ERTMS

First Work Plan of the European Coordinator

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Acronyms and abbreviations

AT	Austria
ATC	Automatic Train Control
ATL	Atlantic Corridor
B2	Baseline 2
B3	Baseline 3
BAC	Baltic-Adriatic Corridor
BE	Belgium
BG	Bulgaria
CBA	Cost-benefit analysis
CCS TSI	Control Command and Signalling Technical Specification for Interoperability
CEF	Connecting Europe Facility
CH	Switzerland
CN	Core Network
CNC	Core Network Corridor
CTCS	Chinese Train Control System
CZ	Czechia
CZK	Czech koruna
DB Netz	Deutsche Bahn Net
DE	Germany
DK	Denmark
DMT	ERTMS Deployment Management Team
EDP	European Deployment Plan
EE	Estonia
EIB	European Investment Bank
EL	Greece
ERA	European Union Agency for Railways
ERDF	European Regional Development Fund
ETCS	European Rail Traffic Management System
ES	Spain
ETCS	European Train Control System
EU	European Union
EVC	European Vital Computer
FI	Finland
FR	France
GPRS	General Packet Radio Service
GSM-R	Global System for Mobile Communications – Railway
Hbf	Central Station, (Hauptbahnhof)
HR	Croatia
HU	Hungary
IE	Ireland
IM	Infrastructure Manager
INEA	Innovation and Networks Executive Agency
IT	Italy

L1	Level 1 of ERTMS
L2	Level 2 of ERTMS
LS	Limited Supervision mode of ERTMS or Czech class B system
LSCH	ETCS Level 1 Limited Supervision Swiss
LT	Lithuania
LU	Luxembourg
LV	Latvia
MED	Mediterranean Corridor
MoU	Memorandum of Understanding
MS	Member State
NIP	National Implementation Plan
NL	Netherlands
NO	Norway
NSB	North Sea-Baltic Corridor
NSB	North Sea -Mediterranean -Mediterranean
OB	On-board
OBU	On-board Unit
OEM	Orient-East-Mediterranean
PL	Poland
PT	Portugal
RALP	Rhine-Alpine Corridor
RDN	Rhine-Danube Corridor
RFC	Rail Freight Corridor
RO	Romania
RU	Railway Undertaking
SCM	Scandinavian-Mediterranean Corridor
SE	Sweden
SEK	Swedish krona
SI	Slovenia
SK	Slovakia
SME	Small and medium-sized enterprises
STM	Specific Transmission Module
TEN-T	Trans-European Transport Network
TENtec	European Commission's Information System to coordinate and support TEN-T Policy
UK	United Kingdom
ŽSR	Railways of the Slovak Republic, (Železnice Slovenskej republiky)

1 Introduction

Discussions on a European Rail Traffic Management System (ERTMS) have been going on for almost 40 years. They were long restricted to specialists and technical controversies. Moreover, they were led essentially by interoperability considerations. However, climate change, and in particular the pivotal role railways will play in the reduction of greenhouse gas emissions by transport, and the overall move to digitalised railways, have put the European Train Control System (ETCS) and the Future Railway Mobile Communication System (FRMCS) on the political agenda of numerous Member States and the European institutions.

ERTMS was also the subject of a detailed report of the European Court of Auditors in 2017[1]. This work plan reflects the response stakeholders have given to the recommendations of the Court.

Long disputed, the implementation of ERTMS is now no longer questioned. Moreover, due to obsolescence of national systems, many Member States (and states outside Europe) see ERTMS as the answer to the overall necessary modernisation of their railway systems.

ERTMS will constitute the backbone for a digital, connected Single European Rail Area. The question today is how quickly the transition from existing national systems can be organised, how the future evolution of ERTMS can be made simpler and less costly, and how rapidly rollout can happen whilst ensuring that investments are not lost with future ERTMS developments.

ERTMS is indeed already now the gold standard of rail signalling systems as can be seen in the worldwide implementation. It is obviously easier to deploy in green field investments. Organising the transition from existing systems is complicated, and it has taken some 25 years for Europe to put into place all the necessary elements.

Modernising railway operations through digitalisation is moreover an important European industrial project, and a well organised transition will be a showcase to the world. Rapid deployment also depends on avoiding mistakes from the past and foreseeing a non-disruptive evolution of ERTMS.

ERTMS has several advantages in comparison to national (class B) systems. Some of these advantages in addition to interoperability are shown in Table 1.

[1] Special report no 13/2017: A single European rail traffic management system: will the political choice ever become reality? (pursuant to Article 287(4), second subparagraph, TFEU), European Court of Auditors

Main advantages of ERTMS	
Safety increase	The continuous supervision of the speed of trains implies a higher safety level in comparison with most of the national train protection systems.
Increased capacity	ERTMS allows the reduction in the minimum distance or time between trains, which results in an increase in train capacity. The impact of benefit depends on several aspect such as the track characteristics and the train protection systems existing before installing ERTMS.
Higher performance	High standards of ERTMS components and subsystems are included in the specifications. Thanks to the high standards of the ERTMS components, failures are in principle less likely to occur, increasing also punctuality.
Creation of a seamless market for rail transport	Class B systems are limiting the competitiveness of rail transport against road across Europe. Once fully deployed, ERTMS will facilitate the development of cross-border rail services.
Potential reduction in maintenance cost	Cost reduction results from a lower number of components trackside, in particular with ERTMS Level 2, given the fact that lineside signals are no longer required and even more with ERTMS Level 3 that can get rid of almost all train detection systems trackside.
Staff	Most of the railways are facing the challenge of staff aging and at the same time struggle to find replacement. ERTMS deployment, including digitalisation of interlocking and Automatic Train Operation (ATO) will help address this issue.
Digitalisation	ERTMS and in particular its coming new radio transmission sub system (FRMCS) is an enabler of digitalisation of the railway system, allowing for the future deployment of ATO and asset management for signalling among others.
Other benefits	ERTMS can make the railway sector more competitive with an open supply market. Besides, using a proven and harmonised system it can help reduce the production costs.

Table 1 Main advantages of ERTMS (complementing interoperability)

This paper is the first work plan of Matthias Ruete, who has been since January of 2019 the European Coordinator for ERTMS. The content of this document is a result of discussions with stakeholders with whom the Coordinator has had more than 100 meetings since his appointment. This document could not have been produced without kind assistance provided by among others DG MOVE, ERA, INEA, S2R and the ERTMS Deployment Management Team. It also builds on the remarkable work accomplished by Karel Vinck, the first European Coordinator for ERTMS (2005 to 2018).

The first part of this work plan takes stock of the current ERTMS deployment, both trackside and on-board, complemented by an overview of the situation outside Europe. Then it explains the business case for ERTMS deployment and outlines the existing funding possibilities. Furthermore, it reports on the removal of the main barriers to ERTMS rollout.

The second part focuses on the envisaged next steps both as regards infrastructure and rolling stock. Furthermore, it addresses the challenges of the future evolution of ERTMS, including the planned 2022 revision of the technical specification for interoperability relating to the 'control-command and signalling' subsystems (CCS TSI). Finally, it calls for a European strategy for decommissioning of class B systems.

The third part provides conclusions of the European Coordinator for ERTMS.

The annexes contain detailed information on ERTMS deployment on the 9 Core Network Corridors and Europe-wide; review of National Implementation Plans; analysis of cross-border agreements; costs estimation; examples of national schemes addressing the challenge of retrofitting; an overview of the evolution of ERTMS; an overview of the portfolio of CEF supported ERTMS actions managed by INEA and a glossary of the key notions.

This work plan has been prepared since November 2019 and was finalised in May 2020. In the meantime, the world has been affected by the COVID 19 virus, which has a tremendous impact on our lives, health systems and economies.

We know only part of the pandemic's dramatic effects on people and economies so far. It is evident that the transport industry has been already heavily impacted, and the repercussions are still to be seen. At this stage it is too early to provide a thorough analysis of the state of play or to draw conclusions in this work plan.

It seems obvious that digitalisation of rail will have to play an important role in relaunching our economies also in line with the European Green Deal. The overall message of this work plan is the need to accelerate the roll-out of ERTMS and to prepare the future transitions in a better way.

2 Stocktaking of the ERTMS deployment

2.1 Trackside deployment according the EDP

The TEN-T guidelines[2] establish ERTMS as one of the priorities for railway infrastructure development and sets out a deadline for its deployment on the Core Network by 2030 and on the Comprehensive Network by 2050. Building on this, the ERTMS European Deployment Plan (EDP)[3], adopted by the European Commission in January 2017, sets out deadlines for deploying ERTMS on some sections of the Core Network Corridors (CNC) for the period 2017-2023. The number of km planned for each year are shown in the figure below:

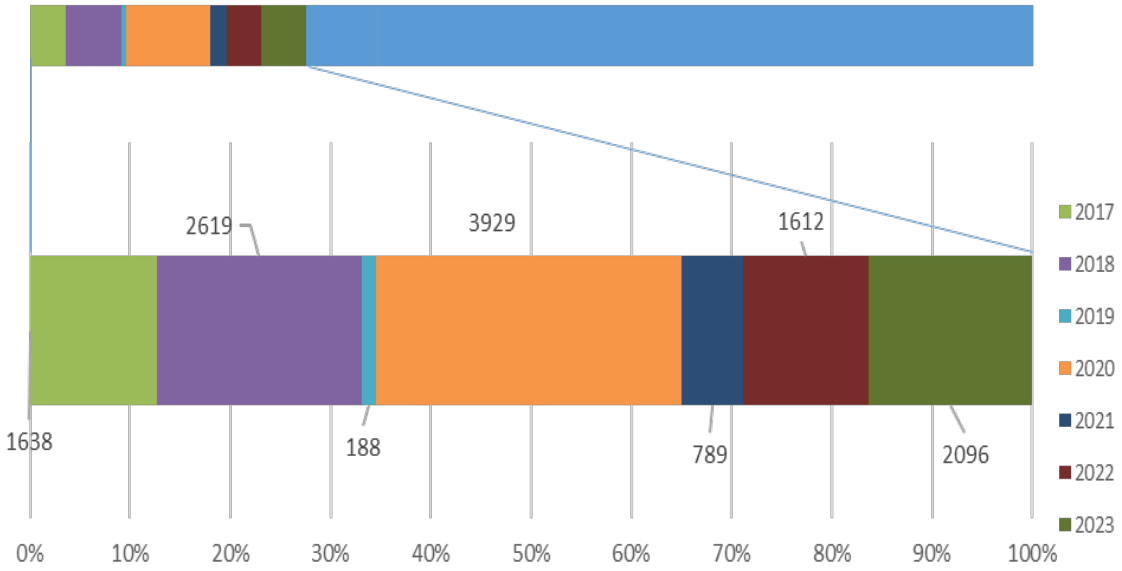

Figure 1 EDP indicative number of km for each year. The top bar shows the overall obligations by 2030 and the bottom bar demonstrates the obligation broken down by years in the period from 2017 to 2023.

In April 2020, **12% of the CNC network was in operation with ETCS (i.e. 6.120 km) and 63% of the CNC network with GSM-R.**[4] Out of the 15.682 km to be put in operation by 2023 according to the EDP, 5.906 km (or 38%) have been commissioned and **78% of what was planned in the EDP by end 2019 has been already achieved.**

[2] Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network

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

[4] ETCS and GSM-R constitute at present the two components of ERTMS, see Annex IX. All data provided in this work plan are based on the alignment of the Core Network Corridors and deployment deadlines as set out in the EDP in force, including the UK.

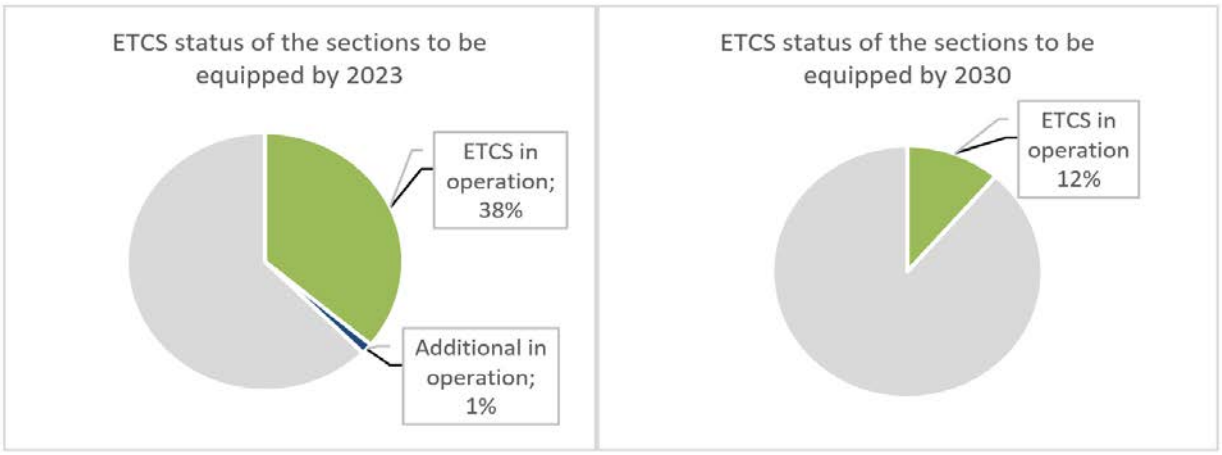

Figure 2 ETCS status of sections to be equipped by 2023 and 2030

The deployment of ETCS and GSM-R per corridor is presented in the graph below.

Regarding ETCS, out of the nine CNC, the most advanced is the Rhine-Alpine corridor (RALP) with 28% of lines already in operation, whilst ETCS deployment in the other corridors ranges between 7% and 18% of the total length.

With respect to GSM-R the most advanced in deployment is also RALP, with 99% of its length already equipped, while deployment on other corridors ranges between 45% and 87%.

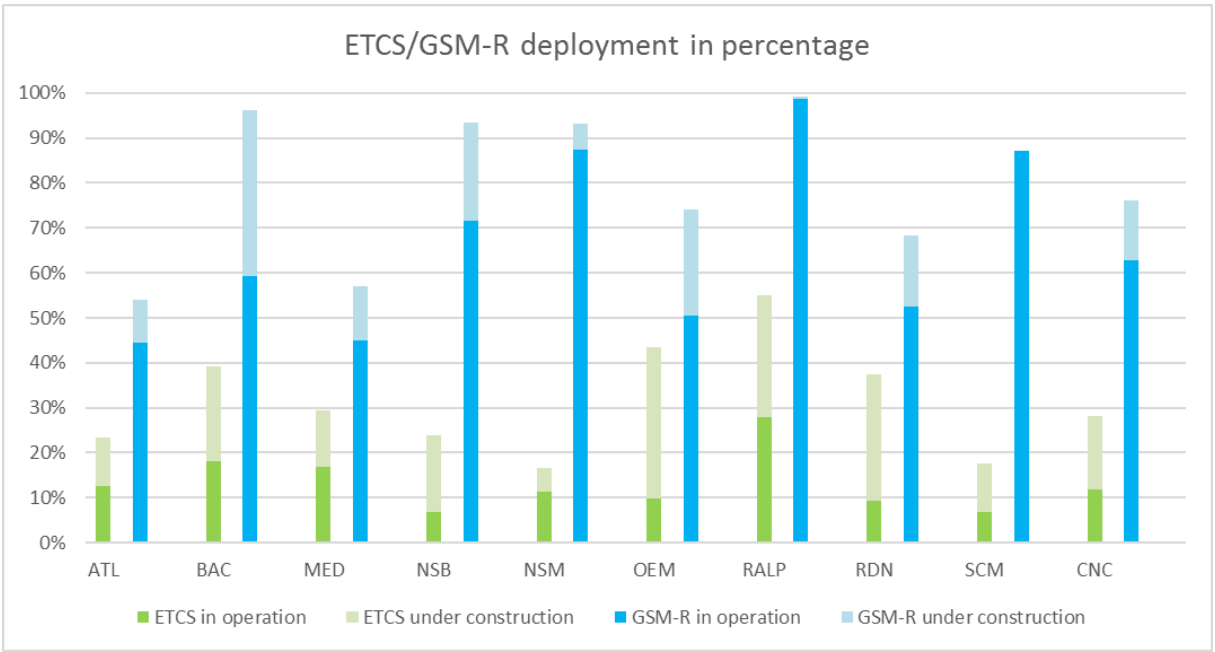

Figure 3 ETCS/GSM-R deployment by corridor

The progress can be also looked at in comparison to deadlines set out in the EDP and the actual length of each of the corridors. Atlantic (ATL), BAC (Baltic-Adriatic), NSB (North Sea-Baltic), RDN (Rhine-Danube) and Scandinavian-Mediterranean (SCM) corridors have under construction or in operation most of the sections planned for 2023 while Mediterranean (MED), North Sea -

Mediterranean (NSM), RALP and OEM (Orient-East-Mediterranean) corridors are below the 2023 target (See figure 4). Length of each of the corridors varies and deployment in the first years (up to 2023) is more demanding in some corridors than others (e.g. ATL, NSM), while SCM has nearly the 80% of the corridor length planned for the period after 2023) (See figure 5).

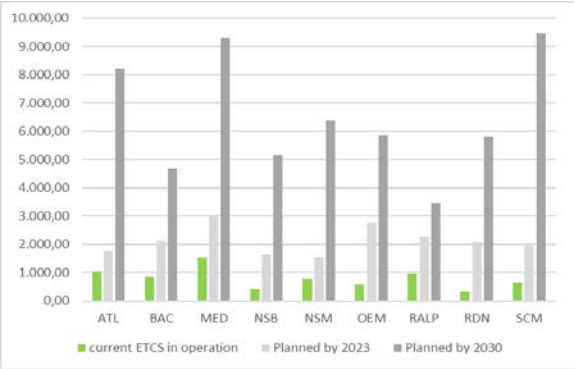

Figure 4 ETCS km deployment state of play

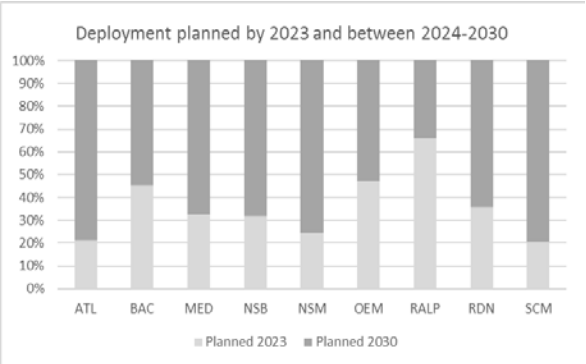

Figure 5 ETCS percentage deployment state of play

Detailed information on the ERTMS deployment on the nine CNC is presented in Annex I

To follow up the EDP and the progress of the deployment of ERTMS on the CNC some key performance indicators (KPIs) have been developed and are regularly updated[5]:

- The ETCS in operation KPI shows the percentage of km with ETCS in operation in comparison to the EDP target of 51.000 km. Ireland and some sections in Latvia, Lithuania, Estonia and Croatia, although belonging to the CNC, are exempt from ERTMS deployment. Thus, the target for ETCS km in operation at the end of 2030 is 97% of the total km of the CNC.
- As regards cross-border agreements KPI report on the number of notified cross-border (c-b) agreements. No c-b agreements are expected for c-b sections in operation where ERTMS was already deployed at least on one side of the border at the time of publication of the EDP. The number of c-b agreements expected for 2023 and 2030 are 21 and 45 respectively. The cross-border status KPI shows the number of c-b in operation; total figure and a figure per year to monitor the progress.
- The compliance to EDP KPI measures the cumulative number of km and percentage of ETCS in operation per year compared to the EDP plans.

The summary of the state of play of the ERTMS deployment is shown in the table below:

KPI	December 2016 (Baseline EDP)	December 2017	December 2018	December 2019	May 2020	2023 (planned)	2030 (planned)

[5] KPIs still include United Kingdom data

KPI	December 2016 (Baseline EDP)	December 2017	December 2018	December 2019	May 2020	2023 (planned)	2030 (planned)
ETCS in operation (% and km)	7% 3.775 km	9% 4.485 km	10% 5.307,31 km	11% 5.829,45 km	12% 6.120,54 km	31% 15.680,07 km	97% 49.818,26km
c-b agreements	0 /21	0/21 + 3 advanced	2/21 + 4 advanced	2/21 + 5 advanced	2/21 + 5 advanced	21/21	45/45
c-b status	4/65	5/65	7/65	8/65	8/65	23/65	21 + 25/46
c-b 2017	-	0/1	1/1	1/1	1/1	-	-
c-b 2018	-	-	1/5	1/5	1/5	-	-
c-b 2019	-	-	-	0/0	0/0	-	-
c-b 2020	-	-	-	-	0/4	-	-
Compliance to EDP 2017	-	75% 1.226,64 km	77% 1.254,80 km	90% 1.468,73 km	91% 1.489,73 km	-	-
Compliance to EDP 2018	-	-	42% 1.090,06	44% 1.151,21 km	52% 1.370,28 km	-	-
Compliance to EDP 2019	-	-	-	0% 0 km	0% 0 km	-	-
Compliance to EDP 2020	-	-	-	-	5% 197,74 km	-	-

Table 2 Summary of the state of play of the ERTMS deployment

The cross-border sections are critical for the ERTMS deployment, as they impact the business case for railway undertakings. The cross-border sections should be completed with national sections allowing a whole origin-destination route with ETCS only. For this reason, coordination of deployment dates and technical solutions was set as a priority in the EDP. Despite this and the obligations in the EDP regarding conclusion of c-b agreements[6] only 7 c-b agreements have been notified till this date.

It is important to highlight that 3 years after the publication of the EDP there are close to 1.600 km delayed (10% of the EDP planned deployment by 2023 and 3.2% of total planned deployment). Nevertheless, most of the delayed sections are under construction (86%) and in principle are not delayed more than 2-3 years. Besides, several Member States have already stated in their National Implementation Plans (NIPs) a delay of some lines relative to their EDP targets.

[6]Article 2(3) of EDP (Regulation (EU) 2017/6) stipulates that "railway infrastructure managers shall, after having consulted the railway undertakings affected, sign an agreement on technical and operational aspects of the deployment for each cross-border section"… "not later than one year before the earlier of the deployment dates for the given cross-border section", and "Member States (MS) shall notify such agreements to the Commission not later than one month after the conclusion"

Most delays are due to insufficient national budgets. Other reasons are that prior to the ERTMS deployment the lines are usually modernised. Any delays in the works, due to longer tendering procedures, insufficient quality of documentation or lacking industrial capacity, affect subsequent ERTMS deployment. In some cases, national systems currently in use have not reached obsolescence and therefore there is a lack of urgency from the Infrastructure Manager's point of view. In addition, the delays in equipping the fleet with ERTMS may affect the deployment plans, delaying the progress in rolling out ERTMS trackside. Finally, lack of experience with the new ETCS Baseline 3 and availability of latest ETCS products are another of the recurrent reasons.

In order to mitigate some of the previously stated reasons for delays, the European Coordinator for ERTMS and the European Commission have, since 2017, taken a very active role in the monitoring of trackside deployment and on-board retrofitting with the support of the ERTMS Deployment Management Team (DMT)[7]. Deployment monitoring reports and lessons learnt for different ERTMS challenges have been produced and are dealt with mainly through ERTMS Stakeholders Platform and ERTMS Action Plan.

2.2 Rolling stock deployment

Between 3.880 and 4.337 ERTMS on-board units have been equipped and/or are in operation in Europe, which, as some trains need two on-board units, can be translated into **3.600 vehicles equipped in Europe**[8]. In the last 5 years, approximately 5.000 new vehicles have been introduced in Europe. However only some **900 of the new vehicles are equipped with ERTMS** as most of them were subject to some derogations or were exempted from the requirement to fit ERTMS (for example because of use on regional services). The exception became the rule: over 80% of vehicles were exempted. The total number of vehicles already **retrofitted** is estimated at approximately **2.700**. As most of retrofitting projects have been delivered in the past 10 years therefore it can be assumed that on average 270 vehicles have been retrofitted on an annual basis.

There are several reasons for this relatively slow pace of retrofitting process, including: limited business case for operators until present, especially in the freight sector; relatively high costs of retrofitting in comparison to a price of entirely new vehicles; general suitability of the vehicles to be retrofitted (e.g. missing documentation, unclear ETCS - vehicle interfaces); country-specific requirements set out in tenders; availability of STMs and/or Class-B systems to integrate with ERTMS onboard core system (EVC), industrial capacity of suppliers; capacity of workshops; lengthy and costly reauthorisation procedures.

The total fleet to be equipped by 2030 is estimated between 27.500 and 38.500 vehicles and detailed below (see section 3.3).

[7] DMT is a consultant facility established by the Commission.

[8] According to UNISIG. This figure is very close to the figure of 3 563 vehicles equipped, based on interviews with Railways Undertakings, Infrastructure Managers and desk research conducted by the Deployment Management Team.

2.3 Deployment outside the European Union

More than 51.000 km of ERTMS trackside lines and 5.180 vehicles are in service or have been contracted outside Europe[9]. A vast majority of the ERTMS lines located outside Europe are new lines. The ERTMS deployment is indeed technically simpler and faster in green field projects. The following map shows the non-EU countries which have ERTMS installed or planned in the future.

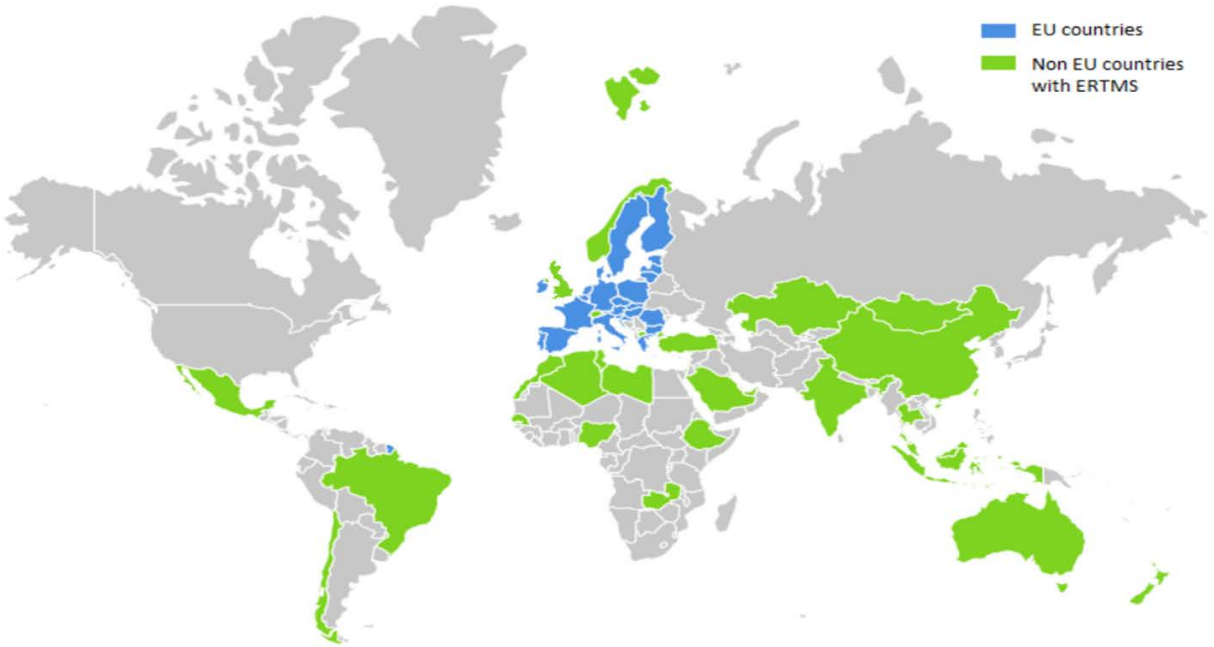

Figure 6 Non-EU countries which have ERTMS installed or planned in the future

Asia is, besides Europe, the area most advanced in terms of ERTMS deployment. There are twelve countries, in which ERTMS is installed or under construction, with China being the frontrunner with more than 20.000 km and more than 1.000 vehicles equipped with CTCS (Chinese Train Control System, largely similar to ERTMS\ETCS). Some countries, like Israel, even have a nation-wide ERTMS deployment plan.

In Africa, there are eight countries with ERTMS in service or under construction. Of those, the countries with most ERTMS kilometres implemented and with an equipped fleet are Algeria and Morocco. According to the available information, Algeria has more than 2.500 km with ERTMS implemented and more than 40 vehicles equipped while Morocco has more than 800 km with ERTMS implemented and more than 90 vehicles equipped.

Three countries in America: Brazil, Chile and Mexico are also deploying the system. According to the available information, the country with the highest ERTMS deployment in this region is Brazil with 300 km and 150 equipped vehicles in service.

In Oceania, both Australia and New Zealand have ERTMS system installed in some sections of their networks and vehicles of their fleet.

[9] Source UNIFE based on contracts signed by UNIFE Members

2.4 Business case

Since 2015 an extensive business case analysis has been conducted for ERTMS on the CNC. This business case study was produced based on data from the EDP, National Implementation Plans and Member States inputs. The study demonstrates that there is a positive business case for ERTMS on the CNC at system level, however a coordinated deployment of all stakeholders, across and within Member States, is a key success factor for the EU wide ERTMS implementation.

The business case analysis showed also that a dual on-board migration strategy for ERTMS deployment on the CNC has the most advantageous economic outcome, as benefits appear earlier than compared to the dual track-side strategy. Contrary to the dual track-side migration strategy where ERTMS is progressively installed on top of legacy systems which are kept operational until the whole fleet is equipped, the dual on-board strategy foresees a focus on equipping the fleet with ERTMS first.

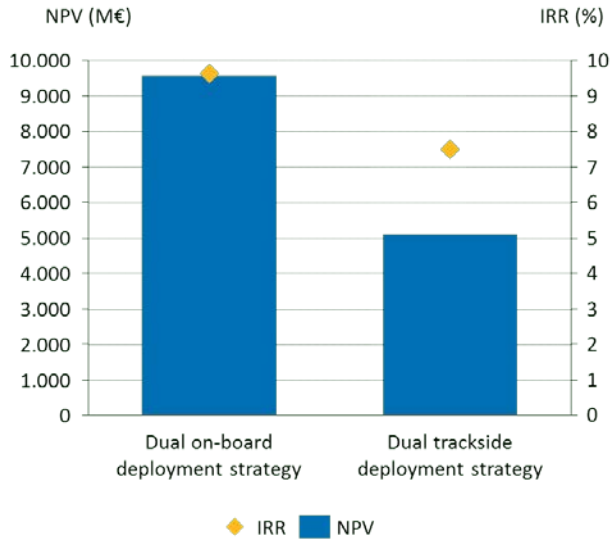

Figure 7 Cumulative cash flows of the different scenarios, all corridors

Once the whole fleet concerned by a certain area is equipped, infrastructure managers can deploy ERTMS and replace class B systems by performing a full decommissioning in that area. Decommissioning of class B systems trackside will bring about significant maintenance savings for infrastructure managers, especially if they opt for Level 2 and even more for Level 3.

In its latest release in June 2019[10], the business case study provided additional evidence for the dual on-board migration strategy. Even though ERTMS as a system could yield important benefits for all stakeholders, there are still important financing gaps, especially for railway undertakings (RU) and rolling stock owners. At national level, on-board retrofitting and upgrade is a bottleneck to the overall ERTMS deployment. For example, rail freight suffers low margins and a harsh competitive pressure from road transport. The sector is heterogeneous, going from incumbents with large fleets,

[10] https://ec.europa.eu/transport/modes/rail/ertms/the-funding-financing-and-economic-corner_en

to new entrants with small fleets and different types of series resulting in a more difficult access to capital and higher retrofitting costs per vehicle. Most of the freight RU are also facing high and near-term costs of retrofitting and upgrade, whereas their direct financial benefits lie in the future and can be uncertain, dependent on the readiness of the network and whether infrastructure companies will pass on their savings resulting from deployment of ERTMS to their customers.

As to passenger services, RUs are also facing high and near-term costs of retrofitting and upgrade, and their benefits are mainly related to improved punctuality, which is an important socio-economic benefit, but difficult to capture from a financial perspective. As with freight, there may be a need to support retrofitting of passenger trains, although the situation can differ significantly according to the type of service considered (public service obligation contracts, high-speed rail or conventional rail).

Overall, there is a strong rationale for EU-level, national-level and regional-level support to remove the system deployment bottlenecks by providing forms of financial support for retrofitting and upgrading of on-board units, in order to foster overall system benefits. This obviously needs to be accompanied by a stable commitment to trackside deployment of ERTMS. From an EU perspective, support for retrofitting and upgrading is particularly needed for international and freight operators, which tend to be least well served by national schemes for retrofitting support. Bridging the financing gap of RUs to equip rail vehicles with ERTMS can be a game changer in pushing forward the whole ERTMS programme.[11]

2.5 Funding

2.5.1 Funding from 2007 and 2019

There is a strong case for funding support to facilitate ERTMS deployment. The EU allocations for ERTMS during the period 2007-2013 amounted to some EUR 1.2 billion (EUR 645 million from the TEN-T programme and EUR 570 million from Cohesion/ESIF funding) and during the current financial perspective (2014-2020) to EUR 2.7 billion (EUR 850 million from the CEF programme and EUR 1.9 billion from the Cohesion/ESIF funds)[12].

During the first perspective, the TEN-T programme focused on supporting ERTMS trackside deployment while in the second period, with the CEF programme, a more balanced approach between on-board and trackside has been pursued. Lately, the EU has started to support ERTMS through innovative financing mechanisms: in 2017 a CEF Blending Call was launched and 8 projects were selected (7 on-board, 1 trackside) for a total EU funding of EUR 197 million. This new type of call foresees the involvement of a financial institution as debt provider to ensure better leverage of EU funds and a higher maturity of projects. In annex VIII, a more detailed overview of the portfolio

[11] In March 2020, the European Commission assisted by the DMT, finalised the European Rolling stock deployment strategy (described in later in this document) that addresses in a comprehensive manner challenges related to the coordinated ERTMS deployment on-board.
[12] Data from Special Report 13 (2017) by the European Court of Auditors

managed by INEA with regards to the CEF supported ERTMS actions is provided, with an update of the portfolio until May 2020.

2.5.2 New forms of funding and financing to support ERTMS

As to additional financial possibilities and innovative financial schemes at EU level some were developed more recently to speed up deployment.

Based on the positive experience of the Blending Call, a new instrument called **CEF Blending Facility** was released in 2019. It is a mix of CEF grants / debt instruments paired with financing from the EIB or national promotional banks (so called implementing partners). There are several rolling deadlines, unlike a CEF call, with the facility remaining open as long as funds are available, allowing project promoters to submit their applications once ready and sufficiently mature. The first deadline for submission of proposals was on 14 February 2020. This new instrument will support ERTMS with a budget of 99 million EUR (grants component). Only proposals addressing the fitment, retrofit or upgrade of vehicles with Baseline 3 compliant ERTMS and/or track-side (equivalent of one double track km, including ETCS and/or GSM-R and/or interlockings deployed) may be funded under this CEF Transport Blending Facility with an eligibility period till December 2023.

One key principle of the Blending Facility is that EU grants must be combined with other sources of financing such as equity or debt. Blending can significantly reduce the riskiness of projects for other investors and enables the mobilisation of private capital. Moreover, the involvement of financial institutions ('Implementing Partners'), such as the European Investment Bank (EIB) or national promotional banks, is mandatory to ensure financial maturity of projects before they are submitted to the Innovation and Networks Executive Agency (INEA).

Finally, this type of EU support is based on a new concept of 'unit contribution' instead of 'eligible cost'. Compared to the 'traditional' system of calculating the grant based on a detailed budget of actual eligible costs per each cost category, a unit contribution shortens the time needed to establish grant amounts. It also implies additional simplifications at beneficiary level both in terms of application and reporting requirements. Furthermore, it decreases the workload for final closure of projects and consequently speeds up the payment procedures. The use of simplified forms of grants for ERTMS deployment actions may reduce risks of irregularities and fraud. Reporting and control on ERTMS deployment actions will focus on the implementation of the supported actions and the achieved outputs rather than on the eligibility of costs incurred, reducing the workload and scope for error of both applicants and INEA. However, in the opinion of some, mostly smaller, operators, the complex financial procedures for accessing the CEF Blending Facility and/or the levels of the thresholds defined create obstacles to benefit from this source of assistance, even when projects are mature.

In 2019, a new **CEF Transport multi-annual work programme (MAP) Call** was launched with a deadline for submission of proposals on 26 February 2020. 10 projects were submitted and at present are being assessed. In this call, EUR 50 million are allocated to ERTMS projects and only prototypes for OBU retrofitting were eligible. One of the objectives of this call is to prepare a projects

pipeline for serial deployment in the next financing perspective. As in the case of the Blending Facility, the EU support will take the form of a unit contribution per authorized prototype.

It should be noted that this call has been financed with a 'reflow' of unspent EU resources from the CEF Programme. In fact, several CEF funded transport projects, including ERTMS projects, have been cancelled or reduced in scope with EU grants being de-committed from those projects[13].

While track-side deployment remains a priority for EU funding in absolute terms, these latest innovative financing instruments focus on on-board deployment. The EU support on ERTMS on-board units allows targeting the market segment most in need of public support due to funding gaps. As the business case analysis shows, the dual on-board deployment strategy is instrumental in accelerating ERTMS deployment overall.

In the next multi-annual programme (the **Connecting Europe Facility 2021 – 2027 Regulation)**, rail transport continues to be a funding priority**,** as the focus in transport shifts to making transport connected, sustainable, inclusive, safe and secure. The proposed transport budget consists of three parts. As before, there are funds available under the general transport envelope (EUR 12.8 billion) and the Cohesion Fund envelope (EUR 11.3 billion). Both figures are subject to final agreement on Multiannual Financial Framework. In this respect, CEF will remain the key financial tool to fund ERTMS projects and should support both track-side and on-board projects. Furthermore, Cohesion and European Regional Development Funds will continue to play their role in financing ERTMS project in eligible Member States and regions[14].

Finally, ERTMS could also benefit from **the InvestEU Programme[15],** which objective is to provide a simplified and streamlined investment support with just one set of rules and procedures and one point of contact for advice. It supports four different policy areas, focusing on where the EU can add the most value by providing a budget guarantee to attract private investment. The InvestEU Fund, which is a market-based and demand-driven instrument, will mobilise both public and private investments through an EU budget guarantee of EUR 38 billion, backing investment projects of financial partners (EIB, EBRD, World Bank, Council of Europe Bank). Especially the policy areas for sustainable infrastructure (EUR 11.5 billion) and research, innovation and digitisation (EUR 11.25 billion) are of potential interest for the financing of railway projects. Member States will have the option to channel some of their allocated Cohesion Policy Funds into the InvestEU budget guarantee. Any funds channelled into the Fund will benefit from the EU guarantee and its high credit rating, giving national and regional investments more firepower. In order for a project to be eligible, it must address market failures or investment gaps and be economically viable, help meet EU policy objectives and achieve a multiplier effect.

[13] In case of ERTMS projects the current CEF support to-date amounts to EUR 800 million instead of EUR 1.1 billion as initially committed.

[14] The Commission has proposed to modify these figures in the Communication on powering the recovery plan for Europe, COM(2020)442 final of 27 May 2020

[15] https://ec.europa.eu/commission/presscorner/detail/en/MEMO_18_4010

2.5.3 Technical assistance for project preparation

In order to facilitate the access to EU funding opportunities and blending financing opportunities, several facilities have been set up to help improve the quality of applications. The **EIB Advisory Hub**[16], a partnership between the European Investment Bank Group and the European Commission, provides support to identify, prepare and develop investment projects across the European Union. It is a single access point to various types of advisory and technical assistance services, gathering expertise from the European Commission, the EIB Group, National Promotional Banks and Institutions and EU Member States' managing authorities. Several sectors are covered, including the development of transport infrastructure, equipment and innovative technologies for transport. **The Joint Assistance to Support Projects in European Regions (JASPERS)**[17] is a technical assistance partnership between the EIB and the European Commission, and an important instrument of the EU Cohesion Policy. JASPERS provides support in preparation of the project, the building of capacity and independent quality review. The focus from JASPERS is on large projects with a total cost for transport exceeding EUR 75 million.

2.6 Removal of barriers

The European Commission published the EDP in early 2017, addressing the delivery of interoperable and compliant infrastructure and setting targets until 2023. Later that year, the European Commission published a report called "Delivering an effective and interoperable European Traffic Management System (ERTMS) - the way ahead" (ERTMS Action Plan[18]). This document identified five elements, which contain actions to address barriers to ERTMS implementation and interoperability and to aim for a system compliant with the European Commission's vision:

- Interoperable and compliant infrastructure
- Standardisation of on-board units
- Efficient testing and validation
- Maintaining ERTMS in a reliable and consistent manner
- Funding/financing support.

Progress against these objectives has been positive, though in certain areas there is still significant work to do. To sum up:

- **The implementation of the new powers for ERA as regards trackside approval and vehicle authorisation:** ERA has now moved beyond successful learning cases and its new powers should significantly improve the enforcement of interoperability in on-board authorisation and trackside procurements.

[16] https://eiah.eib.org/about/index
[17] https://www.eib.org/en/products/advising/jaspers/index.htm
[18] ERTMS Deployment Action Plan. European Commission. 2017. Available online: https://ec.europa.eu/transport/sites/transport/files/2017-ertms-deployment-action-plan.pdf

- **ETCS System Compatibility and Radio System Compatibility** processes as part of the 2019 CCS TSI revision: Implementation of these processes will provide a more harmonised approach to testing, reduce the effort and cost of checking route compatibility, and give on-board unit suppliers the opportunity to demonstrate the maturity of their products. A return of experience on ETCS System Compatibility and Radio System Compatibility should be conducted.

- **National technical rules (NTR)** constitute a significant barrier to interoperability, impeding the harmonization in the engineering rules in relation to ERTMS specifications. ERA and DG MOVE are working with Member States to remove unnecessary rules, and challenge national rules that impact interoperability. As a consequence, the number of NTR were reduced from 14.312 in 2016 to 1.026 in 2019.

- As part of the 2019 CCS TSI revision, additional criteria were set out to allow that certain changes to on-board units do not automatically result in a reauthorisation requirement. This should in practice allow changes such as **software-based error corrections to be carried out without reauthorisation.** This is the first step towards an on-board system that is more adaptable to change.

- **Additional sources of EU support** through the CEF Blending Facility and CEF Reflow call as described above.

- Preliminary analysis of Baseline 3 on-board units against existing infrastructure shows that **compatibility with Baseline 2 infrastructure** is preserved – an important proof of the backwards compatibility principle. Until present only 1 incidence has been reported regarding compatibility. This case has demonstrated the strong commitment of the Commission and ERA as well as the ERTMS stakeholders in tackling this type of issues. As a result, a procedure has been developed to deal with any future compatibility problems. The work on the revision of the CCS TSI 2022 has taken into account the lessons learnt until present with a view to minimising the impact of the on-board upgrades and software corrections.

- **The development of the CCS System Framework** (described later in section 3.4), and the development of the 2022 CCS TSI revision with regulatory changes aimed at:

o Enhanced technical and operational interoperability

o ERTMS game changers

o Modular on-board architecture

2.7 Operational rules and public procurement

2.7.1 Issues with operational rules

The ultimate vocation of ERTMS is to be deployed as a single signalling system on the entire European network. However, as different parts of network may have different technical specificities, they might also have different operational requirements. It is evident that as technical requirements are defined to achieve interoperability, the operational requirements should also be harmonised to allow a driver to operate in a seamless way on the whole European network.

The ERTMS operational rules with impact on interoperability are included in appendix A of the technical specifications of interoperability for operation (OPE TSI), considering e.g. operational aspects not related to ERTMS applicable to a specific line or vehicle (e.g. the rule book and the route book). In addition, appendix A includes a list of non-harmonised rules that are related to ERTMS and impacting interoperability, e.g. running in shunting mode, changing specific on-board parameters or checking route conditions.

In order to achieve standardised operation in Europe, these rules should be harmonised. The European Commission considers this point as a priority and included it, in the context of the forthcoming 2022 CCS TSI revision, in its mandate to the Agency.

It should be noted that due to the existence of technical and operational rules linked to lateral signalling, technical solutions avoiding them allow for the achievement of a more uniform signalling system as a whole. In case of ERTMS this is facilitated by deployment of radio-based systems (Level 2 or Level 3).

2.7.2 Issues with public procurement

Procurement procedures are key for the ERTMS deployment while also being responsible for a significant number of project delays or cancellations. The following list includes examples of issues encountered:

- Tenders failed because there were **no offers received or only one.** There are also examples of cases when all received offers exceeded the budget. These are some of the main blocking points for ERTMS deployment trackside and retrofitting.
- **Lack of long-term national perspective and stability of funding** which affect deployment and building of industrial capacity. Furthermore, changes in national ERTMS deployment strategies affect both ERTMS trackside deployment and on board retrofit projects.
- As regards ERTMS trackside deployment demanding **requirements** in many public procurements resulted in lengthy tenders and delays in project delivery.

There are also technical aspects of the system that should be considered as challenges to achieve successful procurement based on the experience around Europe:

- **Maturity of specifications.** Complexity of technical architecture (e.g. interfaces with Class B systems or with existing interlockings) or changes to specifications may impact the procurement process.
- **Unavailability of products.** Rail companies and specifically RUs raise the issue of inability of suppliers to deliver certain products. This is due to insufficient industrial capacity or very local/tailored specifications like radio in-fill. Furthermore, in some cases the Specific

Transmission Module (STM) units do not exist despite the explicit obligation of Member States set out in CCS TSI to ensure their availability.

- **Lack of product documentation**. This situation can occur during tender or project execution phase. It induces risks of higher costs or exceeding the contractual deadlines. The technical documentation is important for the integration of the ERTMS system into the vehicles and trackside systems (e.g. interlocking). It is however also a challenge to identify which is the level of detail necessary in this documentation making unclear the best way to define system integration roles.
- **Project risks.** There is an initiative to mitigate this by using a common tender format for the ERTMS on-board procurements that was agreed by the sector in 2018. However, this list has not been used in any of the known ERTMS procurements until present.
- **Lack of software maintenance clauses.** This leads to the need of new procurements to update the software on-board, which for a software-based system such as ERTMS should be considered business as usual. The known procurement processes do not include offers honouring this agreement of the sector as laid down in the 2016 MoU.
- **Errors are still found during final testing.** The fact that these problems are encountered just before placing in service often results in major delays and cost overruns. The impact of errors could be mitigated if they are systematically detected by suppliers during the verification and validation processes.

3 Next steps

3.1 Policy background

The Commission in its Green Deal sets out measures aimed at promoting sustainable transport modes. Rail will play a major part in the greening of transport with the aim to combating climate change.

One of the ambitious objectives for transport decarbonisation is a major modal shift of inland freight transport towards inland waterways and (mainly) railways, which calls for a sharp increase in rail transport capacity that cannot be obtained without advanced ERTMS (Level 2 / 3) being widely deployed.

Furthermore, ERTMS will become the backbone of railway digitalisation, which will allow for introduction of new technologies, including but not limited to automatic train operation, satellite positioning and other technologies capable of optimising rail performance and capacity. What is more, digitalisation makes the railway sector more attractive for young personnel and counteracts their perception of it being an outmoded industry.

Thus, climate change and digitalisation are the main drivers for the European Commission's policy and ERTMS deployment will be the main driver for the modernisation of the railways. The European Coordinator for ERTMS will focus, together with all actors concerned, and report back in particular on the following points.

3.2 Trackside

The ERTMS European Deployment Plan (EDP) defines the specific deadlines for the implementation of ERTMS by 2023. Until present out of the 50.000 km on the CNC more than 6.000 kilometres are equipped with ETCS. According to the available information, most of the sections planed in the EDP are expected to be equipped with ETCS by 2023. The percentage of lines to be implemented according to the EDP by 2023, compared to the total length of the Core Network Corridors, is close to 31%, meaning that almost 69% of the CNCs only have a general implementation deadline of 2030 in the current EDP.

Under the TEN-T Regulation the Member States are in principle obliged to deploy ERTMS on all railway lines belonging to the Core Network (except in case of isolated networks) by 2030 and by 2050 on those belonging to the Comprehensive Network. The core network includes the most important connections, linking the most important nodes, whereas the comprehensive network covers all European regions.

As a result, it is estimated that some 65.000 km on the entire Core Network, that include the CNC, should be deployed by 2030. Furthermore, 122.000 km of the Comprehensive Network (including 65.000 km of the Core Network) should be deployed by 2050.

It should be noted that the TEN-T policy is under the review. This process might result in a revision of the current legal text and impact the obligations of the Member States and the length of the TEN-T network[19].

Furthermore, the European Coordinator for ERTMS will revise during the following years the current EDP to provide a framework for deployment per each section of the CNC, especially in the period between 2023 and 2030. This must be done while ensuring consistency with the RFC Regulation[20], the TEN-T Regulation and the new CEF Regulation.

3.3 Rolling stock

European Rolling stock deployment strategy

Considering the current level of demand and a very concentrated market of suppliers, the cost of ERTMS equipment is still relatively high. Approximately the amount of EUR 200.000 is estimated as a cost per one km of ETCS L1/L2 without considering related works (e.g. interlockings), EUR 1.35 million to EUR 2.5 million for a vehicle prototype[21] and EUR 255.000 to EUR 275.000 for serial on-board deployment[22]. Experience shows that an enhanced coordination of all stakeholders, including rolling stock owners and infrastructure managers is instrumental to ensure a successful ERTMS deployment. Therefore, the delivery of a dual on-board migration strategy aligned with the 2030 trackside deadline set out in the EDP faces the following challenges:

- A management challenge to coordinate deployment on-board and trackside in order to ensure appropriate planning, technical compatibility and coordination of tendering;
- A financial challenge to raise sufficient resources to finance ERTMS equipment, retrofit or upgrades;
- An industrial challenge, to ensure sufficient production capacity from ERTMS suppliers in view of the investments needs to equip both the network and the fleet;
- A market challenge, to ensure a sufficient number of ERTMS suppliers in order to allow a fair competition.

In order to understand the magnitude of the problem, a specific estimation of the on-board units to be considered for ERTMS has been performed.

Firstly, it was assessed that the number of vehicles already equipped in the EU amounts to some **3.600 vehicles equipped**. Then, the number of vehicles required to achieve the dual on-board strategy at corridor level and at national level (according to the National Implementation Plans) has been assessed. **The total fleet to be equipped by 2030 is estimated between 27.500 and 38.500**

[19] The review was launched in April 2019, with an evaluation of the existing TEN-T regulation, including a large stakeholder consultation and an external study. The results of this evaluation are expected by mid-2020. The start of concrete planning for a possible revision of the guidelines by the European Commission will depend on the results and conclusion of the evaluation.

[20] Evaluation of Regulation 913/2010 announced in the Commission Work programme for 2020

[21] Depending on the number of class B systems and authorisations needed

[22] Annex 1 of Commission Decision authorising the use of unit contributions to Support ERTMS Deployment under the Connecting Europe Facility (CEF) – Transport Sector (February 2019)

vehicles[23]. The difference between the low bound and the high bound is due to the capacity of railway undertakings to optimize the fleet required to operate on the CNC in countries where these corridors do not represent significant parts of the network.

[23] Non UIC gauge fleet have been excluded from this calculation, though they are eligible for CEF support

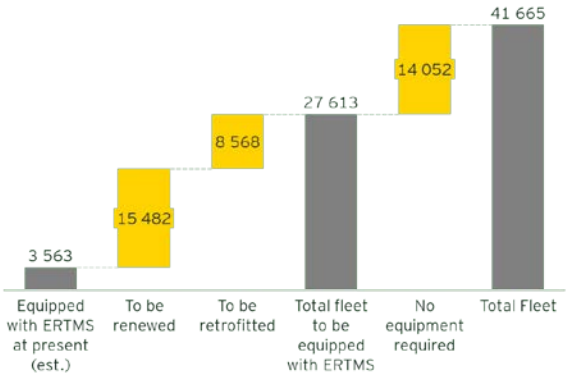

Figure 8 Total fleet to be equipped with ERTMS - low bound

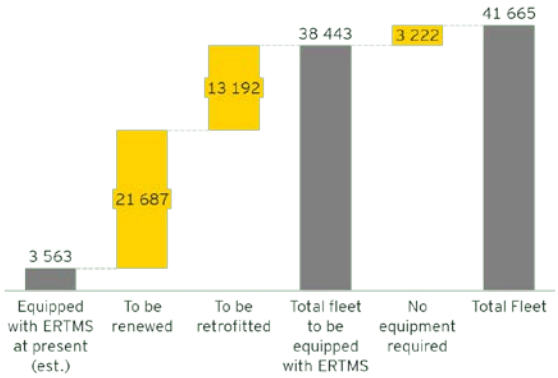

Figure 9 Total fleet to be equipped with ERTMS - high bound

The split between renewal and retrofitting is shown in the figures below, which demonstrates that the demand for retrofitting / renewal of the fleet is expected to peak between 2024 and 2028.

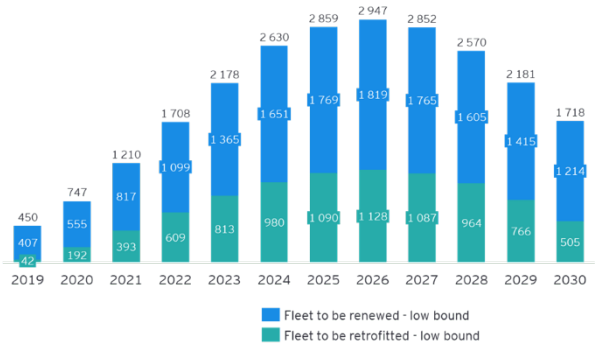

Figure 10 Fleet to be renewed and retrofitted/year - low bound

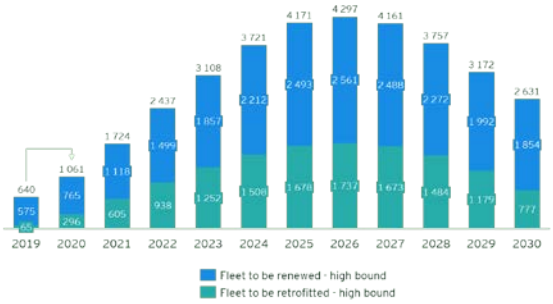

Figure 11 Fleet to be renewed and retrofitted/year - high bound

Furthermore, in 2019 the European Commission launched a study for the "Support to the EC in the deployment of ERTMS on Core and Comprehensive Networks: On-board and Infrastructure deployment strategies". The main objective of this study, that is still on-going, is to analyse 3 European commercially significant networks where ERTMS has clear attractive case for operators, keepers, and owners. The study will assess necessary transition strategies when ERTMS + only 1 class B system is necessary to achieve a business case for the RUs. The study is also analysing which would be the target year for operation with vehicles with only ERTMS would be achievable.

Specific focus on prototypes

A major bottleneck for on-board retrofitting are prototypes, as they are by definition more risky and expensive projects. Moreover, vehicle owners might be willing to wait until another owner commissions a prototype, to avoid the risks and high costs for the "first in class". To quantify this specific issue, the DMT has produced an evaluation of the number of prototypes to be delivered to achieve the dual on-board strategy**, which is estimated between approximately 385 and 850.** The

Commission services, on suggestion of the European Coordinator, have facilitated the built up of a project pipeline for CEF 2 by focusing the recent reflow call on grants for prototypes.

The industrial challenge

As shown above, a large part of the vehicles is expected to be equipped thanks to the renewal of the fleet (**between 15.500 and 21.500**); the rest will have to be retrofitted (**between 8.500 and 13.000**). Between 2019 and 2030, this represents **700 to 1.100 vehicles / year to be retrofitted**, and **1.300 to 1.800 vehicles / year to be renewed**. Furthermore, this assessment does not include the needed upgrades of vehicles from baseline 2 to baseline 3, as well as the need for other periodic updates, which will also affect the industrial capacity of suppliers.[24] These figures have to be compared with the trends in the past years and the number of OBUs already contracted:

- in the past 10 years retrofitting projects represent an average of **270 vehicles / year**
- in the last 5 years, approximately **1.000 new vehicles / year** have been introduced in Europe
- according to UNISIG, approximately **9.500 OBUs** are contracted and expected to be delivered by 2028; this represents an average of 1 000 OBUs / year, even if only vehicles with one OBU were considered.

Therefore, beyond the financing gaps, we may also face an important industrial bottleneck to equip the fleet needed to achieve the dual on-board strategy by 2030.

This will create major industrial challenge for the railway sector in the coming years. The Commission services (DG MOVE and DG GROW) and the European Coordinator are discussing the main aspects of this issue within the industry and wider railway sector, focussing in particular on shortage of qualified staff, lack of sufficient workshops for retrofit, stable and predictable budgets, etc. to see how a major industrial initiative can be launched.

Future funding and financing.

New MFF and CEF Regulation revision

Discussions on the next Multiannual Financial Framework are currently on-going. In May 2018, the Commission adopted its proposal[25]for the MFF 2021-2027 where CEF is to be kept as the financing instrument of the TEN-T. In fact, the Commission proposed a budget for CEF Transport with priorities being:

- Efficient and interconnected networks.
- Smart (digital) sustainable, inclusive, safe and secure mobility, where ERTMS is among the specific policy objectives.

[24] The work on the revision of the CCS TSI 2022 will duly take this issue into account. It is of paramount importance that the future ERTMS system can be updated in a cost effective and efficient way, whenever needed.

[25] COM(2019)321 see also footnote below.

- TEN-T adapted to military mobility requirements.

The draft CEF2 Regulation foresees an increased role for the European Coordinators in the selection of projects. Specifically, award criteria will ensure consistency of projects with the corridor work plans. The CEF2 Regulation is currently going through the legislative process in the European Parliament and the Council, most of the legal provisions are agreed pending the financial figures. In fact, final amounts will depend on the adoption of the new MFF by the co-legislators.

In addition, the EU has adopted, in view of the 2021-2027 budgetary period, proposal to simplify and streamline investment support and Cohesion Policy. For the latter, several simplification measures have been proposed to reduce red tape, have flexible framework for programmes and a single rulebook covering all funds implemented in partnership with MS. On the investment side, by leveraging on the successful Juncker Plan, the new programme InvestEU to expand the crowd-in of other financial sources with the EU budget bring together in one envelope the existing financing instruments for sustainable infrastructure, research, innovation, digitalisation, SMEs and social investments.

It remains to be seen whether other instruments may become available following the proposals to deal with the social, economic and financial consequences of the COVID 19 pandemic[26].

Case for funding support for on-board deployment

According to the analysis carried out by the DMT, ERTMS deployment on the Core Network is expected to represent a total amount of investment needs of at least EUR 12 billion[27] and at least EUR 5 billion for on-board deployment. Therefore, EU support will not be sufficient to bridge the funding gap for stakeholders. Member States and local authorities' support through grants will remain a fundamental factor to assist the deployment.

As explained above, ERTMS deployment is most effective as a coordinated trackside and on-board approach and there is considerable need for continued EU, Member States, and regional authorities support.

As to state aid rules, there is a considerable leeway for Member States or regions to support on-board deployment. Indeed, assistance for ERTMS deployment is allowed by "Community guidelines on State aid for railway undertakings" [28], as long as the maximum support does not exceed the ceiling (point 107 of the guidelines) or the aid scheme fulfils the criteria on the necessity and proportionality of the aid (point 108 of the guidelines). In a nutshell:

[26] See the Commission Communication on powering the recovery plan for Europe, COM (2020)442 final of 27 May 2020

[27] This amount does not include interlockings or additional works which might be required in specific situations to deploy ETCS on track-side

[28] Community guidelines on State aid for railway undertakings https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008XC0722(04)

- if the maximum support from Member States remains below 50% of the eligible costs for ERTMS project, there is a presumption for aid compatibility; that is as long as the state aid remains below this threshold, Member States do not have to demonstrate necessity or proportionality. CEF support is in principle not considered as state aid and as such can be, in principle, excluded from the calculation of the aid intensity ceiling.

- Higher levels of support can be provided as long as Member States can demonstrate the need and proportionality of the measures. As there is often a clear market failure and as ERTMS deployment is a project of common European interest, this is regularly easy to demonstrate.

If the aid is given by an Infrastructure Manager, it can be provided as a pass-through from Member State. In addition, access to such a financing scheme would have to be delivered on a non-discriminatory manner to all rolling stock owners operating on the network of the Infrastructure Manager.

Another solution for infrastructure managers would be to apply differentiated track access charges (TAC), as foreseen in Art. 31 and 32 of Directive 2012/34/EU. Such a scheme would have to comply with the following constraints:

(i) the aid should be limited in time, and the purpose of the aid would be to improve interoperability;
(ii) the scheme should decrease TAC for rail freight undertakings with vehicles equipped with ETCS (and could increase TAC for vehicles not equipped with ETCS if a *malus* is introduced, as long as it does not increase the revenue of Infrastructure Managers on the period considered for the scheme) [29];
(iii) the aid would have to be calibrated to remain below 50% of eligible costs, or the Member States would have to provide a specific justification.

Any aid measure has to be notified to the Commission before its implementation. Several Member States have put into place support for ERTMS deployment and have received the green light from Commission authorities. Those cases are listed in Annex 3.

3.4 Preparing future evolution

3.4.1 2022 CCS TSI revision

We need to look at the development of the overall control command and signalling system at European level more broadly. Digitalisation technologies in rail have a huge potential to improve passenger and freight services. Indeed, digitalisation coupled with automation is the most effective way to increase capacity without major new infrastructure investments.

The structure of CCS implementation to date, however, does not enable rail to take full advantage of these and future opportunities as:

[29] The capacity for an Infrastructure Managers to deploy such a scheme will also depend on the level of its debt.

- The current CCS TSI specifies CCS on-board functionalities and track to train interoperable interfaces.
- The current typical CCS on-board configuration includes multiple proprietary interfaces between the main train on-board building blocks. This induces low on-board upgradeability and dependency on one supplier where on-board upgrades are necessary.
- The current CCS results in a national approach of trackside engineering. Route setting and protection (implemented by interlockings) are not harmonised in the CCS TSI and are implemented following national rules.

As a result, there remains an overall fragmented CCS market covering all national signalling configurations and rail business models. This situation significantly increases CCS complexity and reduces the opportunity for more open and competitive markets across Europe. It also creates a system which is not conducive to evolution and innovation.

The future evolution should take advantage of the single market that will allow, together with the flexibility of the system, to provide economically efficient solutions both to high performance networks but also to networks of lower requirements.

Therefore, DG MOVE, ERA, S2R and the wider sector through the ERTMS Platform have agreed on the CCS system framework, which sets out the vision, principles, and actions needed to:

- Ensure that the CCS system is optimally set up to take advantage of digitalisation
- Develop a more standardised CCS approach across Europe, reducing costs and complexity
- Ensure a non-disruptive evolution, thus maintaining confidence in the viability of current investments and deployments

The following elements are underpinning the vision of an integrated CCS system framework:

- **One European CCS system**

We need to work towards a genuine integrated one European CCS system, beyond the current specifications in the CCS TSI, with much greater standardisation and much less national variation than at present. This integrated CCS system should on the one hand deliver unrestricted movement of trains, on the other hand, create a larger market for components and significantly simplify vehicle and trackside authorisation. We need a common platform to define the future elements of this system. Moreover, developing "One European CCS System" should not impact on the on-going ERTMS deployment and define a cost-effective migration path.

- **A flexible and adaptable CCS system**

CCS – both on-board and trackside - should be based on a functional modular architecture using standardised interfaces, moving beyond the current system with proprietary interfaces. The software and hardware installed on board or trackside should be operated and maintained following principles and standards as used in the IT domain: regular, scheduled updates with pre-tested configurations to ensure that errors and shortcomings are eliminated, maintaining all the products and system throughout the EU in line with the interoperability specifications, with manageable upgrade mechanisms. The ultimate objective would be to reach "plug and play" solution when this is technically and economically feasible.

- **Harmonisation of operations**

Radio based ERTMS will significantly reduce the complexity and network specificities of ETCS Level 1 and class B lineside signalling. A focus on ERTMS Level 2 and 3 implementation should provide the opportunity to streamline the operational principles and rules for ERTMS and CCS. On this basis, operational harmonisation based on ERTMS-alone Level 2 and Level 3 networks needs to be targeted.

- **Optimised traffic management**

An optimised traffic management system improves management operations with automated processes for data integration and exchange with other rail business services. The backbone of the new architecture should be scalable, interoperable and standardised, applicable within an integrated rail management system. Ultimately, technology evolution will allow for real-time decision making.

The following principles should guide the development of the above vision:

- **Principle 1: Fast deployment and development**

o European-wide deployment of ERTMS and CCS investments need to proceed as quickly as possible, with decommissioning of class B systems, at least as regards Core Network, possibly shortly after 2030 with predictable and reasonable deadlines.

o Conditions should be set to create positive business cases for:

- Suppliers to develop the components of the CCS components.
- Railway sector to deploy CCS components and the necessary balancing instruments.

- **Principle 2: A modular, and secure system**

o The CCS system should increasingly be defined in a modular way with common standardised interface specifications between the main CCS-components;

- A clear separation of safety-related and non-safety-related layers is needed; this consequently should enable modular safety cases. Such a clear separation aims to reduce substantially the need for authorisation procedures when modifications are realised in the non-safety related parts of the system.
- Security by design should be embedded in the future CCS development.

- **Principle 3: Optimal preservation of investment**

- Implementation of new functionalities and changes to the CCS system must be enabled but current investments should not be undermined.
- ERTMS Baseline 3 on-board units (and future iterations) should be able to safely run on any compliant line with an acceptable level of performance.

- **Principle 4: Enhanced interoperability**

- Future CCS evolution will deliver significant business case improvements for the railway sector. This evolution must continue to ensure and enhance technical and operational interoperability of the Single European Rail Area.

The most immediate deliverable of the System Framework will be the 2022 CCS TSI revision, which should include:

- the ERTMS game changers, which are the heart of future digitalisation building on ERTMS and aim to achieve higher capacity and better performance. According to the definition given in 2016, these game changers include:
  - **Automatic Train Operation** (ATO grade of Automation (GoA) 1/2), reducing energy consumptions and increasing capacity.
  - **Future Radio Mobile Communication System (FRMCS)**, replacing GSM-R and introducing 5G technologies.
  - **Braking curve model optimisation**, for improvements through balance between safety and capacity requirements.
  - **ETCS Level 3**, increasing capacity and reducing trackside life cycle costs.
  - **Satellite positioning** coupled with innovative sensors, enhancing train localisation and odometry.
  - **On-board train integrity**, complementing Level 3 and providing a major opportunity for cost reduction in trackside equipment.
  - **Cyber-security,** linked to the vital role of radio communication and the digitalisation of the railways.
- The facilitation of the introduction of digital technologies in rail through modularisation. It includes work primarily on changes linked to CCS on-board modular architecture with the aim to deliver a more flexible and robust system.

- Enhancements to ERTMS technical and operational interoperability, including through greater harmonisation of operational rules linked to ERTMS implementation.

Deployment and change of the CCS is technically challenging, and complex and concerns multiple actors. This deployment and migration challenge is multiplied when seeking a pan-European approach, given number of existing national solutions and barriers.

The European Commission and ERA, supported by the European Coordinator, will have to ensure that evolution is managed to achieve an appropriate balance between enabling rapid implementation of new functionalities, delivering performance enhancement, and allowing a clear view on return on investments and overall life cycle costs for operators. This should ensure consideration of the evolution of technical specifications, deployment timetables, and, if appropriate, financial support or mechanisms to balance migration benefits and costs between the stakeholders. A platform to ensure the involvement of all stakeholders in the evolution of technical specifications, pooling expertise for this process, needs to be created.

A more modular and adaptable system will reduce the costs and complexity of adding future functionalities. Being a software-based system, ERTMS should be prepared for the evolution foreseen in the 2022 CCS TSI revision in a non-disruptive way. ERTMS as a system must be flexible and evolve further. However, the success of ERTMS hinges on the protection of the investments already made by stakeholders. This is particularly important where the net costs and benefits of a new functionality are not uniformly allocated across the sector.

The mechanism of backwards compatibility with all previous versions of ERTMS should be carefully managed both as regards the maintenance of the ERTMS specifications and the ERTMS deployment trackside and on-board. This non-disruptive evolution, together with product roadmaps for error corrections are key for the ERTMS future.

As a result, stakeholders should have the confidence to continue investing in Baseline 3 products.

3.4.2 Decommissioning of class B systems

We can observe different deployment strategies amongst the different countries. They reflect various priorities, such as tackling first lines with more dense traffic or higher performance requirements, focussing on lines with higher risks of obsolescence, putting emphasis on commuter lines or on cross-border traffic.

As presented above, there is a business case for ERTMS deployment on all CNC at the system level but not necessarily for each section of the network and each railway undertaking. Consequently, some Member States are following full nation-wide deployment whilst others are only deploying ERTMS where they deem necessary, with or without a decommissioning strategy for their respective Class B systems.

From the European perspective, the international traffic is seen as the priority since it has a higher impact towards achieving Single European Rail Area. This is the reason why the ERTMS Deployment

Plan focuses on the CNC and sets deadlines for ERTMS deployment on these lines. However, most operators do not operate exclusively on the CNC. A clear example of this are last miles or diversionary routes. As such, ERTMS deployment going beyond Core Network is indispensable. Moreover, the complexity of equipping main nodes with ERTMS often leads to delays and gaps in the overall corridor. ERTMS roll out of the corridors without equipping railway nodes might look encouraging on paper, but any gap, if no diversionary line is available, undermines the business case of railway operators. In future, these 'ERTMS holes' will be also part of an increased scrutiny by the European Coordinator.

The European Commission included in the CCS TSI the requirement for Member States to submit the ERTMS National Implementation Plans. In these plans, Member States are required to develop national strategy for the implementation of the CCS TSI.

However, there is at present no legal obligation at EU level to decommission Class B systems. It should be noted that maintaining two systems trackside in parallel makes no sense from a cost perspective, unless in exceptional cases and for a limited period of time it is indispensable in order to preserve interoperability. As such there is a need for a decommissioning strategy of class B systems with regulatory deadlines to be set out at EU level.

The European Coordinator considers that a realistic and stable class B decommissioning timetable with binding deadlines is needed. This should be defined in the framework of the revision of TEN-T Guidelines, ERTMS European Deployment Plan and the 2022 CCS TSI. Such a strategy should address the issue of migration and applicable transitional periods. The forthcoming EU funding mechanism should play a pivotal role in facilitating and smoothening this process.

Furthermore, there are regulatory deployment requirements in the CCS TSI that should be enforced. For example, the existing exemptions for equipping new rolling stock with ERTMS should be tightened. Furthermore, it should not be allowed to require class B systems to operate on lines where ERTMS is already equipped.

4 Conclusions of the European Coordinator for ERTMS

Concluding, this work plan shows that we are at a critical point for ERTMS deployment in Europe and worldwide. Climate change, digitalisation and the need for an industrial renewal all speak in favour of an acceleration.

We have learnt how to organise transition; we have established the methodology and legal framework and have developed a high performing system with a single system authority. We are, albeit only gradually, mobilising the necessary industrial capacities.

We need to focus on deployment, both for trackside and on-board, based on Baseline 3 or subsequent baselines. We need to ensure that at least level 2 ERTMS is deployed, except for cases where it is not justified by operational needs of a specific section.

Trackside deployment has to be accelerated and, seeing also the strong push by some Member States, our ambition should be to have not only Core Network Corridors or the Core Network equipped with ERTMS by 2030 but an all-encompassing functioning ERTMS network in the EU, covering the major parts of the comprehensive network and more, by 2040.

We should continue paying attention to deployment on cross-border sections and concluding well in advance bilateral agreements by neighbouring Member States. At the same time, we should focus infrastructure deployment on existing gaps and close them as soon as possible to allow continuous operation on longer stretches of the network with ERTMS only. A major focus in future also needs to be placed on ERTMS deployment on main rail nodes and terminal connections. In a nutshell, we should make considerable efforts to gradually move from ERTMS islands to entire corridors and networks.

We need to implement the European on-board retrofitting strategy: quick roll-out of proto-types for retrofitting, stable and predictable budgets for retrofitting and upgrading; simplification of authorization processes, in particular for serial vehicles; identification of bottlenecks for on-board deployment and fewer regulatory exemptions for newly built locomotives.

It is vital to provide an enhanced EU assistance for the renewal of the fleet or support for retrofitting of the existing vehicles, whichever solution has a better benefit-cost ratio in a given context. Indeed, to succeed, we will need to raise the necessary funds on the European, national and regional level. Providing a reliable and stable funding framework for the ERTMS deployment, both on-board and trackside, ideally enshrined in law, will be key. We also need to do everything to reduce unit costs of ERTMS.

We need to find a way of rapidly de-commissioning class B systems and thus reducing transition costs. For EU funded projects there should be an obligation to use trackside ERTMS only once it has been commissioned after a limited transition period. Furthermore, we should make sure that the EU is not funding class B systems anymore.

We need to ensure that transition costs do not occur several times and that accelerated investments can take place now without creating sunk costs. At the same time, we also need to make sure that

ERTMS stays the world's leading system and that evolution can take place in a non-disruptive way. This means that increasingly modular and broader standardisation approaches should be privileged and that future developments leave enough time to amortise current investments.

Finally, rail traffic management goes beyond what we currently have defined in our technical specifications. We need to make sure that we stay united in defining the other components of a European rail traffic management system, working with a single systems authority, and building a common platform to provide an agreed and well researched, detailed strategy for future evolution.

In the coming months and years, on top of the close monitoring of the ERTMS deployment, which is and remains my prime mission, I will focus my activity as the European Coordinator for ERTMS also on the above-mentioned key issues and, to my best abilities, ensure that they are addressed.

Moreover, in the next weeks I will start an initial analysis with all the Member States and stakeholders concerned to gather insight on the impact of the COVID 19 crisis and related recovery plans on transport infrastructure investments, as well as views on the future possible orientation of my work and work plan priorities.

One thing is already certain for me, COVID 19 should not be an excuse to delay.

Annex I ERTMS deployment on the 9 Core Network Corridors

Atlantic Corridor

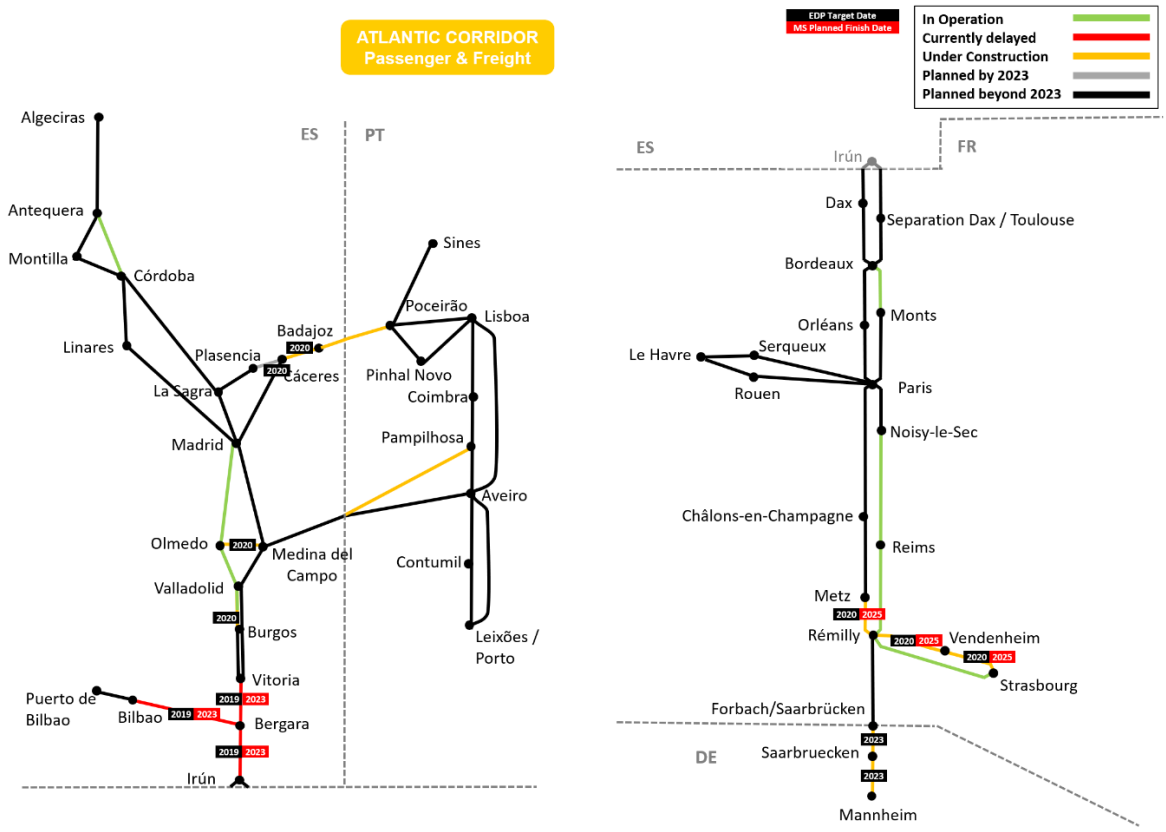

Figure 12 Atlantic Corridor ERTMS deployment plan

There are in the ATL 8.214,23 km where ERTMS is foreseen to be deployed by 2030, with 12% already in operation with ETCS, 45% in operation with GSM-R, 16 % under construction with ETCS and on 9% of the length GSM-R is under construction. The GSM-R deployment is the lowest of all CNCs.

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (1.750,31 km), 59% is in operation, while 31% is still under construction. The ATL has the highest rate of the short-term deployment of the CNC, but the percentage of the total length of the corridor planned to be deployed by 2023 is one of the lowest (21%).

Regarding the Member States where ATL corridor runs, no section is planned to be deployed in Portugal by 2023. In contrast, all German sections within the ATL are planned to be deployed by 2023 (Ludwigshafen - FR/DE Border), but at present they are still under construction. The highest number of km should be put in operation in France, where the rate of km to be commissioned by 2023 is also the highest (83%). Spain is the second country with the highest ETCS deployment to be fulfilled by

2023. There is already a delay in the Basque Country sections that should be in operation by 2019 due to other national priorities, but latest information indicates that it will not be possible until 2023.

Baltic Adriatic Corridor

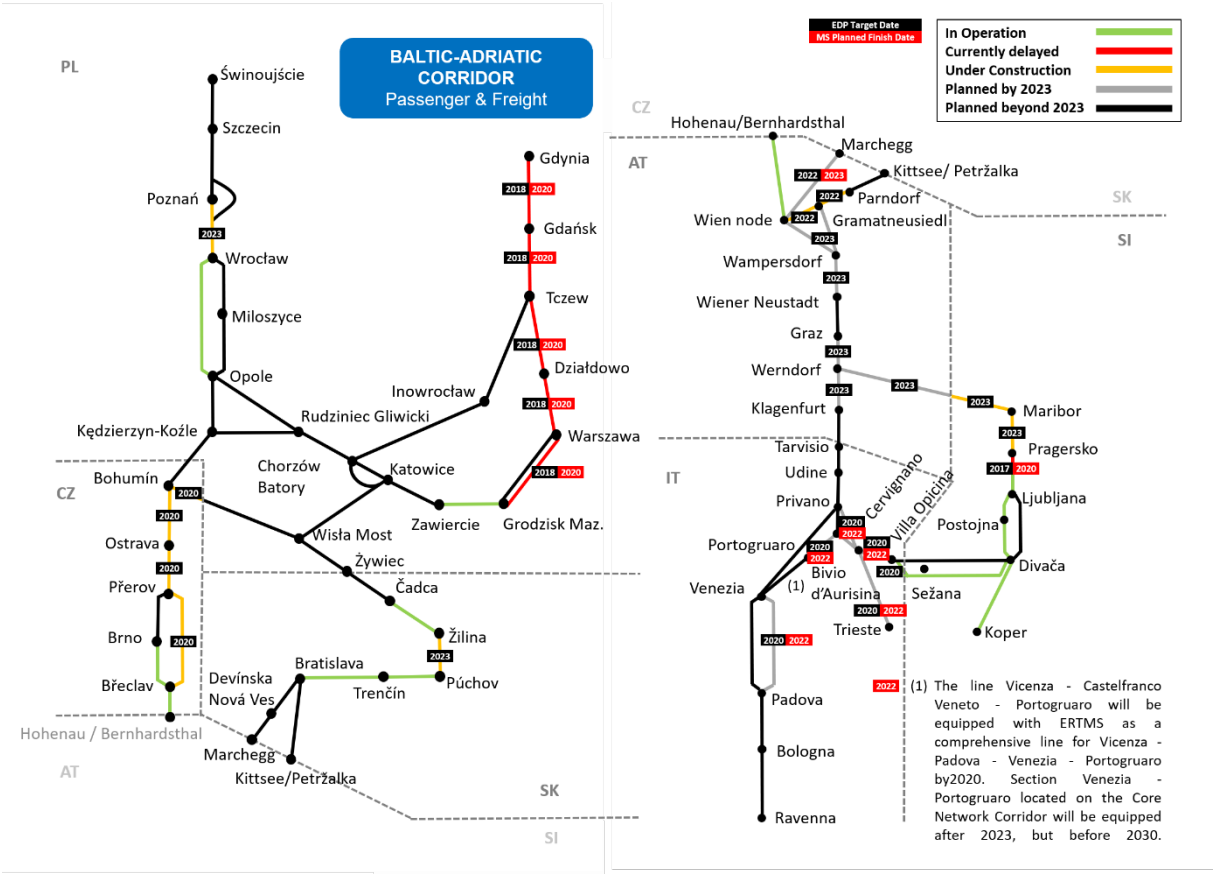

Figure 13 Baltic-Adriatic Corridor ERTMS deployment plan

There are 4.666,96 km where ERTMS is foreseen to be deployed in the BAC corridor by 2030, with 18% already in operation with ETCS, 59% in operation with GSM-R, 37% still under construction for ETCS and 37% of the length GSM-R is under construction.

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (2.110,72 km), 36% is in operation while 45% is under construction. The BAC percentage to be deployed by 2023 is over the average of the CNC short term deployment (45%).

The lowest percentage to be deployed by 2023 is planned in Italy, where ETCS is not under construction on any section of the CNC. The percentage of length where ETCS deployment planned by 2023 has already started is very high in Austria (68%).

Regarding the Member States where the BAC corridor runs, the highest ETCS deployment planned by 2023 takes place in Slovakia and Slovenia (78% and 65% respectively). The ETCS deployment of the planned length to be in operation by 2023 is not very high in Austria, Czechia and Poland (20%, 25% and 29% respectively). In Czechia, Slovenia and Poland the whole length to be put in operation by 2023 is under construction or already in operation. The Polish line which connects Gdynia and Grodzisk Maz is delayed. The same occurs for a section of the Slovenian line which connects Ljubljana and Pragersko.

Mediterranean Corridor

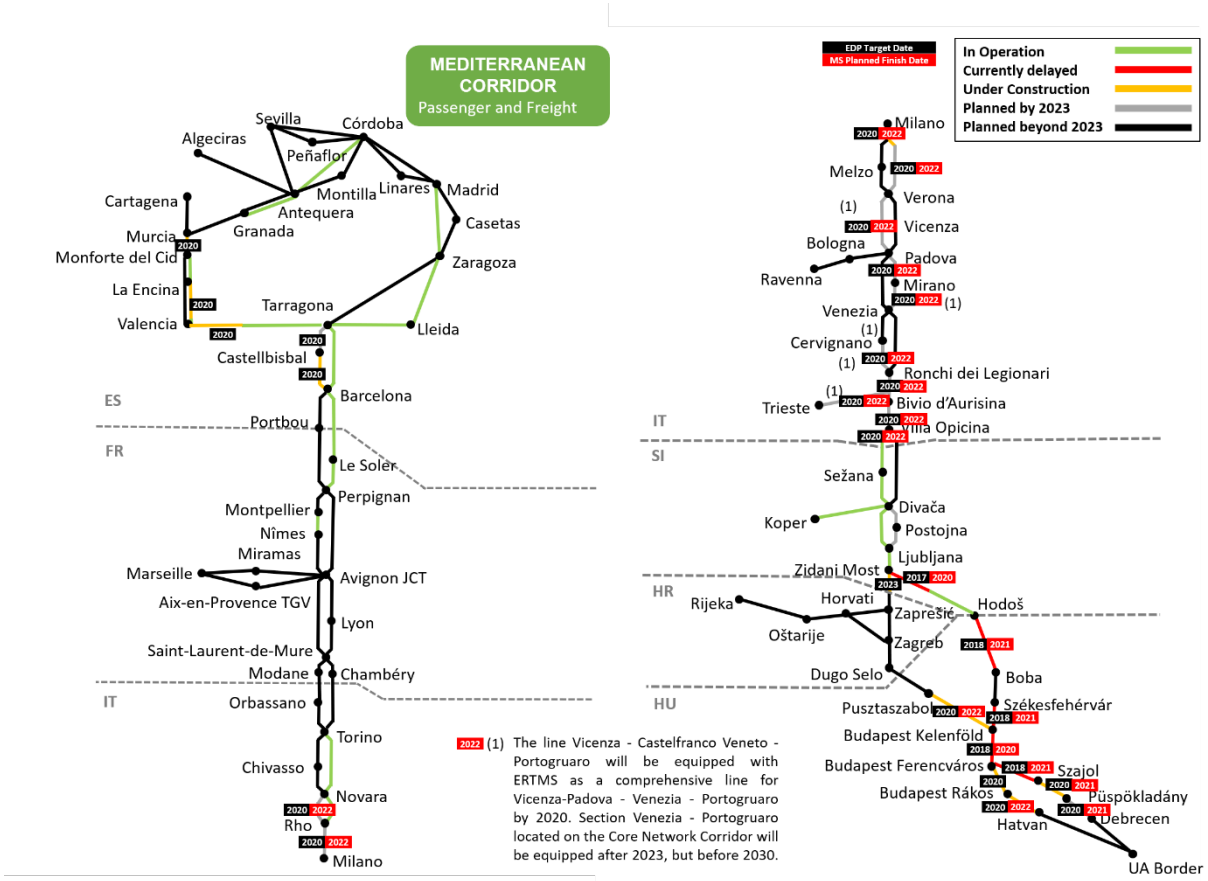

Figure 14 Mediterranean Corridor ERTMS deployment plan

There are 9.375,75 km where ERTMS is foreseen to be deployed in the MED corridor by 2030, with 17% already in operation with ETCS, 45% in operation with GSM-R, 12% under construction with ETCS and in 12% of the length GSM-R is under construction.

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (3.013,67 km), 48% is in operation while 32% is still under construction. The MED corridor has the 32% of its total length planned to be deployed by 2023.

No section is planned to be deployed in Croatia by 2023, and just 2% of the French length of the MED corridor is planned to be put in operation by then (already in operation). Although the most challenging situation is in Spain where 1.520,62 km should be put into operation in the short term. Currently 65% of the planned km by 2023 is in operation so its deployment is progressing well

In Slovenia all the lines to be deployed by 2023 are under construction or already in operation. Ljubljana – Hodos line is delayed from 2017 to 2020 due to infrastructure works. In Hungary none of the sections is in operation yet. Most sections in Hungary to be deployed by 2018 are delayed, due to lack of funding. Some of the existing sections are equipped with ETCS pre-baseline 2 and are going to be upgraded to Baseline 2 Level 2.

North-Sea Baltic Corridor

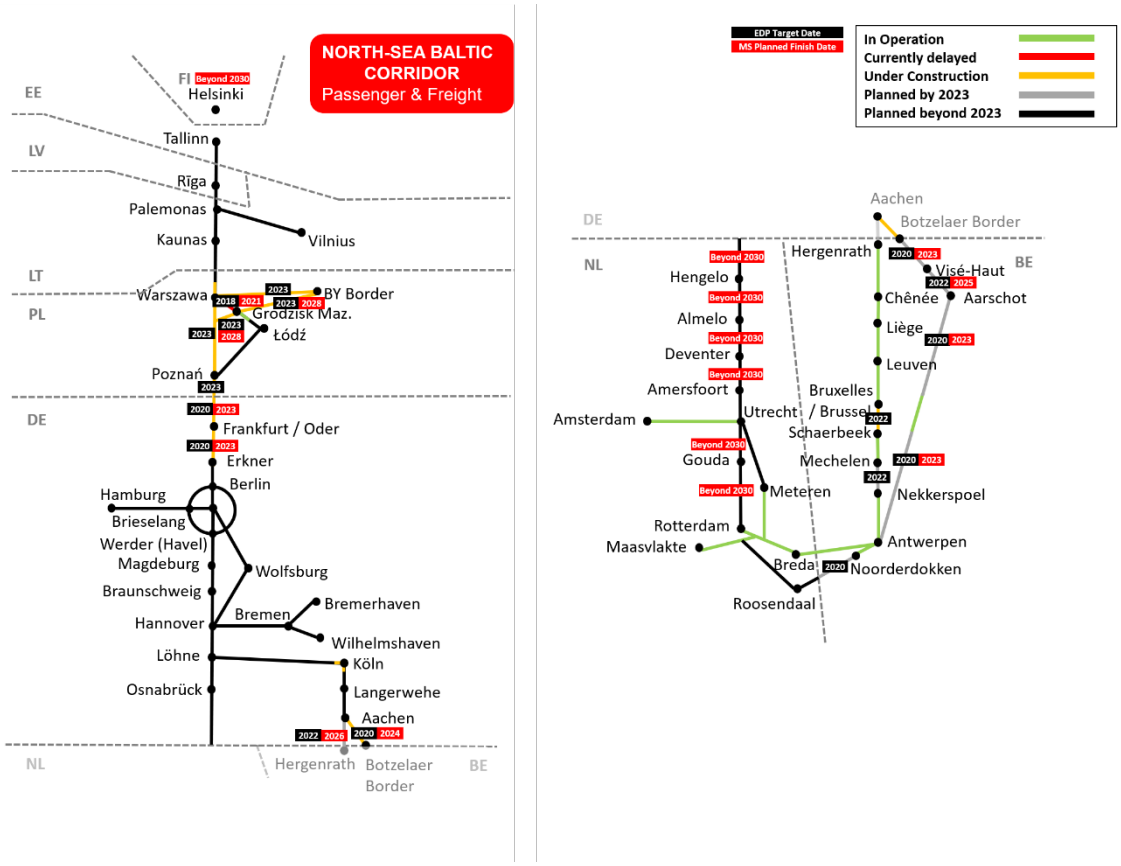

Figure 15 North-Sea Baltic Corridor ERTMS deployment plan

There are 6.189,73 km where ERTMS is foreseen to be deployed in the NSB corridor by 2030, 7% of which are already in operation with ETCS, 72% in operation with GSM-R, 22% under construction with ETCS and in 22% of the length GSM-R is under construction. The ETCS deployment rates are quite low considering the long-term deployment (2030).

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (1.640,39 km), 26% is in operation while 63% is still under construction. The planned ETCS deployment in the NSB, from a short-term point of view, is 27% of its total length.

No section is planned to be deployed in Finland, Estonia, Latvia and Lithuania by 2023. The ongoing design and construction of new 1435 mm gauge Rail Baltica line, aimed to integrate the Estonia, Latvia and Lithuania into the European rail network, foresees deployment of the ERTMS on the entire line. The current project's design guidelines foresee the deployment of the Baseline 3 Level 2 ETCS system, but may be revised, taking into account the latest developments. Decisions regarding the mobile radio communications system will be taken at a later stage of project, when the requirements for FRMCS will be formalised.

In Netherlands all the sections planned to be in operation by 2023 are already in operation. In Poland and Germany, the ETCS rate in operation is low (2% and 0% respectively). The line Warsaw – Grodzisk Mazowiecki in Poland is delayed from 2018 to 2021. On the other hand, Belgium has a good rate of ETCS implementation with 56% of the length planned to be in operation by 2023 already deployed.

North-Sea Mediterranean Corridor

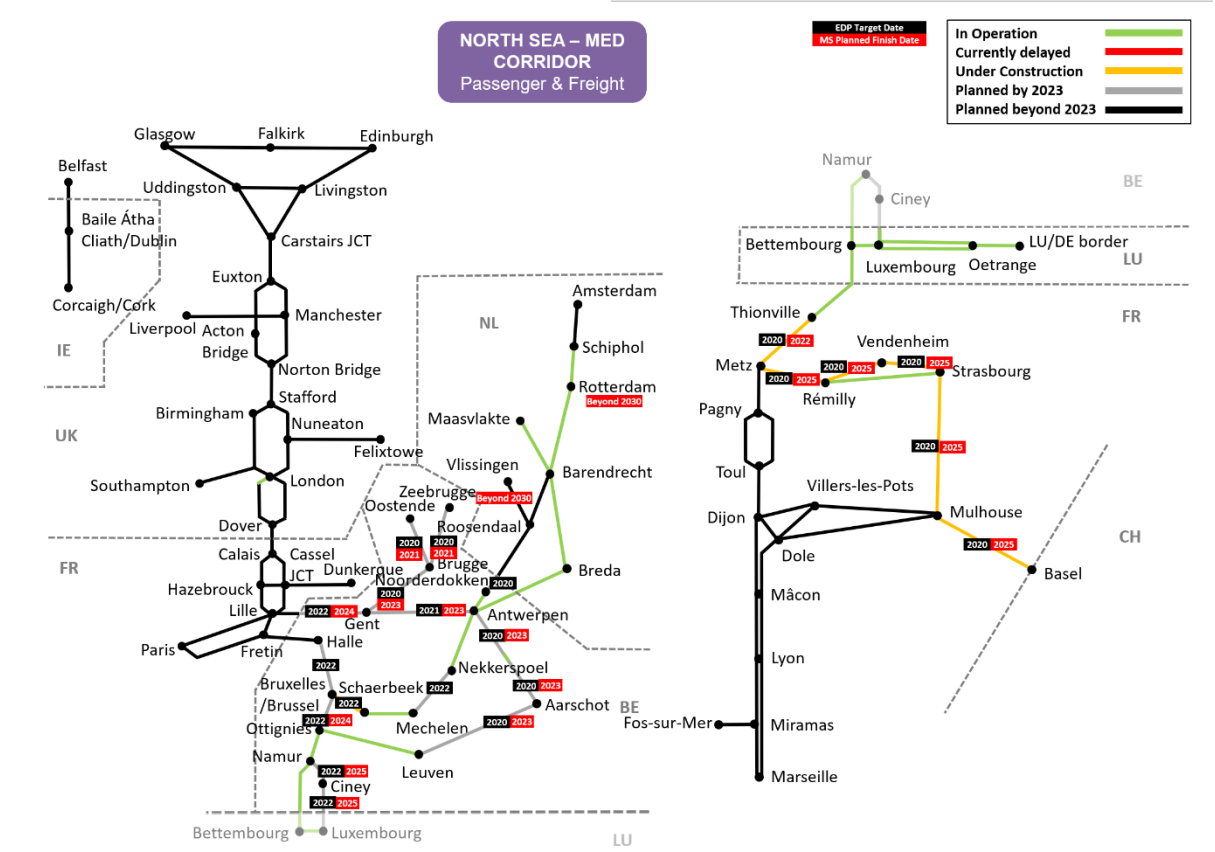

Figure 16 North-Sea Mediterranean Corridor ERTMS deployment plan

There are 6.746,56 km where ERTMS is foreseen to be deployed in the NSM corridor by 2030, 11% of which are already in operation with ETCS, 87% in operation with GSM-R, 5% under construction with ETCS and in 6% of the length GSM-R is under construction. The GSM-R deployment in the NSM is one of the highest in the CNC.

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (1.565,43 km), 49% is in operation while 21% is still under construction. These are good rates relative to the average of the CNC in the short term.

No section is planned to be deployed in Ireland and the UK by 2023, while all the sections planned to be deployed by 2023 in Luxembourg are already in operation.

The percentage of length planned to be operational with ERTMS by 2023 in France that has been already achieved is 29%, but the rest of the lines are under construction.

The short term deployment in Belgium has a rate of 45%.

Orient East-Mediterranean Corridor

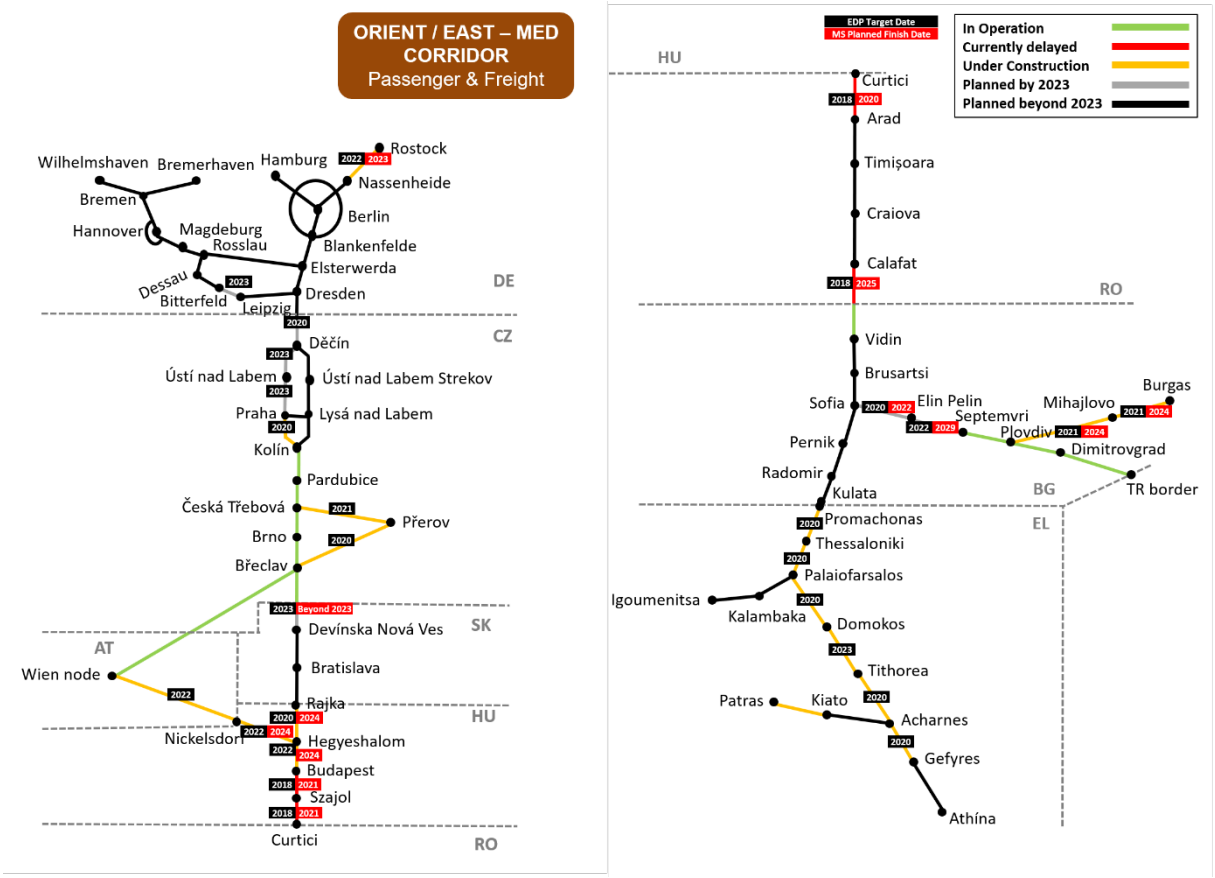

Figure 17 Orient East - Mediterranean Corridor ERTMS deployment plan

There are 5.850,82 km where ERTMS is foreseen to be deployed in the OEM corridor by 2030, 10% of which are already in operation with ETCS, 50% in operation with GSM-R, 34% under construction with ETCS and in 24% of the length GSM-R is under construction. Both the ETCS and GSM-R deployment are quite low considering the long-term (2030).

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (5.850,82 km), 21% is in operation while 67% is still under construction. The percentage to be deployed by 2023 in the OEM is relatively low.

Austria is the most advanced Member State in terms of deployment in the OEM corridor with a 56% of the length to be deployed by 2023 already in operation and the rest under construction. In Romania all the lines to be deployed by 2023 are delayed and no section has been put in operation yet. In Hungary all the sections to be deployed by 2023 are delayed but even with the delay they are planned to be operational by 2023 and in Greece the entire length to be operational by 2023 is under construction. Bulgaria and Czechia are progressing well in the ETCS deployment, with 36% and 42% of their respective lengths planned to be operational by 2023 already in operation. Finally, Slovakia is in the most difficult situation as none of the sections to be deployed by 2023 is under construction. Budapest – Curtici is delayed from 2018 to 2021 or later on the Hungarian side, while Curtici – Arad is also delayed on the Romanian side. RO/BG border - Calafat is also delayed from 2018 to 2025.

Rhine-Alpine Corridor

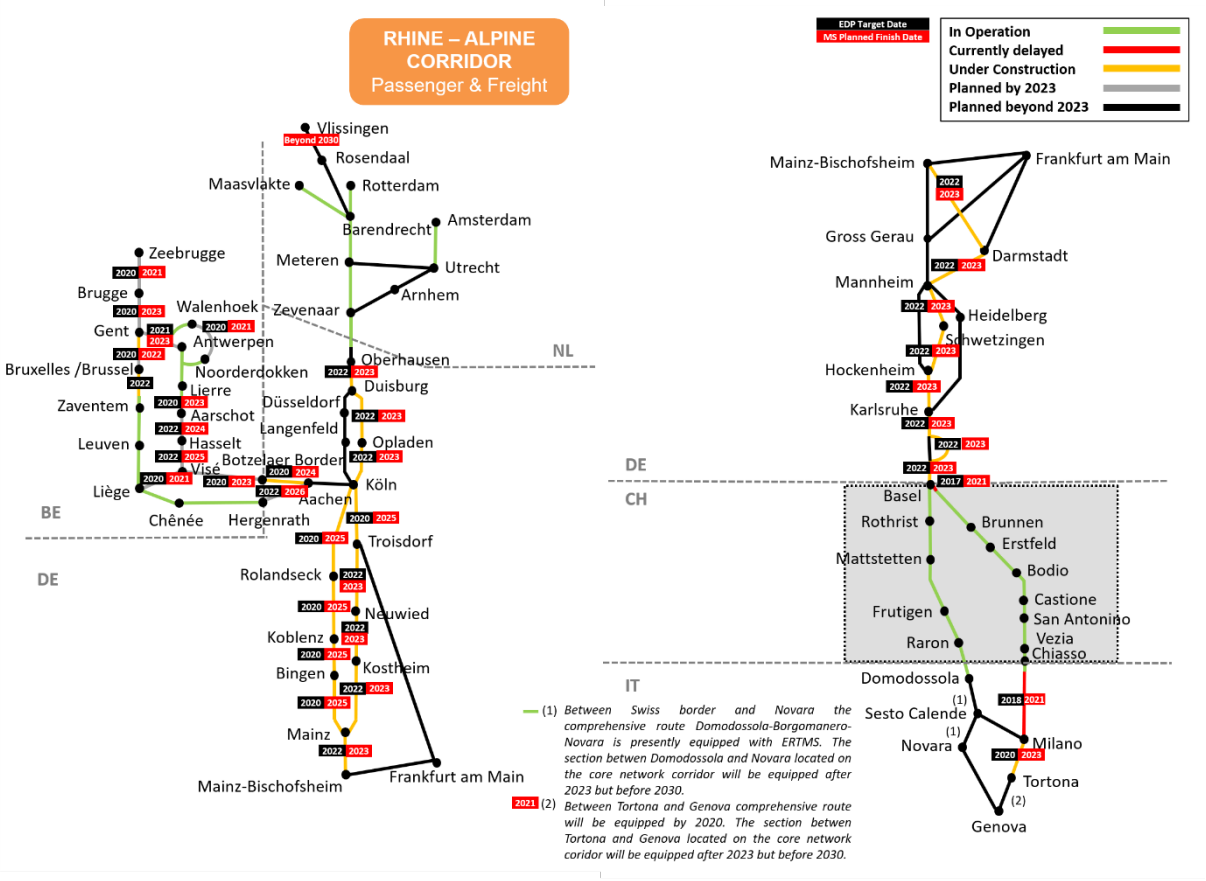

Figure 18 Rhine-Alpine Corridor ERTMS deployment plan

There are 3.457,19 km where ERTMS is foreseen to be deployed in the RALP corridor by 2030, 28% is already in operation with ETCS, 99% is in operation with GSM-R, 27% of the length is under construction with ETCS and in 1% of the length GSM-R is under construction. The GSM-R deployment rate is the highest of the CNC.

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (2.277,71 km), 42% is in operation while 39% is still under construction. The length to be deployed in the short term is over the average (66%) and so it is the ETCS deployment rate in the RALP corridor.

The ETCS deployment of the lines to be operational by 2023 in the Netherlands has been already finished. In Switzerland the short-term deployment (2023) is of 96%, with the remaining 4% under construction.

Belgium has a 34% of the short-term length to be deployed already operational, but only an additional 8% under construction. On the other hand, Germany and Italy have a low ETCS in operation rate (0% and 24% respectively) but 98% and 62% under construction respectively.

Some sections that were foreseen to be already operational are delayed in the RALP corridor. The border between Switzerland and Germany in Basel is delayed. In the Italian/Swiss border, the Milano – Chiasso line is delayed from 2018 to 2021.

Rhine-Danube Corridor

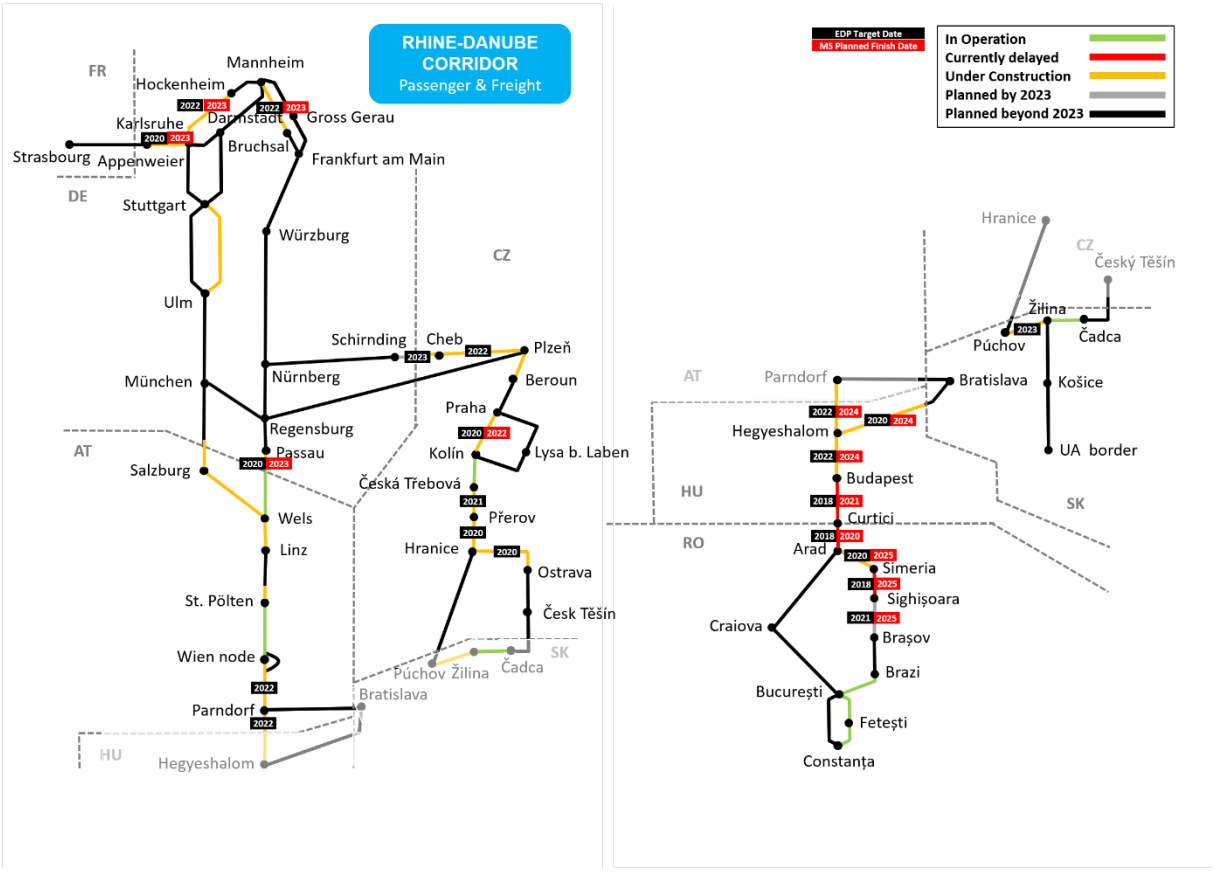

Figure 19 Rhine-Danube Corridor ERTMS deployment plan

There are 5.802,49 km where ERTMS is foreseen to be deployed in the RDN corridor by 2030, 9% is already in operation with ETCS, 52% is in operation with GSM-R, 28% of the length is under construction with ETCS and in 16% of the length GSM-R is under construction. It is the lowest ETCS deployment rate considering the long-term deployment (2030).

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (2.071,25 km), 26% is in operation while 63% is under construction. In the short-term (2023), it is also the lowest ETCS deployment of the CNC.

No section is planned to be deployed in France by 2023. None of the sections planned by 2023 has been put in operation in Germany and Hungary. In Hungary the line from Budapest to Austria and Slovakia is equipped with pre-baseline 2 and not operational. The line between Budapest and Romania border is delayed and some sections (Békéscsaba-RO border) are not under construction. The short-term deployment in Romania is 35% of the whole length by 2023.

Austria and Slovakia are in a good position to meet the 2023 deadline regarding the ETCS deployment (respectively 66% and 43% in operation and most of the remaining length under construction). Czechia has a high length to be deploy by 2023, i.e. 857 km; 23% is in operation and 77 % is under construction. In Romania Curtici – Arad is delayed from 2018 to 2020. In addition, there are delays in the Simeria – Brasov line (from 2018 to 2025) and in the Bucharest – Constanta line (from 2018 to 2025).

Scandinavian- Mediterranean Corridor

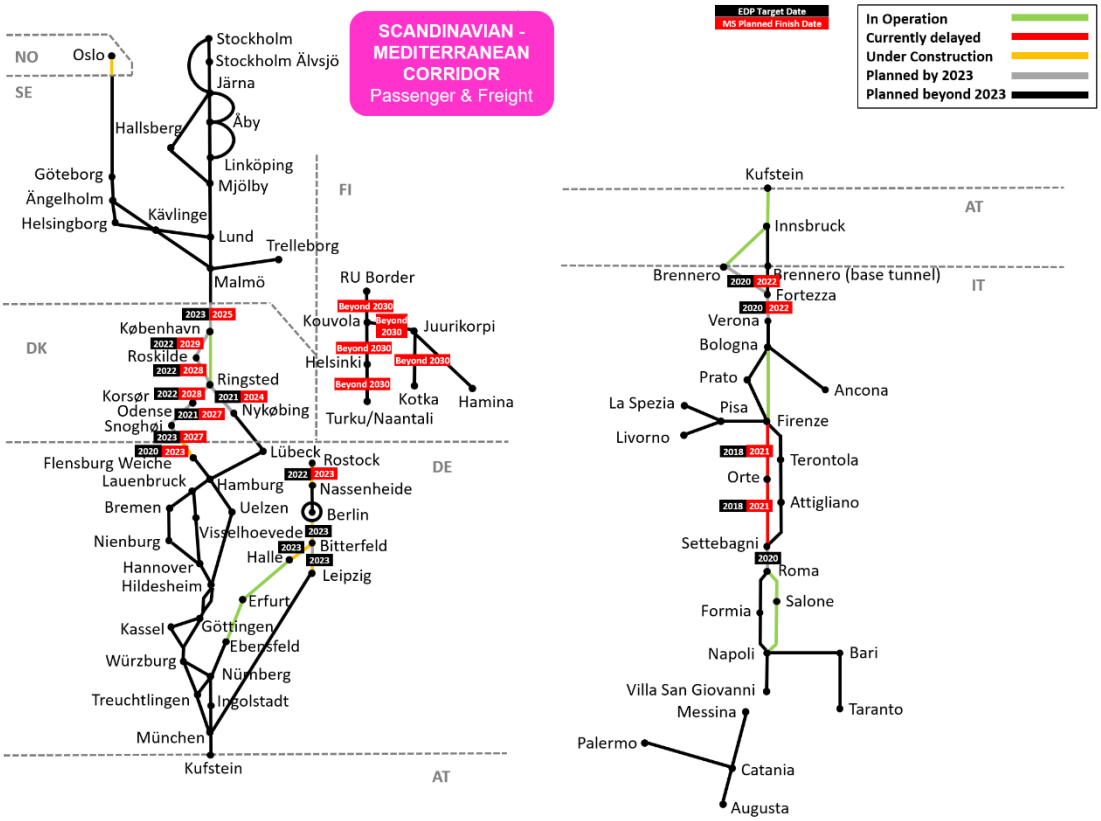

Figure 20 Scandinavian - Mediterranean Corridor ERTMS deployment plan

There are 9.462,74 km where ERTMS is foreseen to be deployed in the SCM corridor by 2030, 7% is already in operation with ETCS, 87% is in operation with GSM-R, 11% of the length is under construction with ETCS. The SCM corridor is the longest of the CNC, and it is concerning how low it is the ETCS deployment rate.

Defining the short term deployment as the length to be deployed by 2023 according to the EDP (1.936,14 km, just a 20% of the total length of the corridor), 33% is in operation while 32% is under construction.

No section in the SCM corridor is planned to be deployed in Finland, Norway and Sweden by 2023. In Austria the short-term ETCS deployment has been achieved. Germany and Italy are progressing well with only a few more sections to be deployed by 2023. In Italy, Firenze – Settebagni section is delayed from 2018 to 2021.

Annex II State of play of ETCS trackside deployment

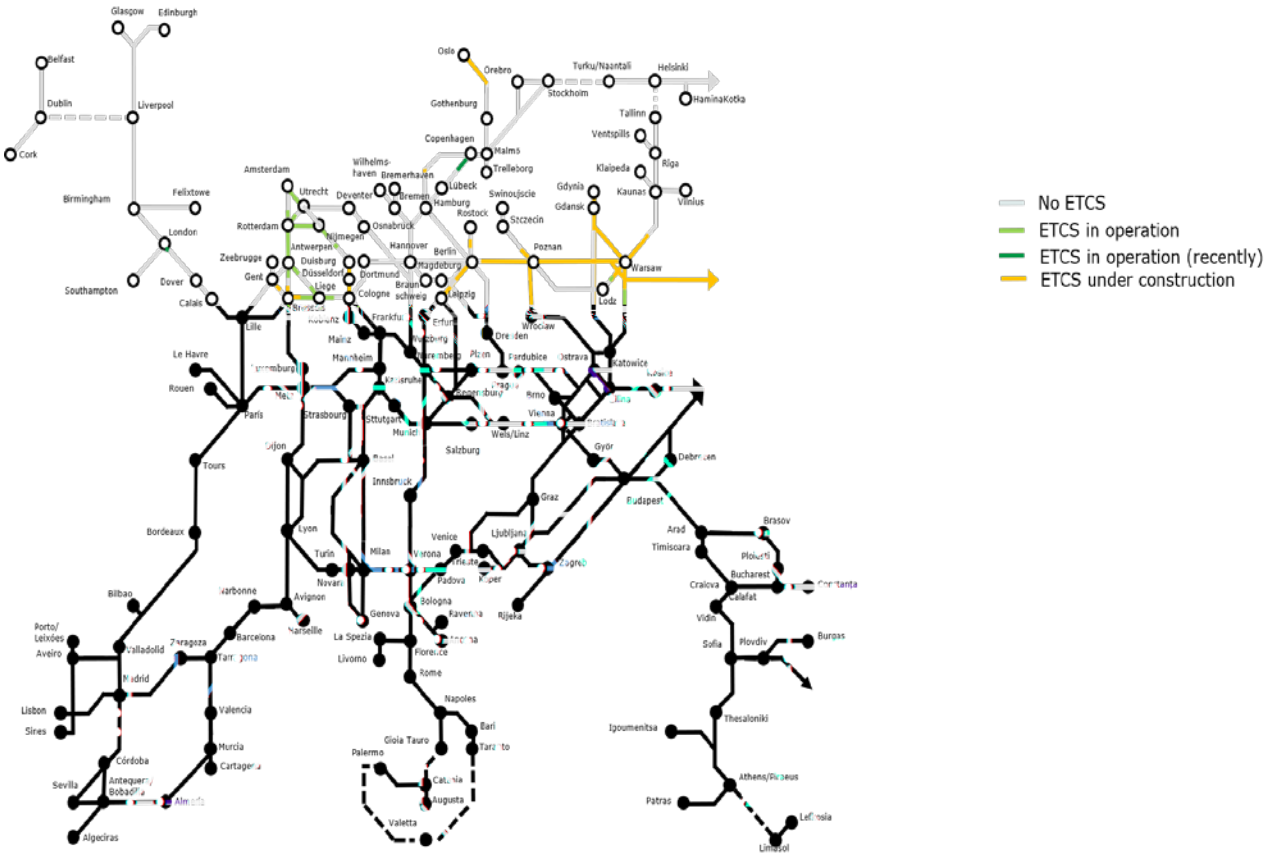

Figure 21 ETCS trackside deployment at EU level in April 2020

Annex III State of play of NIPs

In general, the NIPs give information regarding the deployment dates in each country covered by the EDP.

Austria, Belgium, Czechia, Estonia, Luxembourg, Norway and **Sweden** are fully compliant with EDP and some of the sections will be deployed even before the deadline set.

Croatia, Greece, Italy, Netherlands, Poland, Slovakia, Slovenia, Spain and Switzerland are compliant with the EDP with the following exceptions:

- **Croatia:** The ERTMS deployment will take place beyond 2023 and the upgrade to ERTMS of the existing lines is planned to be finished before 2030. The new line Horvati - Dugo Selo is not included in the "Detailed timetable of the ETCS installation".
- **Greece:** complies with the EDP except for Kalambaka – Igoumenitsa section which is not mentioned.
- **Italy:** The differences compared to EDP are the following ones: Milan area 2021 instead of 2020; Brennero-Verona, Vicenza-Treviso-Portogruaro-Trieste/Villa Opicina and Novara-Padova-Venezia 2022 instead of 2020, and Florence - Rome 2021 instead of 2018. There is a detailed planning for sections beyond 2023.
- **Netherlands:** some sections within the EDP fall out the scope due to the limited budget. These includes some CNC lines like Rotterdam-Utrecht that will be delayed to 2033 or the NSB part from Deventer towards the German border that will be deployed by 2037.
- **Poland**: Compliant with the EDP. All sections but the ones between Lowicz and Pilawa have an estimated date for ETCS in operation equal or earlier than the one set in the EDP.
- **Slovakia**: Sections Devinska Nova Ves-Kuty and Lanzhot-Kuty are delayed till 2030. Also Zilina-Zilina (RRT) is delayed till 2023.
- **Slovenia**: complies with the EDP except for the high-speed line between state border-Sežana-Divača-Ljubljana.
- **Spain**: Some of them are foreseen before the EDP target date (around 120km) and some others are slightly delayed with respect to the EDP (140 km delayed while respecting the 2023 mid-term deadline).
- **Switzerland**: Planning is compliant with the EDP in principle subject to delivering the cross-border sections on time.

Bulgaria, France, Germany, Latvia, Lithuania and Romania are compliant as regards the sections they mention in their Plans but no detailed planning is provided for some sections (mainly beyond 2023 sections):

- **Bulgaria and Romania**: All sections are included in the NIP but without detailed information.
- **France**: Information only covers sections until 2023, these are in line with the EDP. The planning is not complete (around 5.800 km not included in the NIP).
- **Germany:** Partially compliant with the EDP. No detailed planning is specified. Some dates are beyond EDP target dates. There are around 6.450 km not included in the NIP.
- **Lithuania:** plans to deploy ERTMS in section between Kaunas and the Polish border. No additional information is given concerning the rest of the sections belonging to the CNC.
- **Latvia**: no information about the planned ERTMS deployment finish dates. In accordance with NIP the main goal is to maintain full interoperability with the neighbouring countries – Russia, Belarus, Lithuania and Estonia, also having the 1520 mm railways track gauge network ensured by the existing B class system (ALSN). Since the ALSN system provides interoperability on 1520 mm network with neighbouring third countries, any future development of ERTMS on 1520 mm lines shall be done only on the base of coordinated approach and common strategy, in order to preserve the existing interoperability during the transition period.

Finland is not compliant with the EDP as dates go beyond 2030. **Hungary** and **Denmark** are not compliant with the EDP, for most of the sections the NIP shows a delay between one or two years with respect to the EDP for Hungary and between one and five years as regards Denmark. The Danish Signalling Programme shows Denmark's profound and dedicated commitment to replace class B systems with ERTMS by 2030.

Ireland is exempted from mandatory deployment of ERTMS.

Finally, Portugal and the United Kingdom do not give enough details to evaluate the compliance.

- **Portugal**: only 3 TEN-T sections dates are specified. The planning is not complete (e.g. 1200 Km without NIP planning).
- **United Kingdom:** NIP does not detail specific plans or dates about the deployment of ERMTS on the CNC lines.

The following map shows level of compliance between NIP and EDP:

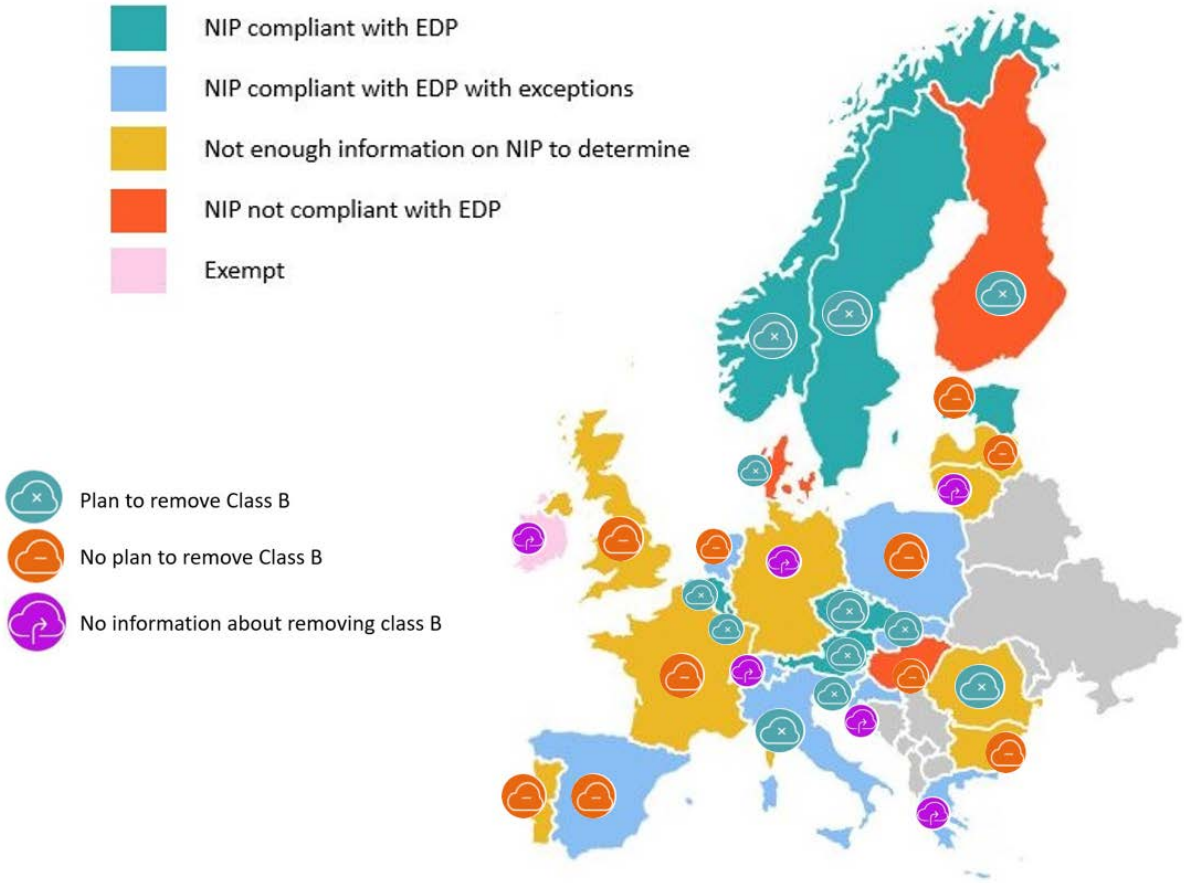

Figure 22 Level of compliance between NIP and EDP

Annex IV State of play of cross-borders

The European Rail Traffic Management System European deployment plan in 2017[30] stipulates in Article 2 (3) that railway infrastructure managers should, after having consulted the railway undertakings affected, sign an agreement on technical and operational aspects of the deployment for each cross-border section. There should be a common effort in cross-border agreements as soon as possible in order to avoid bottlenecks at the operation stage. This should take place not later than one year before the earlier of the deployment dates for the given cross-border section, and Member States should notify such agreements to the Commission not later than one month after the conclusion.

8 cross borders out of the 65 cross-borders defined in the EDP are in operation end 2019 as indicated in Figure 23. Note: a cross-border is considered in operation when both sides of this cross-border are ETCS in operation.

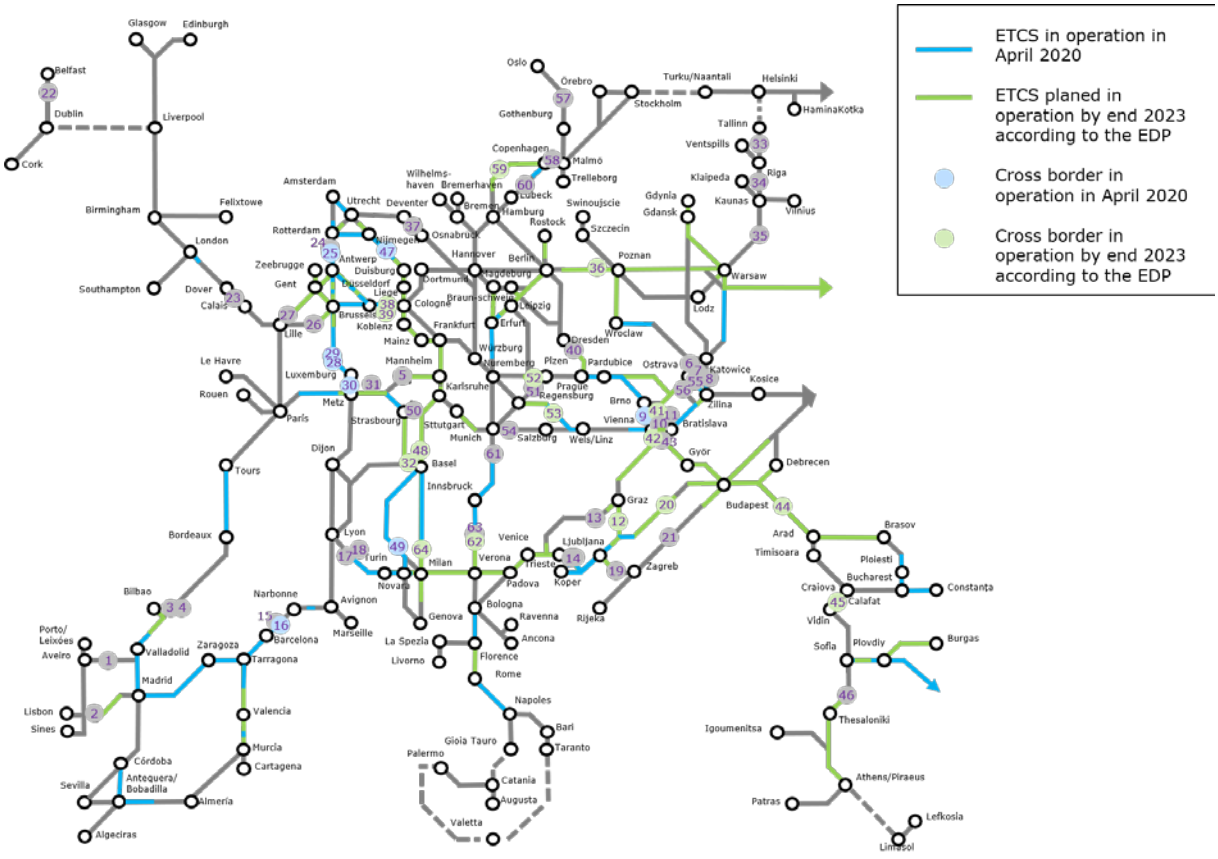

Figure 23 Cross borders status on CNC

By considering that the EDP do not apply retroactively, cross-borders whose agreement date is 2016 or before (i.e. the earlier section of the cross-border is in operation in 2017) are not requested. As a result, none of the 8 cross-border agreements of the cross-borders currently in operation have to be

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

notified to the Commission. However, one cross-borders agreement (i.e. cb49: Raron (CH) – Domodossola (IT)) have been notified.

21 cross border agreements are expected between 2017 and 2022 according to the EDP. At this point in time, 7 cross border agreements have been notified, 5 of them are on the non-expected list (i.e. according to the EDP dates the cb agreement is not expected between 2017 and 2022).

The progress of the cross-border agreement reception is shown in the graph below:

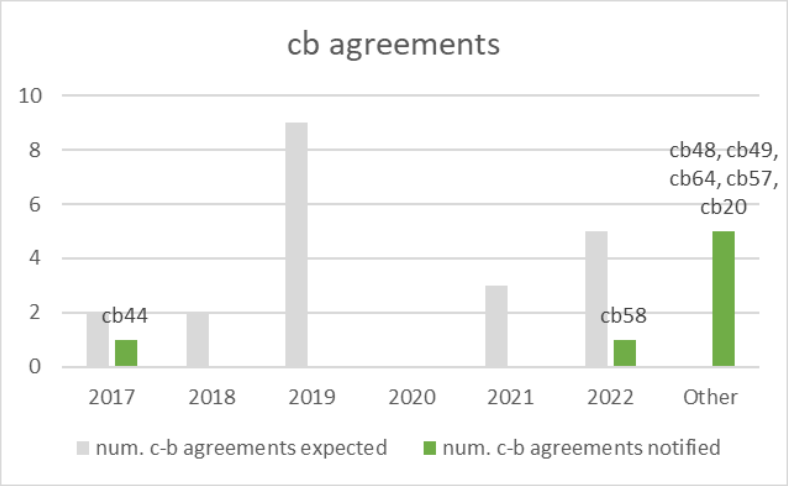

Figure 24 Progress of the cross-border agreement reception

Only one cross-border agreement out of the 13 cross-border agreement expected between 2017 and 2020 have been received. According to information provided by Member States, 6 cross-border sections of these expected agreements will be delayed until 2021, 2022 or 2023.

The following figure shows the cross-border agreements status on CNC:

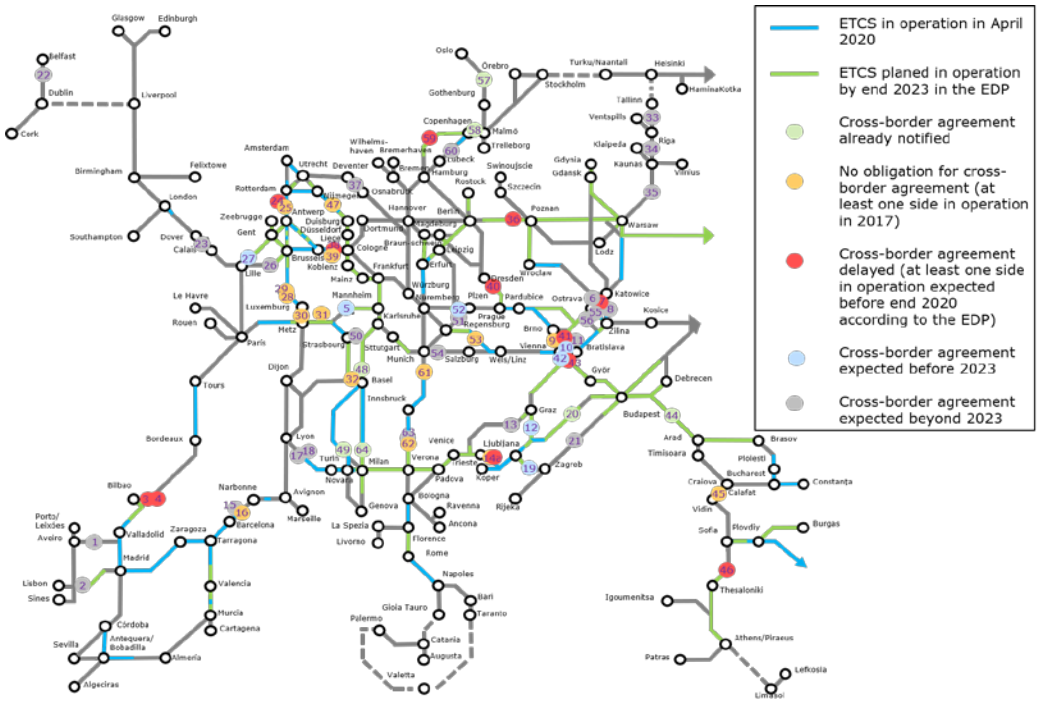

Figure 25 Cross border agreements status on CNC

Annex V Cost estimation

The European Commission commissioned the DMT to draw up cost estimation for ERTMS deployment until 2050. This assessment is based on the assumptions adopted for the Business Case study. It is estimated that almost EUR 10 billion are needed to finalise the deployment of ERTMS trackside on the CNC.

Corridor	Overall ERTMS track-side deployment costs (M€)		
	2015-2020	2021-2030	Total
Total	**2 125,1**	**8 813,5**	**10 938,6**
RDN	257,7	870,2	**1 127,9**
MED	418,4	1 523,0	**1 941,4**
ATL	186,1	1 988,5	**2 174,6**
OEM	312,1	434,2	**746,3**
BAC	190,1	471,3	**661,4**
NSB	121,5	589,8	**711,3**
SCM	214,5	1 617,7	**1 832,2**
RALP	253,9	256,3	**510,2**
NSM	170,9	1 062,4	**1 233,4**

Table 3 Overall ERTMS track-side investment costs (MEUR) - CNC lines per Corridor

An estimate has been also conducted for deployment costs on both the Core and Comprehensive Networks. For sections outside the Core Network, it has been assumed that they would be deployed after 2030. Results are shown in the table below:

Network	Overall ERTMS track-side deployment costs (M€) 2015-2020	2021-2030	2031-2050	Total
Comprehensive Network to be considered for ERTMS deployment			**23 573**	**23 573**
Core Network	**2 125**	**11 580**		**13 705**
Core Corridors	*2 125*	*8 814*		*10 939*
Total core + comprehensive network	**2 125**	**11 580**	**23 573**	**37 278**

Table 4 Overall ERTMS track-side investment costs (MEUR) - Core Corridors, Core Network and Comprehensive Network

According to infrastructure managers, in many instances additional investments are needed to effectively deploy ERTMS such as: new track circuits, upgrade of the interfaces of the existing interlockings or replacement of old interlockings (including buildings) or cabling from interlockings to the trackside equipment. Therefore, it is assumed that the total cost to deploy ERTMS can be increased by 100% to 200% as low and high estimate respectively. The table below presents ERTMS track-side investment costs including associated costs for the whole Core Network. Track-side costs per km can be different in each country, as the mix between level 1 and level 2 can vary significantly depending on the existing infrastructure, experience of the authorities or labour costs.

Member state	Overall ERTMS track-side deployment costs 2015-2050 including associated works Low estimate	High estimate
Total comprehensive network (excl. core network)	**47 145,2**	**70 717,8**
Total core network	**27 410,2**	**41 115,2**

Table 5 ERTMS track-side investment costs incl. associated costs (MEUR) – Comprehensive and Core Network

Furthermore, the DMT carried out an assessment of costs related to the retrofitting of the rolling stock. The table below presents the split between freight, passenger trains and the split between conventional and high speed:

Type of rolling stock	ERTMS on-board retrofitting costs (M€) 2021-2030
Total	**4 774,2**
Freight	1 032,2
Passenger (conventional)	3 514,5
Passenger (high-speed)	227,5

Table 6 ERTMS investment costs for retrofitting – split between freight & passenger trains

The rough estimate of the total ERTMS deployment costs, including associated costs, is in the range between EUR 80 billion and EUR 115 billion. The rolling stock retrofitting and upgrade costs account for some 5% of the total costs.

	Overall ERTMS deployment, including associated costs (bn€)	
	Low estimate	High estimate
Track-side - comprehensive network excl. core network	47,1	70,7
Track-side - core network	27,4	41,1
Sub-total track-side	74,6	111,8
On-board (retrofit & upgrades)	5,0	5,0
Total	**79,6**	**116,8**

Table 7 Overall ERTMS investment costs including associated costs for the core network and the comprehensive

Annex VI Examples of national schemes addressing the challenge of retrofitting

1. Norway

Norway made the decision to implement ERTMS Level 2 on its national railway network with a view to implementing the new signalling system on the main railway lines and Oslo by 2030.

Key facts

Type of support	National grant
Time period	2016 - 2021
Total grant	EUR 133.8 million (NOK 1.3 billion) [31]
Unit support	Maximum 50% of the eligible costs, with a maximum of: NOK 5 million (EUR 502.720) per first of class installation; NOK 2 million (EUR 201.088) per serial installation
Fleet	412 vehicles of approximately 35 different types

The total cost of the deployment of ERTMS is estimated to be between EUR 1.7 and EUR 2.2 billion, of which the Norwegian government approved NOK 6 billion (EUR 750 million) for the period 2014-2023 in the national transportation plan. The Norwegian implementation plan is not based on EU subsidies. The aid scheme supports 50% of eligible costs up to a maximum amount of NOK 5 million (EUR 502.720) per first of class installation and NOK 2 million (EUR 201.088) per serial installation.[32] The aid under the scheme cannot be combined with other forms of public/government aid or other forms of Community financing, if such aid would result in rail vehicle owners receiving a higher level of aid than 50% of the eligible costs.[33]

Description of the framework

The implementation of ERTMS would require the fitting of around 550 vehicles of approximately 56 different types. All vehicles will also be provided with Specific Transmission Module (STM) units. However, since railway interoperability already exists between Norway and Sweden, Norway's implementation of ERTMS will be synchronized with the Swedish one.

Norway has decided to assist railway undertakings (RU) in the project with a Financial Aid Scheme (FAS) for which the Norwegian Railway Directorate is responsible and which is funded on the basis of the Parliaments' annual budget decisions. The Railway Directorate has in turn delegated the

[31] Investment in European Rail Traffic Management System, EFTA Surveillance Authority Decision https://www.eftasurv.int/cms/sites/default/files/documents/decision-063-16-COL.pdf

[32] Rate of exchange used: reference date 13/12/2018 1 EUR = 9.94588 NOK

[33] Financial Aid Scheme for ERTMS Onboard Implementation – Jernbanedirektoratet approved as State aid by the EFTA Surveillance Authority with Decision 2016/C 357/09 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:E2016C0929(01)&from=LV

management and administration to Bane NOR, that leads the procurement and coordinates the implementation of ERTMS onboard.

Bane NOR has entered into an on-board agreement with a single provider of ERTMS on-board equipment (Alstom), selected on the basis of an open tender procedure, and leads development, tests and approval of the generic application of the on-board system. The generic application is a system version that fulfils the Bane NOR requirements and can be adapted to different vehicle types. This leads to economic efficiencies and enables deployment of ERTMS. The contract currently signed covers retrofitting of 374 trains, worth NOK 665 million (EUR 66 million). Bane NOR has entered into "Cooperation Agreements" with each participating rolling stock owners (RSO) (currently 14 RSOs are involved)[34], to regulate roles and responsibilities and the intention to execute a joint acquisition led by Bane NOR. The RSOs remain responsible for purchasing the necessary Specific Applications to retrofit their fleet within the foreseen time schedule. Therefore, each RSO needs to sign a separate contract, "Specific Onboard contract", with Alstom to cover their specific scope.

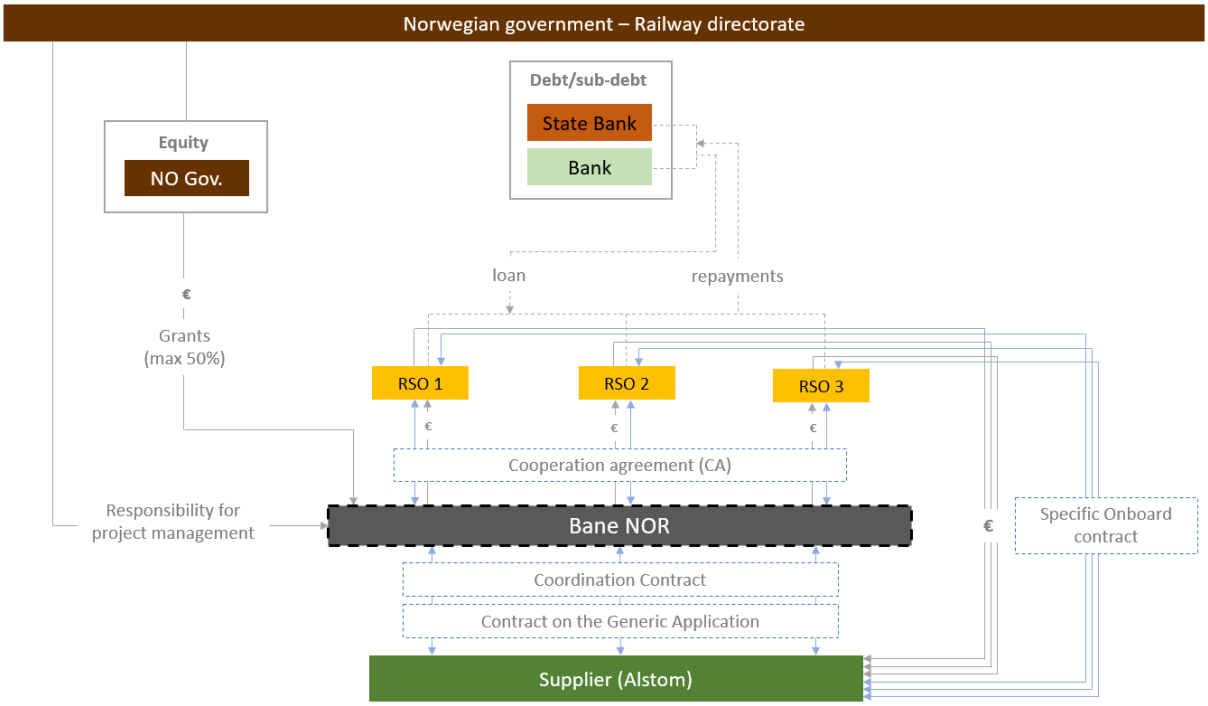

Figure 26 Norwegian financial scheme

In order to be eligible for the Financial Aid Scheme, both passenger and/or freight RSOs will have to meet the below criteria:

- Own vehicles that operate on the Norwegian railway network (operated on the Norwegian national railway network during 2016);
- Have signed a Cooperation Agreement with Bane NOR;
- Have signed the Onboard Contract with the supplier of ERTMS Onboard equipment.

[34] https://www.banenor.no/Prosjekter/prosjekter/ertms/innhold/2018/alstom-to-deliver-ertms-onboard-equipment/

2. The Netherlands

The Netherlands decided to roll-out ERTMS Level 2 Baseline 3 as sole signalling system on most of the entire network (track-side). As a result, both passenger and freight locomotives will have to be upgraded under this scheme. The track-side upgrade and on-board deployment for the passenger fleet is fully state funded.

Key facts

Type of support	CEF Blending: - CEF Blending Call grant: 45% - Bank loan by BNG guaranteed by the Dutch Ministry: 35% - National grant: 20%
Time scheme	2018-2023
Total budget	EUR 17.74 million EUR 6.07 million
Unit support	45% of the eligible costs
Fleet	44 freight vehicles 55 TRAXX Multiple System freight locomotives of 3 different types

The Dutch scheme relies on CEF Blending Call grants (covering roughly 45% of the eligible costs), a bank loan by Bank Nederlandse Gemeented (BNG) guaranteed by the Dutch Ministry (35%), a Ministry grant covering 20% of the total project cost and own contribution of the rolling stock owners. Two CEF blending grants are currently in action: the scheme 2017-NL-TM-0046-W (EUR 17.74 million[35]) and the scheme 2017-NL-TM-0101W (EUR 6.07 million[36]). The Actions cover the upgrade of ERTMS/ETCS on-board units components to Baseline 3 (B3) on 44 freight vehicles (including 8 prototype upgrades and 36 serial upgrades) of various types already equipped with ETCS Level 1 and Level 2, Baseline 2 and the upgrade to Baseline 3 of the ERTMS/ETCS on-board unit components of 55 Bombardier TRAXX Multiple System cross-border freight locomotives of 3 different types. The scope and costs related to STMs are not covered by the Action.

The amount granted by the Ministry, through the Dutch Enterprise Agency (RVO), is capped on a yearly basis. The maximum budget available for ERTMS grants was EUR 15 million in 2018, while in 2019 this was EUR 10 million. The Ministry confirmed that the maximum budget avilable for ERTMS during 2020 up to 2022 will be EUR 59.3 million[37].

In November 2019, the EC approved, under EU State aid rules, EUR 22.2 million of public support by the Dutch government to upgrade 99 cross-border freight locomotives to ERTMS Baseline 3. The support will take the form of direct grants from the government to the owners of the locomotives, to

[35] https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2017-nl-tm-0046-w
[36] https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2017-nl-tm-0101-w
[37] Subsidieregeling ERTMS – 07/02/2019 – Overheid - https://wetten.overheid.nl/BWBR0041878/2019-02-07

be used for the prototyping and serial upgrades of the equipment. This will be further complemented by grants for a total of EUR 23.8 million financed through the Connecting Europe Facility. [38]

Description of the framework

In the current scheme the Ministry of Infrastructure Management acts as an applicant and beneficiary of the CEF Call, concluding a CEF grant agreement with INEA. The Ministry is also the guarantor of an amount of debt taken by RSOs, in accordance with cooperation agreements.

In addition, the Ministry is contributing in-kind with the program Project Management Team for which PRORail has been appointed. This team develops terms of reference for the framework agreement, negotiates and manages framework agreements between owners and suppliers to achieve scale effects and provides technical support for ERTMS installation. The Project Management Team is responsible for the management on an operational level, as well as for the technical organisation of the project such as coordination of international and national procedures and requirements (ERTMS specification, testing and authorisation, system engineering, safety management, etc.). After consultation with the suppliers, RSOs develop their budget for the ERTMS deployment, and every RSO signs a framework agreement, developed by the Project Management Team, with a supplier. The cooperation of multiple RSOs and the Project Management Team results in the reduction of costs and economies of scale.

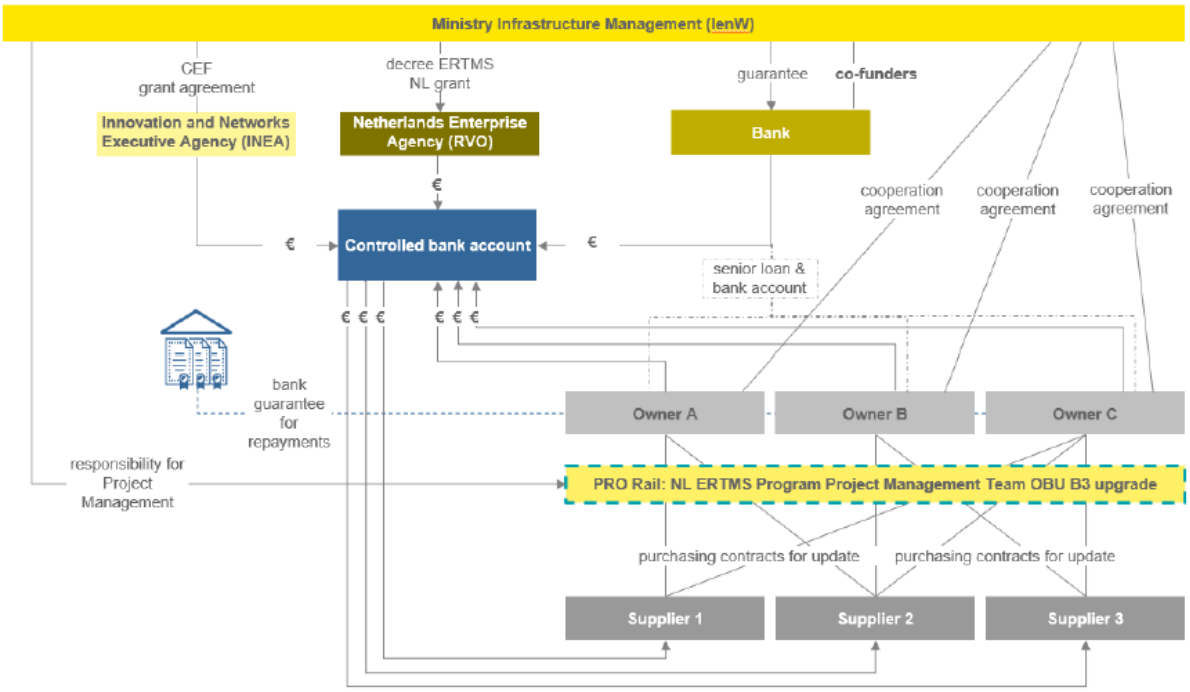

Figure 27 Dutch financing scheme (Source: Dutch ERTMS programme)

[38] Commission Decision not to raise objections to State aid, case SA.55451 (November 2019) https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_55451

The core feature of the Dutch model is the postponed repayment, of the capital borrowed by the RSOs, according to the deadlines of the ERTMS deployment track-side. In fact, rolling stock owners are financially supported in their capital investiture of one-off ERTMS upgrade while being allowed to pay-back only once they can start to actually use the system and enjoy the relevant benefits. The repayment by RSOs was initially planned in 2023, 2024 and 2026 in tranches and will only start once the trackside installation is operational. However, since the track-side implementation is already delayed, this causes concern regarding the repayment of debt. Deadlines have been amended, the locomotives should be equipped by 2023, the last portion of the track by 2031.

3. Denmark

Denmark concluded that the national system in place was obsolete. As a result, Denmark was the first country in the EU who decided to roll out ERTMS (Level 2, Baseline 3) across the whole state-owned railway network.

Key Facts

Type of support	National grant
Time period	2017–2020
Total grant	DKK 55 million (EUR 7 million)
Unit support	Max 50% of the eligible costs with a maximum of: DKK 1.2 million/unit (EUR 160 739) for the prototypes of freight locomotives; DKK 0.5 million/unit (EUR 66 975) for the following freight locomotives in the same series
Fleet	up to 30 locomotives (Estimated by the Danish authorities) [39]

The total budget for the full duration of the scheme is DKK 55 million (EUR 7 million)[40], with a maximum compensation of DKK 1.2 million per unit (EUR 160 739) for the first freight locomotives, whereas a maximum compensation of DKK 0.5 million (EUR 66 975) per unit will apply to the following freight locomotives in the same series[41]. Cost of purchase and installation of Danish STM is eligible up to 100%. Costs for the purchase and installation of ETCS equipment up to 50%, however the total compensation cannot exceed 50% of the total direct costs of purchasing and installation of ETCS and Danish STM.

Description of the framework

In order to facilitate the implementation of ERTMS, a scheme for partial compensation of rail freight operators' investments in on-board ERTMS equipment has been approved by the EC in 2017. The beneficiaries will be the RUs, regardless whether the locomotive concerned is owned or leased by the operator. Compensations are granted in an open, transparent and non-discriminatory manner. The financial scheme, funded by the Danish Government, makes use of direct grants to eligible freight operations from Denmark's national rail Infrastructure Manager (Rail Net Denmark Banedanmark), a government agency that reports to the Danish Ministry of Transport and Housing.

Existing freight RUs with freight locomotives that have driven 50.000 train km or 5.000 operational hours over the last five years are eligible but obliged to continue this operation in the following five-

[39] Rate of exchange: reference date 13/12/2018 1 EUR = 7.46550 DKK

[40] State Aid SA.38283 (2015/N) – Denmark – Scheme for partial compensation of rail freight operators' investments in on-board ERTMS equipment – July, 2017
https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_38283

year period. New railway undertakings must document that beneficiary locomotives will drive the required number of kilometres/hours as stated above, plus a funding guarantee is required.

Apart from the financial aid scheme where a 50% state aid for freight RUs is provided by Denmark, a different set-up for passenger RUs is foreseen, a leasing scheme whereby Banedanmark purchases OBU and leases them to passenger RUs. In the case of DSB (Danske Statsbaner), the national train operating company, the leasing fee is 0 EUR[42].

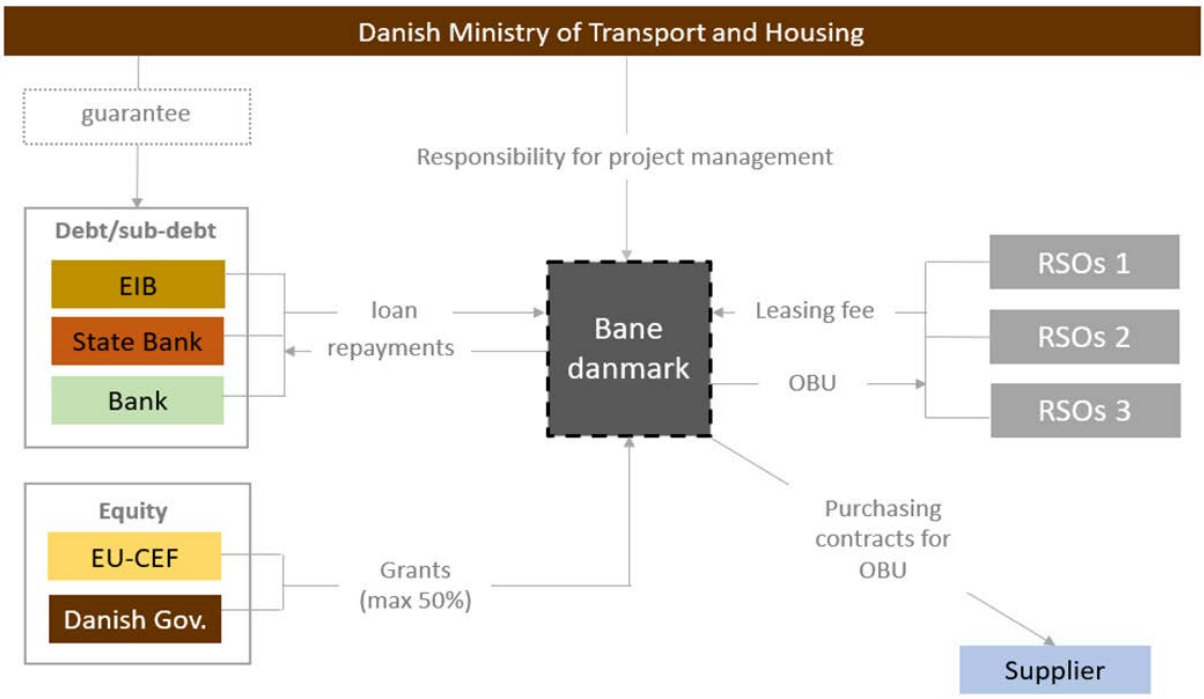

Figure 28 Danish financing scheme

Note that Denmark received a CEF grants for onboard ERTMS deployment in 2015. Below an overview of CEF funded onboard ERTMS deployment project.

Project:	**Period**	**CEF Funding**	**% funded**
2014-DK-TM-0300-W *Retrofitment of vehicles with ERTMS baseline 3 - level 2* Retrofitting of 6 DSB IC3, 14 DSB MQ, 8 Nordjyske Jernbaner's Desiro (hereafter Jernbaner´s) and 31 ARRIVA Lint41 train units with ETCS Level 2, Baseline 3, including a prototype for each unit type	07/2015 - 12/2019	4.96 M€	50%

[42] Interview conducted on 21/06/2019 with members of the DK ERTMS Programme

4. Czechia

Under the TEN-T regulation[43], Czechia will have to implement ERTMS on Corridor E and the European freight corridors RFC 5 (Baltic Sea–Adriatic Sea), RFC 7 (East-Mediterranean into which the original Corridor E has been integrated), and RFC 9 (Czech–Slovak corridor). These lines targeted for ERTMS development represent approximately 26% of the whole Czech network. Czechia aims to have ERTMS implemented on at least 1,200 km of lines and 950 vehicles by the end of 2023. In order to achieve this, Czechia is partly funding the ERTMS deployment.

Key Facts

Type of support	National grant
Time period	First stage: 2009-2013 Second stage: 2017-2022
Total grant	First stage: CZK 1 billion (EUR 39 million) Second stage: CZK 3.4 billion (EUR 134 million)
Unit support	Maximum 50% of the eligible costs 100% for SZDC (except for sub-programmes 3 & 5)
Fleet	Approximately 1200 rail vehicles will be equipped with ETCS by 2022. (under the 2nd stage)

The total amount of state aid approved by the Commission for Czechia amounts up to 4.4 billion CZK (EUR 173 million) [44], covered in two different State Aid schemes.

The first scheme, State aid SA 35948, started in 2009 with an initial duration of 5 years. The Commission approved a request for prolongation till the end of 2013[45]. The overall budget under this scheme, CZK 1 billion (EUR 39 million)[46], remained unchanged. Note that 85 % of this scheme is from the Cohesion Fund and 15% from the Czech state budget.

Next to the initial scheme, another state aid scheme, SA.44621 "Individual subprograms for ensuring interoperability in railway transport", was approved in 2017 to ensure interoperability in railway transport. The notified scheme aims at achieving interoperability through five sub-programmes with a total financial volume of aid of CZK 2.5 billion (EUR 97 million), and annually CZK 500 million (EUR 19 million), financed from the Cohesion Fund.[47] The duration of the scheme is from the beginning of 2017 until the end of December 2021. The duration and financial volume of this scheme has been amended by the state aid scheme SA.55861 (2019/N), in which the timeframe prolonged

[43] Regulation of the European Parliament and of the Council (EU) No 1315/2013
[44] Rate of exchange: reference date 13/12/2018 1 EUR = 25.7067 CZK
[45] State aid SA 35948 (2012/N) December 2012 – Czech Republic - Prolongation of the interoperability scheme in railway transport (ex N 469/2008)
https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_35948
[46] Rate of exchange: reference date 13/12/2018 1 EUR = 25.7067 CZK
[47] State aid SA.44621 (2016/N) – Czech Republic – Individual subprograms for ensuring interoperability in railway transport. April 2017
https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_44621

until the 31st of December and an increase in the budget of CZK 3.4 billion (approximately EUR 134 million), and annually CZK 500 million (approximately EUR 20 million).[48]

Description of the framework

Fitting of vehicles with on-board ETCS will be supported by the state by combining two basic tools:

- funding of purchase and installation of on-board ETCS to RUs and primarily covered from EU funds (basic measure);
- granting a discount on the charge for the use of railway infrastructure (complementary measure).[49]

All RSOs, who have rolling stock operating in Czechia will be able to benefit from this aid in a non-discriminatory way. The scheme benefits both licensed rail transport undertakings (passenger and freight for sub-programmes 1-4, only freight for Sub-programme 5) and the railway Infrastructure Manager SŽDC, which is a state entity in order to upgrade the rail network. In order to apply for grants, individual calls are published for several sub-programmes separately or together. The conditions, duration and the amount of funds to be shared out (broken down by sub-programme) will be duly published on the contractor's website, including all required content.

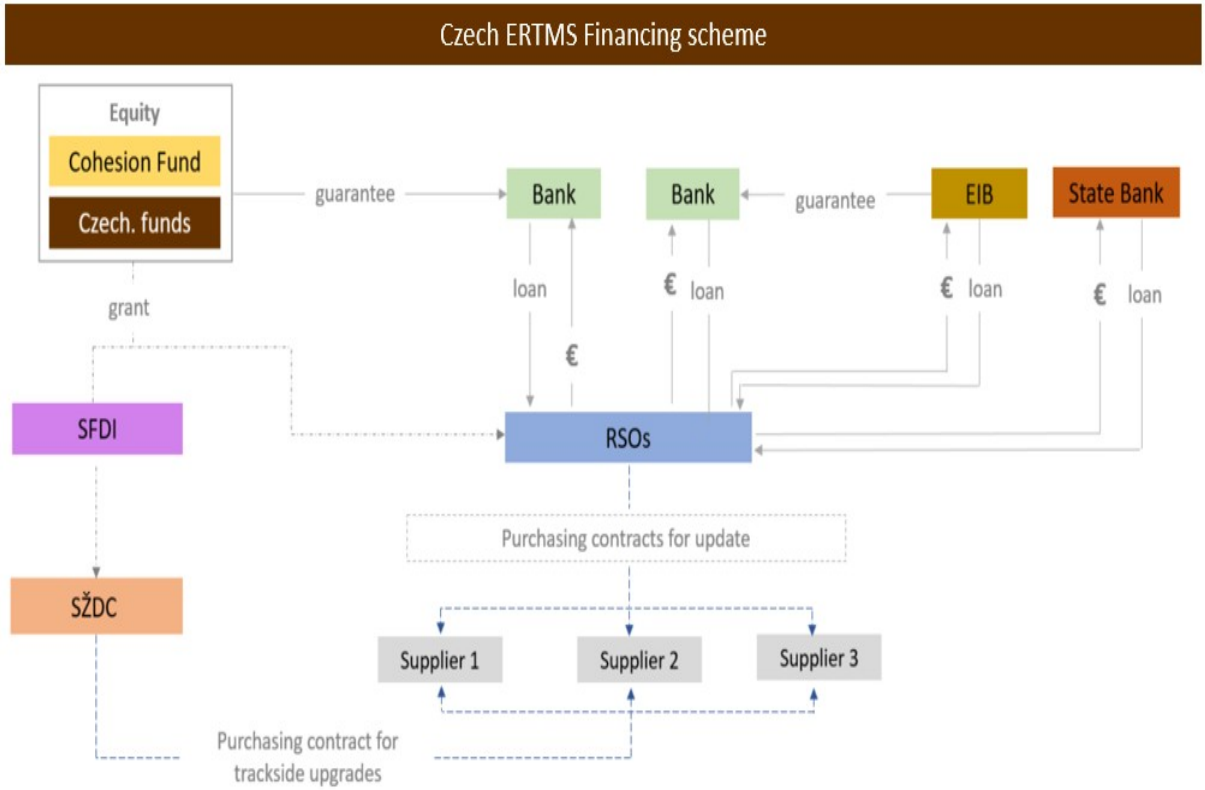

Figure 29 Czech financing scheme

[48] State aid SA.55861 (2019/N) – Czech Republic – CZ ERTMS Prolongation. February 2020 https://ec.europa.eu/competition/state_aid/cases1/202013/283390_2142283_100_2.pdf

[49] National Implementation Plan ERTMS – Czech Republic - 2017

Below an overview of the main CEF funded projects related to the on-board ERTMS deployment of Czechia.

Project:	Period	CEF Funding	% funded
2015-CZ-TM-0057-W *Deployment of ERTMS/ETCS onboard components compliant with ETCS Baseline 3 in ČD CARGO, a.s. vehicles on the Rail Freight/Core Network Corridors* 128 ČDC vehicles (3 prototypes + 125 vehicles) will be fully interoperable for smooth international cooperation.	03/2017 - 12/2022	27.5 M€	85%
2015-CZ-TM-0136-W *Deployment of ERTMS/ETCS onboard components compliant with Baseline 3 in ČESKÉ DRÁHY* Update of 99 vehicles of ČD (4prototypes and 95 retrofits), circulating on the Orient/East-Med, Rhine-Danube and Baltic-Adriatic Core Network Corridors (CNC)	04/2017 - 12/2022	21.2 M€	85%
2016-CZ-TMC-0293-W *ERTMS in RegioJet* On-board equipment of 9 locomotives Type Škoda 162 from RegioJet a.s. with ERTMS/ETCS Level 2, Baseline 3, so that these can seamlessly operate within Czechia, over the Rhine–Danube and the Orient/East-Med corridors into Slovakia before end of 2020, and later to Poland over the Baltic–Adriatic corridor.	01/2018 - 12/2020	2.1 M€	85%

Annex VII Evolution of ERTMS

In the 1980 first discussions took place between European railways on a harmonised approach to train management systems in Europe. Research projects were launched by the European Communities and implemented by stakeholders. The 1996 EC Directive on interoperability for high speed rail[50] introduced the concept of an interoperable control and command system and signalling and defined the characteristics of ERTMS, albeit limited to high speed rail.

At the end of 1990, a group of infrastructure managers with common interests (ERTMS Users' Group) created the initial version of ERTMS as we know it, with the aim of demonstrating the feasibility of railway interoperability. At the outset, the ERTMS User Group (EUG) consisted only of experts from infrastructure managers, but they detected relatively quickly the need to involve the signalling suppliers in the finalisation of the ERTMS technical specifications. The organisation of signalling companies, i.e. UNISIG, produced the first ERTMS technical specifications in 2000.

It was in 2002 when the European Commission included the ERTMS specifications in the control command and signalling technical specifications for interoperability of the trans-European high-speed rail system[51]. Afterwards, in 2006 the first control command and signalling technical specifications for interoperability of the trans-European conventional rail system[52] were issued by the European Commission. Only in 2012 the command and signalling technical specifications for interoperability[53] were merged covering from this moment on both the high speed and conventional railways.

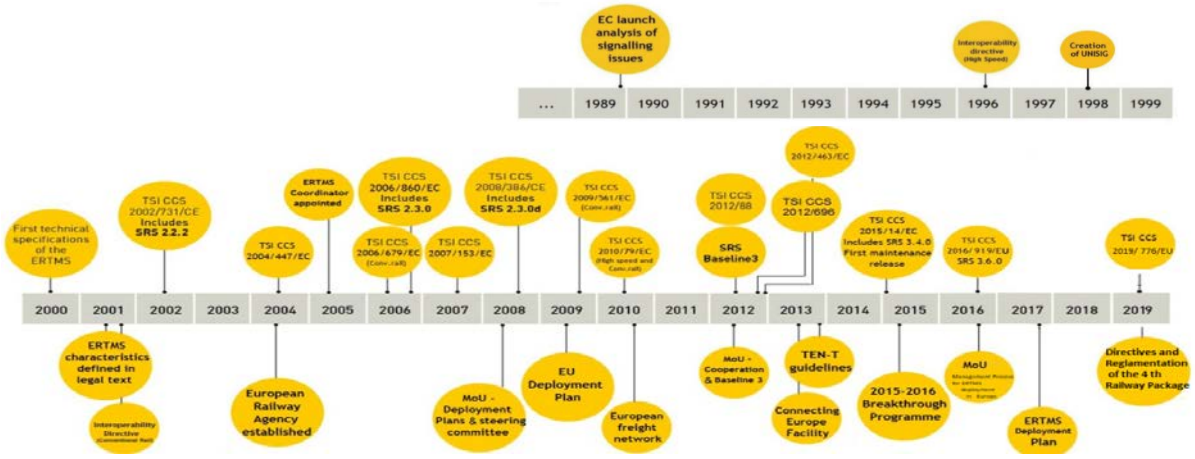

Figure 30 ERTMS milestone timeline

[50] Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system

[51] Commission Decision 2002/731/EC of 30 May 2002 concerning the technical specification for interoperability relating to the control-command and signalling subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Council Directive 96/48/EC

[52] Commission Decision 2006/679/EC of 28 March 2006 concerning the technical specification for interoperability relating to the control-command and signalling subsystem of the trans-European conventional rail system

[53] Commission Decision 2012/88/EU of 25 January 2012 on the technical specification for interoperability relating to the control-command and signalling subsystems of the trans-European rail system

In 2005, the sector produced the first ERTMS Memorandum of Understanding (MoU) focused on deployment strategies. In order to facilitate the implementation of that MoU, also in 2005, the European Commission appointed Karel Vinck as the first European Coordinator for ERTMS.

Three other MoUs have followed that first MoU, each addressing the main challenges at the given stage. The last MoU adopted in 2016 established a framework providing a legal and technical certainty for a train equipped with the latest ERTMS release to run on any compatible line equipped with ERTMS.

Throughout these years of ERTMS development, the technical specifications have included two different Baselines, i.e. two stable kernels of system functionality, performance and other non-functional characteristics. The first reference version of the system was Baseline 2. In 2015 the revised CCS TSI[54] included additional functions to the system kernel that is referred to as Baseline 3 maintenance release 1. Then, in 2016 Baseline 3 release 2 was issued with the inclusion of GPRS in the GSM-R specification.

Significant steps have been taken in recent years to address core issues relating to the achievement of an interoperable rail system based on ERTMS:

- **Fourth Railway Package:** The technical pillar of the Fourth Railway Package provides for important changes concerning ERTMS. It enhances the role of the European Union Agency for Railways (ERA) as the ERTMS system authority. The set of measures introduced by the Fourth Railway Package, and the 2019 revision to the CCS TSI[55] enables more efficient authorisation processes and leads to enhanced interoperability and compatibility between on-board and trackside subsystem. On the basis of the Fourth Railway Package, ERA is in charge of issuing vehicle authorisations and safety certificates in the European Union, as well as pre-authorising ERTMS trackside equipment. The Member States (MS) are obliged to transpose the technical pillar of the Fourth Railway Package by 16 June 2019, or if notified to the Commission and the ERA, by 16 June 2020[56].

- **Stability of specification:** The Baseline 3 release 2 is considered functionally complete and has been stable since 2016. It is maintained by the ERA Change Control Management (CCM) process that addresses backward compatibility and protection of investments.

- **The ERTMS European Deployment Plan (EDP):** EDP lays down target dates until 2023 by which time about 30-40% of the Core Network Corridors should be equipped.

[54] Commission Decision (EU) 2015/14 of 5 January 2015 amending Decision 2012/88/EU on the technical specification for interoperability relating to the control-command and signalling subsystems of the trans-European rail system

[55] 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

[56] The following Member States transposed the technical pillar of the Fourth Railway Package by 16 June 2019: Bulgaria, Finland, France, Greece, Italy, The Netherlands, Romania and Slovenia. On 20 May 2020, following the Covid-19 crisis, the EP and Council adopted a Directive amending Directives (EU)2016/797 and (EU)2016/798, as regards the extension of their transposition periods prolonging the transition period (in this case until 31 October 2020).

- **ERTMS: The way ahead, (Action plan):** The Action plan sets out the steps beyond the legislative framework to address challenges to interoperable deployment.

Annex VIII CEF supported ERTMS Actions' portfolio managed by INEA

Overall, grant agreements for CEF support to 76 ERTMS-related actions were signed so far under the general and cohesion CEF envelopes, including:

- 58 actions under dedicated ERTMS calls. These calls aimed predominantly at the ERTMS deployment, but covered also additional necessary works such as interlockings' modernisation. The initial CEF assistance amounted in total to EUR 1.3 billion, including EUR 1 billion for ERTMS deployment only.
- 18 actions under the calls aimed at general Core Network Corridors (CNC). These calls addressed predominantly railway infrastructure works, but covered, among others, the deployment of ERTMS through so-called "combined" actions encompassing both rail and ERTMS infrastructure. The initial CEF assistance for these actions amounted in total to EUR 3.7 billion, including EUR 121.6 million for ERTMS deployment only.

By May 2020, the actual CEF supported portfolio of actions with ERTMS component consists of:

- 49 actions under dedicated ERTMS calls with a total CEF assistance amounting to EUR 957.3 million, including EUR 747.5 million for ERTMS deployment only.
- 11 "combined" actions under the CNC calls with a total CEF funding of EUR 2.6 billion, including EUR 55.4 million for ERTMS deployment only.

The decrease in number of respective actions and related CEF funding is due to the termination or modification of the signed grant agreements, resulting in reduction or cancellation of CEF support for ERTMS activities.

The actions contribute predominantly to the ERTMS deployment and cover following activities: i) track-side or on-board ERTMS installation and ii) Memorandum of Understanding (MoU) tasks.

In the period 2014-2019 the following areas of intervention were the three principal ERTMS priorities receiving CEF support:

1. ERTMS **track-side** deployment, including:
    a. **Retrofit**, i.e. first installation of ERTMS on a railway line already in operation
    b. **Upgrade**, i.e. equipment of the legally binding baseline on a railway line already in operation and equipped with ERTMS compliant with a previous baseline.
    c. **Preparatory actions**, i.e. activities preparing ERTMS deployment. The outcome of preparatory actions is a basis for launching a tendering procedure for ERTMS works.
2. ERTMS **on-board** deployment, including:
    a. **Retrofit:** i.e. first installation of ERTMS on existing vehicles.
    b. **Upgrade:** i.e. installation of ERTMS Baseline 3 on existing vehicles equipped with pre-Baseline 3.

c. **Training activities:** i.e. specific ad-hoc expertise to assist beneficiaries being small and medium-sized enterprises (SME).

3. **Memorandum of Understanding** (MoU): activities, contributing to the fulfilment of MoUs signed between the European Commission and the railway sector. Related activities covered in particular test campaigns (both in field and in laboratories), assistance to ERA regarding development and maintenance of ERTMS specifications. The MoU actions were only eligible under 2014 dedicated ERTMS call.

Figure 31 shows that a total of 38 actions contribute to track-side deployment (including studies), 20 actions to on-board deployment and 2 actions to MoU. The bulk of CEF funding, EUR 564.8 million (70%), is allocated to track-side, while the funding for on-board amounts to EUR 232.4 million (29%). Activities related to MoU received EUR 5.7 million (1%) from CEF.

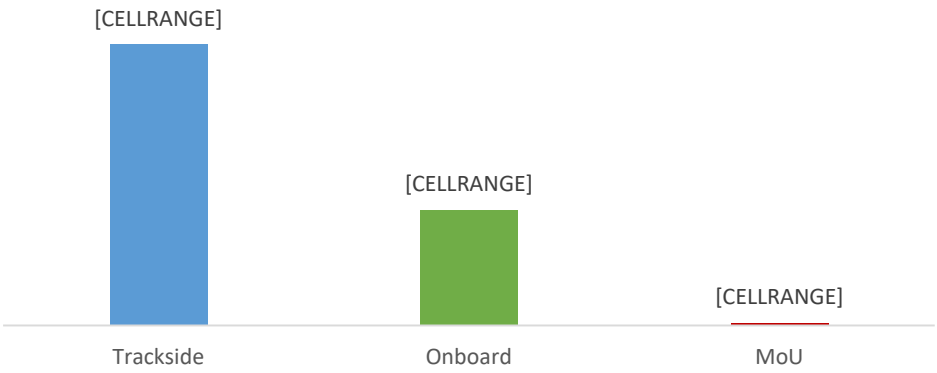

Figure 31: Actual CEF Transport funding for ERTMS Actions per component, EUR million (number of actions)

As far as the **trackside** is concerned, 38 actions help deploying ERTMS (first deployment and upgrade, including studies) on a total of **6,382 km** of double-track lines equivalent, with the following breakdown between first deployment and upgrade:

1. First deployment along lines (5,497 km, 86%)
2. Upgrade of already equipped lines (885 km, 14%)

As far as the **on-board** component is concerned, 20 actions will contribute to the deployment of ERTMS on a total of **1,927 vehicles**, classified as follows:

1. retrofitting (1,418, i.e. 74%)
2. upgrade (448, i.e. 23%)
3. prototype (61, i.e. 3%, both for retrofit and upgrade).

Figure 32 shows the actual distribution of CEF Transport grants at Member State level. A difference in the funding strategy between the involved Member States can be noted. Whereas Bulgaria, Germany, Denmark, Greece, France, Italy, Poland, Portugal and Slovenia concentrate on track-side deployment, Spain, Finland, Luxembourg, the Netherlands, Sweden and Slovakia focus on on-board

deployment. At the same time Belgium, Czechia and Hungary adopted a more balanced approach. Considerable parts of MoU activities are implemented within multi-beneficiary actions gathering stakeholders from different Member States.

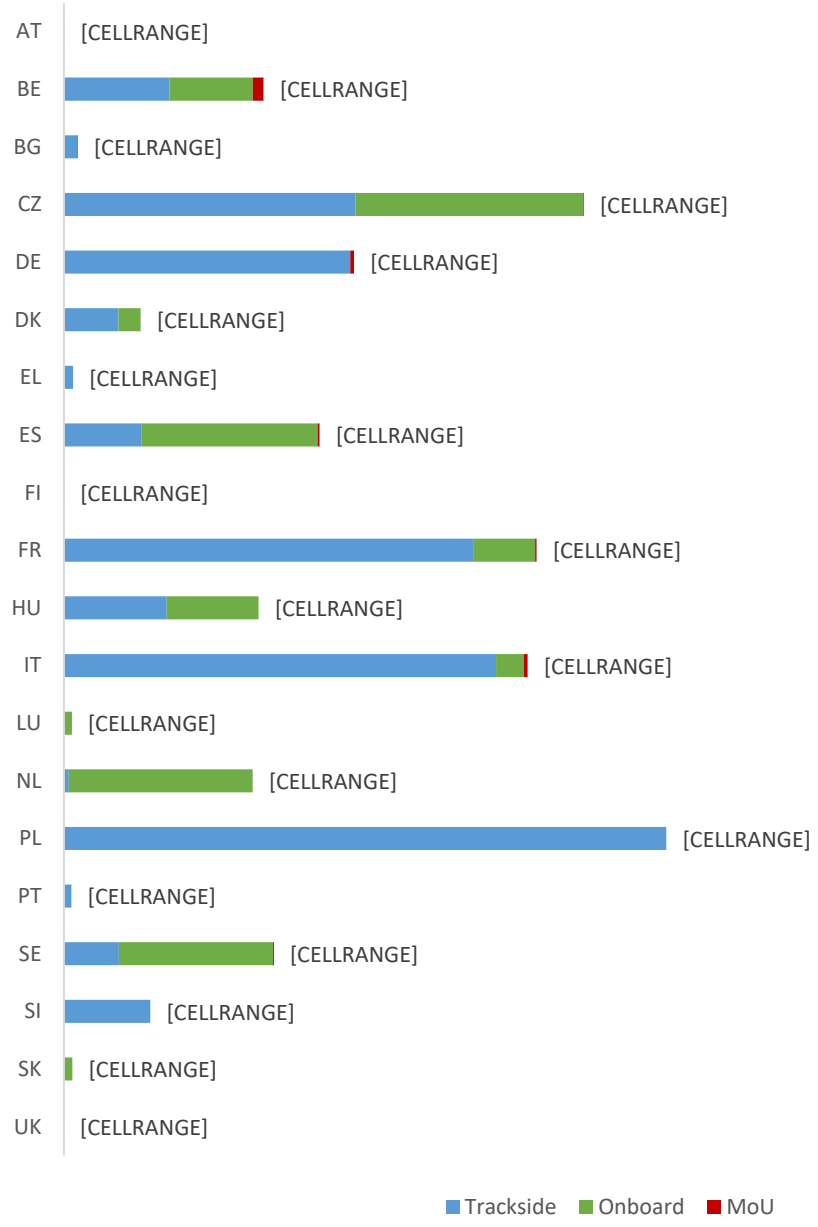

Figure 32: Actual CEF Transport ERTMS funding per Member State and component, EUR million (number of actions)

Annex IX Glossary

- **ERTMS - what is it about and how does it work?**

ERTMS is a system contributing to interoperable railways throughout Europe. It allows a train equipped with an ERTMS on-board device produced by any supplier to run on track sections equipped with ERTMS devices made by other suppliers. This also implies the ability for any on-board equipment installed on any train to behave in exactly the same way in the same circumstances.

ERTMS refers to two systems:

- The ETCS (European Train Control System), a train control standard, based on on-board equipment able to supervise train movements at all times and to stop the train if the permitted speed is exceeded. Information to the cab is received from the trackside ETCS equipment, eurobalises or radio, depending on the level. The driver's response is continuously monitored, and, if necessary, ETCS takes control and activates the emergency brakes.
- GSM-R (Global System for Mobile Communications - Railways) is the second ERTMS system, the European radio communications standard for railway operations. Based on GSM radio technology, GSM-R uses exclusive frequency bands to communicate the train with traffic control centres and the trackside devices (Radio Block Centers (RBCs))

- **ERTMS - Set of Specifications and Baselines**

A Set of Specifications is a set of documents of different files versions as laid down in the TSI CCS, i.e. the specifications of many aspects, components, interfaces, etc. concerning ERTMS architecture. Each Set of Specifications is built of both an ETCS Baseline and a GSM-R Baseline.

A Baseline is defined by a stable kernel in terms of system functionalities. New baseline implies significant changes to the kernel by changing existing ones or adding new functionalities. Baselines evolution should be backwards compatible, i.e. on-boards compliant with a newer Baselines can run on a trackside compliant with an older Baseline.

- **ETCS - System Versions**

The System Version is a concept of the ETCS system that refers to the version of the ETCS language in the information exchanged between both trackside and on-board subsystems (i.e. packets, telegrams and messages).

The System Version identifies the functionalities available to be used by these subsystems.

- **ETCS - Levels**

The level is a basic concept of the ETCS system. A short definition can be given as follows:

Level 1 involves continuous supervision of train movement (i.e. the on-board computer is continuously supervising the maximum permitted speed and calculating the braking curve to the end of movement authority) with a non-continuous communication between train and trackside, normally by means of eurobalises. Lineside signals are necessary and train detection and train integrity (i.e. that the train is complete and has not been accidentally split) is performed by the trackside equipment out of the scope of ERTMS.

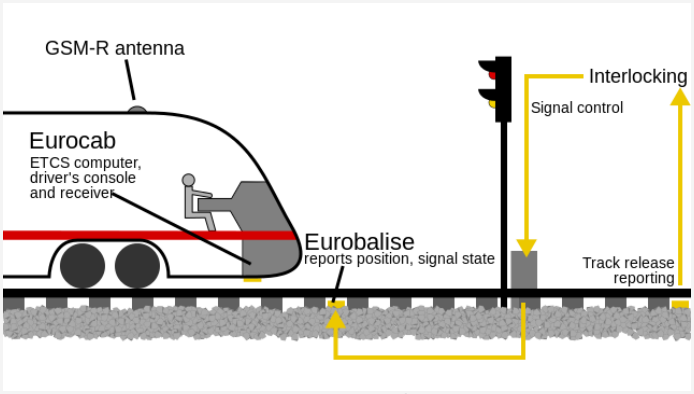

Figure 33 Level 1

Level 2 involves continuous supervision of train movement with continuous communication via GSM-R between the train and trackside. Lineside signals are optional in this case, and train detection and train integrity is performed by the trackside equipment out of the scope of ERTMS.

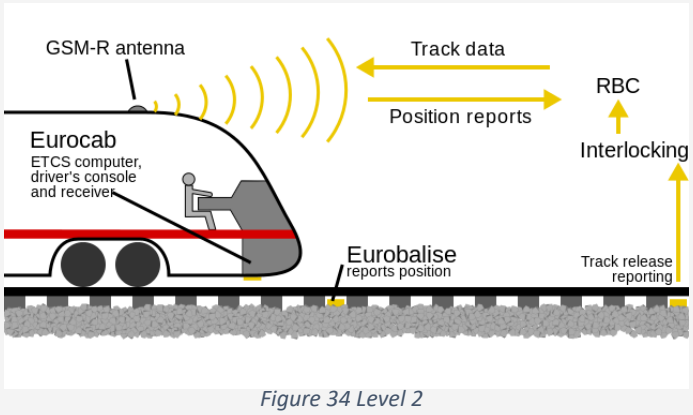

Figure 34 Level 2

Level 3 involves continuous train supervision with continuous communication between the train and trackside. The main difference with level 2 is that the train location and integrity is managed within the scope of the ERTMS system, i.e. there is no need for lineside signals or train detection systems on the trackside other than eurobalises. Train integrity is supervised by the train.

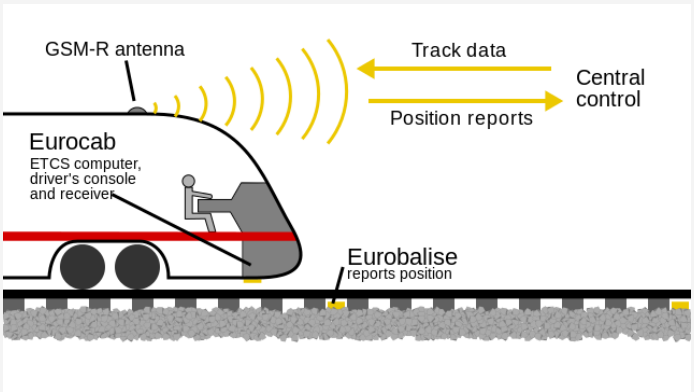

Figure 35 Level 3

In addition, there are two more levels defined: **Level 0**, which applies to trains equipped with ETCS running on non-equipped lines; and **Level STM**, which is meant for trains equipped with ETCS running on lines where the class B system needs to be operated. Regarding the STM level, the ETCS acts as an interface between the driver and the national ATP.

ETCS - Modes

Operation modes can be defined as conditions required for managing different situations regarding the status of the trackside and the train itself. Unlike the ETCS levels (associated with train-trackside communication), ETCS modes are related to the operational circumstances of the line or the on-board equipment status.

The main ETCS mode is Full supervision. The ERTMS/ETCS on-board equipment will be in Full Supervision mode when all train and track data, which is required for complete supervision of the train, is available on-board. In this mode, the on-board ERTMS/ETCS equipment is responsible for train protection (ensuring always that the maximum permitted speed and the end of movement authority are not overpassed).

There are also modes related to specific information that the trackside ERTMS/ETCS subsystem is able to send, for example the Limited Supervision mode enables the train to be operated in areas where trackside information can be supplied to carry out background supervision of the train. In contrast to Full Supervision, in this mode the information is simplified and the driver is the responsible of the train movement.

There are also other modes for different operational situations, the following are some examples: there is a shunting mode, an on-sight mode that allows the train to enter an occupied section and a staff responsible mode which is a transition mode that allows train movement when it is acquiring data from the trackside under driver responsibility.

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