMS, including 22 000 km on the core network, tripling the length of tracks already put in operation. These figures, although signs of steady progress, fall considerably behind the legal requirement of 62 960[2] km for 2030. Moreover, this workplan reveals that based on current planning, the target of deploying ERTMS on the core network will be achieved only to about 50%. In terms of on-board deployment, **around 8 730 vehicles were already equipped with ETCS** at the end of 2024, i.e., 19% of the existing total fleet (see chapter 4). The number of vehicles contracted or planned to be equipped is about 13 600, significantly increasing the annual rate achieved over the past four years. Again, this shows progress but is insufficient in many cases to allow for a phasing out of national -so-called class B – systems. It is now undisputed that the ERTMS roll-out must be a synchronised process, involving both trackside equipment and rolling stock.

Overcoming Remaining Obstacles

Several obstacles remain on the path to achieving its full roll-out and reaping its full benefits. Rather than viewing ERTMS as a single European system, infrastructure managers have in the past preferred to treat it as a supplementary overlay system alongside national systems. The historical **precedence of national systems** means that

[2] Length of the core network EU-27

railways have long operated under varying standards and practices, creating significant hurdles for the adoption of a unified system like ERTMS. Introducing ERTMS in what is often a **brownfield environment** - where existing operations must continue uninterrupted - adds an additional layer of difficulty. Other obstacles relate to lengthy authorisation procedures and the lack of coordination to migrate rolling stock and infrastructure in a coherent manner. The railway sector, often characterised by long innovation cycles, has not yet fully faced up to the challenges presented by digitalisation.

Financial factors compound these technical and operational challenges. The **costs** associated with deploying ERTMS are significant, encompassing the expenses for both on-board and trackside equipment. As detailed in my workplan, these mounting costs of ERTMS can inhibit an accelerated roll-out, especially given the **historical under-investment in railway** infrastructure in many European countries.

The result is a **patchwork roll-out** across the EU. This is clearly illustrated through the very different ambitions for roll-out in the European Transport Corridors (ETCs) and the specific difficulty in cross-border coordination. Inconsistent, uncoordinated implementation means that economies of scale and scope cannot be fully realised. Without stronger coordination, the cost savings and operational efficiencies of ERTMS will remain elusive, especially for vehicle owners and operators.

Key actions to promote the roll-out

Addressing these challenges requires a concerted effort.

First, the roll-out of ERTMS should not be treated merely as a complex technical challenge but rather considered at the highest level of all stakeholders concerned as a strategic modernisation project which also requires a deeper change to simplify current national solutions. Crucially, stakeholders must recognise the ERTMS roll-out as **a long-term project, with a strong industrial and policy dimension**. Viewing it through this lens shifts the focus from immediate returns to sustainable development, digitalisation and **reinvigoration of the European rail industry**. ERTMS is not merely a technical upgrade but a transformative journey towards modernising an essential mode of sustainable transport for Europe. In practical terms, this means ensuring a high level of standardisation, a continuous control of costs and a reliable form of transition management to safeguard the support of all stakeholders concerned.

Second, the different levels providing finance need to enable stable and predictable budgets to allow for more rational planning for what will be an industrial roll out in the decades to come. This involves the **up-scaling and industrialisation** of ERTMS deployment. Transitioning from a fragmented and experimental approach to a unified long-term strategy is essential. Member States must embrace this unified vision, developing strategies that go beyond pilot projects to fully scaled implementations. Some Member States have set a good example in this respect and achieved considerable success.

Third, simplifying rules, processes, and streamlining institutional involvement in the ERTMS roll-out is paramount. By reducing bureaucratic complexity and fostering a more agile regulatory environment, stakeholders can expedite the deployment process while minimising disruption.

Collaborating for Progress

Central to a successful roll-out is the robust **cooperation between all stakeholders** involved. Establishing a common strategy for ERTMS deployment involves developing the necessary regulatory and institutional framework and ensuring financial and legal certainty. Collective responsibility and commitment are required to pool resources, share knowledge, and foster innovation. For this, the appropriate governance needs to be in place.

My work plan is addressed to the European Parliament, the Council and to Member States. But it also aims to trigger **a sector-wide discussion with all relevant stakeholders** on how to accelerate the roll-out of ERTMS and to achieve pragmatic solutions to reap the benefits in terms greater efficiency, safety and reliability.

Contents of this work plan

Chapter 2 of my work plan gives an overview of the major legal and institutional achievements since the 2022 work plan. Legally, the 2024 TEN-T Regulation lays down the obligations to roll out ERTMS with clear deadlines. Moreover, the 2023 CCS TSI has defined technical specifications in more detail and strengthened implementation requirements, while the institutional framework for European coordination is in place. However, the legal obligations are subject to the availability of finance, some major elements of the technical specifications, as concerns radio communication, are still missing and there is a need for a more streamlined coordination at the European, but also at the national level.

Chapter 3 gives an overview of the track side deployment of ETCS and GSM-R in the EU27 by 2024 both by Member States and European Transport Corridors. As to ETCS, approximately 12 400 km are in operation and 16 400 km are under construction. Still, the deployment picture is a patchwork rather than a network. An analysis of national implementation plans (detail in Annex III) shows very clearly that by 2030 ETCS will in large parts of the EU not yet provide a continuous network but continue to rely also on national class B systems. An analysis of the plans as to cross-border connections (Annex IX) also shows a mismatch. However, all Member States[3] are planning to deploy ETCS on parts of their network by 2030. 8 Member States plan to equip at least 89% of their share of the core network. Major laggards unfortunately are Member States with a large share of the overall network.

This chapter also analyses the deployment prospects until 2050. As to the 2050 trackside projection, the comprehensive network is expected to be ERTMS fitted by 66% and the core network by 76%. The share in individual Member States varies considerably with some projecting a 90% to 100% coverage whereas six others envisage a deployment rate below 40%. Moreover, the share of the network where on-board class B systems will still be required is analysed on the basis of current planning. This will be approximately 48% by 2035, 38% by 2040, and 28% by 2050.

First results of the trackside cost-benefit analysis are reported.

Chapter 4 gives an overview of on-board deployment of ETCS and its outlook. It underlines the need for a synchronous deployment of ERTMS on-board and trackside. By 2024, some 8 730 vehicles were equipped, equipment of 13 600 vehicles is either contracted or planned. For over 50% of vehicles (about 23 000) needed by 2050, no information is available. There is a need to accelerate on-board equipment between 2025 and 2040 if phasing out of class B systems is to remain a realistic option. The projected current figures fall short of the necessary share of rolling stock needed to operate on the network.

The chapter also gives an overview of the efforts done by Member States, the national financing schemes for on-board deployment, the system compatibility tests for ETCS and radio communication (ESC and RSC) as well as a summary of the cost drivers for on-board equipment and recommendations to contain costs.

Chapter 5 details the different funding needs and schemes on EU and national level. A rough estimate reveals that between EUR 75 and EUR 85 billion would be needed to

[3] Cyprus and Malta have no ERTMS deployment, as they have no railways TEN-T network

complete trackside deployment on the TEN-T network and between EUR 10 and EUR 15 billion for onboard equipment. In the case of on-board, it is assumed that a significant part of the fleet will be equipped through renewal of vehicles. As to EU finance for deployment, over EUR 6 billion has been mobilised up to now in grants and the European Investment Bank (EIB) has over the last ten years provided loans of around EUR 6 billion. National finance clearly must provide the bulk of ERTMS deployment finance, and stability and predictability are needed on both EU and national level to allow for a coherent roll-out. Finally, this chapter refers to the relevance of the Commission's proposal for the next multiannual financial framework for future ERTMS financing.

Chapter 6 focuses on ERTMS as an industrial project. Given the relatively ambitious plans of ERTMS deployment the question of industrial capacity needs to be tackled. The chapter identifies lacunae of industrial capacity, including workshop capacity and necessary engineering skills, the revision of state aid rules as well as the prospect of developing an approach including ERTMS as part of a unified railway system as Important Projects of Common European Interest (IPCEI). Moreover, the international industrial dimension with over 62 000 km deployed outside the EU is underlined.

Chapter 7 details the state of play on the preparation for the future deployment of FRMCS. It outlines the risks of the rapidly approaching obsolescence of the current 2G based GSM-R system. The delays and deficiencies in developing the specifications of the future radio communication systems are detailed, and risks and possible solutions are described. Increasingly, most infrastructure managers are also turning to solutions at least including the use of public mobile network operators. The delays in developing specifications and products also constitute a major impediment to updating current on-board equipment. The chapter also describes the contribution of the deployment group to identifying approaches and solutions.

Chapter 8 gives an outlook on future transformational programmes for rail which interact with the ERTMS roll-out. Military mobility and the plan for a high-speed rail network bring additional challenges for ERTMS. Plans for automated train operations, digital automatic coupling, FRMCS (5G for rail) and satellite communication, capacity management and telematics applications all rely on ERTMS providing the digital backbone for these programmes.

Chapter 9 deals with the next steps to prepare an accelerated roll-out of ERTMS. Elements for a future European Deployment Plan, planned revisions of the TSI CCS, a streamlined European governance, future finance and the development of a common operational rulebook for Level 2 are covered.

Chapter 10 contains my 10 conclusions and recommendations: These cover, amongst others, a reinforced governance, deployment strategies for phasing out class B systems, cross-border implementation, FRMCS, steps to industrial deployment, finance strategies, elements for an action plan to cut costs and a better communication strategy.

This workplan also provides in the Annexes a comprehensive analysis of the national ERTMS implementation plans (NIPs, Annex III), the analysis of the implementation of the 2017 EDP (Annex IV) and an overview over the state of ERTMS deployment outside the EU, where altogether some 62 000 km are either in operation with ERTMS or under construction (Annex VII). Moreover, a number of documents on cross border actions, methodologies and more technical issues are included for reference and future action.

2. MAJOR POLICY AND REGULATORY DEVELOPMENTS SINCE 2022

2.1. Overall legal and governance framework in 2022

Since the publication of the last work plan in 2022, important policy and regulatory developments with respect to ERTMS have taken place. Together, they help to consolidate and further develop the legal and institutional framework in which ERTMS can be implemented. This chapter elaborates on the main changes to the ERTMS rules brought about by the revised TEN-T Regulation adopted in 2024, by the Command, Control and Signalling (CCS) Technical Specifications for Interoperability (TSI) revised in 2023 and the institutional set-up, notably in Europe's Rail Joint Undertaking where the System Pillar, Innovation Pillar and the Deployment Group promote rail research and innovation and develop further the ERTMS specifications.

2.2. TEN-T Regulation 2024

In 2024, a new TEN-T Regulation4 entered into force which introduced significant enhancements to the ERTMS provisions, underscoring the EU's commitment to modernising rail transport. The substantive provisions on ERTMS are included in Article 18 of the Regulation.

Firstly, the Regulation redefines and renames nine European transport corridors (ETCs) which integrate also rail freight corridors.

Second, the regulation introduces the concept of the 'extended core network'. For this part of the network, the Regulation lays down the obligation to roll out ERTMS by 2040. This obligation complements those already present in the previous TEN-T Regulation which mandated the roll-out of ERTMS on the core network by 2030 and on the comprehensive network by 2050.

Thirdly, the Regulation lays down that newly constructed lines need to be equipped with radio-based ERTMS as of 2030. In the case of an upgrade of the signalling system, the obligation of radio-based ERTMS applies as of 2040. Moreover, the Regulation specifies that by 2050, all ERTMS has to be radio-based.

Fourthly, a major novelty in the 2024 Regulation is the obligation to decommission national legacy class B systems. On the core network, class B systems must be phased out by 2040, on the extended core network by 2045 and on the comprehensive network by 2050. By setting clear and mandatory deadlines for the decommissioning of class B systems, the Regulation gives a clear signal to Member States and railway stakeholders to expedite their transition to ERTMS5.

The 2024 Regulation also reinforces the TEN-T governance and the role of the European Coordinators, including the role of the European Coordinator for ERTMS.

Article 53 of the Regulation establishes a consultative Forum for ERTMS that assists the European Coordinator in the performance of his tasks concerning the work plan and its implementation. The first Forum took place in Utrecht in October 2024. This was followed by the second Forum in March 2025 and the third in June 2025 both in Brussels. Each Member State had to designate one responsible national representative involved in the coordination of ERTMS deployment in that Member State to attend the Forum. Where appropriate and in agreement with the Member States, representatives of the

[4] Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the trans-European transport network, amending Regulations (EU) 2021/1153 and (EU) No 913/2010 and repealing Regulation (EU) No 1315/2013

[5] Provided that an appropriate level of safety is ensured, and except for sections in urban nodes also used by suburban passenger trains equipped with dedicated class B train protection systems

neighbouring countries concerned and of the relevant sectors can participate in the Forum. Article 53 also requires the European Coordinator for ERTMS to cooperate closely with ERA and Europe's Rail Joint Undertaking (EU-RAIL).

Article 54 of the Regulation tasks the European Coordinator to come up, at the latest by July 2026 and then every four years, with a work plan that provides a detailed analysis of the state of implementation of ERTMS and its compliance with the requirements of this Regulation, as well as the priorities for its future development.

According to Article 52, the European Coordinator must submit an annual status report to the European Parliament, the Council, the Commission and the Member States concerned on the progress achieved in implementing ERTMS.

Article 55 of the Regulation gives the Commission the right to adopt implementing acts for the implementation of ERTMS, i.e. the European Deployment Plan (EDP). The implementing act shall be drawn up in close collaboration with the Member States concerned and would be updated every four years.

Finally, Article 60 of the Regulation obliges Member States to align their national plans and programmes with Union transport policy, notably, they should take into account the priorities set out in the work plans for ERTMS and where applicable the implementing acts.

Limited exceptions to the obligation to deploy ERTMS are laid down in Article 8 (5) and Article 18 (8) of the Regulation. The Article 8 (5) states that the projects implementation depends on their degree of maturity, compliance with Union and national legal procedures, and the availability of financial resources. The Article 18 (8) provides for the possibility of exemptions, allowing Member States to request derogations in cases of a negative socio-economic cost-benefit analysis and an assessment of the interoperability impact. The exemption process requires substantial justification and coordination with neighbouring Member States in cross-border sections, ensuring that interoperability objectives are upheld while allowing flexibility in specific, duly substantiated cases.

2.3. Technical Specifications for Interoperability (TSI) for Control-Command and Signalling (CCS) 2023

In 2023, the EU adopted a revised version of the Technical Specifications for Interoperability (TSI) for Control-Command and Signalling (CCS)6 providing the technical specifications for ERTMS. The purpose of the revision was to make a significant step towards a more unified and digital European rail system in particular by standardising systems and reducing national variations. This section summarises the most important changes in comparison with the 2016 version.

Reduction of exemptions to install ETCS on-board vehicles

All new vehicles need to be equipped with ETCS (see point 7.4.2.1 of CCS TSI). The only exemption concerns special vehicles (see point 7.4.3.2 of CCS TSI), provided a Member State exempts them through national legislation and notified in the network statement[7]. Existing vehicles need to install ETCS when upgrading the CCS part, when installing another class B or extending the area of use to another Member State. In many cases, it is required to install ETCS in the latest available version.

[6] Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919

[7] CCS TSI Amendment foresees that this notification shall be registered in RINF.

All these rules contribute to ensure that the fleet is gradually equipped with ETCS. This strengthens incentives for ERTMS deployment also on the infrastructure, by overcoming the 'chicken-and-egg problem' that neither the infrastructure managers nor the railway operators have a strong incentive to be the first to install ERTMS as the benefits only materialise when both sides have ERTMS in place.

Introduction of Baseline 4

The CCS TSI introduces Baseline 4 for ETCS in a unique set of specifications. Baseline 4 encompasses the previous specifications for ETCS system version 2.1 while adding, firstly, a new system version 2.2 related to the ATO GoA2 functionality (ETCS ready for ATO) and, secondly, a system version 3.0 mainly to be ready for future technologies such as 5G Rail (FRMCS) and DAC (i.e. supervised manoeuvres functionality). System version 3.0 therefore allows the future decommissioning of GSM-R and the removal of shunting signals (i.e. no more lineside signalling). 5G for rail (FRMCS) and the supervised manoeuvre functionality can in a first step also be implemented in a compatible manner trackside-wise (as ETCS system version 2.3) as long as there are GSM-R and shunting signals. This allows for a smooth transition. Moreover, Baseline 4 has the advantage of supporting railway efficiency by improving punctuality, reducing energy consumption through optimized driving and increasing line capacity.

On-board modularity

More generally, the 2023 CCS TSI aims at standardising and promoting modularity of on-board equipment, focusing on new vehicles. As modularity allows integration of interoperability constituents/subsystems from different suppliers it enables further market opening. The Regulation therefore includes specifications for a common Ethernet-based system and provides harmonised interfaces between ATO, ETCS, FRMCS parts and RST-subsystem.

Preparation for 5G Rail communication (FRMCS)

The 2023 CCS TSI lays the groundwork for transitioning from the GSM-R radio system to the more advanced Future Railway Mobile Communication System (FRMCS) based on 5G. While falling short of providing for the full specifications of FRMCS, the CCS TSI includes specifications which allow suppliers to design 'FRMCS-ready' products. This means that ETCS products can be designed to work with the future FRMCS equipment, supporting the necessary hardware and software capabilities to transition from the current GSM-R system to FRMCS without major modifications.

Introduction of Automatic Train Operation (ATO) at Grades of Automation (GoA) 2

The revised CCS TSI incorporates specifications for Automatic Train Operation (ATO) at Grades of Automation (GoA) 2. This means trains can handle certain driving tasks automatically, such as maintaining speed and stopping at stations, while drivers oversee operations and manage emergencies.

Integration of ETCS Level 3 Features into Level 2

Previously, ETCS Level 3 was a separate system requiring additional transitions between ETCS Level 2 and Level 3. The new TSI merges Level 2 and Level 3 and integrates Level 3 features, such as train integrity reporting required for moving block, into Level 2. In addition, safety requirements are defined for these Level 3 features. This allows for more flexible train spacing and increased line capacity without extensive infrastructure changes.

Enhanced Error Correction Procedure

The CCS TSI 2023 introduces a more structured and transparent procedure for the implementation of error corrections into products and projects, compared to the 2016 version where errors or ambiguities in the specifications were implemented in projects and products on a case-by-case basis with no formal, EU-wide mechanism for identifying, documenting, and resolving them. The Regulation now clarifies who does what: ERA coordinates the error management and maintains the official register, while stakeholders (mostly suppliers, railway undertakings and infrastructure managers) perform the necessary analysis and implement the necessary measures derived from it. This proactive approach ensures that any issues are addressed systematically, maintaining system reliability and safety.

National Implementation Plans (NIPs)

The CCS TSI 2023 introduces a comprehensive overhaul of the framework governing National Implementation Plans (NIPs), which Member States submit to the Commission to report on their ERTMS roll-out. The TSI now mandates a structured and unified methodology to prepare the NIP, requiring Member States for example to define detailed timelines and to set out clear migration strategies, particularly concerning the deployment of 5G Rail, ATO, and the latest ETCS baselines. Member States should also coordinate between the interests of infrastructure managers and railway undertakings, as well as consult the national plans with their neighbours. NIPs should cover a period of at least 20 years. Member States were required to notify their NIPs to the Commission by 15 June 2024[8] and have to update it regularly, at least every five years.

2.4. ERTMS Governance at EU level

To coordinate the ERTMS roll-out at EU level, an institutional set-up has been put in place that has further evolved in recent years.

The **European Commission** defines the overall ERTMS policies, requests updates of technical specifications to ERA, and allocates CEF funding for deployment. It is supported by the ERTMS Deployment Management Team. The **European Coordinator for ERTMS**, appointed by the Commission, ensures the coordinated implementation of ERTMS, particularly on the nine European Transport Corridors (ETCs), reporting progress and challenges to the European Parliament and the Council. The ERTMS Coordinator's role has evolved significantly. Initially focused on promoting a Europe-wide deployment, stabilising technical specifications, and fostering cross-border agreements, the role soon expanded to accelerate implementation through financial and governance strategies. As mentioned in chapter 2.2, the 2024 TEN-T Regulation further reinforced the Coordinator’s mandate, establishing the **ERTMS forum** for national representatives to ensure effective coordination and oversight of ERTMS deployment across Member States.

The **European Union Agency for Railways (ERA)** is the system authority for ERTMS, ensuring stability and compatibility of specifications and facilitating implementation. The technical pillar of the 4th Railway Package adopted in 2016 transformed ERA from a technical adviser into a full-fledged authorising body authority for the EU rail network[9]. Since the start of this operational role in 2016, ERA has been responsible for authorising new or existing vehicles running cross-border, usually equipped with ERTMS and issuing trackside approvals for ERTMS infrastructure projects, guaranteeing interoperability of ERTMS at EU level. Vehicles for domestic use can be authorised either by ERA or the national safety authorities (NSAs), but the same ERTMS specifications enshrined in the

[8] CCS TSI, article 5, point 4.

[9] Regulation (EU) 2016/796 of the European Parliament and of the Council of 11 May 2016 on the European Union Agency for Railways and repealing Regulation (EC) No 881/2004

CCS TSI apply. As regards railway infrastructure, ERA verifies the envisaged trackside technical solution before the NSAs grant operational authorisation.

Since the publication of the last work plan in 2022, the main changes in the ERTMS governance at European level are related to **Europe's Rail Joint Undertaking (EU-RAIL)**. It carries out rail research, promotes innovation and develops rail solutions to enhance interoperability and reduce lifecycle costs.

The governance within EU-RAIL is laid down in the Single Basic Act[10] establishing the System Pillar, Innovation Pillar, and Deployment Group of EU-RAIL.

The System Pillar is tasked with developing a coherent and harmonised approach to railway transformation, defining the operational and technical framework for implementation. The Innovation Pillar drives research and development, creating new technologies and operational solutions to enhance efficiency, sustainability, and interoperability. Finally, the Deployment Group, which was formalised at the end of 2024[11], is meant to facilitate the practical implementation of these advancements, supporting the transition from innovation to real-world application across the European rail network.

The **European Climate, Infrastructure and Environment Executive Agency (CINEA)** manages the funds allocated under the Connecting Europe Facility (CEF) to support ERTMS deployment trackside and on-board. Other EU funding for ERTMS is provided by regional and cohesion funds, the Recovery and Resilience Facility (RRF) and the European Investment Bank (EIB)[12]. CEF funding for ERTMS is distributed through dedicated calls for proposals, where applications for projects compete and are evaluated by means of common selection criteria, such as priority and urgency, maturity and quality.

[10] Council Regulation (EU) 2021/2085, of 19 November 2021, establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

[11] Commission Decision of 29.11.2024 approving the composition of the Deployment Group and of the System Pillar steering group of the Europe's Rail Joint Undertaking

[12] For more details about funding, see chapter 5.

3. TRACKSIDE DEPLOYMENT IN THE EUROPEAN UNION

All Member States with railways13 have started to deploy ERTMS and pursue ambitious plans for the coming years. The data on trackside deployment in the present report are based on the information gathered using the methodology explained in Annex I.

3.1. Definitions of the relevant network scope

According to Article 1 of the TEN-T Regulation[14], the Trans-European Transport Network (TEN-T) consists of a comprehensive network and of a core network, and extended core network, with the core network and extended Core network established on the basis of the Comprehensive network.

The core network includes the most important urban nodes, ports, airports and border crossing points. The extended core network is defined on the basis of priority sections of the comprehensive network which are part of the European Transport Corridors (ETCs). The extended core network complements the core network, and together they form the ETC.

The ETC consist of the parts of the core network or extended core network which are of the highest strategic importance for the development of sustainable and multimodal freight and passenger transport flows in Europe and for the development of interoperable high-quality infrastructure and operational performance.

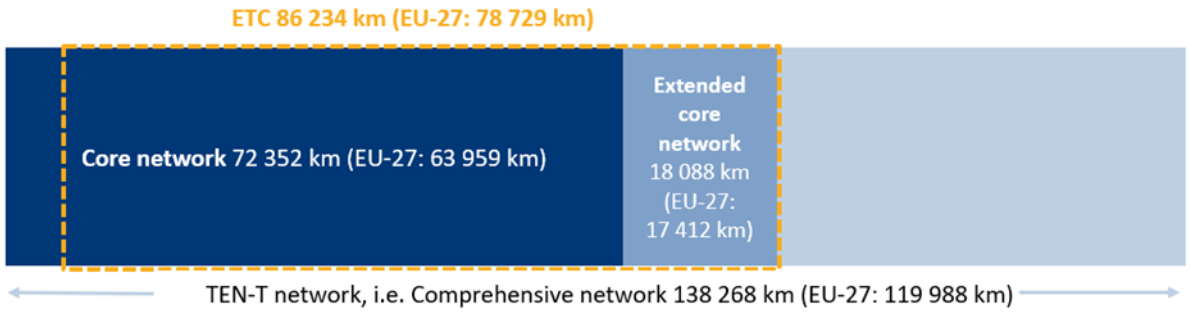


Figure 1: Description of the structure of the TEN-T network

As indicated in chapter 2.2, the TEN-T Regulation establishes deadlines for ERTMS deployment and class B decommissioning on the core network, the extended core network and the comprehensive network. These requirements do not apply to isolated networks, which are networks with a track gauge different from that of the European standard nominal track gauge of 1 435 mm.

However, according to TEN-T Regulation, Article 17 (3), Member States with an existing rail network, or a part thereof, with a track gauge different from that of the European standard nominal track gauge of 1 435 mm shall, by 19 July 2026, assess which railway lines on the ETCs could be converted to the standard gauge[15]. This assessment must include:

- Coordination with neighbouring countries for cross-border sections.

[13] Cyprus and Malta have no ERTMS deployment, as they have no railways.

[14] Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the trans-European transport network, amending Regulations (EU) 2021/1153 and (EU) No 913/2010 and repealing Regulation (EU) No 1315/2013

[15] According to Article 65 in TEN-T Regulation: "The provisions related to European standard nominal track gauge of 1 435 mm for rail in Article 17 shall not apply to Ireland, islands and outermost regions."

- A socio-economic cost-benefit analysis.
- An interoperability impact assessment.

Based on this, each Member State concerned must, within one year of completing the assessment, develop a migration plan. This plan should identify the lines to be converted and include a timeline for the migration.

3.2. Trackside ETCS deployment

At the end of 2024, ETCS was in operation on 10% of the TEN-T network EU-27 (i.e., about 12 400 km) and on 16% of the core network (i.e., about 10 600 km)[16]. The following chart indicates the ETCS status by end 2024 of the lines belonging to the entire TEN-T network (EU-27).

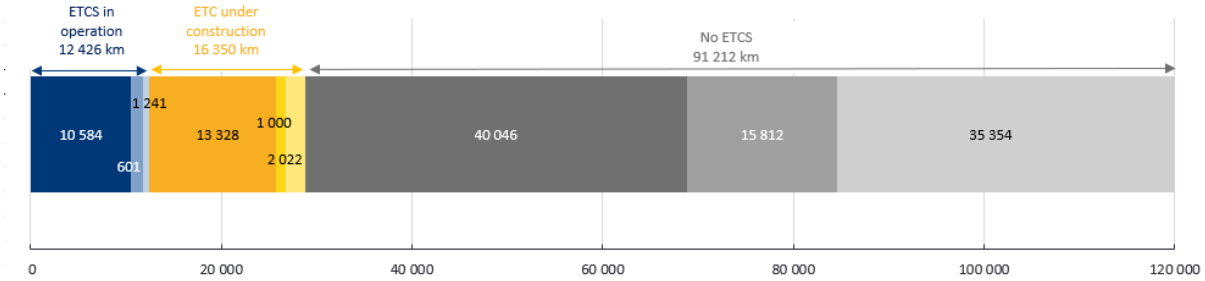


Figure 2: ETCS status by end 2024 (km) - TEN-T network (EU-27)

The length and ETCS deployment status of the core network, the extended core network and comprehensive network per Member State are detailed in Annex II.

The following map presents the status of the ETCS deployment by end 2024 on the TEN-T network.

[16] Lines equipped with non-interoperable ETCS baseline (e.g. pre-baseline 2) are not considered as equipped with ETCS in the figures included in this Work Plan.

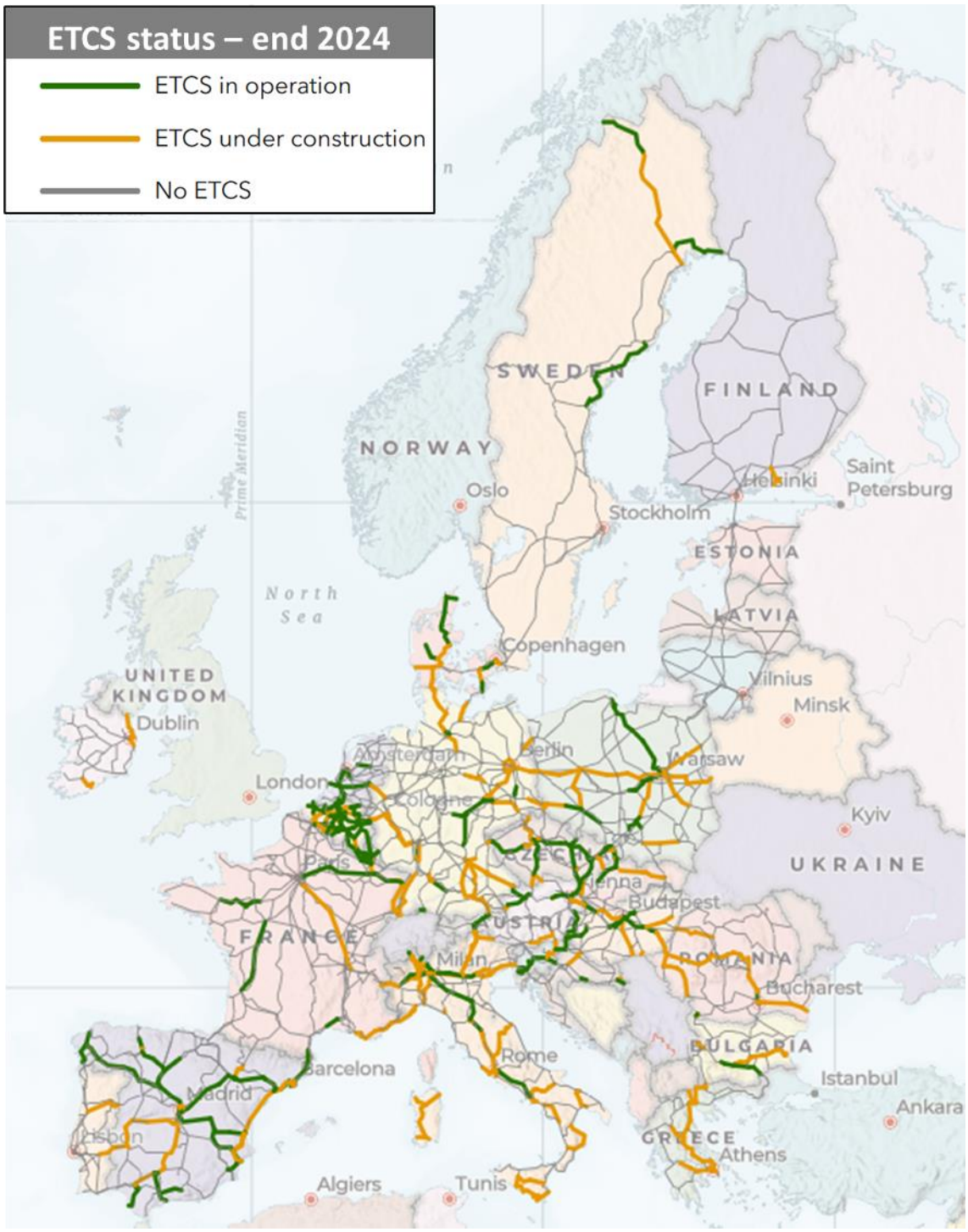


Figure 3: Map of ETCS deployment status by end 2024 – TEN-T network (EU-27)[17]

In 2017, the Commission adopted the European Deployment Plan (EDP) for ERTMS[18]. The EDP set out deadlines for deploying ERTMS on some sections of the network covering the 2017-2023 period[19]. Based on Member States data, almost 50% of the kilometres

[17] The Annex VI includes a detailed map with the ETCS deployment status by end 2024 – TEN-T network (EU-27)

[18] Commission Implementing Regulation (EU) 2017/6 on the European Rail Traffic Management System European deployment plan on 5 January 2017

[19] The relevant network scope at the time were the Core Network Corridors under the 2013 TEN-T Regulation, see Annex I for definition.

planned to be equipped with ETCS by 2023 according to the EDP (EU-27) have been equipped with ETCS (i.e., about 7 500 km)[20]. Additionally, ETCS is in operation on around 4 900 km (EU-27), which were not planned by 2023 according to the EDP. These data show that in practice Member States have modified their priorities compared to those previously defined in the EDP.

Over the years, the roll-out of ERTMS has tended to accelerate. A notable increase was observed in the period from 2016 to 2018 (around 2 600 km were put in operation during this period). The increase in this period directly correlates with the number of Member States equipping their lines, increasing from 8 to 13 compared to the previous 3-year period. However, there was a decline between 2019 and 2021 probably attributable to the impact of COVID-19. Encouragingly, from 2022 to 2024, there was a resurgence in the number of kilometres being equipped, accompanied by a rise in the number of Member States equipping their lines.

As regards the coming years, the number of kilometres planned to be equipped with ETCS between 2025 and 2030 seems challenging. The number of kilometres planned between 2025 and 2027 appears in principle achievable considering the growing number of Member States involved (i.e., 21 Member States equipping around 12 200 km). However, whether the number of kilometres planned between 2028 and 2030 (i.e. 21 Member States equipping around 15 700 km) can be achieved essentially depends on the experience and the potential to scale up the deployment. Some Member States may rather be driven by the intent to meet the 2030 deadline for the core network as stipulated in the revised TEN-T regulation, hence proposing very challenging roll-out plans.

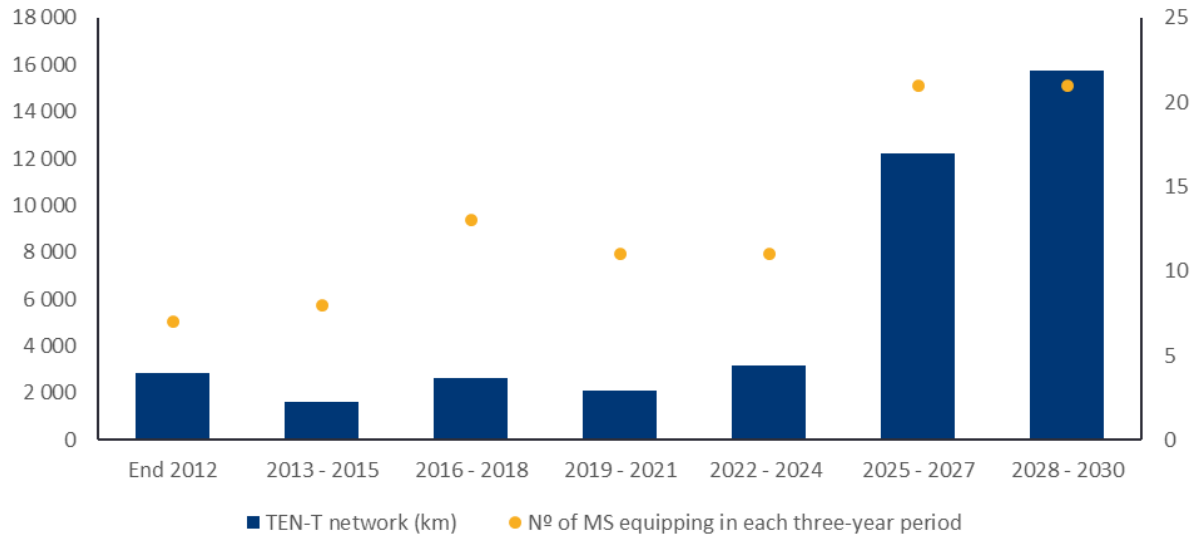


Figure 4: ETCS deployment per three-year periods – TEN-T network (EU-27)

17% of the core network is already equipped with ETCS (i.e. about 10 600 km). According to the Member States' plans, 51% of the core network is planned to be equipped by 2030 (i.e. about 32 600 km). It should be noted that there are also around 7 800 km outside the core network that Member States plan to equip by 2030.

The following map presents the ETCS status of TEN-T network planned to be equipped with ETCS by 2030.

[20] The Annex IV includes the state of play of the EDP 2017 per Member State.



Figure 5: Map of lines planned to be equipped with ETCS by 2030 – TEN-T network (EU-27)

As mentioned above, the TEN-T Regulation sets out deadlines for decommissioning class B systems. The decommissioning of class B systems should significantly reduce the complexity and costs for infrastructure managers to operate and maintain signalling systems. The TEN-T Regulation lays down 2040 as deadline for the class B decommissioning on the core network, 2045 on the extended core network and by 2050 on the comprehensive network.

Austria, Belgium[21], Bulgaria, Czechia, Denmark, Germany, Hungary, Italy, Slovakia, Spain, Sweden and the Netherlands already have lines in operation with ETCS-only. Luxembourg completed the class B decommissioning at the end of 2020. By end of 2025, approximately 6 400 km of the TEN-T Network (EU-27) will be operated with ETCS only.

Based on the experience from EU countries with an advanced ERTMS deployment, Annex XIII proposes how optimise the ERTMS deployment strategy to address key challenges.

3.2.1. Evolution of ETCS deployment by Member State

EU Member States are actively advancing ETCS deployment across their rail networks. Luxembourg has fully equipped its network with ETCS, Belgium will complete most of its network by 202521, and Slovenia's core network is either ETCS operational or under construction, with full availability expected by 2030.

The status of the ETCS deployment by Member State by end 2024 is shown in

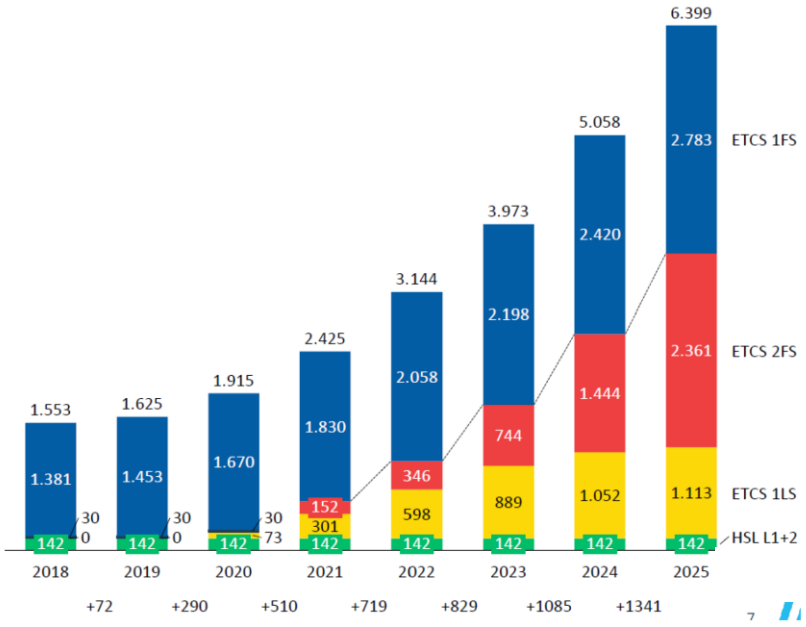
Table 2 below. It is expressed in terms of both the absolute number of kilometres already equipped with ETCS and its share in the network.

In relation to the core network, Belgium, Luxembourg and Slovenia are the countries with the highest share already equipped with ETCS[22]. Belgium has also already equipped a large share of the extended core and the comprehensive network with ETCS.

[21] Belgium authorities have announced an updated of the NIP.

[22] In the case of Luxembourg, the entire TEN-T network is already equipped with ETCS except a new line still to be built by 2030 (representing 8% of Luxembourg's core network).

The deployment of ERTMS on the overall network in Belgium (not only TEN-T network) is an interesting example of the ramp-up curve of ERTMS deployment, as shown in the figure below:



The deployment started with some pilot lines for all level of ERTMS. The development of these pilot lines only took 2 years for ERTMS level 1 with limited supervision, while it took 8 years with ERTMS level 2 with full supervision. But once the pilot lines have been equipped, there was a strong acceleration of ERTMS deployment, with more than 1 000 km of ERTMS put in operation per year in 2024-2025.

Textbox 1: ERTMS deployment in Belgium over 2018-2025. Source: Infrabel

Denmark is a particular case as the share of the comprehensive network equipped with ERTMS is significantly higher than the share of the core network. As pointed out in the Danish NIP, Denmark has prioritised branch lines as they were less complex and required less ERTMS equipped vehicles. Austria, Czechia, France, Hungary, Italy, Spain, and The Netherlands have also already equipped lines outside the core network while they still need to equip important parts of the core network. The column "ETCS in operation – Comprehensive" in the table 2 excludes the core and extended core network to emphasise that some Member States are prioritising the ETCS deployment on sections outside of the core and extended core networks.

As regards recent developments between 2022 and 2024, Belgium, Czechia, and Spain have made significant efforts in deployment, equipping more than 500 km of their TEN-T lines with ETCS. Austria, Denmark, Germany, Hungary, Italy, Poland and Sweden have also equipped more than 100 km of their lines during the same period.

MS	TEN-T network (km)	ETCS in operation end 2024 (km)	Length commissioned with ETCS 2022 - 2024 (km)	ETCS in operation - Core (%)	ETCS in operation - Extended Core (%)	ETCS in operation - Comprehensive (1) (%)
Luxembourg	216	207	0	92%	100%	100%
Belgium	2 387	1 683	854	79%	66%	58%
Slovenia	987	389	0	72%	24%	0%
Czechia	3 200	1 062	554	46%	14%	17%
The Netherlands	2 513	354	0	36%	0%	3%
Austria	3 028	456	106	34%	5%	0%
Denmark	1 076	386	272	33%	N/A	56%
Hungary	3 667	597	255	29%	6%	6%
Spain (*)	14 672	3 011	505	28%	0%	7%
Slovakia	1 578	135	0	19%	0%	0%
Italy	11 622	998	186	17%	1%	0%
Sweden	5 240	588	126	15%	N/A	0%
Poland	10 261	737	143	15%	0%	0%
Bulgaria	2 437	209	0	12%	0%	0%
France	17 560	1 076	50	10%	3%	2%
Croatia	2 048	54	0	9%	0%	0%
Germany	15 116	445	102	5%	0%	0%
Romania	5 742	40	0	1%	0%	0%
Portugal (*)	3 216	0	0	0%	0%	0%
Greece	3 047	0	0	0%	0%	0%
Estonia (*)	1 158	0	0	0%	0%	0%
Lithuania (*)	1 986	0	0	0%	0%	0%
Latvia (*)	1 623	0	0	0%	0%	0%
Finland (*)	3 813	0	0	0%	0%	0%
Ireland (*)	1 796	0	0	0%	N/A	0%
TOTAL EU-27	119 988	12 426	3 153	17%	3%	3%

(*) Member States having most lines that are isolated networks

(1) Comprehensive network without considering Core or Extended Core network

Table 2: ETCS status per type of network and Member State by end 2024

Figure 6 presents a detailed map illustrating the ETCS deployment status across the core network in 2024. The circle size reflects the size of each Member State's core network, while the colour gradient, from red to green, indicates the proportion of the core network equipped with ETCS, ranging from 0% to 100%. This map points to the need especially for Member States with large networks in the centre of EU such as Germany and France to accelerate roll out plans for ERTMS.

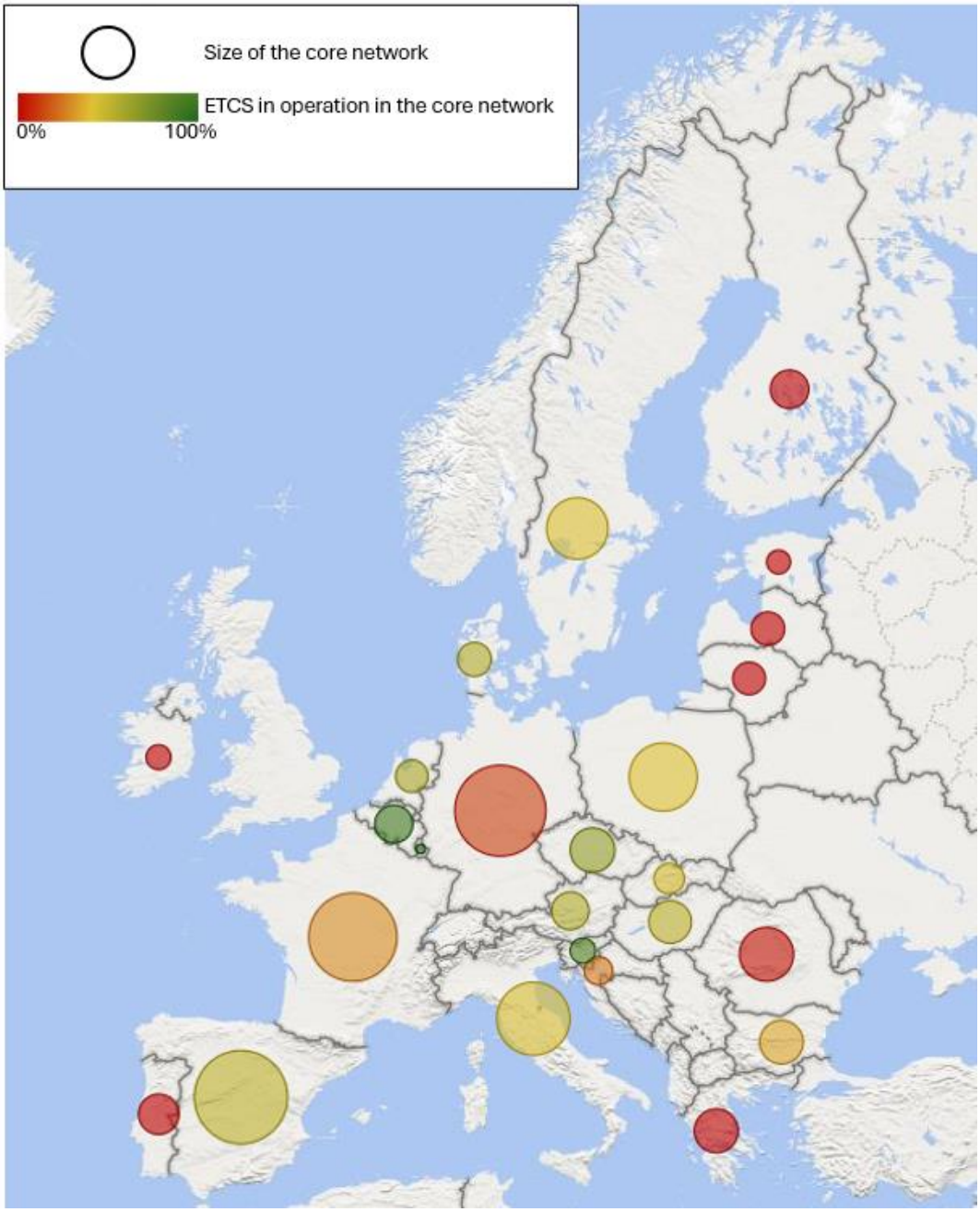


Figure 6: Map showing the core network size and the degree of ETCS equipment per MS at the end of 2024

The following Table 3 shows the number and percentage of kilometres planned to be equipped with ETCS by 2030 per Member State in the core network and in the entire TEN-T network.

As regards the core network, Luxembourg, Slovenia, Belgium, Austria, Denmark and Poland plan to equip more than 90% of their lines by 2030. In contrast, Sweden, Croatia, France and Finland have significantly lower targets, aiming to equip less than 25% of their core network by 2030. These countries fall clearly short of meeting the requirements set by the TEN-T Regulation[23].

As regards the TEN-T network, Belgium, Czechia, Denmark and Luxembourg plan to equip most of their lines with ETCS by 2030. To fully realise the potential of ETCS, it is

[23] In the case of 'isolated networks' such as Finland, the TEN-T targets however do not formally apply.

essential that neighbouring countries also equip their railway networks with ETCS. Although several countries are expected to achieve high levels of ETCS deployment by 2030, Germany, France, and the Netherlands currently lack comparable progress. This disparity hinders the overall effectiveness and interoperability of ETCS across Europe.

MS	TEN-T network (km)	ETCS planned to be equipped by 2030 (km) - Core	ETCS planned to be equipped by 2030 (%) - Core	ETCS planned to be equipped by 2030 (km)	ETCS planned to be equipped by 2030 (%)
Luxembourg	216	117	100%	216	100%
Slovenia	987	475	100%	522	53%
Belgium	2 387	1 225	99%	2 261	95%
Austria	3 028	1 171	96%	1 629	54%
Denmark	1 076	875	93%	1 003	93%
Poland	10 261	4 479	92%	5 177	50%
Romania	5 742	2 561	89%	2 770	48%
Czechia	3 200	1 631	89%	2 565	80%
Slovakia	1 578	632	87%	632	40%
Portugal (*)	3 216	1 020	71%	1 222	38%
Italy	11 622	3 976	69%	5 908	51%
Hungary	3 667	997	60%	1 125	31%
Greece	3 047	979	55%	1 011	33%
Estonia (*)	1 158	212	52%	212	18%
Spain (*)	14 672	4 573	46%	4 972	34%
Lithuania (*)	1 986	344	40%	344	17%
The Netherlands	2 513	307	36%	354	14%
Germany	15 116	3 131	33%	3 676	24%
Bulgaria	2 437	566	33%	701	29%
Latvia (*)	1 623	271	29%	271	17%
Ireland (*)	1 796	127	29%	191	11%
Sweden	5 240	880	23%	880	17%
Croatia	2 048	132	21%	150	7%
France	17 560	1 733	20%	1 991	11%
Finland (*)	3 813	109	8%	596	16%
TOTAL EU-27	119 988	32 524	51%	40 378	34%

(*) Member States having most lines that are isolated networks

Table 3: ETCS deployment envisaged by Member State by 2030[24]

Based on the Member States' plans up to 2030, Figure 7 illustrates the percentage of kilometres already equipped and the kilometres scheduled for implementation between 2025 and 2027, as well as between 2028 and 2030. This analysis aims to assess how realistic the national plans are.

Belgium, France, Hungary, Luxembourg, Slovenia, Spain, Sweden and The Netherlands have deployment plans which appear, in principle, realistic. They have already equipped 50% of the lines planned for ETCS deployment by 2030, having gained valuable experience in the roll-out.

Austria, Bulgaria, Croatia, Czechia, Denmark, and Slovakia have set ambitious plans, with 60-80% of the kilometres planned for 2030 still to be deployed. Equipping such a high share of the network within five years would appear quite ambitious. Germany,

[24] Excluding the isolated network, the projected average for both the core network and the TEN-T network by 2030 is estimated to be approximately two percentage points higher.

Poland, Italy and Romania have even more challenging deployment plans since ETCS still needs to be put in operation on around 90% of kilometres planned for 2030.

The strategies set out by Estonia, Finland, Ireland, Latvia, Lithuania to equip ETCS by 2030, while not ambitious in terms of kilometres per year (less than 100 km per year), present a challenge due to lack of prior experience in ETCS deployment.[25] The plans of Portugal and Greece represent a significant challenge because these countries have little or no experience with ETCS operation while planning to equip more than 100 km per year by 2030.

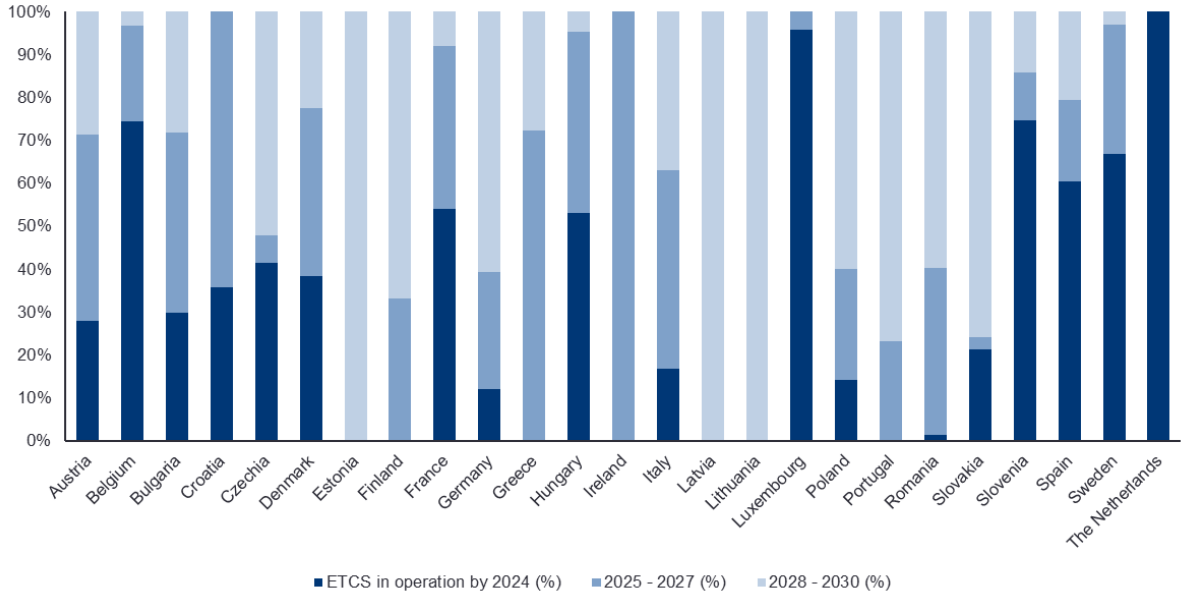


Figure 7: ETCS progress envisaged by Member State by 2030

3.2.2. Evolution of ETCS deployment by ETC

To complement the progress in ETCS deployment along the European Transport Corridors (ETCs), it is essential to equip remaining gaps, nodes and access routes to terminals to enable full ETCS operation without dependence on class B systems. ETCS deployment plans in major EU nodes are included in Annex VIII.

The status of the ETCS deployment along the ETCs[26], expressed in terms of number and percentage of kilometres equipped with ETCS by end 2024, is compiled below. A more detailed description of the ERTMS deployment on the nine ETCs is included in Annex V.

MED, BSAS, NSMR and WBEM are the ETCs with the highest share of kilometres equipped with ETCS with about 20%. In contrast, SCM, NSB and BBA have a very low share of kilometres equipped with ETCS.

[25] As mentioned in table 3, these five Member States have 'isolated networks' and are therefore not formally subject to the 2030 roll-our targets under the TEN-T Regulation.

[26] Atlantic (ATL), Baltic Sea — Adriatic Sea (BSAS), Baltic Sea — Black Sea — Aegean Sea (BBA), Mediterranean (MED), North Sea - Baltic (NSB), North Sea - Rhine - Mediterranean (NSRM), Rhine – Danube (RDB), Scandinavian — Mediterranean (SCM) andWestern Balkans — Eastern Mediterranean (WBEM)

ETC	TEN-T network (km)	Total network - EU 27 (km)	Length commissioned with ETCS 2022 - 2024 EU 27 (km)	ETCS in operation end 2024 - EU 27 (%)
MED	13 296	13 029	444	23%
BSAS	10 312	10 312	171	19%
NSRM	12 133	11 594	689	17%
WBEM	6 201	3 520	0	15%
ATL	13 551	13 551	331	14%
RDB	12 772	12 218	774	14%
SCM	14 082	13 742	327	12%
NSB	14 038	11 936	358	11%
BBA	12 390	10 788	9	6%

Table 4: ETCS status by end 2024 categorised by ETC (EU-27)

The following table shows the number and percentage of kilometres planned to be equipped with ETCS by 2030 by ETC. Most ETCs are expected to be equipped by at least around 50% by 2030, with the exception of MED, NSRM, SCM and ATL.

ETC	TEN-T network (km)	Total network - EU 27 (km)	Length planned to be equipped by 2030 - EU 27 (km)	Length planned to be equipped by 2030 - EU 27 (%)
WBEM	6 201	3 520	1 928	55%
RDB	12 772	12 218	6 690	55%
BSAS	10 312	10 312	5 446	53%
NSB	14 038	11 936	6 089	51%
BBA	12 390	10 788	5 377	50%
MED	13 296	13 029	6 063	47%
NSRM	12 133	11 594	4 785	41%
SCM	14 082	13 742	5 621	41%
ATL	13 551	13 551	4 144	31%

Table 5: ETCS deployment envisaged by 2030 per ETC (EU-27)

3.2.3. Role of ERA in the ERTMS Trackside Approval

The ERTMS trackside approval process started in 2019, as per the Interoperability of the rail system Directive[27] ('Interoperability Directive'). ERTMS trackside approval is mandatory for any deployment of ERTMS trackside equipment where the call for tenders was launched after 16 June 2019. The aim of the ERTMS trackside approval is to check whether the technical solutions envisaged by the infrastructure managers are fully compliant with the relevant Technical Specifications for Interoperability and are therefore fully interoperable. Possible exceptions are included in the Article 55 of the Interoperability Directive. Until the end of March 2025, ERA had issued 33 approval decisions, and 106 applications were pending as shown in the table in Annex XIV. To date, ERA has not issued any negative decisions.

[27] Directive (EU) 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union

ERA will initiate a more thorough reflection on how to make the ERTMS trackside approval process as meaningful as possible in terms of scope and timing. While its purpose (i.e. making sure that ERTMS is deployed in an interoperable way across Member States) is in principle valid, there may be room for improvement by answering questions such as:

- Does ERA's trackside approval process start at the right moment in time?
- Are the right gateways envisaged in the process?
- Are the projects likely to evolve anyway after ERA has started the first round of checks?
- Is the scope of the checks in line with the evolution of the scope of the projects?
- How can the length of the process be improved for all contributors (applicants, ERA)?

With such reflections, based on the evidence collected from previous and ongoing applications, ERA is planning to make proposals for improving the approval process. These considerations also link to the issue that public funding, notably at EU level, should only be granted to projects which are fully compliant with the CCS TSI and should ensure seamless cross-border traffic.

3.2.4. Issues and cost drivers for trackside deployment

On behalf of the Commission, the ERTMS Deployment Management Team is investigating the cost drivers of ERTMS trackside deployment in Europe. The study's objective is to identify the cost drivers affecting trackside deployment and to propose solutions to mitigate them. Mitigating cost drivers for trackside deployment is particularly important considering the scale of the deployment. Although the study has not been published at the time of writing, the first results, based on 30 interviews with sector representatives (infrastructure managers, suppliers, associations, EU institutions, assessors), indicate that stakeholders are experiencing the following challenges and cost drivers when deploying ERTMS trackside:

- **Legacy effects of the class B systems**: The class B system and the signalling rules[28] that were adopted in conjunction with its deployment are seen as one of the key challenges. Given that parts of the class-B system will be in operation in parallel with ERTMS and that it formed the basis of the signalling rules, infrastructure managers normally request the engineering of the ERTMS architecture to replicate the rules in place so that it behaves like the class B systems. This concerns especially the interface to the interlockings which is reported to be particularly complex.

  Moreover, this replication and the lack of harmonisation entails that suppliers need to develop and maintain the ERTMS architecture specifically for each IM hereby increasing the engineering effort required and limiting the knowledge of the system to a small number of specialised experts.

  Some IMs are trying to counter the negative effects of the class B signalling and operational rules by performing a review of the rules prior to launching the tender for the ERTMS deployment. It's a cumbersome task but is seen as useful since it simplifies the system and builds up knowledge within the IM and hereby reduces dependency upon the supplier reducing future deployment and maintenance costs. Broader harmonisation of the signalling and operational rules, avoiding national rules only due to historic signalling rules of class B and reducing variability of ERTMS deployment would mitigate this point. This need is already

[28] Signalling rules cover operational rules and also engineering rules linked with the detailed design of the CCS system. Operational rules are covered by the OPE TSI, whereas Engineering rules are covered by CCS TSI only to a limited extent and therefore are not mandatory.

identified in the EC request for the update of the CCS TSI. ERA has created a topical working group for the harmonisation of engineering rules with the input of the ERTMS User's group engineering guidelines and the outcomes of the operational harmonisation work within EU-Rail's System Pillar. This will contribute to a broader harmonisation of the operational rules in the OPE TSI appendix A since there will be a more uniform ERTMS trackside implementation.

- **Legal and technical requirements:** interviewees stressed that there has been an increase in the requirements that govern ERTMS deployment and railways in general. These are both exogenous and endogenous to railways. Common for both is that they increase the engineering effort required to design and maintain the ERTMS solutions deployed. It was reported that it takes substantial engineering capacity to develop CCS related trackside products.

  - Exogenous requirements: some national legislation outside the railway area is not harmonised at EU level and affects ERTMS costs. An example is related to level crossings where varying national legislation related to road infrastructure hinders the harmonisation of ERTMS implementation at level crossings.

  - Endogenous requirements: The complexity and engineering efforts associated with ERTMS are partly due to the extensive data and configuration inputs required by the system. This encompasses both trackside data and the signalling principles governing the Radio Block Centre (RBC). This complexity impacts not only the deployment but also the ongoing operation of the network. The significant engineering effort is evident not only during the design of the generic product but also in the deployment of the system across different networks. Furthermore, any modifications to these engineering data, such as topology, RBC configuration, maximum speeds, and information on components in stations, can have a substantial cost impact. However, these challenges are inherent to the railway industry, as most actions within the rail network will influence the ERTMS as its signalling system. It is important to recognize that these engineering costs are among the differential cost drivers of ERTMS compared to most class B systems, underscoring the need for comprehensive analysis throughout the system's complete lifecycle.

- **Authorisation procedures:** interviewees highlight that the authorisation process (including safety analysis, ERA trackside approval and NSA authorisation) is lengthy, both for new deployments and any change in engineering. There is a significant amount of documentation to be produced for example to demonstrate the safety of the new system. Digitalisation means that software updates need to be made, which should be simple and cost-effective to manage. It is important to ensure that digitalisation leads to simplification and increased efficiency.

- **Stability of the National Deployment Plans:** lack of stable, long-term planning and sufficient funding for ERTMS deployment at national level, which makes it difficult for infrastructure managers and other stakeholders to conclude long-term contracts.

The challenges and the cost drivers mentioned above, in particular the effects of the class B system, have also the effect of limiting the competition in the market, as the unit cost to deploy ERTMS and associated elements such as interlockings[29] is estimated at

[29] Associated elements can include cabling, power supply but also the replacement of interlockings for instance.

approx. EUR 850 000/ km of line. This includes 15 to 25% of central costs (project management, design) and 75 to 85% for field work and equipment. This is due to the specific knowledge needed to deploy ERTMS within an existing class B system environment.

Hence, some IMs report that only the supplier of the Class-B system is able to develop and deploy ERTMS on their network. This creates supplier dependencies for the infrastructure manager but also issues for the suppliers of the railway industry who are dependent on specific knowledge to deploy ERTMS instead of focusing on developing the system or other products within their portfolio.

Lastly, most interviewees are concerned that there will be a lack of production and engineering capacity in the industry to meet the future deployment targets if current deployment approaches persist.

3.3. Deployment of radio communications (GSM-R)

At the end of 2024, GSM-R was in operation on almost 55 % of the TEN-T network EU-27 (i.e. around 64 700 km) and on 61 % of the core network (i.e., about 39 200 km)[30]. The following chart indicates the GSM-R status by end 2024 of the lines belonging to the entire TEN-T network (EU-27).

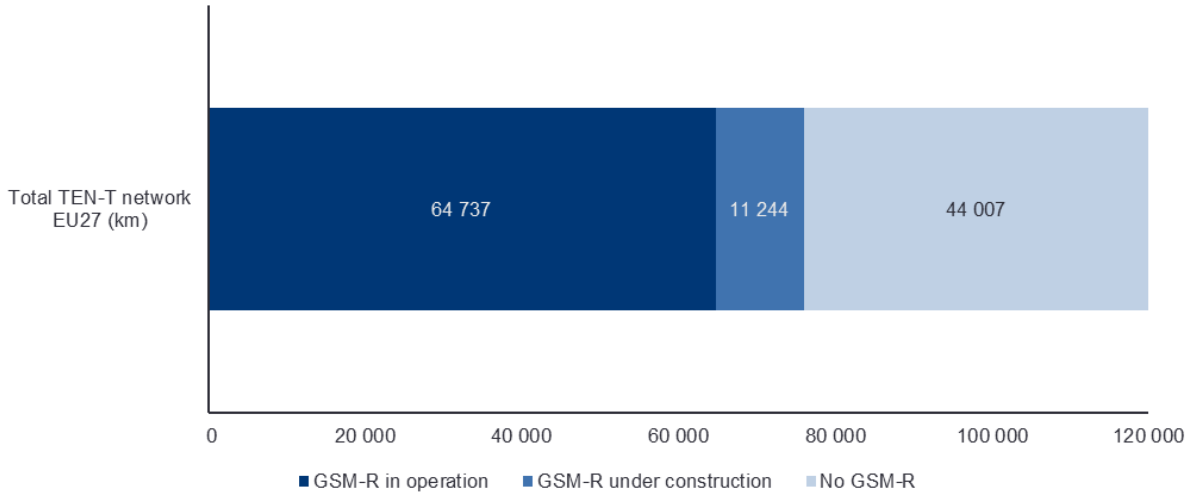


Figure 8: Map of GSM-R status in total length by end 2024 – TEN-T network (EU-27)

The following map presents the status of the GSM-R deployment by end 2024 on the TEN-T network.

[30] GSM-R deployment is not only used for ETCS, but also for voice communication.



Figure 9: Map of GSM-R deployment status by end 2024 – TEN-T network (EU-27)

Table 6 below shows the status of the GSM-R deployment by Member State by end 2024. It is expressed in terms of number and percentage of kilometres already equipped with GSM-R. These figures refer to the TEN-T network, the actual deployment is even larger as some Member States have installed GSM-R beyond the TEN-T lines.

In general, GSM-R deployment is quite advanced in the Member States.

Sweden, Germany, Luxembourg, Belgium, The Netherlands, Denmark, Austria and Slovenia have more than 80% of their network already equipped with GSM-R. While Lithuania has no lines equipped with ETCS, more than 70% of its network is already equipped with GSM-R.

MS	TEN-T network (km)	GSM-R in operation end 2024 (km)	GSM-R in operation end 2024 (%)
Sweden	5 240	5 240	100%
Germany	15 116	14 702	97%
Luxembourg	216	207	96%
Belgium	2 387	2 261	95%
The Netherlands	2 513	2 339	93%
Denmark	1 076	965	90%
Austria	3 028	2 567	85%
Slovenia	987	821	83%
Italy	11 622	9 329	80%
France	17 560	14 015	80%
Lithuania (*)	1 986	1 405	71%
Czechia	3 200	2 211	69%
Hungary	3 667	1 740	47%
Spain (*)	14 672	3 598	25%
Slovakia	1 578	372	24%
Greece	3 047	707	23%
Poland	10 261	1 546	15%
Bulgaria	2 437	301	12%
Portugal (*)	3 216	321	10%
Ireland (*)	1 796	50	3%
Romania	5 742	40	1%
Croatia	2 048	0	0%
Estonia (*)	1 158	0	0%
Finland (*)	3 813	0	0%
Latvia (*)	1 623	0	0%
TOTAL EU-27	119 988	64 737	54%
(*) Member States having most lines that are isolated networks			

Table 6: GSM-R status per Member State end 2024 - TEN-T network (EU-27)

The status of GSM-R deployment by end 2024, categorised by ETC, expressed in terms of number and percentage of kilometres already equipped with GSM-R, is shown in Table 7 below.

NSRM and SCM have achieved a high level of GSM-R deployment, with approximately 90% of their network already equipped with GSM-R. The remaining ETCs have around 50% of their network already equipped with GSM-R, except for BBA, which only has 19% of its network equipped.

ETC	TEN-T network (km)	Total network - EU 27 (km)	GSM-R in operation end 2024 - EU 27 (km)	GSM-R in operation end 2024 - EU 27 (%)
NSRM	12 133	11 594	10 804	93%
SCM	14 082	13 742	12 025	88%
RDB	12 772	12 218	7 204	59%
MED	13 296	13 029	7 537	58%
NSB	14 038	11 936	6 218	52%
WBEM	6 201	3 520	1 830	52%
ATL	13 551	13 551	6 239	46%
BSAS	10 312	10 312	4 738	46%
BBA	12 390	10 788	2 015	19%

Table 7: GSM-R status per ETC (EU-27) end 2024

The following table shows the number and percentage of kilometres planned to be equipped with GSM-R by 2030 per Member State.

There are some Member States that plan to complete deployment of GSM-R their network after 2030, such as Austria, Italy and Spain. Austria has plans for GSM-R deployment until 2034, and there are new lines for which it has not yet been determined whether they will be equipped with GSM-R or 5G Rail. In their NIPs, Italy and Spain have outlined GSM-R deployment plans extending until 2040 and 2045, respectively.

Estonia, Latvia, and Finland have not submitted plans to deploy GSM-R. Estonia and Latvia are solely focused on deploying 5G Rail on Rail Baltica. Likewise, Finland intends to transition from its class B radio system directly to 5G Rail without implementing GSM-R.

MS	TEN-T network (km)	GSM-R planned to be in operation by 2030 (km) - Core	GSM-R planned to be in operation by 2030 (%) - Core	GSM-R planned to be in operation by 2030 (km) - Comprehensive	GSM-R planned to be in operation by 2030 (%) - Comprehensive
Sweden	5 240	3 883	100%	5 240	100%
The Netherlands	2 513	846	100%	2 339	93%
Slovenia	987	475	100%	845	86%
Slovakia	1 578	727	100%	815	52%
Ireland (*)	1 796	446	100%	1 487	83%
Hungary	3 667	1 651	100%	2 102	57%
Germany	15 116	9 258	99%	14 702	97%
Belgium	2 387	1 225	99%	2 261	95%
Poland	10 261	4 776	98%	9 154	89%
Austria	3 028	1 171	96%	2 892	96%
Italy	11 622	5 429	95%	10 540	91%
Denmark	1 076	879	93%	1 010	94%
Luxembourg	216	108	92%	207	96%
Czechia	3 200	1 675	91%	2 651	83%
France	17 560	7 604	87%	14 015	80%
Portugal (*)	3 216	951	66%	2 115	66%
Lithuania (*)	1 986	522	60%	1 405	71%
Greece	3 047	1 012	57%	1 126	37%
Spain (*)	14 672	4 140	42%	5 485	37%
Bulgaria	2 437	653	37%	788	32%
Romania	5 742	572	20%	750	13%
Croatia	2 048	0	0%	0	0%
Estonia (*)	1 158	0	0%	0	0%
Finland (*)	3 813	0	0%	0	0%
Latvia (*)	1 623	0	0%	0	0%
TOTAL EU-27	119 988	48 002	75%	81 928	68%
(*) Member States having most lines that are isolated networks					

Table 8: GSM-R deployment envisaged by Member State by 2030

Table 9 shows the number and percentage of kilometres planned to be equipped with GSM-R by 2030 per ETC. NSRM, SCM and BSAS will achieve a high level of GSM-R deployment, with most of these corridors already equipped with GSM-R by 2030. The remaining ETCs plan to equip more than 50% of the corridor with GSM-R by 2030, except for BBA, which plans to have only 43% equipped with GSM-R by 2030.

ETC	TEN-T network (km)	Total network - EU 27 (km)	Length planned to be equipped by 2030 - EU 27 (km)	Length planned to be equipped by 2030 - EU 27 (%)
NSRM	12 133	11 594	11 295	97%
SCM	14 082	13 742	12 443	91%
BSAS	10 312	10 312	8 488	82%
NSB	14 038	11 936	9 349	78%
RDB	12 772	12 218	8 739	72%
WBEM	6 201	3 520	2 426	69%
MED	13 296	13 029	8 748	67%
ATL	13 551	13 551	7 818	58%
BBA	12 390	10 788	4 629	43%

Table 9: GSM-R deployment envisaged by 2030 per ETC (EU-27)

3.4. Outlook on ERTMS trackside deployment by 2035, 2040 and 2050

According to the NIPs and data submitted by Member States or collected by the Commission, it is projected that approximately 43% of the TEN-T network and 62% of

the core network within the EU-27 will be equipped with ERTMS by 2035. These deployment levels are expected to increase to 54% and 67% by 2040 and to 66% and 76% by 2050. It should be noted that the TEN-T network includes for example isolated networks which are formally exempt from the obligation to roll out ERTMS. The following table presents the projected ERTMS deployment by 2035, 2040, and 2050 for each of the 25 Member States with a rail network.

MS	TEN-T network (km)	ETCS planned to be equipped by 2035 (km)	ETCS planned to be equipped by 2035 (%)	ETCS planned to be equipped by 2040 (km)	ETCS planned to be equipped by 2040 (%)	ETCS planned to be equipped by 2050 (km)	ETCS planned to be equipped by 2050 (%)
Luxembourg	216	216	100%	216	100%	216	100%
Denmark	1 076	1 042	97%	1 059	98%	1 059	98%
Belgium	2 387	2 261	95%	2 261	95%	2 261	95%
Czechia	3 200	2 662	83%	2 662	83%	2 662	83%
Austria	3 028	2 445	81%	2 860	94%	2 959	98%
Italy	11 622	9 102	78%	11 295	97%	11 426	98%
Slovenia	987	522	53%	592	60%	592	60%
Poland	10 261	5 289	52%	8 459	82%	9 059	88%
Romania	5 742	2 770	48%	2 770	48%	2 770	48%
Portugal (*)	3 216	1 501	47%	1 501	47%	1 501	47%
Germany	15 116	6 548	43%	7 739	51%	14 886	98%
Slovakia	1 578	632	40%	1 101	70%	1 461	93%
Finland (*)	3 813	1 480	39%	3 559	93%	3 559	93%
Spain (*)	14 672	5 142	35%	5 142	35%	5 911	40%
Greece	3 047	1 011	33%	1 011	33%	1 011	33%
Sweden	5 240	1 722	33%	1 722	33%	2 712	52%
Hungary	3 667	1 125	31%	1 125	31%	1 125	31%
Bulgaria	2 437	701	29%	701	29%	701	29%
The Netherlands	2 513	688	27%	688	27%	2 289	91%
Latvia (*)	1 623	348	21%	513	32%	675	42%
Croatia	2 048	410	20%	1 375	67%	1 896	93%
Estonia (*)	1 158	212	18%	212	18%	857	74%
France	17 560	3 133	18%	4 553	26%	5 464	31%
Lithuania (*)	1 986	344	17%	344	17%	344	17%
Ireland (*)	1 796	250	14%	1 445	80%	1 445	80%
TOTAL EU-27	119 988	51 556	43%	64 906	54%	78 841	66%

(*) Member States having lines that are isolated networks

Table 10: ETCS deployment plans by 2035, 2040 and 2050 by Member State

It is worth noting that based on the NIPs, by 2035, most of the TEN-T network will be equipped with ERTMS or, at least, without class B system[31]. Hence, the share of the network where on-board class B systems will still be required will be approximately 48% by 2035, 38% by 2040, and 28% by 2050.

Luxembourg, Belgium and Czechia have committed to equipping their entire existing railway networks with ERTMS by 2035. Finland is set to achieve this milestone by 2040, followed by Croatia and Germany by 2050.

In contrast, Bulgaria, Hungary, France, the Netherlands and Greece currently envisage to equip less than 40% of their TEN-T network with ETCS by 2050. If followed, this situation would constitute a breach of the requirements set forth in the TEN-T Regulation.

A description of the ERTMS deployment on the nine ETC is included in the Annex V.

The connection between countries using ERTMS is also important. Annex IX includes a list of ERTMS equipment installed on cross-border sections planned for 2030, 2035, 2040, and 2043.

[31] Lines without class B systems do not present any operational barriers for vehicles equipped solely with ETCS.

4. ON-BOARD DEPLOYMENT IN THE EUROPEAN UNION

A successful ERTMS deployment requires a synchronised deployment strategy between trackside and on-board roll-out. In practical terms, infrastructure managers rely on railway undertakings and rolling stock lessors already having equipped their relevant rolling stock when they move to ETCS-only by decommissioning their class B system simultaneously. It is only once the fleet is equipped and approved for ETCS operation that it will be possible to reap the full benefits of ERTMS deployment.

The available data show that in the various Member States, the share of the fleet equipped with ETCS is indeed broadly consistent with the share of the equipped railway network measured in kilometres. The data on on-board deployment in the present report are based on the information gathered using the methodology explained in Annex I.

4.1. Evolution of ETCS on-board deployment

4.1.1. State of play

Based on the data collected, it is estimated that around 8 730 vehicles were already equipped with ETCS (EU-27) at the end of 2024[32], i.e., 19% of the existing estimated total fleet, which amounts to 45 060 vehicles (EU-27)[33].

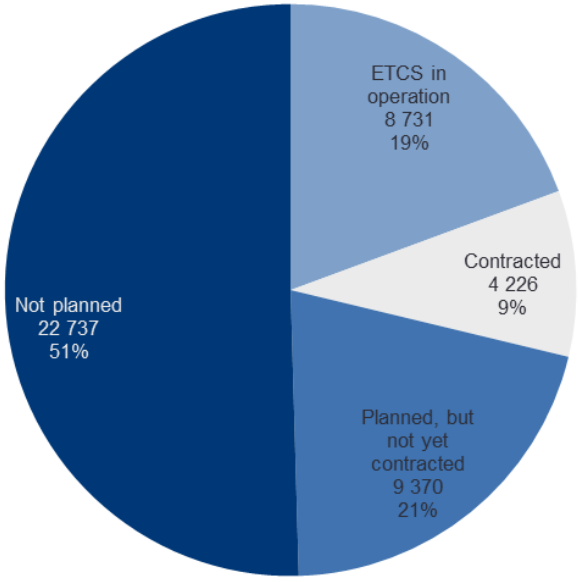


Figure 10: ETCS on-board status by end 2024 (EU-27)

In Luxembourg, the total fleet is already equipped with ETCS. Belgium, Denmark, Slovakia and The Netherlands have made significant progress with ETCS deployment on-board, with 80%, 70%, 65% and 59% of their existing fleet, respectively, already equipped with ETCS. In the case of Finland, there are vehicles equipped with ETCS, but

[32] According to UNISIG data 26 900 ETCS on-board units are contracted in Europe (i.e., EU-27 plus Switzerland, Norway and United Kingdom). It is important to note that the UNISIG data includes vehicles currently contracted although they are not in operation yet, data from Switzerland, Norway and United Kingdom and some vehicles have two on-boards units,

[33] Clustering by type of works in vehicles, according to the data gathered, 10% of the estimated total fleet are new vehicles, 11% are vehicles retrofitted and 3% are vehicles upgraded. The type of work of the remaining 76 % vehicles is not specified from the available sources.

they are only approved for STM operation with the national class B system, as there are no ERTMS tracks yet in Finland[34].

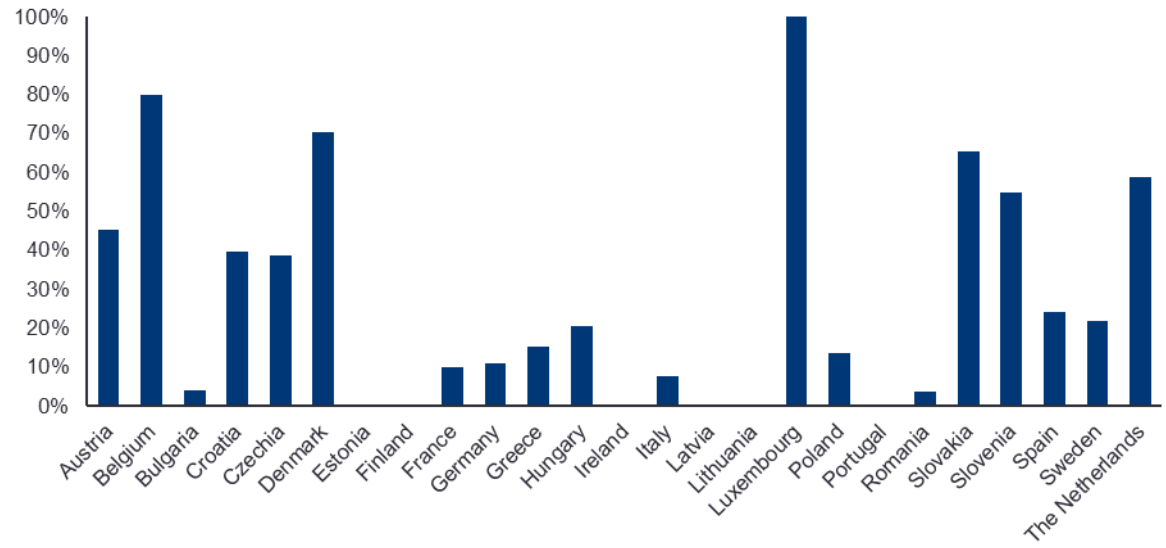


Figure 11: ETCS status on the estimated total fleet by Member State

Clustering by type of Baseline in vehicles, according to the data gathered, 24% of the estimated total fleet are in Baseline 2, 17% are in Baseline 3 and 1% are in Pre-Baseline 2 (i.e. non-interoperable Baseline). The baseline of the remaining 58 % vehicles is not specified from the available sources.

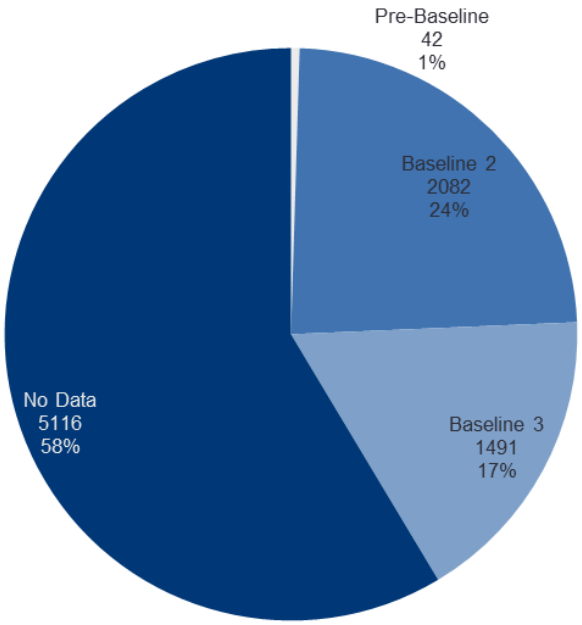


Figure 12: Type of Baseline in the fleet equipped with ETCS by end 2024 (EU-27)

[34] The STM is a device that allows the ETCS onboard equipment to act as interface with the onboard part of an existing national class B system.

Figure 13 shows the progress made between 2021 and 2024 in equipping vehicles with ETCS. Since 2021, around 3 400 vehicles have been put into operation, meaning an average of 850 vehicles per year.

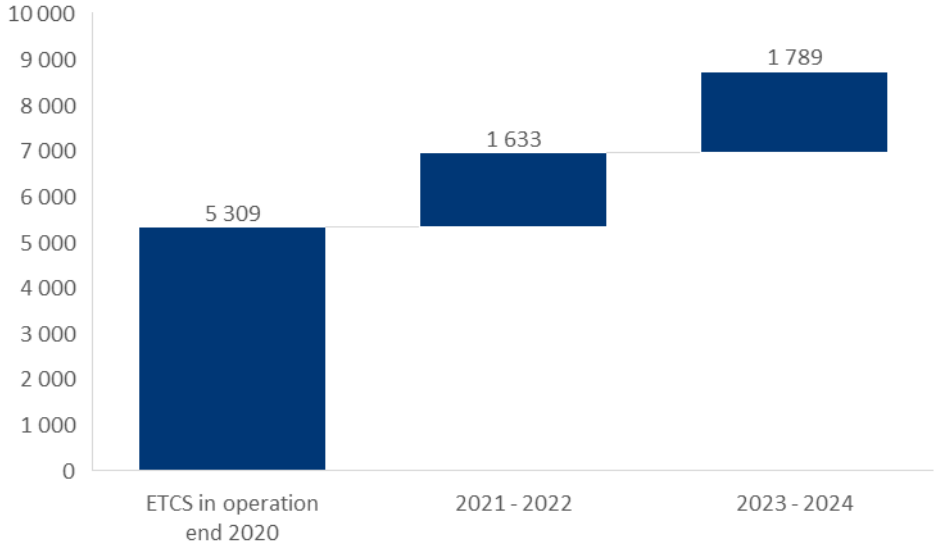


Figure 13: Vehicles equipped with ETCS from 2020 to 2024 (EU-27)

According to the data gathered, it is expected that by end 2030 around 18 000 vehicles, i.e., 40% of the estimated total fleet will be already equipped with ETCS.

Figure 14 shows vehicles planned to be equipped with ETCS by 2030. Czechia and Denmark aim to have their entire fleet equipped with ETCS by this time. Additionally, Austria, Belgium, Italy, Portugal, Slovakia, Slovenia and The Netherlands are on track to achieve a high share, with over 70% of their existing fleets planned to be equipped with ETCS by 2030.

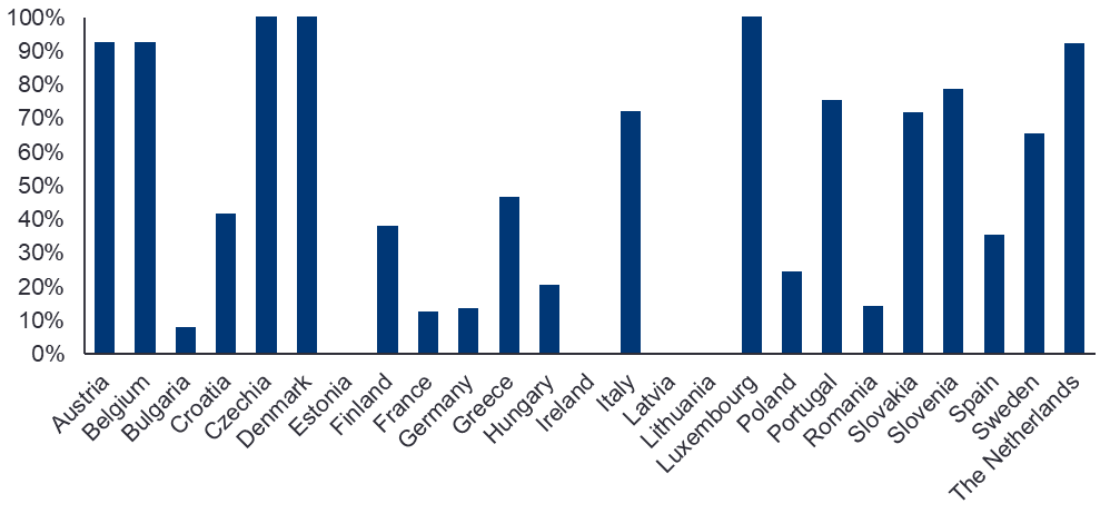


Figure 14: ETCS vehicles planned by 2030 compared with the estimated total fleet

4.1.2. Outlook to 2030 and beyond

By 2030, the number of vehicles equipped with ERTMS in the EU-27 is expected to rise to 18 000 vehicles (i.e. 40% of the estimated total fleet), and by 2040, to 18 600 vehicles (i.e. 41% of the estimated total fleet). Additionally, approximately 3 700 vehicles are planned to be equipped with ETCS, although a commissioning date has not been

specified[35]. If these vehicles are equipped by 2040, 50% of the estimated total fleet will be equipped by that year[36].

Most Member States lack a detailed plan for the deployment of ETCS in vehicles, making it difficult to obtain a realistic picture of the future situation. The number of vehicles planned to be equipped between 2025 and 2030 (i.e. 9 270 vehicles) is not comparable to the number planned from 2031 to 2040 (i.e., 645 vehicles). This discrepancy arises because few Member States have outlined plans for the deployment of ETCS on vehicles beyond 2030.

The following graph illustrates the number and percentage of vehicles in operation with ETCS by the end of 2024, relative to the estimated total fleet of the EU-27 (i.e., 45 060 vehicles). It also depicts the vehicles planned to be equipped with ETCS between 2025 and 2030, those planned to be equipped between 2030 and 2040, vehicles intended to be equipped with ETCS, but without a specific commissioning date, and vehicles currently not planned to be equipped with ETCS.

It should be noted that it will be necessary to equip more vehicles with ERTMS in the period from 2025 to 2040 than currently planned. If by 2040, only about half of the vehicles are equipped with ERTMS, while the core and extended core network are meant to be equipped with ERTMS according to the TEN-T Regulation, this is likely to fall short of the necessary share of rolling stock needed to operate on the network. At the same time, considering the age of the rolling stock, a significant part of the European fleet will have to be renewed by 2040 and, consequently, they will be equipped with ERTMS which is a legal requirement for all new vehicles coming out of factory.

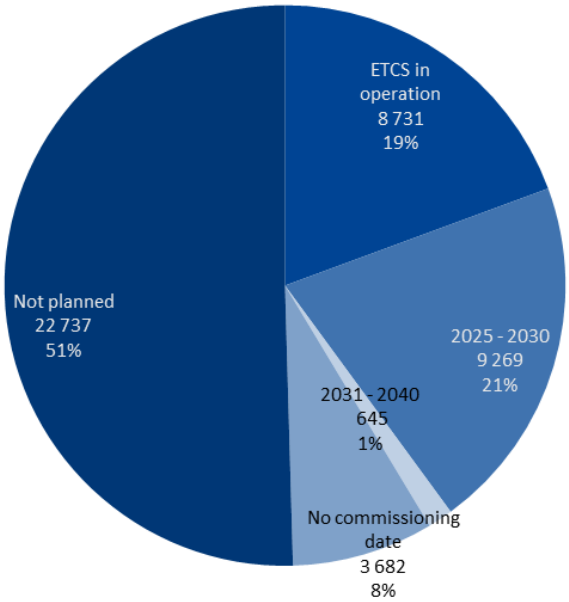


Figure 15: Estimation of existing vehicles planned to be equipped with ETCS until 2040

[35] The ETCS on-board deployment plans are collected following the methodology described in the Annex I. In some cases, deployment plans are not public available or exist without clear timelines for entry into service.

[36] The percentages included in this section are compared with the estimated total fleet. Although there are new vehicles planned to be equipped with ETCS, it is considered the hypothesis that some existing vehicles will be phased out and replaced by new vehicles

4.2. National financing schemes: State aid procedures

Member States, through their national budgets, play a critical role in the financing of ERTMS deployment[37]. In the period between 2009 and 2025, Member States notified to the Commission State aid of the order of EUR 957 million under EU State aid rules[38]. The table below presents the State aid per Member State as approved under the Commission's State aid decisions[39]. Notably, State aid is typically granted to ERTMS on-board equipment as State support for rail infrastructure[40] is usually exempt from State aid rules.

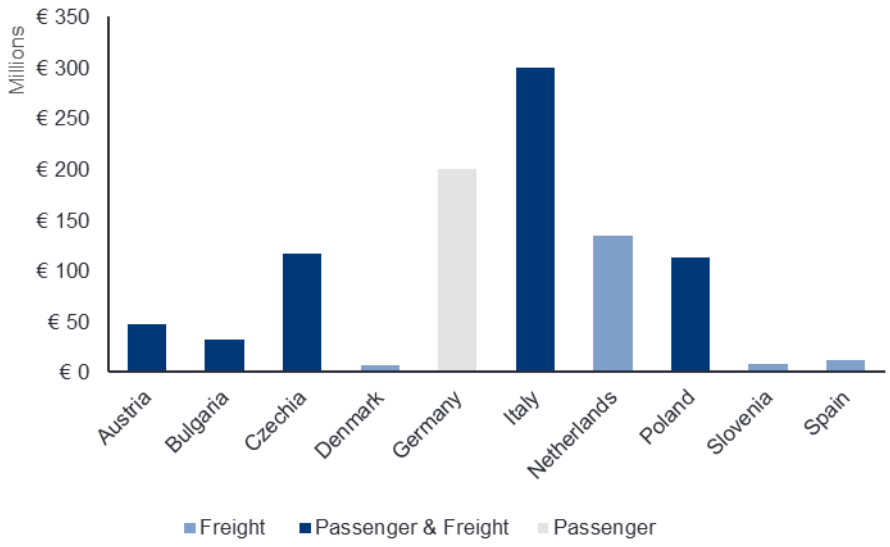


Figure 16: Sample of ERTMS On-board State support by MS (based on the Commission's State aid decisions)

Source: elaboration of DG MOVE provided data, based on https://competition-cases.ec.europa.eu/search?caseInstrument=SA. Data is aggregated 2009 - 2025.

The above figure illustrates that Italy and Germany have dedicated significant amounts of national funding to the on-board deployment and upgrading of ERTMS: EC decisions on State aid show values of EUR 300 million in Italy and EUR 200 million in Germany. They are followed by the Netherlands (EUR 135 million) and Poland (EUR 113 million).

Several countries indicate smaller, though still notable State aid, namely Austria (EUR 47 million), Bulgaria (EUR 32 million), Czechia (EUR 81 million), Denmark (EUR 7 million), Slovenia (EUR 8 million) and Spain (EUR 12 million).

4.3. System compatibility checks

For trackside implementation, ERTMS can be regarded as a toolbox, with different functionalities and variants defined in the ERTMS specifications. These multiple options to

[37] Also see chapter 5.3.

[38] Please see https://competition-cases.ec.europa.eu/

[39] Please note that these State aid figures may not provide a complete overview of public support for on-board deployment in individual Member States, as operators may also have received additional support that was not subject to notification under State aid rules. In Denmark, for example, the national IM is investing EUR 210 million in on-board deployment. The Spanish government has cumulatively granted almost EUR 60 million, German national funding amounts to EUR 500 million and combined Czech state resources amount to EUR 230 million.

[40] Some Member States mention values for trackside ERTMS investments in their NIPs. It must be noted, however, that the scope of these estimates (both geographical as well as technical) varies greatly across Member States. Annual estimates for trackside deployment in 2029, for example, vary from EUR 263 million in Czechia, to a rough estimate of EUR 700 million in Italy.

implement ERTMS trackside at national or project specific level triggered the request to test compatibility of certified on-board and trackside products within a defined area of use. These tests are known as the ETCS System Compatibility (ESC) and Radio System Compatibility (RSC) tests. They were introduced through the amendment of the CCS TSI 2016 in 2019[41] and detailed in the CCS TSI 2023[42].

The need for ESC checks arose for example from ambiguous requirements, partial fulfilments, critical function checks and specific trackside implementations. The variety of reasons and situations has led to a multitude of ESC tests. According to feedback from the sector, ESC tests have in some Member States become an issue in itself as they have led to increased costs, longer project durations and a fragmentation of the ERTMS landscape.

Based on the obligation under the CCS TSI 2023/1695, ERA issued a report[43] to analyse the potential to phase out ESC and RSC checks. The report has proposed recommendations and actions to reach this objective, based on a survey of the railway sector.

The data collected by the surveys included in the ERA report reveal that the number of ESC types is high. According to the ESC/RSC technical document[44], at the date 25 April 2025, there were in total 134 valid ESC types in 16 countries. It is however not only the sheer number of ESC types that is impacting the authorisation process, but also the detail and complexity of the checks included in those types.

Member State	Valid ESC Type by MS
Austria	1
Belgium	4
Czech Republic	2
Denmark	2
France	36
Germany	5
Italy	14

[41] Commission Implementing Regulation (EU) 2019/776 of 16 May 2019 amending Commission Regulations (EU) No 321/2013, (EU) No 1299/2014, (EU) No 1301/2014, (EU) No 1302/2014, (EU) No 1303/2014 and (EU) 2016/919 and Commission Implementing Decision 2011/665/EU as regards the alignment with Directive (EU) 2016/797 of the European Parliament and of the Council and the implementation of specific objectives set out in Commission Delegated Decision (EU) 2017/1474

[42] Regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919

[43] ERA report: TSI CCS (EU) 2023/1695 Article 12, ERTMS compatibility and future revision (Ref: 2024-REP-Art.12_CCS_TSI_V2.0).

https://www.era.europa.eu/sites/default/files/2024-12/2024-rep-art.12_ccs_tsi_v2.0_0.pdf?t=1741594500

[44] ESC/RSC Technical Document. Document ID: TD/011REC1028. Version: 36.0

https://www.era.europa.eu/system/files/2023-05/esc-rsc_technical_document_en.pdf?t=1745822776

Member State	Valid ESC Type by MS
Luxembourg	3
Norway	2
Poland	6
Romania	1
Slovenia	1
Spain	25
Sweden	5
Switzerland	3
The Netherlands	24

Table 11: Number of valid ESC Type by Member State

According to the data collected in the ERA report[45] those that have been tested at least 4 times (approximately 70% of the total ESC Types), approximately 50% have always been reported with success or minor shortcomings, 40% have been reported at least once with product non-conformities, and only 10% have at least once been reported with train-track incompatibilities.

The incompatibilities often arise from product non-conformities, misinterpretations, or design incompatibilities. Typically, on-board configuration updates solve these issues. However, when the on-board update process takes too long, trackside modifications may be seen as an alternative to avoid significant delays in the authorisation for placing the trains into service on the affected lines.

One of the major concerns for applicants is the high costs and long duration of ESC testing in many Member States prompting calls for example for a moratorium on new ESC types or a time limitation on the test during and, ultimately, for its phase-out. ESC testing is a part of the "validation/ authorisation" category of cost drivers for on-board equipment (see chapter 4.4.1) It significantly impacts overall costs due to advance track bookings and potential project delays, leading to increased downtime and expenses.

To address this issue, ERA has launched a topical working group which investigates the potential to reduce or eliminate ESC testing, afterwards conclusions may also be applied to RSC. ERA will use the information gathered from stakeholders in the topical working group to make proposals for reducing or eliminating ESC testing.

Optimising ESC/RSC Checks: An example of reducing costs and streamlining approvals

One way to streamline approvals is to optimise ESC/RSC checks. This is in line with the recommendations from ERA to reduce ESC/RSC checks include a harmonised definition of ESC content, guidelines for ESC definition, harmonised trackside engineering rules, the review of conformity assessment requirements in CCS TSI, a better coverage of ESC by SUBSET-076, the monitoring of modifications introduced in CCS TSI, a greater focus on

[45] The ERA report is based on the ESC/RSC technical document (TD/011REC1028), version 27.0, 10/10/2023

product deviations and the cleaning up of CCS national rules. These recommendations aim to streamline and standardise processes, improve coverage, and enhance the focus on product deviations, ultimately contributing to a more efficient and effective ETCS system compatibility.

In general, there is significant room for improvement. It appears imperative to implement a moratorium on new ESC/RSC types to prevent further proliferation of tests. Such a moratorium would simply require that new lines would use the same engineering solutions as existing lines rather than implementing a new ERTMS variant. Moreover, harmonising trackside engineering rules and focusing on identifying potential compatibility issues earlier in the project development process would be clear steps forward in achieving this goal.

An analysis of ESC/RSC test specifications published on ERA websites indicates that up to 25% of the tests could be reduced, as they assess either solely on-board or trackside functions and should therefore be integrated into the test campaigns related to these interoperability constituents. Furthermore, over 50% of the ESC checks evaluate aspects related to only 5 ERTMS functionalities. Harmonising these functionalities would significantly reduce ESC/RSC tests.

Moreover, as will be mentioned in chapter 7 on 5G Rail, the need for RSC should be eliminated when deploying FRMCS.

4.4. Cost drivers and recommendations for cost reductions

4.4.1. Cost drivers

The cost of deploying ERTMS on-board rolling stock has risen significantly in recent years. A recent study[46] commissioned by the Commission estimates that on average, retrofitting costs increased from EUR 450 000 to EUR 900 000 per vehicle and upgrade costs doubled from EUR 200 000 to EUR 400 000 between 2018 and 2022. These escalating costs pose a significant threat to the deployment timeline and the financial viability of the transition to ERTMS. The study also analysed the main cost drivers behind this trend. The project can be divided into three main phases:

- design, which accounts for 20-30% of the total project costs;
- deployment, representing 40-50% of the total costs; and
- authorisation, comprising 20-30% of the overall project expenses.

It should be noted that the shares indicated can vary depending on the number of prototypes and the number of countries in which the vehicle operates. Moreover, there are cross-cutting market and economic factors.

Design Phase

In the design phase, the diversity of the vehicle fleet emerged as a major contributor to cost. Retrofitting projects often require bespoke engineering solutions due to national rules, differences in vehicle type, age, and design. The absence of a standardised vehicle-to-ERTMS interface (for existing vehicles) and incomplete or outdated vehicle documentation, further increases complexity.

Deployment Phase

The deployment phase is characterised by limited industrialisation and constrained operational planning. Most retrofit projects involve small series or even one-off installations, which makes it difficult for suppliers to achieve economies of scale. The

[46] Please refer to the ERTMS on-board cost drivers study for a full overview of solutions. Please see https://data.europa.eu/doi/10.2832/0774726.

need to interface with legacy class B systems (once developed) adds to the technical workload, especially when the standardised interface (STM) is not used.

Authorisation Phase

Despite the harmonising role of TSIs and the 4th Railway Package, authorisation processes still have a national element due to local rules and operational set-ups to be respected. Furthermore, evidence generated in one project—such as test results and validation reports—is seldom reused effectively in other contexts. Limited access to harmonised testing facilities exacerbates the issue, especially for on-track trials.

Cross-cutting Cost Drivers

A lack of market competition in the ERTMS supply chain results in high procurement costs and long lead times, with prototypes which can take more than 3 years. Inflation and supply chain disruptions further increase costs, while the absence of upgradeable ERTMS solutions forces operators to invest in costly full-system replacements rather than incremental upgrades.

4.4.2. Solutions

The study outlines a wide array of solutions[47] with the potential to mitigate identified cost drivers. In the following, such solutions are considered that have the strongest expected impact. They are grouped according to their time horizon. The expected impact was based on a stakeholder survey, where stakeholders ranked the solutions from 1-5 (5 being the most impactful). The ranking per listed solutions is included below.

Short-Term Solutions

- **Reduction of ESC tests**

  The reduction of testing activities, particularly ESC tests, has been a major request from the sector. By harmonising test types and analysing test outcomes through numerical and probabilistic analyses, the need for certain tests may be significantly reduced, especially during later project stages.

Medium-term Solutions

- **Increase modularity in design and product updates**

  Moving towards a modular on-board architecture can lower integration effort in type design and product updates. While this shift may incur initial costs, it will lead to lower costs for future upgrades thanks to the possibility to replace only parts of the system and increased competition for these parts.

- **Broader harmonisation**

  Harmonising operational processes, signalling concepts, and trackside engineering can simplify the ERTMS system and reduce the overspecification caused by country-specific requirements. A realistic target for harmonisation should be established to balance flexibility and complexity, helping to reduce testing demands. An ongoing technical working group in ERA, TWG Engineering Rules, aims to achieve this broader harmonisation.

[47] A complete list of detailed solutions can be consulted in the OB cost drivers report, which can be consulted here: https://op.europa.eu/en/publication-detail/-/publication/89f05852-1680-11f0-b1a3-01aa75ed71a1/language-en

Further solutions to achieve broader harmonisation are:

- Development of common harmonised operational rules for Level 2 operation and linked technical solutions for the whole CCS system.
- Define ERTMS parameters for vehicle types.
- Simplify national rules and design guidelines
- Reduction of project-specific requirements
- Simplify the authorisation process

5. FUNDING SCHEMES

Deploying ERTMS requires substantial investment due to its scale and complexity. It is estimated that that between EUR 75 and EUR 85 billion[48] is needed to complete trackside deployment across the entire TEN-T Network of which between EUR 37 and EUR 42 billion is required for the core network. These costs cover the ERTMS deployment but also associated costs to deploy this new signalling system, such as the replacement of mechanical or analogue interlockings with digital ones[49]. An additional EUR 10 to EUR 15 billion is required for on-board deployment in rolling stock of which EUR 5 to EUR 10 billion is needed for vehicles operating on the core network. It is important to note that cost estimates provided by Member States are often considerably higher. This discrepancy typically arises because Member States frequently include additional components, such as extra work to increase capacity or the removal of class B systems, thereby broadening the technical scope. Furthermore, several large Member States include in their calculation infrastructure works on sections located outside the TEN-T network, significantly expanding the geographical scope relative to the aforementioned estimates.

To ensure a timely and successful implementation, a diversified funding approach has therefore been developed at both EU and national level. The Commission considers ERTMS a strategic priority and has integrated it into several EU funding programmes, including the Connecting Europe Facility (CEF), the Recovery and Resilience Facility (RRF), and European Investment Bank (EIB) financial instruments. In parallel, Member States' budgets play a crucial role in co-financing projects, particularly for infrastructure managers and railway undertakings. In total, more than EUR 6 billion have already been mobilised at EU level to support the deployment of ERTMS, as described more detailed in the paragraphs below.

The Commission proposed a new approach to the next Multiannual Financial Framework (MFF) on 16 July 2025 which will be discussed in relation to ERTMS in chapter 5.4.

The following section outlines the key funding mechanisms that have been used for ERTMS deployment as well as the Commission's proposal for the next MFF.

5.1. Connecting Europe Facility (CEF)

The CEF is the EU's primary funding instrument for transport infrastructure projects. As ERTMS is a cornerstone of Europe's rail digitalisation strategy, CEF has dedicated significant financial resources to its deployment. This being said, the implementation of the projects retained for CEF support is often delayed or reduced for reasons addressed in chapters 3 and 4 above. The actual absorption of the allocated CEF funding is therefore in general lower than its nominal value.

5.1.1. CEF I (2014-2020)

During the 2014-2020 period, CEF allocated over EUR 1.03 billion to ERTMS projects, marking a significant increase compared to the 2007-2013 TEN-T programme, when it was EUR 645 million. A total of 92 Grant Agreements were signed under CEF I, supporting a mix of trackside and on-board projects.

[48] Note that this value is based on recent NIP data from 22 Member States: the EU27, excluding Malta and Cyprus because of their lack of rail network and excluding Greece, Bulgaria and Romania because of the lack of NIP available for analysis. For these Member States, data from the DMT database was used. Please see annex XII to this report for the complete cost estimation methodology. Please also note that pure ERTMS costs represent a bit less than 30% of the total cost.

[49] These new interlockings are also expected to bring benefits to the railway system by reducing vendor lock-in and maintenance costs and improving upgradability.

Trackside Deployment: 46 agreements were initially signed, but following terminations and modifications, 38 actions were ultimately supported. These projects covered over 5 200 km of double-track equivalent rail lines, with 85% of the funding directed towards first-time deployment. The total CEF contribution for trackside projects amounted to EUR 480 million. In addition, CEF contributions of a total of EUR 242 million support the deployment of electronic interlockings in certain CEF I actions addressing ETCS Level 2.

On-Board Deployment: of the 44 initial agreements, 35 actions received financial support covering almost 3 000 vehicles. This included over 1 500 serial retrofits (first-time deployment of ERTMS on existing vehicles), 550 upgrades (deployment of baseline 3 on existing vehicles already equipped with ERTMS), 740 new fitments (deployment of ERTMS on new vehicles), and 120 prototypes (both retrofit and upgrade). The total funding for on-board projects under CEF I was EUR 306 million.

Memorandum of Understanding Activities: Two additional actions, focusing on testing campaigns and validation activities, were funded with EUR 5.7 million from CEF I.

5.1.2. CEF II (2021-2027)

Under the ongoing CEF II programme (2021-2027), ERTMS remains a high funding priority, supporting the EU's goal of a smart, sustainable, and interoperable rail network. The overall CEF II programme is divided into two main envelopes:

- General Transport Envelope (EUR 14.52 billion) – open to all Member States.
- Cohesion Fund Envelope (EUR 11.29 billion) – available only to Cohesion Member States to support infrastructure investments.

CEF II is structured around annual calls for proposals, managed by CINEA. These calls provide stakeholders with greater visibility and predictability regarding available funding.

To date[50], CEF II has supported 48 projects contributing to ERTMS deployment, covering ETCS, Class A radio (GSM-R), and interlocking systems for ERTMS Level 2. Specifically:

- 27 trackside projects have been supported, covering approximately 3 600 km of ETCS, 1 800 km of interlocking, and 400 km of Class A radio. The total CEF contribution for trackside deployment under CEF II is approximately EUR 638 million.
- 52 on-board projects are currently funded, covering nearly 5 200 vehicles, with a CEF contribution of approximately EUR 414 million.

CEF II funding levels for ERTMS projects are based on unit contributions per deployed unit. These contributions were initially set in 2019 and revised in 2021 to reflect updated deployment costs[51].

5.2. Other EU Funds

Beyond CEF, several additional EU funding instruments play a role in supporting ERTMS deployment, including the Recovery and Resilience Facility (RRF), European Investment Bank (EIB), European Investment Fund (EIF) and European Regional Development Fund (ERDF).

[50] The cut-off point for these statistics is end July 2025.

[51] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/cef/guidance/unit-cost-decision-cef-ertms-afif-evri-rfn_en.pdf

5.2.1. Recovery and Resilience Facility (RRF)

The RRF was established in response to the COVID-19 pandemic, providing EUR 672.5 billion in grants and loans to Member States to support economic recovery. The RRF Regulation requires Member States to devise national Recovery and Resilience Plans (RRPs) that contribute to green and digital transitions, including ERTMS deployment.

Rail development represents approximately 40% (EUR 38.4 billion) of transport-related investments under the RRF, demonstrating the strong emphasis on sustainable mobility. Several Member States have included ERTMS-related investments in their national RRPs. Countries such as Bulgaria, Finland, Italy, Netherlands, Romania and Spain have earmarked specific funding for ERTMS deployment, as described in the table below:[52]

Member State	EUR million
Bulgaria	17
Finland	85
Italy	2 466
Netherlands	149
Romania	99
Spain	12
Total	**2 828**

Table 12: RRF ERTMS funding by Member State. Source: European Commission

5.2.2. European Investment Bank (EIB)

The EIB, as the EU's long-term lending institution, plays a pivotal role in financing large-scale infrastructure projects that align with EU policy priorities, including sustainable transport and digitalisation. In support of ERTMS deployment, the EIB provides loans, guarantees, and advisory services to both public and private sector entities undertaking railway modernisation projects.

Eligible projects typically include the deployment of railway lines with ERTMS equipment, procurement of ERTMS-compatible rolling stock to enhance safety and interoperability across EU rail networks.

The EIB's involvement often facilitates the mobilisation of additional public and private investment by reducing perceived risks and improving the financial viability of complex rail infrastructure projects.

In the period between 2014 and 2025, the EIB has provided support for ERTMS deployment amounting to EUR 5 billion[53]. Note that in some cases, the scope of the projects supported includes other rail infrastructure works.

[52] The RRF supports the deployment of ERTMS for example also in Greece as part of a comprehensive measure of a total of about EUR 335 million to remedy the effects of storms Daniel and Elias in 2023.

[53] Source: www.eib.org/en/projects

5.2.3. European Regional Development Fund (ERDF) and Cohesion Fund (CF)

The European Regional Development Fund (ERDF) is one of the EU's primary financial instruments aimed at strengthening economic and social cohesion by correcting regional imbalances. It is complemented by the Cohesion Fund (CF) which supports investment in 15 Member States in transport, the environment, energy efficiency and renewable energy. In the context of sustainable transport and digital infrastructure, the ERDF and CF play a key role in co-financing ERTMS deployment across less developed and transition regions.

Under the 2021–2027 Multiannual Financial Framework, the ERDF and CF prioritise investments that support a greener, more connected Europe. This includes funding projects that modernise railway infrastructure to enhance interoperability and reduce environmental impact, with ERTMS being a key enabler of these goals.

Several Member States have used or plan to use ERDF/CF allocations to support the deployment of ERTMS on the TEN-T network. Eligible activities include the installation of ERTMS on rolling stock and trackside equipment, upgrading legacy signalling systems, and integration of digital solutions that facilitate cross-border rail operations. Member States such as Italy and Romania have prominently featured ERTMS in their ERDF-funded regional and national programmes, targeting improved rail efficiency, safety, and sustainability. The table below describes the ERDF and CF allocations specific to ERTMS in the 2021-2027 period.

Member State	ERDF EUR million	CF EUR million
Bulgaria		24
Czechia		107
Greece		96
Italy	29	
Poland		225
Portugal		66
Romania	8	
Total	**37**	**518**

Table 13: Planned ERDF and CF ERTMS funding by Member State.

Source: https://cohesiondata.ec.europa.eu/funds/erdf/21-27

Five Member States have allocated a total of EUR 518 million to ERTMS installations in the CF 2021-2027 Programme[54], while the ERDF included funding of over EUR 37 million in Italy and Romania.

[54] The estimates for Bulgaria, Czechia, Greece and Poland include funding across the ERDF and CF.

5.3. National financing schemes

Some Member States have already widely contributed to ERTMS deployment through national budgets. While the scale and structure of national funding vary between countries, many governments provide direct investment, co-financing for EU-funded projects, and incentives for railway operators to upgrade their fleets. National financing schemes mentioned in the National Implementation Plans are elaborated in Annex III.

For some countries, ERTMS deployment is partially covered by national infrastructure funds, particularly for trackside upgrades. Others provide state-backed financing schemes to support rolling stock retrofitting.

Moreover, some Member States have integrated ERTMS funding into broader transport modernisation plans, ensuring alignment with national sustainability and digitalisation objectives. However, national contributions often depend on budgetary constraints and political priorities, making EU funding a critical driver for sustained investment.

While it would exceed the scope of this report to give an overview of the various national financing mechanisms for ERTMS, the text boxes below give an overview of the Austrian and the Danish financing mechanisms which stands out as long-term mechanisms to deploy ERTMS.

Austria presents a notable example of a stable, long-term national financing scheme for ERTMS deployment. Austria's financing approach is anchored in long-term strategic plans like the Target Network (2025+ and 2040). These plans prioritise key investments such as trackside upgrades essential for ERTMS. The implementation is guided by six-year framework rolling plans developed by ÖBB-Infrastruktur AG and updated annually, which outline detailed projects, costs and timelines, ensuring consistency and predictability.

The Austrian government supports these investments through public support for both infrastructure construction and maintenance. Additionally, ÖBB-Infrastruktur AG raises funds via state-backed bonds issued by the Austrian Federal Financing Agency (OeBFA), benefiting from favourable financing conditions. Track access charges and regional contributions further supplement funding, while EU co-financing supports specific projects.

In order to secure the financing, Austria has adopted the Prior Charges Act. Prior charges are obligations by the Federal Government to fulfil federal expenditures that are due in one or more future financial years. The subsidy contracts signed by ÖBB-Infrastruktur AG fall under this category, ensuring financial security for long-term projects like ERTMS.

Textbox 2: The Austrian national financing mechanism[55]

In 2009, the Danish Parliament approved the overall plans for a comprehensive signalling renewal programme comprising 1) trackside deployment of digital signalling, interlockings renewal, and GSM-R on Banedanmark's network, 2) onboard deployment on relevant yellow machines and passenger rolling stock operating on PSO contracts on Banedanmark's network, 3) a new traffic management system, and 4) various associated projects. All these projects were combined in the Signalling Programme under the auspices of the national infrastructure manager, Banedanmark, including the onboard deployment project. Banedanmark tendered and signed all relevant contracts in 2011-2012.hAs part of the national budget, the Danish Parliament has committed to funding the total cost of the Signalling Programme as well as made available grants of EUR7.4 million for the retrofitment of freight vehicles and EUR2.9 million for the retrofitment of veteran rolling stock.

Onboard deployment on passenger rolling stock procured after 2012 is the responsibility of the railway undertakings themselves.

Textbox 3: The Danish national financing mechanism

[55] The CER Essay series, "Laying Tracks for Growth: European Railway Infrastructure as Strategic Investment", February 2025, https://www.cer.be/cer-essay-series/essay-9-laying-tracks-for-growth-european-railway-infrastructure-as-strategic-investment

5.4. The Commission's proposal for the next Multiannual Financial Framework

On 16 July 2025, the Commission presented a proposal for the Multiannual Financial Framework (MFF) for the next budget period from 2028 to 2034. The upcoming MFF proposes a total budget of nearly EUR 2 trillion and aims to strengthen Europe's competitiveness, resilience, and strategic autonomy.

The Commission is proposing a new approach for the upcoming MFF to ensure more coordinated, efficient, and targeted financial support for cross-border rail projects. This includes adapting the structure and allocation of funds to enhance synergies between EU-level resources and national co-financing. ERTMS, as a cornerstone of the EU's rail digitalisation strategy, stands to benefit from this shift.

The CEF with a proposed envelope of EUR 81.4 billion for the 7-year period remains the primary EU instrument for funding ERTMS. Of this amount, EUR 51.5 billion is indicatively allocated to transport and military mobility, which includes support for interoperable systems such as ERTMS.

CEF funding is increasingly being paired with other EU instruments, including:

- Cohesion Policy Instruments
- Recovery and Resilience Facility (RRF) or its successors
- National and Regional Partnership Plans (NRPP), which are expected to complement CEF investments, particularly on national sections connecting to cross-border links
- European Competitiveness Fund (ECF), which will support the scale-up and deployment of innovative solutions for decarbonisation, digitalisation, and resilience in transport and energy

While the MFF proposal does not yet provide detailed allocations for NRPP or ECF, these instruments are expected to play a complementary role in supporting infrastructure and digitalisation projects, including those related to ERTMS. The proposal emphasises the importance of synergies between these envelopes to maximise EU added value and avoid any duplication.

In particular, the EU-RAIL Joint Undertaking can be instrumental to realise the synergies between the ECF and the next Horizon Europe to investigate innovative solutions to accelerate ERTMS adoption and implementation. It is capable of handling large-scale validation of innovative approaches under real commercial conditions across multiple Member States with stakeholders' resources and commitment.

A boost comes from the new economic governance framework agreed in February 2024, which excludes national co-financing for high-value EU-funded projects from the Stability and Growth Pact's expenditure indicators. This change is expected to unlock more national investments in cross-border rail initiatives.

The process to negotiate and ultimately adopt the next MFF is underway. Final adoption is expected in 2027.

6. ERTMS AS INDUSTRIAL PROJECT

6.1. Introduction

ERTMS is as a flagship project of strategic European interest. Designed to unify and modernise railway signalling across Member States, ERTMS serves as a cornerstone for delivering interoperable, digital, and sustainable rail transport within the EU. Beyond its role as a technical standard to achieve EU-wide interoperability, ERTMS represents a major industrial endeavour—mobilising suppliers, operators, and public authorities to create a single market for railway control and command systems. As deployment accelerates under the revised TEN-T Regulation and the NIPs, ERTMS now transitions to a large-scale industrial project, requiring coordinated capacity expansion, supply chain scaling, and targeted innovation to meet Europe's rail modernisation goals. Both the Draghi[56] and the Letta[57] report underline the importance of equipping the Single European Railway Area with ERTMS.

6.2. A sharp increase in ERTMS deployment is expected in the coming years

Figure 17 shows the kilometres planned to be equipped with ETCS per year. The infrastructure managers and industry should prepare to equip around 28 000 kilometres of tracks within the next six years, averaging about 4 650 kilometres per year.

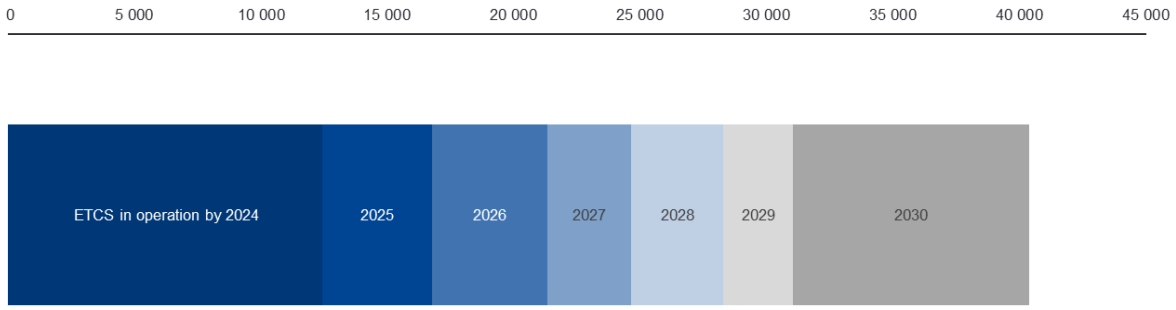


Figure 17: Length envisaged to be equipped per year (km) – TEN-T network (EU-27)

The analysis of the NIPs[58] shows that the number of kilometres of ERTMS to be deployed annually in the next 5 years is expected to be almost five times higher than what has been achieved annually in the past 3 years. See Figure 4.

For on-board, as detailed in chapter 4, around 8 700 vehicles are already equipped with ETCS (EU-27); and in the past 4 years, an average of 850 vehicles per year have been equipped with ETCS. According to the data gathered, it is expected that by end 2030, around an additional 9 300 vehicles will be equipped with ETCS, which corresponds to an annual pace of approximately 1 550 vehicles per year, representing a 82% increase compared to the past trend. Going beyond the next five years, particular efforts will be needed for the industrial roll-out of ERTMS, including also the move to the future 5G radio communication system.

[56] The full report can be consulted at: https://commission.europa.eu/topics/eu-competitiveness/draghi-report_en#paragraph_47059

[57] The full report can be consulted at: https://www.consilium.europa.eu/media/ny3j24sm/much-more-than-a-market-report-by-enrico-letta.pdf

[58] Please see Annex III to this report for the findings from the analysis of the NIPs

The 2030 target for ERTMS deployment already presents a significant challenge for the sector. This is particularly true for the trackside because trackside deployment needs to be accelerated even more than on-board deployment. This will require several actions such as:

1. The need for more harmonisation of operational and engineering rules;
2. A reliable, comprehensive, long-term planning by infrastructure managers and railway undertakings to deploy ERTMS to ensure visibility and investment certainty;
3. The need for the industry to increase their production capacity;
4. The adaptation of the EU legal framework on State Aid (relevant for on-board equipment) and other regulatory requirements.

The four points are discussed in the following sections.

6.3. The need for more harmonisation

6.3.1. Harmonisation of engineering and operational rules

As mentioned above in chapter 3.2.4, the Commission is currently finishing a study on trackside cost drivers, similar to the one already carried out on on-board cost drivers[59]. These studies show that the lack of harmonised engineering rules in the European railway system is generating considerable extra costs and situations of vendor lock-in, as a very comprehensive knowledge of the national engineering rules is required to enter the market. The findings also highlight that harmonisation should extend beyond engineering rules to include operational rules, authorisation procedures, and system interfaces. National variations in signalling logic, operational procedures, and approval workflows significantly increase complexity, reduce interoperability, and limit the scalability of industrial solutions. Both studies strongly recommend broader harmonisation as a key enabler for reducing costs, shortening deployment timelines, and enabling off-the-shelf solutions. Therefore, all initiatives for a more harmonised technical framework in Europe should be strongly encouraged.

In practice, there are already specific initiatives to harmonise engineering rules. This concerns for example the engineering guidelines already delivered by the ERTMS User's group[60], the work on operational harmonisation and trackside uniformity in EU RAIL's System Pillar[61] and the work in ERA's Topical Working Group ERTMS Trackside Engineering Rules[62] for the next revision of the TSI.

The results of these working groups should be considered together so that the outcomes benefit the entire railway system. Infrastructure managers can significantly contribute to this effort by revising their own engineering rules when deploying ERTMS.

6.3.2. Harmonisation of system architecture

EU RAIL's System Pillar is currently working on a harmonised system architecture for ERTMS. The new architecture is expected to bring multiple benefits to the railway system, as more harmonised products should lead to more competition and lower costs; more modularity should lead to a faster uptake of innovation and increased competition; separation of hardware and software should allow for easier updateability; and finally less

[59] https://op.europa.eu/en/publication-detail/-/publication/89f05852-1680-11f0-b1a3-01aa75ed71a1/language-en

[60] EEIG ERTMS Users Group

[61] System Pillar - Europe's Rail

[62] European Union Agency for Railways Moving Europe towards a sustainable and safe railway system without frontiers.

trackside assets should lead to a decrease in infrastructure management costs and more flexibility to review the design of the system.

A clear example of this solution is the use of EUlynx specifications as a harmonised description of interfaces for trackside assets. When this type of harmonisation is agreed in a common target architecture, the benefits are maximised.

6.4. A reliable, comprehensive, long-term planning to ensure investment certainty

Achieving the 2030 ERTMS deployment targets moreover requires a reliable, long-term planning by infrastructure managers and railway undertakings. The trackside cost drivers study highlights that fragmented, short-term planning contributes to inefficiencies, cost inflation, and delays. Lack of visibility is also preventing vehicle owners to retrofit or upgrade their vehicles as they do not know when they will be able to operate with ERTMS on the relevant network.

Long-term planning is essential to provide investment certainty for suppliers and service providers. Without clear visibility on future deployment volumes, suppliers are unable to scale production, invest in workforce development, or optimise engineering processes. This uncertainty leads to risk premiums in tenders, reduced competition and slower innovation uptake.

To support industrialisation, Member States, infrastructure managers and railway undertakings should:

- Develop realistic long-term plans for ERTMS trackside and on-board deployment in order to phase out class B systems and to operate with ERTMS-only as soon as possible;
- Secure financial resources for those plans. There are already good examples of these kinds of schemes in Europe both for on-board (chapter 4.2) and trackside (chapter 3.2.4). Support for on-board deployment can come for instance through national support schemes such as those implemented in Germany (EUR 200 million)[63] and Italy (EUR 300 million)[64], or through targeted funding for freight operators as one of several schemes in the Netherlands, worth EUR 67 million)[65]or through Public Service Obligation Contracts where the rolling stock is paid by the Public Transport Authority. Good examples of a long-term support for trackside deployment are the Austrian Prior Charges Act or the Danish Signalling Programme described in chapter 5.3 above.

6.5. The need for the industry to increase its production capacity

To meet the 2030 deployment target of Member States and the sector[66], the railway system must significantly increase its efficiency and its capacity, particularly in project management and engineering capacity. This is not only a challenge, but also an

[63] For more details, please see: https://ec.europa.eu/competition/state_aid/cases1/20255/SA_58908_96.pdf

[64] For more details, please see: https://ec.europa.eu/competition/state_aid/cases1/202328/SA_102707_501D4589-0000-C47D-A821-957EDFA6B626_41_1.pdf

[65]For more details, please see: https://ec.europa.eu/competition/state_aid/cases1/202337/SA_104642_70DE8D8A-0000-C671-92C3-649B53609426_52_1.pdf

[66] The deployment target of Member States and the sector does not fully cover the Core Network today.

opportunity for the European railway industry. According to Commission[67], there are today at least 6 companies able to provide ERTMS products and interlockings. The precise number of competitors depends on the type of product (on-board units, ERTMS trackside, interlockings) and the specificities of each tender (geographical location, technical requirements, etc.).

According to UNIFE, the current global industrial capacity is between 2 000 – 2 500 on-board units per year. This includes capacity to handle both new and retrofitted units. The industrial capacity has increased over the last few years from a 3-year average being around 1 300 on-board units between 2015 and 2017 to 1 900 on-board units for 2022-2024. This capacity should be compared to the demand identified until 2030, representing an average of approximately 1 550 vehicles / year for EU27 only. As some vehicles will require two on-board units (like for instance multiple units for passengers or high-speed trainsets), the demand for the EU27 will likely exceed 2 000 OBUs / year. Considering the need to equip vehicles with ETCS in other European countries (like for instance Switzerland or Norway) and outside Europe, there is a significant risk that even with the recent capacity increase, the industry cannot cope with the expected demand in the coming years. However, the even bigger challenge will most probably be on trackside.

Indeed, it is estimated that 40 to 80 000 persons are working in the signalling industry[68] in Europe today. Based on the data presented in chapter 6.2 above, it is estimated that the capacity for trackside deployment should be multiplied by 5 to meet the 2030 target.

While training railway signalling engineers is time-consuming, and new employees will not become operational in the short term, the sector needs to ramp up urgently. The growing demand for ERTMS deployment requires immediate action to mobilise resources and attract talent. That being said, it may simply not be possible to recruit and train 200 000 to 400 000 signalling engineers and supporting staff. At the same time, processes and working methods will have to be simplified and automated to the largest possible extent. The increased use of artificial intelligence needs to be explored.

Moreover, the current fragmentation of national engineering and operational rules makes it harder to scale efficiently. It may also be difficult for the industry to attract new talent with the prospect of them working on implementing ERTMS in a national context rather than developing the interoperable technologies of the future. Therefore, it is critical to move toward greater harmonisation to limit the number of individuals working on national specificities and to develop new tools to industrialise work on ERTMS projects, both for trackside and on-board deployment.

6.6. Adaptation of the EU State aid framework

The deployment of ERTMS across Europe is guided by a dedicated State aid framework, recognising its role as a project of common European interest. Public support for ERTMS investments has so far been assessed under the 2008 Railway Guidelines, which treat ERTMS-related aid as contributing to interoperability objectives, consistent with Articles 107 and 93 of the Treaty on the Functioning of the European Union (TFEU).

Under the 2008 Guidelines, Member States can support key elements of ERTMS deployment, including investment costs, installation expenses, and downtime costs linked to retrofitting, upgrades, and installations in new vehicles. While the basic aid intensity is set at 50% of eligible costs, higher levels of public financing have been permitted for

[67] Case M.8677 - SIEMENS/ALSTOM, tables 28, 36 and 39. Bombardier Transport is now merged with Alstom.

[68] This is covering suppliers, but also staff working on signalling within infrastructure managers and railway undertakings

interoperability projects linked to the TEN-T network, with aid intensities of up to 90% accepted for support measures in the Netherlands and Czechia[69].

However, the current framework also presents limitations:

- A formal notification and approval process is required, which constitute an administrative burden and may delay the introduction of a support measure ("standstill obligation").
- The rules on eligible costs and aid intensities are relatively rigid, offering less flexibility for large-scale or innovative deployments as vehicle owners tend to keep their rolling stock as long as possible.

In response, the Commission is carrying out a comprehensive reform of the State aid framework for rail and multimodal transport. Land and Multimodal Transport Guidelines (LMTG) and a new Transport Block Exemption Regulation (TBER) are expected to be adopted by the end of 2025 or in early 2026. Together, they will replace the current Railway Guidelines and introduce a more flexible, modernised legal framework better suited to support digitalisation and interoperability objectives, including the large-scale roll-out of ERTMS.

The revised framework should introduce several important changes. Eligible costs will be broadened to include not only core investments but also ancillary activities such as preparatory studies, testing, approval procedures, pilot installations, and downtime costs. In terms of aid intensity, Member States will be able to cover up to 90% of eligible costs directly under the TBER without requiring prior notification to the Commission. For measures falling under the LMTG, aid intensities of up to 100% will be possible, provided that Member States can demonstrate a funding gap requiring full public support.

Based on the concept of Important Projects of Common European Interest (IPCEI), it is considered to launch an IPCEI for a Unified Railway System. The purpose of IPCEIs is to coordinate and pool resources of at least four Member States, which should be in the lead of such an initiative, and to facilitate funding at EU[70] and national level[71]. The considered initiative would help to promote Europe's railway competitiveness through cutting-edge technology and harmonised operations building on a simplified and modernised ERTMS.

In particular, the IPCEI should transform the European rail through simplified systems, automated and fully interoperable operations, and intelligent capacity and traffic management through a new and secure communication system. The vision would encompass not only control systems but also innovative approaches to rolling stock design, infrastructure components and automated organisation of rail traffic, creating an integrated ecosystem of simplified technologies across the entire rail value chain. The objectives of this transformation of the railway network are a harmonised rail system, increased capacity and efficiency; cost reduction (up to 40% in capital and operational expenditure); enhanced (cyber-)security; strengthened EU competitiveness and autonomy in this sector.

[69] EC- DG COMPETITION (2025). National support to ETCS on-board equipment: Overview of approved State aid measures and planned modification of State aid rules.

[70] According to the Commission proposal for a European Competitiveness Fund (Article 19), the ECF may in future top up projects directly participating in an IPCEI approved by the Commission.

[71] Communication from the Commission, Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest 2021/C 528/02.

6.7. An opportunity to develop cutting edge solutions for the European railway industry

The years ahead are a unique opportunity for the European railway industry to develop new skills, products and methodologies which could give them a competitive edge over their global competitors in the signalling business (both urban and interurban). It is a market which represented a total value of EUR 17.9 billion in 2023 and is expected to grow with a compounded annual growth rate of 4.6% up to 2028[72]. Moreover, ERTMS is a key component to operate modern railways which are a critical infrastructure and which are the backbone of the military mobility in the EU.

As mentioned in Annex VII, ERTMS is already being deployed in 35 countries outside the EU, with nearly 62 500 kilometres of railway lines and 8 400 vehicles either in service or contracted. This includes significant deployments in countries such as Switzerland, Serbia, Norway, Saudi Arabia, South Korea, Mexico, Australia, and China (with CTCS, a system based on ERTMS). These figures illustrate the global relevance and growing demand for interoperable signalling systems.

Given this international momentum, ERTMS has the potential to become an even greater export success for the European rail supply industry. By investing in harmonised, modular, and scalable solutions, Europe can position itself as the global leader in railway signalling technology, offering interoperable systems that meet both European and international standards.

[72] SCI Verkehr (2024) *Control Command and Signalling - Worldwide Market Trends 2023,* [SCI Verkehr - Shop]

7. 5G RAIL COMMUNICATION (FRMCS)

7.1. Introduction

GSM-R is an international standard for wireless communication based on 3GPP 2G standards that enables communication between trains and railway control centres, ensuring efficient and secure transmission of data and voice. As is indicated in chapter 3.3, it is implemented on around 64 700 km of the TEN-T network in Europe and supports voice and data radio communication, railway emergency calls (REC), group calls, and data transmission. It is widely used but will reach obsolescence in the 2030s[73]. The longer GSM-R remains in operation, the greater the risk that its support will rely on a shrinking pool of suppliers. This could lead to increased maintenance costs and reduced availability of critical components and expertise.

As GSM-R is based on the ageing 2G technology, European railways began exploring a successor to GSM-R in 2013. This led to the launch of the 'Future Railway Mobile Communication System' (FRMCS) programme by the International Union of Railways (UIC) in 2018. It aimed at developing a new railway mobile system based on 3GPP 5G. FRMCS will not only be a vital replacement of GSM-R, but it also provides critical communications with higher data capacity, lower latency, enhanced cybersecurity and greater flexibility compared to GSM-R.

7.2. Development of specifications

Despite the early initiative to develop the technical specifications for the new 5G Rail standard FRMCS, the timeline has faced repeated setbacks[74]. The first version (V1) of the specifications provided the basic interface with ETCS and was included in CCS TSI 2023. This version was meant to allow developing ETCS versions that will be 'future proof', i.e. compatible with the final FRMCS version (V3). Subsequently, a draft of version 2 (V2) was developed for testing. It was meant to be developed by UIC by June 2024. However, the experts evaluating V2 i.e. the extended ERA core team (EECT) identified substantial open points and gaps in the draft V2 specifications. In view of these deficiencies, ERA's technical opinion on V2 was delayed to December 2024, with an addendum in May 2025[75]. ERA included a series of recommendations in its technical opinion aimed at improving the quality and transparency of the process.

These delays and deficiencies required an adjustment to the timing, scope and governance of the development process. The adjusted approach is reflected in a report by EU-RAIL's System Pillar[76]. The approach consists of a reduced set of functionalities of FRMCS as agreed in the EECT in January 2025 and expressed in the ERA technical

[73] UNIFE Position Paper. September 2021: https://www.unife.org/wp-content/uploads/2021/09/UNIFE-Postion-Paper_Successful-Transition-to-FRMCS_v28092021Final.pdf

UNIFE Position Paper. September 2024: https://www.unife.org/wp-content/uploads/2024/09/UNIFE-Paper_Achieving-FRMCS-in-TSI-2027_170924.pdf

[74] FRMCS specifications are based on 5G technology, but they are designed as a flexible and forward-looking communication platform that should also be valid for future mobile network generations.

[75] Addendum to opinion ERA/OPI/2024-10 of the European Union Agency for Railways for the European Commission regarding version 2 of Future Railway Mobile Communication System (FRMCS) specifications https://www.era.europa.eu/sites/default/files/2025-05/opi-2024-10-addendum%20v1.0.pdf?t=1748434155

[76] Report on FRMCS V2 and V3 Scope and Planning. Version 2.4 (October 2025). EU-RAIL JU System Pillar

opinion of May 2025[77]. UIC proposed a new timing for the development process; specifications V2.2[78] will be ready in two steps: the functional part in December 2025 validated by EECT and the system part in February 2026 (unchecked by EECT). The nearly final and complete specifications V3p should be ready in November 2026 to allow working with the EECT in advance of the work on the final V3 specifications. These are to be delivered after the testing to EECT in September 2027. Depending on the maturity of input for final EECT Railway Mobile Radio process, ERA will be able to submit a recommendation to the Commission between December 2027 and September 2028. On this basis, the Commission would adopt the revised CCS TSI in six to nine months depending on the agreement with Member States.

The improved governance relies on a planning manager and a regular reporting from the UIC both to the internal UIC ERIG (European Radio Implementers' Group) and to the newly established FRMCS Stakeholder Alignment Meeting. This will help improve transparency and identify more rapidly deviations from the current plan.

Nevertheless, the Commission and ERA believe the risk to the timely delivery is still high, notably due to the unclarity when and how some postponed functional and system requirements will be tested. Without testing of these requirements, it may be challenging to provide mature and complete specifications on time. One may need to consider if it is possible to introduce those remaining functionalities on board, only relying on a software upgrade and with no or a simplified authorisation process.

Additional risks relate to the availability of chipsets that will meet all current specifications and regulatory requirements (today moderate risk), and the uncertainty about studies that will validate the MNO frequencies for the specifications. Special attention should be paid to eliminate the need for Radio System Compatibility (RSC) checks when deploying FRMCS, as this would delay deployment. To this end, the necessary test specifications and engineering rules should be provided so that the compatibility is fully validated in the certification process of each subsystem. Efforts to make FRMCS compatible with Baseline 3 turn out to be challenging. At the same time, there is a risk that FRMCS-compatible Baseline 4 products will be available on the market only sometime after FRMCS standardisation. Considering that infrastructure managers have to announce the decommissioning of GSM-R trackside systems 5 years in advance, there is a risk that the limited availability of Baseline 4 on-board and trackside products will slow down the deployment of FRMCS-compatible projects and, hence, the migration from GSM-R to FRMCS.

Use of Public Mobile Networks in FRMCS

The current FRMCS specifications include the possibility to use dedicated railway frequencies[79]. The possibility to use public networks (Mobile Network Operators – MNO) has been planned but is not yet fully validated[80].

Nearly all European infrastructure managers plan to use MNO services. MNOs are planned as backup option on the main lines, as the main solution for secondary and low frequency traffic lines. Finland is planning to use MNOs as the main solution for the entire network.

[77] The reduced set of functionalities of FRMCS focuses on addressing the comprehensive replacement of GSM-R system functionalities.

[78] FRMCS specifications V2.2 will be the basis for the testing in Morane 2

[79] 900 and 1900 MHz

[80] Tentatively the envisaged frequencies are 800 MHz, 2.6 GHz and 3.5 GHz. The final choice of the frequencies will depend on the tests done by Member States on the coexistence of railway and public mobile frequencies and on the overall usability of public services by operating trains. These studies should be concluded by September 2027 to ensure their results are considered in the FRMCS Specifications V3.

The use of MNOs is a potentially cost-effective solution that avoids the cost of building and maintaining a dedicated railway radio network, even if there will be costs related to the service provider contracts. This possibility depends on the quality of the radio coverage and on the reliability of the service. The coverage depends on the incentives for MNOs to use or build new masts along the tracks and the reliability depends also on the willingness of MNOs to commit to minimum conditions required by railways in a service level agreement. Finland guaranteed both conditions by inserting the necessary provisions in their radio spectrum licensing conditions. This approach is reflecting the Commission's policy to support 5G deployment along the transport corridors as expressed in the Commission Communication on Digital Decade[81].

7.3. Deployment Group

In 2024, EU-RAIL established a High-Level Deployment Group following the Governing Board Decision No 11/2023. According to Article 97 of the Single Basic Act[82], the Deployment Group is responsible for advising the Governing Board on the market adoption of rail innovations developed by EU-RAIL and supporting the deployment of innovative solutions. The group analyses different aspects of the ERTMS deployment and, on this basis, it provides recommendations to the Governing Board or may issue recommendations independently.

To address the deployment of FRMCS, a specialised group for FRMCS was created. The group's goal is to provide advice and recommendations on the best way to deploy FRMCS from a business perspective i.e. in a cost efficient, simple and fast manner.

The group aims:

- To analyse current infrastructure, rolling stock, industry and workshop capacity for a fast, easy and cost-effective deployment and estimate necessary capacities,
- To accelerate and simplify authorisation procedures,
- To perform cost analyses, CBA and risk assessments,
- To develop a toolbox with diverse migration scenarios (greenfield and brownfield situations),
- To analyse cross-border alignment and public-private mobile network interface,
- To align with other major rail programmes (ERTMS, DAC, …) and stakeholders.

The implementation and financing remain the responsibility of infrastructure managers, rolling stock owners and Member States. The Deployment Group works together with related programmes such as the UIC programme; MORANE2; the EECT process within ERA and standardisation within ETSI.

To achieve its objectives, three specific working groups were formed: one for technology (WG1), another for legal and financial matters (WG2), and a third for migration and alignment (WG3).

[81] https://commission.europa.eu/europes-digital-decade-digital-targets-2030-documents_en

[82] Council Regulation (EU) 2021/2085, of 19 November 2021, establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

WG1 has completed a report on border crossings and the landscape of MNOs, as well as a status report on railway communication in Europe based on the NIPs[83].

Further analyses will add technical migration aspects for each migration scenario (in collaboration with WG3) and different migration cases for usage of GSM-R/FRMCS, and a more detailed report on cross-border and MNO aspects.

The WG2 carries out an analysis of the authorisation process in collaboration with ERA. The aim is to assess the impact of different authorisation processes on the timing and costs of deployment. The group has made first proposals for adapting the authorisation process.

This WG also develops a financial analysis, in which the main cost drivers are identified, including equipment, on-board implementation, authorisation and conformity processes, conformity to type timelines, vehicle immobilisation and operational costs.

WG3 has defined migration scenarios for the deployment of FRMCS, focusing on on-board migration options (voice only, data only, or a progressive combination of both). Both greenfield and brownfield scenarios are being considered, in collaboration with UIC.

In the first quarter of 2026, a toolbox containing different deployment scenarios will be published, including aspects relating to vehicles, trackside, operations and handhelds:

- Parallel operation of existing GSM-R and specific FRMCS networks.
- Parallel operation of existing GSM-R and specific FRMCS networks as well as MNO networks (hybrid).
- Parallel operation of shared FRMCS infrastructure.
- Existing GSM-R network migrated to FRMCS based on MNOs.
- FRMCS greenfield deployment.
- Handheld migration scenarios.

Given limited awareness about the FRMCS migration, especially among small railway undertakings, the Deployment Group will carry out dedicated dissemination activities. In 2026 – 2027, it will present analyses and recommendations on technical deployment activities, cost reduction measures, on the legal framework and an overview of deployment scenarios which can be used by the various stakeholders concerned.

[83] https://rail-research.europa.eu/wp-content/uploads/2025/10/WG1-Status-Report-V-1.0.pdf

8. FUTURE TRANSFORMATIONAL PROGRAMMES FOR RAIL

This section gives an overview of policy initiatives, legislative revisions and technological developments which concern the rail sector in parallel to the roll out of ERTMS. Like ERTMS, these initiatives and developments have the potential to substantially transform and modernise the rail sector. It is therefore all the more important that these transformational programmes are coordinated with the ERTMS roll-out to realise synergies in their design and implementation.

The transformational programmes discussed in this section are the initiatives to promote military mobility and a high-speed rail network, the introduction of 5G Rail (FRMCS), Digital Automated Coupling (DAC) and Automated Train Operation (ATO) and the revisions of the Capacity Regulation and the Telematics Application TSI.

8.1. Military Mobility

The ability to move troops and military equipment quickly and safely across Europe is fundamental to the EU's security and defence strategy. Recognising this, the Commission presented the White Paper for European Defence Readiness 2030[84]. It makes proposals to strengthen the defence industry by closing important gaps and ensuring long-term readiness. In November 2025, the Commission and the High Representative followed up with the Military Mobility Package. It consists of a proposal for a Regulation and a Joint Communication outlining measures to ensure fast, coordinated, and secure military transport. The Package aims to strengthen Europe's defence by removing regulatory, infrastructure, and capability barriers that currently hinder cross-border military mobility[85].

ERTMS is essential to support military mobility. While primarily designed to improve civilian rail operations, ERTMS can facilitate and speed up the movement of military assets across Europe by harmonising signalling and train control systems along the relevant rail corridors. Hence, ERTMS will not only improve the performance of the necessary military movements but also avoid unnecessary stops at borders.

Moreover, in relation to security and reliability, ERTMS offers multiple levels of redundancy, which was not the case with some legacy signalling systems. ERTMS has cybersecurity protection already built in for the communication between ETCS on-board and ETCS trackside equipment. Additionally, the combination of the Cyber Resilience Act (CRA) and the NIS2 Directive will establish a framework that can enhance the overall cybersecurity of ERTMS. Enhancing cybersecurity is also a priority for the next update of the TSIs for example incorporating the rules of the latest cybersecurity Regulations. Major issues for the future are the impact of cybersecurity threats on 5G Rail communication and the analysis of the need for redundancies, for example through public mobile network operators (MNOs), additional communication channels or satellite-based systems. In this context, IRIS^2, the EU's secure satellite communication infrastructure, could play a key role in enhancing the resilience of railway communications by providing a sovereign and robust backup channel. Comprehensive assessments should be conducted to evaluate the robustness of ERTMS in crisis or conflict scenarios—such as cyberattacks, sabotage, or armed conflict—including whether the system is adequately protected against threats like radio interference, spoofing, and other forms of disruption.

Recognising the importance of robust transport infrastructure that serves both civilian and military needs, the EU is supporting strategic investments in dual-use infrastructure.

[84] White paper for European Defence readiness 2030, 19th March 2025. URL: ReArm Europe Plan/Readiness 2030

[85] Military mobility Package, 19th November 2025. URL: Commission moves towards 'Military Schengen' and transformation of defence industry - Mobility and Transport

Under recent CEF funding allocations of 1.7 billion euros have been committed to military mobility initiatives[86] - the modernisation of transport networks across Member States is supported with dual objectives: reinforcing security preparedness and resilience of Europe's transport system. As mentioned in chapter 5.4 above, the Commission's proposal for the next MFF envisages a budget for military mobility amounting to EUR 17 billion, some of which could be usefully applied to fund ERTMS on the military corridors. Recently set up financial instruments, like the Security Action for Europe (SAFE)[87], for example, also include support for the procurement of systems supporting military mobility.

Recently, the European Rail Supply Industry (UNIFE) has also expressed the view that an accelerated and harmonised deployment of ERTMS should be a cornerstone of military mobility. The industry recommends that EU funding instruments, such as CEF, explicitly prioritise ERTMS deployment on military corridors and at border crossings, also highlighting the need for robust cybersecurity measures, integration with satellite communications (such as IRIS2), and fallback operational modes to ensure resilience in crisis scenarios.

8.2. High-speed rail action plan

The Commission adopted an action plan to promote high-speed rail on 5 November 2025. The purpose of the action plan is to enhance connectivity, promote rail as a sustainable means of transport, boost economic growth and encourage the adoption of cutting-edge technologies to enhance service quality and safety. The objectives should be achieved through network expansion and modernisation, for example by establishing new high-speed rail lines in under-served regions and upgrading existing lines to improve speed and capacity.

The action plan recognises the importance of ERTMS as a cornerstone of rail modernisation. By harmonising train control systems across Europe, ERTMS contributes to several key objectives of the high-speed rail network. In particular, ERTMS eliminates the technical barriers caused by multiple national train control and signalling systems, offering seamless cross-border travel. Moreover, the action plan stresses the role of ERTMS to boost the competitiveness of the European industry. As already pointed out in chapter 6, ERTMS brings major market opportunities for the rail supply industry as the production capacity needs to scale up considerably to enable the envisaged acceleration of the roll-out.

The action plan announces that Commission will strictly enforce ERTMS roll-out obligations, empower a strong European deployment manager for an efficient ERTMS roll-out, and strengthen coordination between Member States to reap these economic benefits. The Member States are invited to address missing section of ERTMS deployment on the high-speed network and prioritise removing other technical differences between high-speed lines and access routes, for efficient and uninterrupted train operations.

8.3. Other major rail transformation programmes

Introduction of technological innovations such as 5G Rail, ATO and DAC

There are trackside and on-board systems linked with ERTMS which are expected to evolve significantly in the following years e.g. 5G Rail (FRMCS), ATO and DAC. ERTMS can be seen as an enabler of these other systems and of digitalisation of the railway system more generally.

[86] https://cinea.ec.europa.eu/news-events/news/military-mobility-eu-supports-strategic-investments-dual-use-transport-infrastructure-eu807-million-2024-01-24_en

[87] For more information, please visit https://defence-industry-space.ec.europa.eu/eu-defence-industry/safe-security-action-europe_en

It is essential to coordinate all programmes and system upgrades affecting on-board and trackside equipment. Proper alignment of these initiatives will minimise disruptions and optimise migration processes, ensuring a smooth and cost-efficient transition toward a more advanced and interoperable railway system. It would for example save vehicle owners time and costs if different ERTMS-related systems could be installed in their rolling stock in parallel rather than in separate steps. As explained in chapter 7.2 above, the full **5G Rail (FRMCS)** specifications are planned to be published in the next CCS TSI whose adoption is planned by June 2029 at the latest. Subsequently, the migration from the current GSM-R communication system to 5G Rail will need to be carried out. This transition requires careful coordination of processes and among stakeholders to ensure a seamless implementation and optimisation of the new communication framework. This migration process is currently discussed in the Deployment Group described in chapter 7.3.

Another major transformation in railways is likely to originate from **ATO**, which enables trains to operate autonomously minimising human intervention. ATO improves efficiency by optimising train speed, energy consumption, operating costs and scheduling, contributing to a more reliable and efficient rail network. A technically harmonised solution for ATO Grade of Automation (GoA) 1-2 was developed in Shift2Rail. ATO was then defined as an ERTMS part in the CCS TSI 2023, including the specifications of the ATO with a GoA 2 (i.e. ATO with driver). As indicated in Annex III, some Members States have plans to deploy ATO on some lines of their network. Additionally, EU-RAIL is already developing the next grade of automation (GoA 3-4 i.e. driverless ATO).

A third example of such a major transformative technology is Digital Automatic Coupling (DAC). This innovation enables the automatic mechanical, pneumatic, and electrical coupling of freight wagons, thereby eliminating the need for manual intervention and significantly optimising shunting operations. In addition, its integrated digital interface facilitates real-time data exchange throughout the train, providing critical information - such as train length and train integrity - to the ETCS on-board system. The combined deployment of DAC and ETCS will enable supervised manoeuvrers and ensure both train integrity and train positioning are managed by the ETCS on-board system.

Revision of the Capacity Regulation and Telematics Applications TSI

To what extent the full benefits of the ERTMS deployment can be realised will also depend on the development of related legislative and regulatory initiatives. The Capacity Regulation[88] and the Telematics Applications TSI[89] were agreed in November 2025 and are meant to improve railway efficiency by digitalising and modernising the traffic and capacity management.

The Capacity Regulation aims to set up a framework allowing rail infrastructure capacity and traffic to be managed more efficiently, thereby improving the quality of service and accommodating more traffic on the network. The Telematics Applications TSI establishes standardised data exchange protocols between infrastructure managers and railway operators. The TSI will therefore facilitate planning and operational efficiency, allowing for better track use and coordination across networks.

By integrating feedback from the ERTMS operations - such as more accurate train positioning and data from ATO - into the capacity and traffic management systems,

[88] Proposal for a Regulation of The European Parliament and of The Council on the use of railway infrastructure capacity in the single European railway area, amending Directive 2012/34/EU and repealing Regulation (EU) No 913/2010: EUR-Lex - 52023PC0443 - EN - EUR-Lex

[89] Commission Implementing Regulation (EU) on a technical specification relating to the telematics subsystem of the rail system in the European Union for interoperability of data sharing in rail transport and repealing Regulations (EU) No 454/2011 and (EU) No 1305/2014: EUR-Lex - Ares(2025)1199975 - EN - EUR-Lex

railway operations can achieve a more precise management of train movements, reduce delays and increase network capacity. Notably, incorporating new ERTMS features - such as ATO, Hybrid Train Detection and Moving Block - into capacity calculations can significantly improve railway performance and efficiency of the railway system.

While ERTMS increases the performance of the rail network, its potential can be further expanded through initiatives such as the Capacity Regulation and the Telematics TSI that lead to a better management of the capacity and traffic flows and define a clear interface between the different systems.

9. PREPARING THE FUTURE FRAMEWORK FOR ERTMS

9.1. The European Deployment Plan (EDP) for ERTMS

Legal framework

The ERTMS European Deployment Plan (EDP) was adopted in early 2017 and laid down the timetable for the deployment of ERTMS on the core network corridors (CNC) for the period 2017-2023[90]. Article 4 of the EDP set out the obligation on the Commission to carry out a review of the dates in the EDP. Under Article 55 of the TEN-T Regulation, the Commission can adopt, in close collaboration with Member States, implementing acts for the implementation of the nine ETCs and the two horizontal priorities. In the case of ERTMS, the implementing act can take the form of another EDP.

Objective of the EDP

The objective of the EDP is to consolidate the national implementation plans into a single European deployment plan and where necessary request Member States to modify or complement their plans to optimise a coherent roll-out across Europe. Such a unified overview provides for transparency and legal certainty about the progress of the ERTMS implementation so that all stakeholders can plan accordingly. A key element of the EDP is on the cross-border sections which are often insufficiently considered at national level despite being the key enabler for interoperability across borders.

Key changes since the 2017 EDP

The EDP 2017 focused on CNCs. In contrast, the geographic scope has changed and encompasses now the nine ETCs, which comprise the segments of the core and extended core networks deemed to be of the highest strategic importance. As outlined in Annex I, the core network defined in the TEN-T Regulation is not comparable to the CNC since the core network is wider and includes lines that did not belong to the CNCs.

In terms of time horizon, the previous EDP ended in 2023. The planning horizon for ERTMS deployment should now be extended for example to 2040. This aligns with the TEN-T Regulation, which sets 2030 as the deadline for ERTMS deployment on the core network and 2040 for the extended core network. Intermediate deadlines as in the 2017 EDP could be defined.

Regarding cross-border coordination, the EDP 2017 underscored the importance of cooperation among infrastructure managers to ensure the simultaneous deployment and operational readiness of ERTMS on cross-border sections. It also highlighted the necessity of concluding agreements on technical and operational aspects for each cross-border section no later than one year before the earliest scheduled deployment date. To reinforce the significance of such agreements, Member States may be required to notify the Commission of the conclusion of each cross-border agreement within one month of its signing. In this context, it may be useful to devise templates for cross-border agreements to provide Member States with guidance. At the same time, a reflection needs to be done as to the formal status of such cross-border arrangements.

Furthermore, the TEN-T Regulation establishes for the first time deadlines for the decommissioning of class B systems, notably by 2040 on the core network. Accordingly, the EDP may provide a timetable for the decommissioning of class B signalling systems until 2040.

[90] Commission Implementing Regulation (EU) 2017/6 of 5 January 2017 on the European Rail Traffic Management System European deployment plan

To fully realise the benefits of ERTMS, it is essential that ERTMS is rolled out simultaneously on-board and trackside. While the EDP 2017 was silent on ERTMS on-board equipment, the EDP could include a dedicated deployment plan for on-board ERTMS equipment, specifying on the basis of Member States indications, the expected number of vehicles to be equipped in each Member State by 2040. Following the implementation acts for the different ETCs to ensure more seamless interoperability along corridors and incentivise international freight and passenger services, the Commission may in future also explore with Member States the value of an additional EDP for ERTMS related aspects as a coordination tool.

9.2. Future revisions of the CCS TSI

In the fourth quarter of 2025, the Commission will present an amendment of the latest CCS TSI[91] for adoption by Member States in RISC. This amendment will encompass the test specifications for the ERTMS on-board interoperability constituent, a clarification of the specific content of the different reduced envelopes of ETCS system versions, and provisions for a clearer and in some cases less strict transition regime. While the relaxation of the transition regime aims to address the sector's request, it poses a risk to the overall ERTMS deployment by potentially diminishing the industry's motivation to develop and upgrade their systems to meet the latest specifications.

In the coming years, the CCS TSI will need to be revised further in order to respond to technological developments as well as to further improve the interoperability of the railway system through greater harmonisation and simplification[92]. As regards technological developments, the TSI should facilitate the rapid uptake of innovation to ensure a future-proof rail system, while safeguarding existing investments to the extent possible. With respect to harmonisation, the reduced variability on the possible implementation of the ERTMS specifications will allow for economies of scale and a more flexible use of rolling stock across the EU. Finally, with respect to simplification, the revision of the TSI and other instruments should significantly reduce the administrative burden and ensuing costs for example in relation to the authorisation of vehicles and tracks.

Annex X lists the planned short-term, medium-term and long-term updates of the CCS TSI based on the multi-annual plan requested by the Commission.

On a general note, stakeholders request on the one hand stability of the TSI to safeguard existing investments and avoid repeated costs for upgrading, on the other hand they ask for innovations that make the railway system more efficient and competitive. To strike the right balance between stability and innovation, several guiding principles can be helpful. Firstly, systems which are strongly software-based such as ERTMS are in any event likely to be subject to regular changes. It is therefore essential to build in modularity and upgradability into ERTMS to implement future changes quickly and at low costs. Secondly, to safeguard existing investments, predictability and operational stability need to be ensured. It appears therefore crucial to follow a systematic planning of the CCS TSI revisions as outlined above, defining the different topics as short-, medium- and long-term changes and thus allowing for a stepwise predictable evolution of ERTMS.

9.3. Governance

In spite of the increased momentum in recent years, the ERTMS roll-out has been hampered by a lack of coordination in the roll-out planning and its technical

[91] Commission Implementing Regulation (EU) 2023/1695

[92] The process will follow Art. 5 of Directive (EU) 2016/797 (the interoperability Directive) where change requests from the rail sector are discussed and analysed.

implementation across Member States. The absence of a unified approach has led to increasingly visible difficulties, including operational inconsistencies and rising costs. Stakeholders have emphasized the need for an enhanced European coordination to ensure a streamlined, effective, and economically sustainable roll-out. A fast ERTMS deployment across the EU is also of high relevance for current and future European priorities, such as military mobility (including related cybersecurity aspects) and the high-speed rail action plan (which cannot fully materialise without complete ERTMS deployment on the relevant lines.

Various European institutions and entities, including the Commission, the ERTMS Coordinator, ERA and EU-RAIL as well as the sector's representative bodies, have been actively engaged in improving governance and harmonisation efforts. While some progress has been achieved (see chapter 2.4), the efforts still seem to fall short, and a more structured, streamlined and strengthened governance framework appears warranted.

In this regard, the three following proposals should be considered to reinforce coordination and governance at the European level:

- Establishment of a central coordination body / ERTMS Task Force. Given the existence of multiple forums addressing ERTMS implementation, efforts risk fragmentation. The creation of a dedicated European focal point, such as an ERTMS Task Force in the Commission's Transport and Mobility DG, would facilitate a comprehensive alignment of on-going initiatives, ensure coherent direction, and foster the engagement of all relevant actors. This body would require additional resources and could for example be involved (i) in the assessment of derogation requests submitted by Member States whether related to the CCS TSI or Article 18(8) of the TEN-T Regulation, (ii) in proactively monitoring the cross-border implementation of ERTMS on the nine ETCs, (iii) in tracking progress of the implementation of the NIPs and (iv) in refining future deployment strategies, including those related to the high-speed rail action plan[93]. A cross-border vision and strategy in the deployment is pivotal, i.e. MS cannot be expected to self-coordinate with the neighbours. In as much as technical aspects are concerned, it has to be explored whether ERA can provide support.

- Exploration of an EU-level deployment manager. Digital transport projects present considerable complexities in their design and implementation. Many infrastructure managers have therefore remained in the early stages of digital transformation. An EU deployment manager could provide essential guidance and structured support for example to infrastructure managers to ensure effective implementation and adaptation to emerging technological advancements. The deployment manager could also run pilot projects such as joint approaches for vehicle prototypes together with interested Member States under CEF 3. Its tasks should however also go beyond the innovation phase and include for example support for project implementation, political negotiations and stakeholder alignment across borders (see chapter 8.2).

- Continuation of the public-private partnership for rail. The high level of technological maintenance and support required by today's railway systems cannot be sustained if every country pursues its own individualised digital solutions. By necessity, stakeholders are compelled to harmonise ERTMS design

[93] There are two European Union entities applications that provide infrastructure-related data relevant for monitoring the ERTMS deployment: the Register of Infrastructure (RINF) and TENtec. The RINF is a web-based application maintained by ERA, serving as the single-entry point for the publication of infrastructure-related data provided by Member States. TENtec is the European Commission's information system used to support the implementation, monitoring and reporting of the trans-European transport network (TEN-T).

across the EU. To do this the continuation of a public private partnership at European level is essential. Building upon the foundation established by previous initiatives such as Shift2Rail and Europe's Rail Joint Undertaking, a new Public Private Partnership in the form of a Joint Undertaking would take a decisive step toward creating a truly unified, intelligent, and efficient rail network spanning the continent.

In conclusion, a strengthened organisational framework at the European level is imperative to achieve the planned acceleration of the ERTMS roll-out. Overcoming barriers of diverse nature e.g. bureaucratic, national, and market related requires collective political will and decisive action. A strengthened governance will ensure that ERTMS fully realises its potential as a cornerstone of Europe's rail modernisation strategy.

9.4. Financial aspects of the future ERTMS deployment

Due to their typically large scale and EU-wide positive externalities, projects on the TEN-T network require strong public support as put forward by European coordinators in their joint position paper "A transport funding and financing that is adapted to the challenges ahead".[94]

To live up to this expectation, the EU should continue to rely on financing as currently provided under the CEF. As discussed in chapter 5.1, the CEF should also be paired with other EU instruments to support the development of TEN-T, such as Cohesion Policy Instruments and the Recovery and Resilience Facility (RRF) or its possible successors. To ensure effective and sustainable deployment, EU funding criteria must be strengthened—drawing lessons from past cases where investments did not result in operational infrastructure or fell short of technical or regulatory standards. Additionally, enabling joint procurement—integrating EU and national funds—would facilitate cost-efficient retrofitting and upgrading of vehicles.

Support will also be required from national authorities to achieve the deployment of ERTMS on the core and comprehensive network. The new economic governance framework which excludes national co-financing from expenditure indicators (see chapter 5.4) represents an opportunity for cross-border rail initiatives. New State aid rules are also expected to be adopted in the coming months, setting up a new legal framework that greatly facilitates public funding for ERTMS.

It should also be recalled that ERTMS concerns not only the infrastructure but also the rolling stock. As noted in chapter 5 above, it is estimated that investments of between EUR 75 and EUR 85 billion are needed to complete the trackside deployment across the entire TEN-T network and an additional EUR 10 to EUR 15 billion for on-board deployment on the rolling stock. The Commission's economic analysis[95] showed that the dual on-board strategy, where the whole fleet is equipped first with ERTMS on top of the class B system, is the best economic approach for ERTMS deployment. This conclusion has been confirmed by several analyses at national level as included in the NIPs[96].

Indeed, equipping first the rolling stock allows a faster decommissioning of class B systems on the trackside, giving a strong incentive for infrastructure managers to deploy

[94] The position paper can be consulted at: https://transport.ec.europa.eu/system/files/2024-03/coordinators_joint_position_paper.pdf

[95] https://op.europa.eu/fr/publication-detail/-/publication/995e2d1b-9950-11e9-9d01-01aa75ed71a1

[96] https://transport.ec.europa.eu/transport-modes/rail/interoperability-safety/interoperability/national-implementation-plans-2024-under-control-command-and-signalling-tsi_en

ERTMS. Moreover, phasing out the national class B systems is an important step towards the harmonisation of engineering and operational rules at European level, which is expected to foster competition for ERTMS projects (both on-board and trackside) and lead to an overall decrease in the cost of the system.

The benefits for vehicle owners to equip their vehicles with ERTMS is not straight-forward and varies from one market to another, in particular due to varying degrees of trackside deployment. For instance, for high-speed trains, which is a profitable market for rail, there is already a strong incentive to equip vehicles with ETCS on-board[97], as many high-speed lines in Europe are already equipped with ERTMS. For freight, the benefits are increasing progressively as more and more countries equip their networks with ERTMS or plan to equip their full network in the coming years (e.g. Belgium, Denmark and Czechia).

In this context, public support to retrofit vehicles should be considered a priority at the EU and national level. Notably, the CEF 2024 call for ERTMS projects put a clear focus on support to retrofit vehicles with ERTMS[98]. This is also justified by the fact that ERTMS functionalities are increasingly moved from the trackside on board of the rolling stock, putting a greater burden on vehicle owners. The development of long-term, secure national sources of funding for ERTMS would be another key success factor as was illustrated by the Austrian example in chapter 5.3 above.

Finally, it should be recalled that the effect of financing on the ERTMS deployment would be strengthened if at the same time the costs of deployment is reduced or at least contained. As outlined in this report notably in relation to the on-board and trackside cost drivers, it is therefore of crucial importance that the cost drivers are addressed, for example by reducing or eliminating ESC tests, promoting further harmonisation and increasing modularity in design and product updates.

ERTMS should not only be a high performing signalling system and an enabler for the digitalisation of the railway system, it should also be affordable to deploy, maintain and upgrade.

9.5. Development of a common operational rulebook for ETCS Level 2

ERTMS offers choice when engineering a trackside system. The so-called ETCS toolbox can be used in numerous ways, all leading to TSI-compliant implementations. However attractive to designers, this freedom can lead to a large disparity among implementations, each offering substantially different "user experience" to the driver and continuing to fragment the CCS market of signaling configurations and rail business models.

Within EU RAIL's System Pillar, work has focused on a particular subset of implementation – Level 2 ETCS without lineside signalling, and specific harmonised technical approaches and the associated operational processes, harmonised architecture, signalling principles and linked engineering rules. It is a specific operational design depending on specific system functionalities, as a prerequisite for harmonised products.

The strict harmonisation that will mean a unique rulebook for ETCS Level 2 operations and a common technical solution aims for the broader harmonisation in ERTMS. This will include a new approach to how to describe operational scenarios, increase the scope of

[97] https://www.railjournal.com/passenger/high-speed/sncf-launches-low-cost-high-speed-ouigo-service-in-spain/, https://www.railwaypro.com/wp/trenitalia-orders-frecciarossa-train-fleet-for-operation-in-spain/, https://www.trenitalia.com/en/frecce/frecciarossa-1000.html

[98] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/cef/wp-call/2024/call-fiche_cef-t-2024-simobgen_en.pdf

operational harmonisation to signallers in addition to drivers and enable the harmonisation of not only the nominal scenarios but also the degraded scenarios.

This greater harmonisation will reduce freedom of implementation flexibility but also bring several positive side-effects, for example in standardising hardware and software modules, reducing cost, freeing expert resource capacity for faster development and implementation, accelerating deployment and streamlining certification and authorisation.

10. CONCLUSIONS

My present work plan takes stock of the development and deployment of ERTMS in recent years. It analyses the major challenges for the further ERTMS roll-out. As regards the legal requirements under the previous EDP, the TEN-T Regulation and the CCS TSI, the action of Member States and stakeholders have so far mostly fallen short of expectations. Still, momentum is building, with progress in many Member States, in conjunction with various regulatory developments. A sizeable number Member States and stakeholders pursue ambitious plans, pointing to a substantial acceleration of the ERTMS roll-out towards the end of this decade. Others need to follow their lead. To make this happen, I make the following recommendations:

1. The **governance and coordination** of the various stakeholders and work streams **at the European level** should be reinforced and streamlined. The *Commission* should strengthen its oversight and policy directing role, together with the *European ERTMS Coordinator, by* creating a task force for ERTMS and the digitalisation of railways[99]. *ERA* should build on its role as ERTMS system authority, use its responsibilities for vehicle authorisation and ERTMS trackside approval, its work on reducing cross-border bottlenecks and cleaning up national rules, its management of data on infrastructure and vehicles to support accelerating deployment. The *European public-private partnership* following on from *EU-RAIL* should be continued to allow for harmonised research and development and pre-deployment activities linked to ERTMS and broader signalling equipment. The creation of an *EU deployment manager* should be considered.

2. As to **national governance**, Member States should be encouraged to establish or keep a central coordination of ERTMS deployment (track side and vehicles) at a sufficiently high level in each Member State[100]. These national coordinators should participate in the consultative ERTMS Forum of the European Coordinator.

3. There should be close coordination of the ERTMS deployment with the implementation plans for the **nine European Transport Corridors** to ensure smooth deployment across borders. Member States must adhere to their legal obligations[101]. Moreover, Member States should agree on bilateral arrangements to facilitate ERTMS deployment at cross-border sections.

4. A roll-out strategy for the **introduction of the 5G radio communication (FRMCS)** should be devised. Furthermore, the project monitoring and stakeholder involvement should be improved to finalise the technical specifications[102].

5. The European rail industry must invest in building the necessary **industrial capacity with ERTMS expertise** to allow for the development of fully compliant, updateable and interoperable products, to decrease the cost of ERTMS in operation, and to increase the number of suppliers[103]. Member States and stakeholders should encourage an IPCEI for rail digitalisation.

99 See chapter 9.3

100 See chapter 9.3

101 See chapter 3.2

102 See chapter 7

103 See chapter 6

6. Strategies for **phasing out the national legacy (class B) systems** on-board and trackside should be developed and coordinated[104].

7. Sufficient and centrally managed European **financing under the next multi-annual financial framework** (MFF 2028-2034) and stable national public financing should be secured to comply with the TEN-T requirements[105]. The use of military mobility funding for resilience, enhanced cyber protection and redundant communication systems should be explored. The **business case analysis for ERTMS deployment** should be updated; identifying the relevant costs, analysing the potential to increase infrastructure capacity and efficiency as well as potential sources of finance (e.g. track access charges and cross-finance) [106].

8. The various factors increasing costs for on-board and trackside deployment of ERTMS should be addressed in an **action plan** proposing measures to mitigate them with all actors concerned[107]. Notably,

   - A **prototype strategy** for on-board equipment should be developed to prepare for the retrofit and upgrade of the rolling stock and to reduce the number and length of authorisation procedures.
   - All stakeholders i.e. not only infrastructure managers, railway undertakings and rolling stock lessors, but also suppliers should make a concerted effort to achieve a quicker and more coherent ERTMS roll-out by making **software-updatable** systems.
   - A harmonised **operational rulebook for ETCS L2 only operations** is being developed in EU-RAIL's System Pillar and should provide a blueprint for Member States and infrastructure managers for fully harmonised L2 operations.
   - **National rules, including engineering rules,** should be further reduced to allow for economies of scale.
   - The **authorisation procedures** related to ERTMS should be significantly simplified to speed up deployment and reduce costs. An example is ESC/RSC checks, but a more general review of approval procedures for both trackside and on-board equipment is necessary.

9. A **deployment strategy for future innovations** (e.g. satellite positioning, communication, cybersecurity, DAC) should be prepared including a reflection on cost-effective transition management for lines and vehicles already operating with ERTMS, as well as a reflection on the effective use of EU-funding for development[108].

10. An **integrated communications strategy** on the benefits and challenges of ERTMS should be developed, addressed not only to specialists but also to political levels in EU and Member States.

[104] See Annex III, chapter 3.2

[105] See chapters 5 and **Error! Reference source not found.**

[106] See chapters 5, 8.1 and 9.4

[107] Se chapters 4.4 and 3.2.4

[108] See chapter 9.2

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