European Rail Infrastructure Managers EIM

ERTMS

A guide for ‘expert’ EIM members

Brussels, 1st June 2021

European Rail Infrastructure Managers EIM

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Introduction

Dear 'expert' Member,

The European control-command, signalling and communication system (ERTMS) was launched in the early 1990s as a research project by some engineers and evolved over time to the main EU flagship initiative. ERTMS objective is to increase safety and capacity of the railway system, decrease costs due to easier maintenance and ensure a fully interoperable system by replacing the national legacy systems. Furthermore, the EU and the European industry endeavour to establish ERTMS as a global reference.

By 2030, the European Union has the ambition to equip all the European core network corridors with ERTMS. To achieve this objective, the EU has set up various platforms in charge of solving interoperability issues, harmonise laboratory tests and protocols, work on the next generation of ERTMS and cater for the arrival of new technologies, such as Automatic Train Operations (ATO). Furthermore, the next generation Shift2Rail, Europe's Rail, will include a specific governance layer ('system pillar') to address the main game changers for ERTMS, including a modular system architecture[1]. Thus, there are plenty of opportunities to make ERTMS a success.

But the challenges are also increasing. The problems of lack of interoperability, reliability, cost effectiveness, time, service, etc. will further increase with the ongoing digitalisation of the rail sector, both on IM and RU level. By the same token, the EU deployment target for ERTMS on the TEN-T corridors until 2030 will most likely not be met, despite several EU initiatives. In addition, telecommunication systems play a crucial role for ERTMS. The main issues with ERTMS are also illustrated by EU ERTMS coordinator Matthias Ruete, who published a first work plan in 2020[2] and by MEP María Izaskun Bilbao Barandica, who drafted an 'on initiative report on ERTMS'[3]. Both provide for an excellent 360-degree overview of the main ERTMS issues today.

European rail infrastructure managers have every interest to work towards a well-functioning, 'plug-and-play' technology which is competitive in terms of pricing, quality, service, reliability and digitalisation backbone and to address any issue more systematically on market and EU level.

The current 'ERTMS guide for expert members' is an updated version of the second edition entitled 'EIM Guide for advanced' issued in May 2019. It intends to provide you with updated facts and figures but also opportunities and challenges related to ERTMS. It also includes a telecoms section that explains the current technology and future challenges and opportunities in relation to the communications in ERTMS.

Enjoy the read

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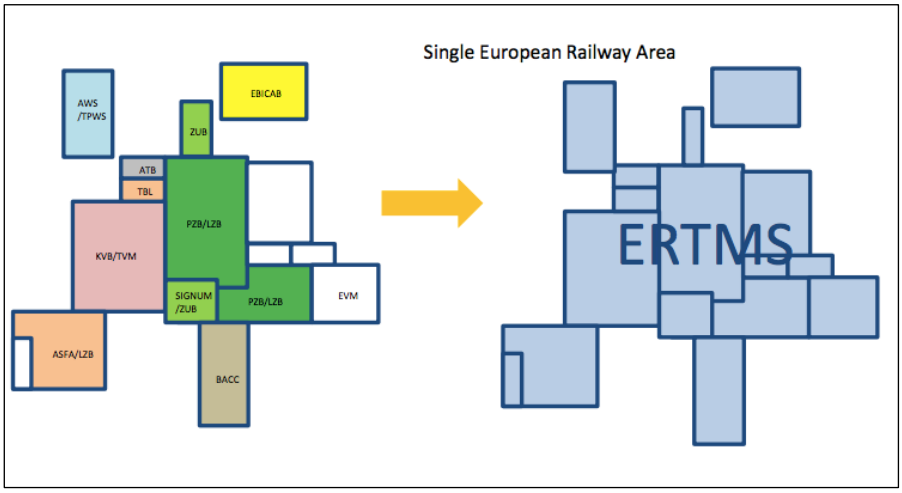
1 See "EIM's update on Europe's Rail" for the CEOs Club on 23rd June 2021

2 The "ERTMS First Work Plan of the European Coordinator", Matthias Ruete, of May 2020, can be consulted here: https://ec.europa.eu/transport/sites/default/files/work_plan_ertms_2020.pdf

3 The "Draft Report on railway safety and signalling: assessing the state of play of the European Rail Traffic Management System (ERTMS) deployment" (2019/2191(INI)) of 24th February 2021 can be consulted here: https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/TRAN/PR/2021/03-15/1224420EN.pdf. The press release of 25th May 2021 related to the report can be consulted here: https://www.europarl.europa.eu/news/en/press-room/20210523IPR04617/railway-safety-and-signalling-transport-meps-call-for-more-coordination.

1. ERTMS in a nutshell

What is ERTMS?	ERTMS ("European Rail Traffic Management System") is the European standard for the Automatic Train Protection (ATP) that allows an interoperable railway system in Europe. Furthermore, ERTMS is a major industrial project being implemented by Europe, a project whose aim is to make rail transport safer and more competitive. As an ATP, ERTMS is a safety system that enforces compliance by the train with speed restrictions and signalling status. Due to its nature and the required functions, it is a system that must be installed on both, the rail track ('trackside version') and the locomotives ('on-board version'). ERTMS was adopted by the European Union as a standard. ☝ ERTMS is not the same as ETCS. ERTMS is composed of ETCS and GSM-R: ▪ ETCS (European Train Control System), is an automatic train protection system (ATP) that continuously ensures that the train does not exceed the safe speed and distance. In addition, it provides the relevant information to support the task of the train driver. ▪ GSM-R (Global System for Mobile Communications - Railways), is a dedicated radio communication system for voice and data services supporting railway operations. It is indispensable for ERTMS in terms of data transmission.
Why ERTMS?	An interoperable railway market needs common technical solutions, also in the area of signalling. As different national signalling systems existed with different features and performance levels, the sector and the EU agreed to develop a single European system, called ERTMS. The reason for doing so was to overcome the technical barriers related to national signalling systems, preventing trains from crossing borders. Hence, ERTMS is one of the key enablers to create a single European railway area (SERA) in which trains can circulate in a seamless manner. An important aspect is also the fact that national systems have been developed by a national or a single manufacturer for a single client. This created a sort of 'locked-in system' which did not allow for easy interfacing with the system of the neighbouring country. Furthermore, the users and the EU were targeting cost reductions, as a single European system would allow more mass-produced components which would be cheaper. In addition, a single European system would also become easier and quicker to maintain. However, in May 2019, this target has not been reached but is a focus area that are prioritised by the European Commission.
What about the national systems?	As outlined above, each EU Member State developed its own technical specifications for signalling, gauge width, safety and electricity standards. These differences are historic and meant to create a barrier of entry for foreign train operators. With the emergence of the EU and the objective to create a Single European Rail Area (SERA), these obstacles have to be successively reduced as liberalisation of the rail markets came into play. The existing barriers to enter a market are now less legal but more technical. The

	removal of technical barriers is more complicated due to the safety-related features of these systems. Due to the fact that national rail infrastructure and signalling systems have grown organically over many years, changes to parts of this system are very complicated. In the field of signalling, this translates into a much slower process to switch from a national to a European system. Hence, in 2018, there are still some 30 different signalling systems in place, which are not interoperable (Annex A1). Railway operators complain that after so many years, they still cannot cross the EU with a single locomotive. In addition, track-side and on-board versions do not always work smoothly together, especially when they come from different suppliers. In that case, the experts refer to 'open points', which need to be closed. For the moment, there are 16 open points related to interference issues between different hardware and software. The chart below shows the current and the target system:  Chart: EU Agency for Railways Despite these problems, ERTMS has become a global standard and is deployed all over the world. The global success is due to the fact that other railway markets are much less fragmented and were less developed. Hence the shift to a new system is much easier. Although the deployment of ERTMS in Europe is cumbersome, the system is also a key enabler for innovative technologies in an effective manner, such as automatic train operations (ATO) which requires more interfaces. You can find in Annex A1 the updated list containing the Class B systems following the ERA report published in May 2019 'List of CCS Class B systems ERA/TD/2011-11 V 3.12'.
How old is ERTMS?	In 2019, ERTMS is 26 years old. In the late 1980s, it was clear for the then EEC (European Economic Community) that a single European railway market was needed and that it would require an interoperable standard for signalling. Following a study of the EC in 1989, the EU Council issued an Interoperability Directive in 1993. It was decided to set up a group of railway experts called "ERTMS Group" to define a Technical Specification for Interoperability (TSI) in this domain.

In the summer of 1998, the main European signalling manufacturers created a joint consortium called UNISIG (Union Industry of signaling) to finalise the TSI for the then-called ERTMS project.

In order to allow the communication between trains, trackside and rail control centres, the EU and the sector agreed also on an international wireless communications standard for railway communication and applications which serves to transmit data related to signalling and thus ERTMS. This system is not a stand-alone system but requires ERTMS to work as a 'hub' and is therefore a subsystem of ERTMS. The name of the wireless communications subsystem is GSM-R. R stands for railways as it is only used in the railway sector. In 2019, the EU and the sector are working on a legacy system as the telecom operators will no longer maintain GSM-R as a standard.

To summarise: ERTMS is a system, consisting of ETCS and GSM-R.

What is the timeline of ERTMS?

The timeline of ERTMS is shown in the chart below:

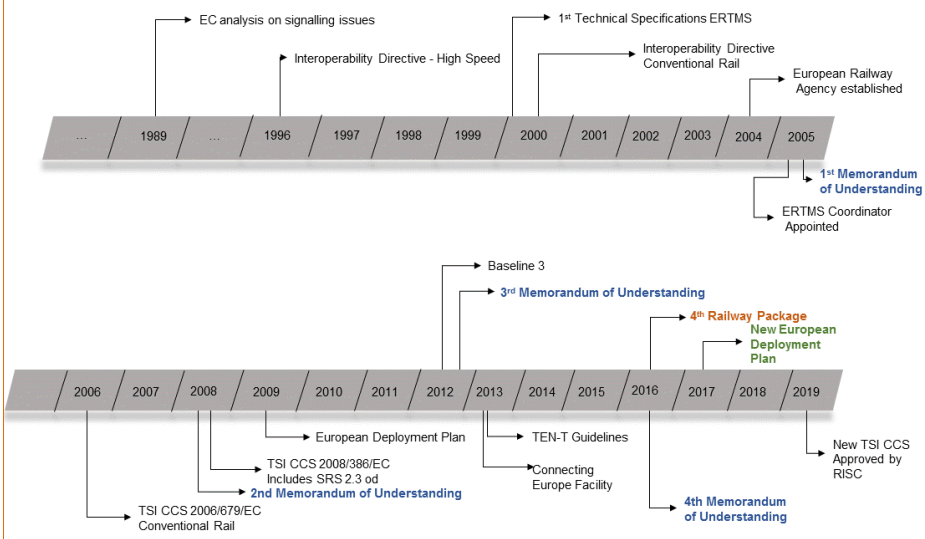


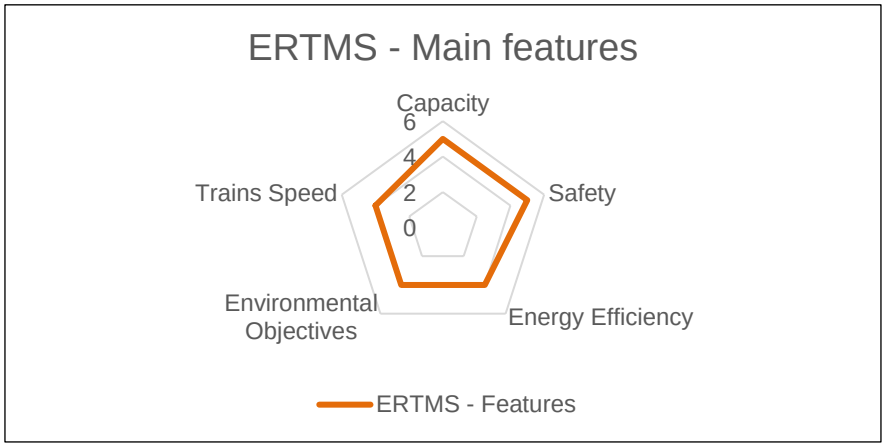
Chart: EIM

What are the benefits of ERTMS?

The success of ERTMS is due to the fact that it is the most performant train control system worldwide. Outside Europe, it is deployed in China, India, Taiwan, South Korea and Saudi Arabia, often by European rail signalling manufacturers and suppliers, although this is about to change with non-EU manufacturers and suppliers developing ERTMS by themselves based on European know-how. In this context, Chinese manufacturers are taking the leading role in the development and deployment of ERTMS outside Europe.

In general, the benefits of ERTMS can be resumed as follows:

- Innovation uptake and maintenance are quicker due to a single standard;
- ERTMS ensures the compatibility between the networks and the rolling stock equipped with ERTMS;
- ERTMS increases safety as it translates the former physical signs along the track into signals in the drivers' cabin;

	▪ ERTMS allows to reduce the distance ('headways') between the trains operating on the same track due to a better monitoring of train movements. This, in turn, increases the capacity of a given track without having to build new ones. In simple words, ERTMS reduces 'congestion' due to shorter train intervals to a certain level. ▪ ERTMS as a single European system reduces the technical barriers of entry to other networks regarding signalling. Hence, ERTMS is a key enabler to the Single European Railway Area (SERA) as trains would be able to cross borders without noticing it. The main features of ERTMS are illustrated below:  Chart: EIM
What are the benefits of ERTMS for IMs and RUs ?	Infrastructure Managers: ▪ Increase of safety ▪ Higher capacity on lines ▪ High reliability rates: increase of punctuality rates ▪ Savings on the renewal of the legacy system and on maintenance. Operators: ▪ Improvement of interoperability (decrease in Opex[4]) ▪ Higher speeds: up to 500 km/h ▪ Increase of modal share ▪ Potential increase of capacity available ▪ More services and cross border trains ▪ More competition between operators creates price competition.
Is ERTMS mandatory ?	Yes, it is. Actually, the relevant ERTMS standard (CCS TSI 2016/919) states in article 9 that ETCS shall be installed in railway infrastructure projects receiving financial support from European funds when: ▪ installing the train protection part of a CCS subsystem for the first time; or ▪ upgrading the train protection part of a CCS subsystem already in service, where the upgrade changes the functions or the performance of the subsystem.

[4] An operational expenditure (OPEX) is the money a company spends on an ongoing, day-to-day basis in order to run a system.

	Other EU legislation, such as the one related to the Trans-European Network Transport (TEN-T), also make the deployment of ERTMS mandatory (see specification section on TEN-T further below). The scope of the EU ERTMS legislation is shown in annex A2.
What are the challenges of ERTMS?	ERTMS development and deployment are costly as the shift from 33 national systems to a single European system is complex. Therefore, ERTMS is a collaborative exercise of EU and national authorities, railway operators and infrastructure mangers as well as certification and notification bodies and, of course, signalling manufacturers and suppliers. To achieve the Single European Railway Area, ERTMS system is necessary and it is mandatory to establish clear standards for systems on board, the connection / communication interfaces between modules and the development of common procedures. Infrastructure managers are facing deployment costs for installing the technology on their tracks and maintaining multiple systems (national and ERTMS). The digitalisation of interlockings, the need to ensure interoperability among different subsystems, as well as the forthcoming deployment of the new communication technologies, are also challenges for the IMs that should not be underestimated. IMs will likely face new methods of operations and maintenance. Railway operators also face deployment costs by having to equip existing locomotives with ERTMS or to buy new locomotives which are already ERTMS-compliant. In addition, locomotives or trainsets must be equipped with ERTMS, irrespective whether they run on ERTMS equipped lines or not. However, recent figures indicate that costs are falling as more and more locomotives and lines are equipped with ERTMS. The table below shows an indicative the cost range for all ERTMS-related expenditure (all subsystems) for infrastructure managers and operators.

Trackside	On-Board	Retrofitting
Infrastructure Managers		
Trackside costs/km: 100.000 € - 350.000 €	Not applicable	Costs for: ▪ compatibility checks; ▪ studies
Railway Operators		
Not applicable	▪ New locomotive: 300.000€ ▪ Existing locomotive: 75.000€ - 550.000€	▪ Upgrade to ERTMS baseline 2.3.0.d/locomotive: 420.000€ - 970.000€; ▪ Upgrade to ERTMS baseline 3/locomotive: ▪ approx 270.000€

Source: EIM

2. ERTMS Deployment

What are the main deployment initiatives of the EU?	The EU is keen in fostering a deployment as quickly as possible to realise its objective of a Single European Railway Area without any market access hurdles. Hence, the EU has developed a number of initiatives to remind EU Member States of different deployment targets and to have a clearer picture about the progress in national level. The main initiatives are: ▪ Trans-European Network Transport Programme (TEN-T) ▪ Core Network Corridor regulation (CNC) ▪ European Deployment Plans (EDPs) ▪ National Implementation Plans (NIPs) ▪ Memorandums of Understanding (MoUs)
What is the role of TEN-T for ERTMS deployment?	The Trans-European Network Transport (TEN-T) Programme was established by the EU in 2006 to support the construction and upgrade of [interoperable] transport infrastructure across the European Union. The TEN-T Guidelines (Regulation 1315/2013) were adopted in 2013 establishing an EU policy on transport infrastructure. The European Commission is currently evaluating the implementation of Regulation 1315/2013 with the aim to revise this legislation in 2020. The TEN-T projects are not related to rail only but to all modes which provide connectivity, i.e. air, rail, road, waterways, logistics and intelligent transport systems. The TEN-T applies to all EU Member States. To steer the deployment of the TEN-T, the EU set up a special "Executive Agency in charge of the deployment of TEN-T". In 2014, the agency became the "Innovation and Networks Executive Agency" (INEA), with the objective to increase the efficiency of the technical and financial management of the relevant EU programmes supporting the deployment of TEN-T.
What are the Core Network Corridors - CNC?	Given the complexity and costs involved with the implementation of the TEN-T, the EU realised that Member States would not be able to meet the initial implementation deadline of 2030 for the entire network. Hence, it reformed its TEN-T approach by splitting the TEN-T network in a Comprehensive and a Core Network. While there is no fixed deadline for the Comprehensive Network, the deadline of 2030 applies to the Core Network Corridors (CNC). Regulation (EU) No 1315/2013 established core networks for the following ways of transport: ▪ Inland waterways and ports ▪ Railways (freight), ports and rail road terminals (RRT) ▪ Railways (passengers) and airports ▪ Roads, ports, rail road terminals (RRT) and airports The list of the Core Network Corridor routes is shown in annex A3. The map below indicates all the 9 Core Network Corridors to be equipped with ERTMS by 2030.

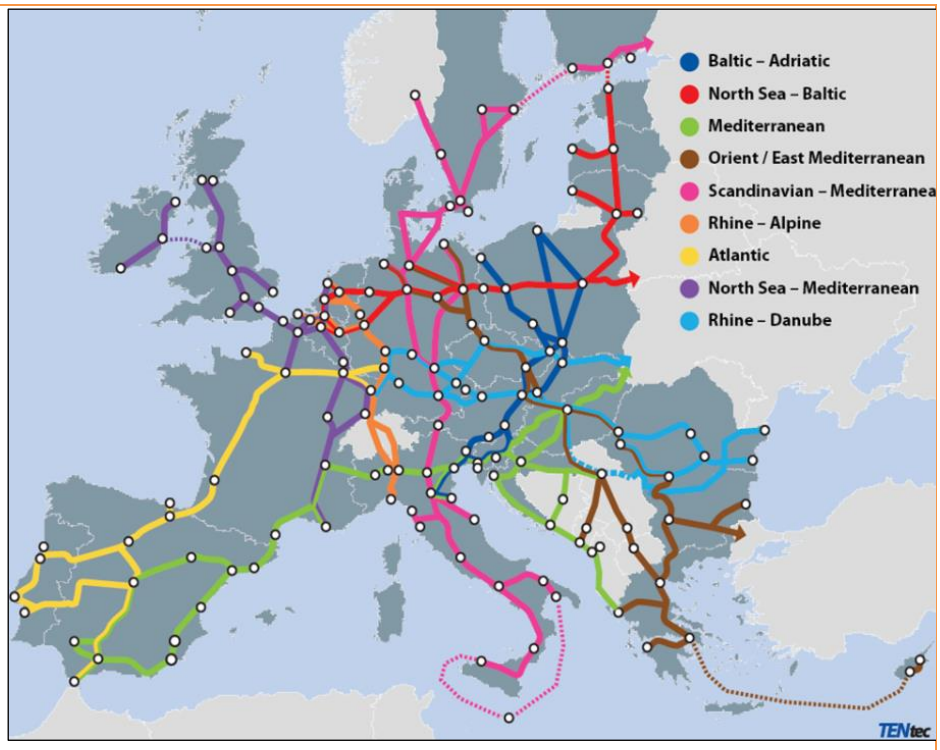


Chart: European Commission

What is the status of ERTMS deployment on CNC?

According to the latest figures available, in 2017 out of 51.000 km of the Core Network Corridors (CNC), only 4.400 km have been equipped with ERTMS. According to the table below, the EC foresees different deployment milestones:

Deadline	Today	2023	2030	No deadline
Length (km)	7.200	15.700	50.000	217.000 – entire EU Rail Network

Table: EIM based on the figures in the EU TEN-T Regulation (EU) No 1315/2013

The 4.400 km of ERTMS deployment represent 8% of the CNC of which the Rhine-Alpine corridor is the best in class in terms of ERTMS rollout (13 % of lines already equipped). However, the European Institutions recognise that the overall slow pace of ERTMS deployment may put at risk the target of 30% of the CNC equipped with ERTMS by 2030.

The graph below illustrates the ERTMS deployment in km (2017):

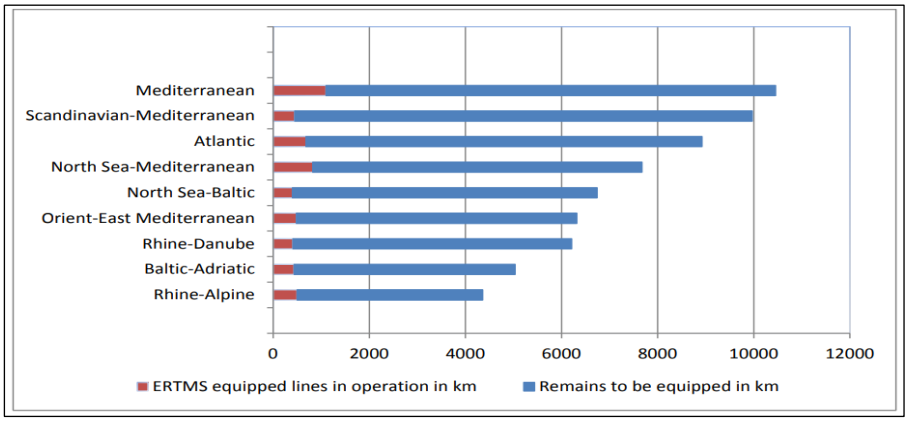


Chart: European Court of Auditors based on data of the European Commission

The following chart shows the CNC status as of 2018 and the plan up to 2023.

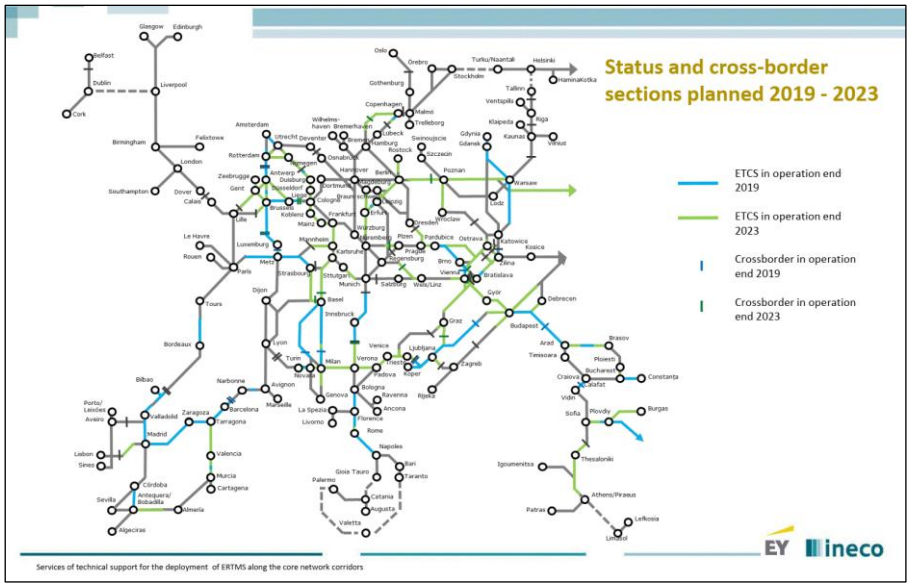


Chart: CNC Services of technical support for the deployment of ERTMS along the core network corridors © EY/Ineco

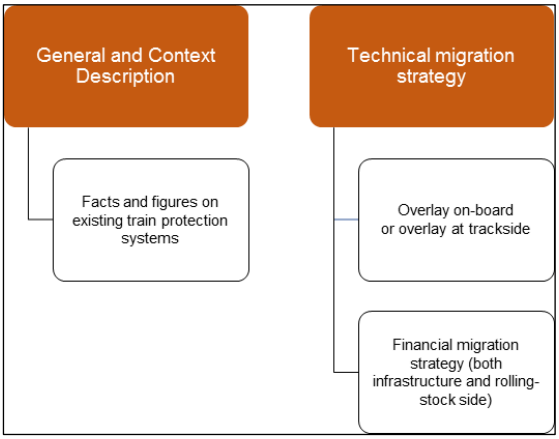
More information about CNCs and ERTMS can be found in annex 4.

What is the ERTMS European Deployment Plan (EDP)?

To foster the deployment in a controlled and transparent manner, on 5th January 2017 the EC adopted the Commission Implementing Regulation (EU) 2017/6. Its aim is to ensure the progressive deployment of ERTMS along the main European rail routes according to a so-called European Deployment Plan for ERTMS referred to in the Regulation.

As from 1st January 2019, the European Coordinator for ERTMS is Mathias Ruete, succeeding to Karel Vinck.

In 2023, the ERTMS European Deployment Plan (EDP) will be updated again. It will define precise implementation dates for the remaining part of the corridors between 2024 and 2030. The new ERTMS EDP is the result of

	consultations and negotiations with Member States, carried out by the European ERTMS coordinator. In May 2020, the first 'Work Plan of the European Coordinator' [5]was published by Matthias Ruete and points out that '*rapid deployment depends on avoiding mistakes from the past and foreseeing a non-disruptive evolution of ERTMS'*. The report includes updated figures on the deployment (trackside and on-board), reports on the removal of the main barriers to ERTMS rollout and 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.
What are the National Implementation Plans (NIPs)?	In 2016, the EC also asked the EU Member States to establish the so-called "National Implementation Plans" (NIPs) in which they have to describe their actions to comply with the relevant standard for ERTMS, i.e. CCS TSI 2016/919. The CCS TSI regulates the implementation of fully interoperable 'control-command and signalling' subsystems. The NIPs have to fulfil two conditions, i.e. they must cover a period of at least 15 years and they must be updated every 5 years. In addition, they have to contain the following information:  Chart: European Commission, EIM
What is the current status of NIPs?	Most EU Member States have submitted their NIP during 2018 detailing their ERTMS implementation plan. According to the EC, the current NIPs of Austria, Belgium, Czech Republic, Norway and Sweden are fully in line with the European Development Plan (EDP), with some of the ERTMS sections being deployed even ahead of the deadlines. Poland, Italy, Switzerland, Slovakia, Croatia and the Netherlands are 'mostly' in line with the EDP. The same principle applies to France, Germany, Bulgaria and Latvia, although their NIPs do not mention detailed planning beyond 2023. Finland provided deployment dates beyond 2030 while Portugal did not provide enough details for a compliance check by the EC. For more information about the state of the NIPs, please refer to annex 5.

[5] See 'Work Plan of the European Coordinator' – Matthias Ruete here

What are the Memoranda of Understanding (MoU)?	Despite the various EU legislation and initiatives outlined above, the EU Commission, the EU Agency for Railways and the rail sector realised that the success of ERTMS requires a commonly agreed, collective, disciplined and structured approach. To confirm these principles and create a sort of self-commitment, the EU and the sector signed 5 Memoranda of Understanding (MoU) between 2005 and 2016, initiated by the EU Agency for Railways and the rail sector itself. For more information about the MoUs, please refer to annex 6.
Have the various EU initiatives fostered ERTMS deployment?	Despite the initiatives taken at EU level to facilitate and speed up ERTMS deployment, ongoing issues and obstacles remain at different levels: ▪ National issues: Uncoordinated ERTMS trackside deployment; ▪ Technical issues: Requirements introduced to On Board Units (OBUs), e.g. due to national rules. Due to the specific requirements for OBUs, trains can run in one Member State but not necessarily in another. In addition, high variety of trackside configurations impact testing procedures and raising of costs. Missing of standard functionalities. ▪ Conformity and authorisation issues: Different assessments by National Safety Agencies (NSAs) on whether modifications are minor or major (with re-authorisation being needed for major modifications); ▪ Financial issues: Short-term economic incentives for suppliers and customers may work against the goal of interoperability. ▪ Commercial issues: the low number of ERTMS suppliers does not incentive competition, innovation and reduction of costs. ☝ To summarise: ERTMS could offer a great added value, provided that ongoing issues can be solved.

3. ERTMS Funding

What are the main funding tools of the EU?	The EU has four main funding instruments for ERTMS: 1. CEF – Connecting Europe Facility The Connecting Europe Facility (CEF) for Transport is the funding instrument to realise European transport infrastructure policy. It aims at supporting investments in building new transport infrastructure in Europe or rehabilitating and upgrading the existing one. Synergies between CEF Transport and CEF Digital are possible for ERTMS funding. 2. CEF – Transport Blending Facility The Transport Blending Facility combines grants and debt from private or public investors, such as the European Investment Bank (EIB), and can be used by rail Infrastructure Managers with high credit quality to support the deployment of ERTMS. A dedicated rolling call for new project proposals is scheduled to be published in mid-2019 with quarterly cut-off dates until March 2021. 3. ESIF Funds - European Structural and Investment Funds Over half of EU funding is channelled through the 5 European structural and investment funds (ESIF). They are jointly managed by the European Commission and the EU countries. The ESIF mainly focuses on 5 areas: ▪ research and innovation ▪ digital technologies ▪ supporting the low-carbon economy ▪ sustainable management of natural resources ▪ small businesses 4. EFSI - European Fund for Strategic Investments The European Fund for Strategic Investments is an initiative to help to overcome the current investment gap in the EU. Jointly launched by the EIB Group and the European Commission, it aims to mobilise private investment in projects which are strategically important for the EU. The EFSI 2.0 Regulation entered into force on 30th December 2017 and extends the timeline from mid-2018 to the end of 2020 with an investment target from EUR 315 billion to at least EUR 500 billion. Under the new EU financial framework 2021-2027, the European Commission has proposed to replace EFSI with a new initiative called InvestEU Programme. This initiative aims to trigger EUR 650 billion of investments for sustainable infrastructures by blending them with EUR 40 billion of guarantees[6].

[6] For an update of the available EU funding, please refer to the EIM note for the CEOS Club on 18th November 2020 on EU Budget options for IMs under the next MFF 2021-2027. *'An overview of available EU funding opportunities for IMs'*

What are the main funding tools for ERTMS?

According to official estimates of the EU and the sector, the costs of deploying ERTMS on the CNC total some EUR 80 billion till 2030 and up to EUR 190 billion by 2050 when the comprehensive network is 'expected' to be equipped with ERTMS.

According to the European Court of Auditors report on ERTMS, deploying ERTMS on the core network (both on trackside and on board) between 2017 and 2030 would cost around EUR 107 billion.

The Commission estimates around EUR 27-41 billion investments needed for ERTMS trackside on the Core Network Corridors by 2030 and around EUR 4-5 billion for ERTMS in rolling stock.

The EU budget mostly co-finances two types of projects in relation to ERTMS:

- trackside: equipping rail tracks with the necessary equipment
- on-board: equipping locomotives with ERTMS units

Other co-financed projects consisting of testing, developing specifications or corridor approach projects may also be eligible for support.

The main financial support of the EU for TEN-T is illustrated below:

	2007-2013	2014-2020	Co-financing rate
TEN-T/CEF	645	850	Up to 50 %
ERDF/Cohesion Fund/ESIF	570	1 900	Up to 85 %
Total	**1 215**	**2 750**	

Source: EU Commission (figures in million)

The European Investment Bank provides loans and guarantee schemes for ERTMS trackside deployment and purchase of new rolling stock equipped with ERTMS (sometimes blended with EU grants, see above CEF Transport Blending Facility).

There is the possibility to finance ERTMS with the EU long-term budget (also known as Multiannual Financial Framework – MFF), running from 2021 to 2027, and the recovery instrument NextGenerationEU, which include new structure, new funding programmes and specific allocations per Member States.

What about research funds for ERTMS?

The main research instrument for rail-related research is Shift2Rail. It is a so-called 'Joint Undertaking', i.e. a public-private partnership with 50% of the funds provided by the EU and 50% by the sector participating in the initiative.[7]

The Shift2Rail funds for the period 2014-2020 foresee the following overall investment framework:

- EUR 450 million from the EU budget
- EUR 470 million from industry

[7] For an update of the Shift2Rail and its successor, please refer to the EIM note on 'Europe´s Rail' for the CEOS Club on 23rd of June 2021.

Do EU funds cover the investment needs?	The EU funding available for ERTMS only represents a limited percentage of the overall cost of deployment with most of the financing to be found from other sources. The EU financial support for ERTMS projects during the 2007-2020 period amounts to EUR 4 billion, or less than 5 % of the total cost of ERTMS deployment on core network corridors. ☝ There is a general concern on European level that the next EU budget 2021-2027 will not provide enough financial resources for ERTMS development and deployment. Some Member States hesitated to provide classical CEF funding for ERTMS as they considered EFSI (the future InvestEU) Programme as a suitable funding instrument (blending of public/private money). The EC confirmed to EIM that it advocates grant-based funding via CEF for ERTMS on EU level.

4. The role of the 4th Railway Package

What is the 4th Railway Package (4RP)?	Since 1991, the EU railway sector is constantly being reformed by the European Union. The largest initiative is the 4th Railway Package, which was adopted in 2016. It is by far the largest and most complex legal initiative as it was launched to close the open gaps in rail liberalisation and establish a single legal and technical European railway area. The 4th RP is split in two pillars: 1. The political pillar addresses market opening (governance of rail infrastructure managers, tendering of public service contracts and access to national rail passenger markets); 2. The technical pillar addresses interoperability, safety authorisation, ERTMS track-side certification but also the reduction of national rules and the increased role of the EU Agency for Railways (ERA) to deliver authorisations and certifications. For more information about the 4th Railway Package, please refer to the EIM Beginners Guide on the 4th Railway Package which is available on EIM's intranet (OnlyOffice) or by sending a short request to monika.heiming@eimrail.org.
Why is the 4RP relevant for ERTMS?	For ERTMS and for the purpose of this report, the technical pillar and in particular its EU Directive 2016/797 "Interoperability" and its EU Regulation 2016/796 "EUAR" are relevant. They foresee a formal (legal) shift from the current national to a European single certification and authorisation system run the EU Agency for Railways (ERA). The main changes are: ▪ Shift of technical and safety rule-making from the national to the EU level ▪ Issuing of safety certificates and vehicle authorisations by the ERA ▪ Creation of a new ERTMS trackside approval procedure by the ERA ▪ Fees and charges of the ERA for its certification, authorisation and approval activities (including ERTMS trackside approvals) ▪ Reduction of national rules by the ERA ▪ Creation of new tools and processes by the ERA (IT portal, board of appeal, pool of experts, etc.) The EU Agency for Railways, the sector but also EU DG MOVE and Members States are currently preparing for the implementation of these reforms. In 2017 the EU Agency for Railways launched the so-called 'learning cases' into the processes on national and IM level related to ERTMS track side components. The ERA formal mandate related to ERTMS track side approvals enters into force the 16th June 2019 for those EU Member States which have opted for the implementation of the 4th Railway Package by that date (the alternative being the 16th June 2020)[8].

[8] The following EU Members States agreed to implement the 4th RP as of June 2019: Italy, the Netherlands, France, Croatia, Bulgaria, Finland, Greece, Romania and Slovenia (plus Switzerland). All other MS have postponed the implementation to June 2020.

What is the ERTMS Trackside approval?[9]

The ERTMS track side approval was introduced by the EU to ensure greater interoperability of ERTMS trackside systems by scrutinising the tenders before they are published.

In fact, the initiative is a follow-up of the reactions (or rather complaints) of the railway undertakings, according to which rail infrastructure is not interoperable as regards ERTMS equipment as every infrastructure manager launches tenders 'à la carte' instead of following the EU requirements in a strict and disciplined manner.

This means that from 16th June 2019 onwards, rail infrastructure managers will have to submit their tenders for ERTMS track-side components to the EU Agency for Railways for approval before they can proceed with the actual tender procedure on national level.

The procedure, detailed in art. 19 of Directive (EU) 2016/797, consists of a 3-step approach:

- Before any call for tender on ERTMS trackside equipment the Agency must check that the technical solutions are fully complaint with the relevant TSIs and are therefore fully interoperable, and take a decision for approval;
- Within 1 month of the receipt of the applicant's request (i.e. the IM), the Agency informs the IM that the tender is complete or asks for relevant supplementary information, setting a reasonable deadline;
- The Agency shall base its opinion on the tender of the IM and on possible opinions from the National Safety Authorities (NSAs).

The ERTMS trackside approval procedure is illustrated below:

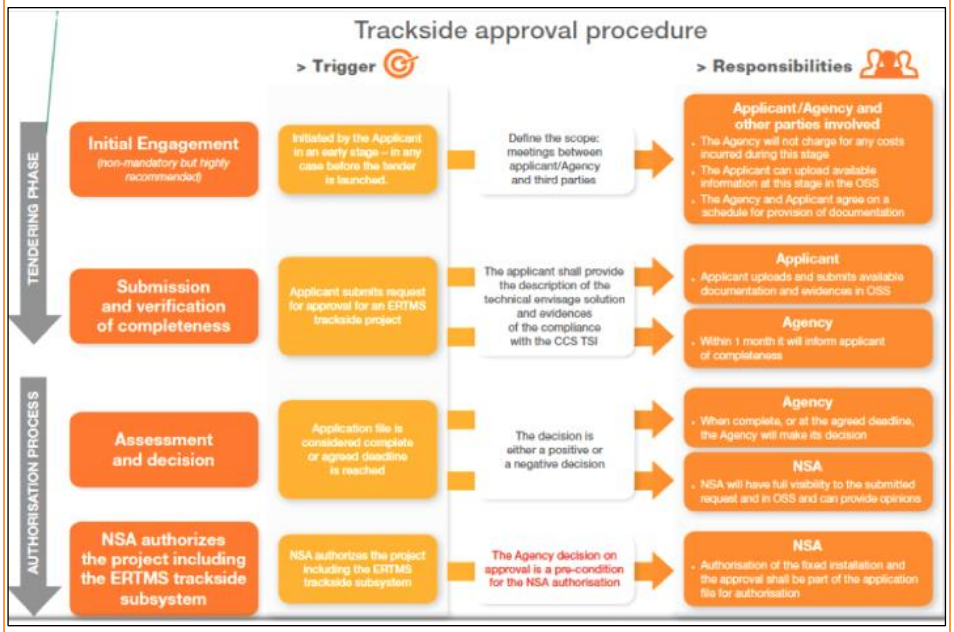
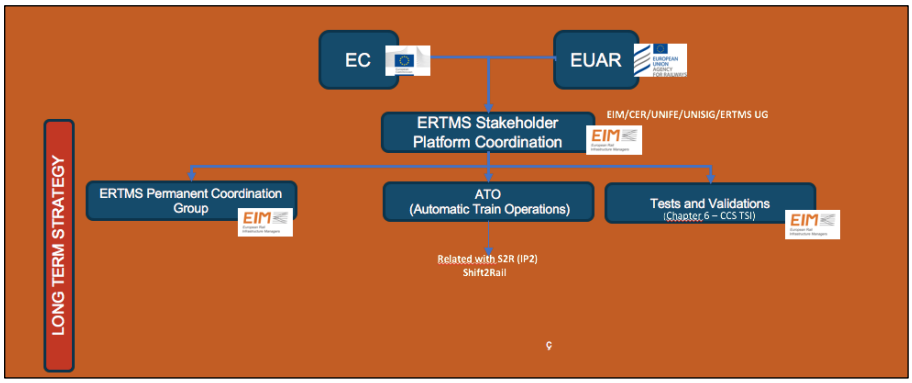


Chart: EU Agency for Railways, EIM

[9] See in the annex 8) the EIM One-Page created for the ERTMS Trackside approval (2Q 2021)

What is the role of the EU Agency for Railways?	The EU Agency for Railways has a much bigger role than 'only' checking tenders ERTMS trackside equipment for EU interoperability compliance. It is also the ERTMS system authority, which provides it with enlarged powers related to ERTMS, such as: ▪ maintain, monitor and manage the corresponding subsystem requirements, including ETCS and GSM-R; ▪ new tasks (currently carried out by the NSA) regarding the authorisation of rolling stock (including ERTMS on-board subsystems) and safety certificates for RUs; ▪ new process concerning the pre-approval of ERTMS trackside implementations. The Annual Work Programme of the Agency for 2018 ('SPD 2018') also states that the Agency will elaborate a harmonised operational rulebook to foster the consistent use of ERTMS. For an overview of the role of the EU Agency for Railways see annex 7.
Has the ERTMS Trackside Approval any impact on IMs?	Yes, it has. The impact can be resumed as follows: ▪ Financial: The Agency will invoice fees & charges for its approval process of ERTMS trackside tenders. The current rate/hr was fixed by the EU at 130 EUR/hour. This fee will be complementary to those charged by the National Safety Authorities (NSAs) which are free to charge individual rates. According to internal assessments of EIM, a single application can cost up to EUR 0,5 million. *NB: EIM has lobbied for fixed fees and an initial fee estimate prior to the actual assessment process. However, given the fact that this process is new on EU level and virtually no benchmark exists and that the return from the 'learning cases' launched in 2017 by the EU Agency of Railways is still too low, IMs have a strong interest in preparing a fully EU-compliant file to avoid excessive costs and time delays.* ▪ Procedural: The Agency will set up a One-Stop-Shop (OSS) as an IT portal to handle all applications. IMs will have to be familiar with the tool and adapt their internal processes related to ERTMS trackside tenders. ▪ Time: Although the Agency has a 3-month period to assess applications, this timeframe may become longer in the case of a shortage of resources to assess applications. IMs may need to cater for longer approval periods on EU level and on national level regarding to ERTMS tack side tenders and adapt their internal planning. ▪ Legal: In the case of a non-approval of an application, the applicant can launch a compliant via a so-called Board of Appeal. This Board of Appeal is located with the Agency and made up of different experts. In complaint may mean a delay in the approval process and also additional fees in the case that the complaint of the infrastructure manager was rejected. ☝ In general, the 4th Railway Package introduced new procedures and costs for the rail infrastructure manager while it will reduce procedures and costs for rail operators and manufacturers.
What is the issue list?	Following internal preparatory work and the 'learning cases' conducted by the Agency staff with various rail infrastructure managers, the Agency set up a so-called 'issue list' for various topics, including ERTMS. It shall help address issues of joint concerns related to ERTMS and was endorsed by the sector and NSAs.

	The list is also an excellent tool for the ERTMs trackside approval process and includes feedback and observations from the 'learning cases' of the Agency with several rail infrastructure managers. One of the positive outcome of this list is that the ERTMS track side approval process now includes the possibility of re-using the documentation or parts of it that were provided in a previous positive approval, without the need for the Agency to re-assess them. IMs have an interest in providing feedback on ERTMS track side application processes. The more 'standardised' the procedure becomes, the higher the chances to reduce the overall burden of the process for the applicant.
What is role of the ERTMS Stakeholders Platform?	The ERTMS Stakeholder Platform was established on 15th December 2015 to address ERTMS related issues by all related stakeholders investing and/or using the system. The Platform brings together the EU (EC and Agency), the suppliers and manufacturers and the users (IMs, RUs). The platform is co-chaired by the EC and the Agency. The main purpose of the Platform is to facilitate a fully synchronised approach to the development of ERTMS, in order to ensure an economically beneficial ERTMS setting across Europe. The structure and interfaces of the ERTMS Stakeholder Platform is illustrated in the organisational chart below:  Source: EU Agency for Railways The platform covers the following topics: ▪ ERTMS status report and the long-term perspective (state of play of CCS TSI; harmonised specifications; future validation of functionalities); ▪ speeding-up of ERTMS deployment; ▪ supplier's proposals on testing and certification; ▪ setting-up of necessary working groups. EIM is part of the Platform via its ERTMS speaker Henri van Houten (ProRail). In 2018 the Platform agreed to focus all the efforts on the ERTMS deployment and it has committed to take the necessary steps to achieve the deployment targets planned for 2019. Within the ERTMS Stakeholders Platform, the railway sector also pointed out the importance of the following aspects: ▪ Interoperability: the need to focus on transparency of manufactures and functional maintenance of deployment; ▪ Economic drivers: the need to focus on reducing cost;

	▪ Deployment: the need to focus on avoiding delays and mitigate delay risks to comply with deadlines in EDP and NIP; ▪ Compliant infrastructure: through the use of the baseline 3 as a reference; ▪ Shift2Rail: to support this EU joint undertaking as the main driver for setting out the innovation framework for business cases on modular approaches and new system architecture.

5. Telecoms in ERTMS

What is the current Telecom technology used by ERTSM?	All over the world, rail infrastructure managers and operators use Global System for Mobile Communications – Railway (GSM-R). It is the only fully interoperable radio communications network, which provides the data bearer (i.e. it transmits information) for ETCS (European Train Control System). The first implementation of GSM-R started in 2000 and today over 200.000 km[10] of lines are covered by GSM-R worldwide. Furthermore, it is a very stable system and there are no changes expected until the system's end of life (apart from those coming from Art.10[11] process of the CCS TSI related to the error corrections).Still, the support for GSM-R could prove more difficult and costly on the long term as it is based on an old technology and its customer basis will diminish with the migration to the successor of GSM-R. However, the technology may still be in operation after that date in those countries which have deployed GSM-R at a later stage. The first target date of 2030 has alarmed the railway sector as it will need a new system from 2030 onwards which does not exist yet. Hence, the sector works since 2012 to identify a successor technology for GSM-R, called "Future Railway Mobile Communications System" (in short: FRMCS) under the supervision of the EU Agency for Railways.
Why do we need another Telecom technology for ERTMS?	Moving to FRMCS should not only be dictated by the future obsolescence of GSM-R. FRMCS will use broadband technology (5G) and offer a much higher communications capacity for railway applications. This will enable to optimize operations by leveraging this capacity for future signalling, ATO (Automatic Train Operation) and / or business support systems. The future communication technology will therefore be pivotal to support the digitalization of railways as it will enable to increase the data flow between the train and the network.

[10] Source: https://www.unife.org/component/topic/topic/30.html

[11] Control command and signalling TSI: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02016R0919-20200311&from=ENommand and Control Spec

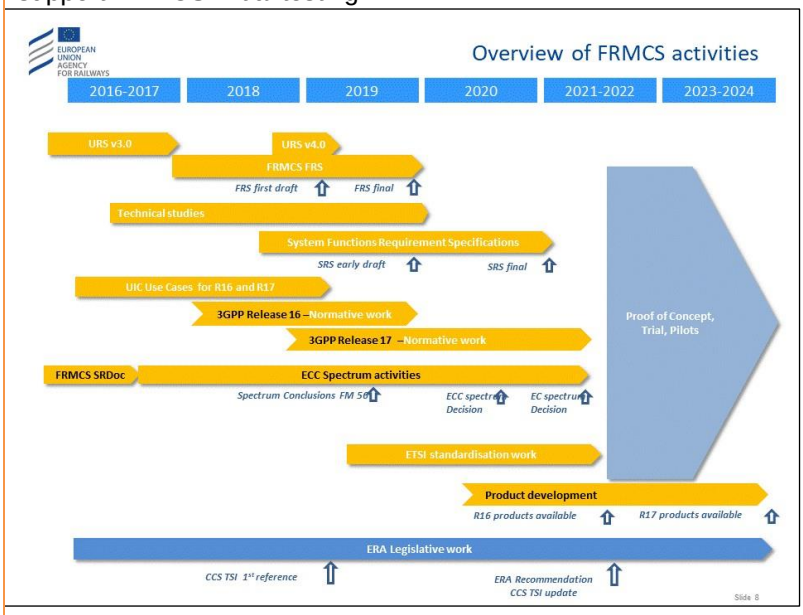
What will be the technology of the future Telecom solution?	The Future Railway Mobile Communication Solution (FRMCS) will be based on 5G, more specifically the 5G Mission Critical version (MCX) version which is being developed under the supervision of 3GPP.
What are the expectations of IM for the future Telecom solution?	While the future solution is still being specified, IMs via EIM have expressed the following expectations for the future system[12]: • Be cost effective by maximizing the use of "off the shelf technologies" while leveraging the existing infrastructure of GSM-R (using similar bandwidth for the FRMCS and GSM-R will be key for this purpose • Ensure vendor independence • Be future proof, and provide a long-term evolutionary solution for railways • Offer flexibility in network usage and modelling (i.e. offer possibility to use private mobile networks, public mobile networks, Wi-Fi-networks, other technology networks with mobility, or hybrid solutions between those systems) • Allow flexibility at the application level for the applications which are not critical for interoperability (i.e. IMs/RUs need to have the freedom to implement applications which do not affect interoperability) • Ensure high availability of service at least equivalent to GSM-R • Offer high robustness (also under mobility conditions) including robustness against interference
Which spectrum will be used by the future Telecom solution?	EIM suggested that the 873-876MHz/918-921MHz band should be reserved in addition to the current GSM-R band for FRMCS. It was stated that this was the most favourable option to re-use infrastructure investments and to allow a smoother migration. Work on spectrum allocation is still ongoing within the FM56 (WG on Future Rail Radio) within the ECC (Electronic Communications Committee which develops policies on electronic communications activities in European context). While it is key to retain the bandwidths for IMs proprietary network, it will also be essential to ensure that FMRCS is compatible with the bandwidth used by Public Mobile Operators to allow a smooth roaming to these networks when this is appropriate.

[12] EIM position paper on FRMCS https://eimrail.org/wp-content/uploads/2019/07/2016-12-EIM-FRMCS-position-paper-1.pdf

Which migration strategy will be used to move from GSM-R to FRMCS?	The migration timing will be country specific and will depend of multiple factors (obsolescence of GSM-R in the country, availability of spectrum to support parallel operations of FRMCS and GSM-R in the same territory), Furthermore, the infrastructure managers should be granted a sufficiently long period for implementation of FRMCS and GSM-R decommissioning. EIM members consider[13] that on-boards will play a pivotal role for a smooth migration and that these need to support dual technology (FMRCS and GSM-R). This will enable to shift rapidly from GSM-R to FRMCS and allow to use spectrum efficiently (using 2 communication technologies in parallel for a long time would prove very inefficient from a spectrum perspective) It is therefore essential to rapidly specify the on-board architecture to allow a roll-out of future proof on-boards as soon as possible.
What are the main challenges for FRMCS?	While significant progress is being made on the front of FRMCS, EIM considers that it is important to clarify the following topics as soon as possible considering the expected architecture for FRMCS: • Guarantee that all the specificities of the 5G MCX version are handled at the application level and not through specific hardware (like this is the case for GSM-R) so that over the shelf 5G hardware can be used by FRMCS (this is much more cost effective) • Guarantee smooth roaming between a 5G MCX network and a 5G standard network of Public Mobile Operators to enable IMs to use PMOs network to transport data when relevant • Secure appropriate spectrum for IMs proprietary networks to secure a smooth operation from FRMCS while allowing an efficient usage of the existing infrastructure implemented for GSM-R • Move rapidly with the final specification of FRMCS to include these in the upcoming TSI update and ensure future proof investments in the coming years. • FRMCS migration should be performed taking into account preservation of investment for both On-board and for ETCS trackside constituents already in service.

13 EIM position paper on ERTMS / FRMCS migration strategy (18th July 2019) - https://eimrail.org/2019/07/18/eim-position-paper-on-ertms-frmcs-migration-strategy/

When will FRMCS be available?	It is expected that FRMCS will be available for roll-out in 2025. A Strategic Deployment Agenda (SDA) has been recently developed under by EIM (among others). This SDA will be used to secure funding from the Horizon 2020 program to support FRMCS initial testing

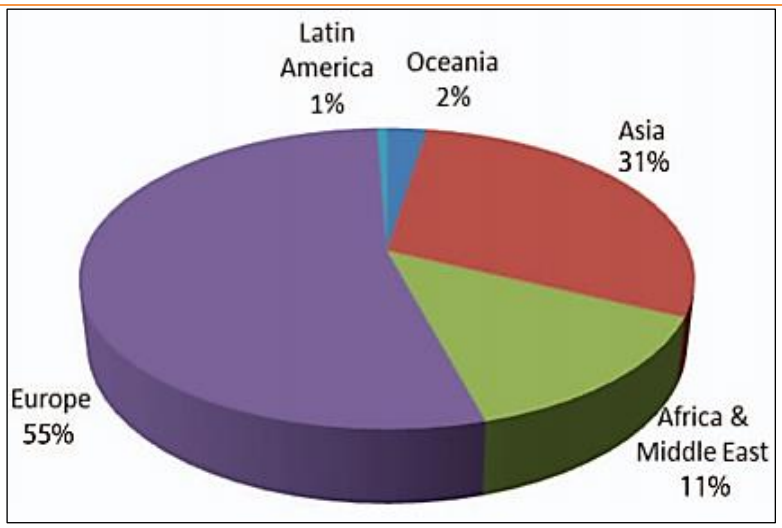


Source: EU Agency for Railways

6. ERTMS in the future

Does ERTMS have a bright future?	Well, that depends. For the moment, it definitively has a *challenging life*. As the previous sections have shown, ERTMS is a system constantly on the move and as the European railway sector is about to become digital, the requirements regarding interoperability, economies of scale, reliability, cost effectiveness, life cycles and upgrades, etc. raise in importance. The future of ERTMS will certainly be influenced by the following events: ▪ The formal shift from the current national to the future EU authorisation and certification system in June 2019, introducing the new ERTMS trackside approval procedure; ▪ The EU Agency for Railways acting as the *de jure and de facto* ERTMS System Authority from June 2019 onwards; ▪ The deployment of the ERTMS outside the EU and the reimportation of ERTMS know-how by non-EU actors in Europe based on European technology (but with 'variants'); ▪ The digitalisation of interlockings, block systems and traffic management systems[14]; ▪ The development and deployment of Automatic Train Operations (ATO) requiring a stable ERTMS and increased supervision; ▪ The abolishment of the GSM-R technology by the telecom operators and the arrival of a new successor technology ('Future Railway Mobile Communication System', in short: FRMCS); ▪ The role of laboratory testing to reduce tests in the field and thereby decreasing costs and time; ▪ The growing need for interoperable ERTMS sub-systems, requiring new open technologies; ▪ The increasing cost of development, deployment and maintenance of ERTMS reduces the profit margin for suppliers and increases the costs for customers; ▪ The impact of various industry-led (buyers) initiatives to standardise the ERTMS architecture or the interfaces.
What about the global evolution of ERTMS ?	In contrast to the 'meagre' 4.400 km of lines equipped with ERTMS in Europe, non-European markets are much more ambitious, bringing together some 88.000 km of railway tracks and nearly 120.000 vehicles operating with ERTMS. Significant investments are currently being made in Asia (31% of total ERTMS trackside investments), Africa and in the Middle East (11%). ERTMS is deployed for various applications, from freight (e.g. in Gulf countries) to high-speed lines (Chinese network or Mecca-Medina High-speed line), and suburban transport (Auckland, Sydney and Rio de Janeiro suburban networks). The geographical share is as follow:

[14] In November 2018, the EU Agency for Railways published a study on "Digitalization of control command and signaling and the transition to ERTMS" (see: https://www.era.europa.eu/library/studies_en)



Source: UNIFE ©

A more detailed insight of the main investments outside Europe related to ERTMS in terms of contracted routes (in km) is shown below. The leading country is China, followed by Saudi Arabia and Turkey:

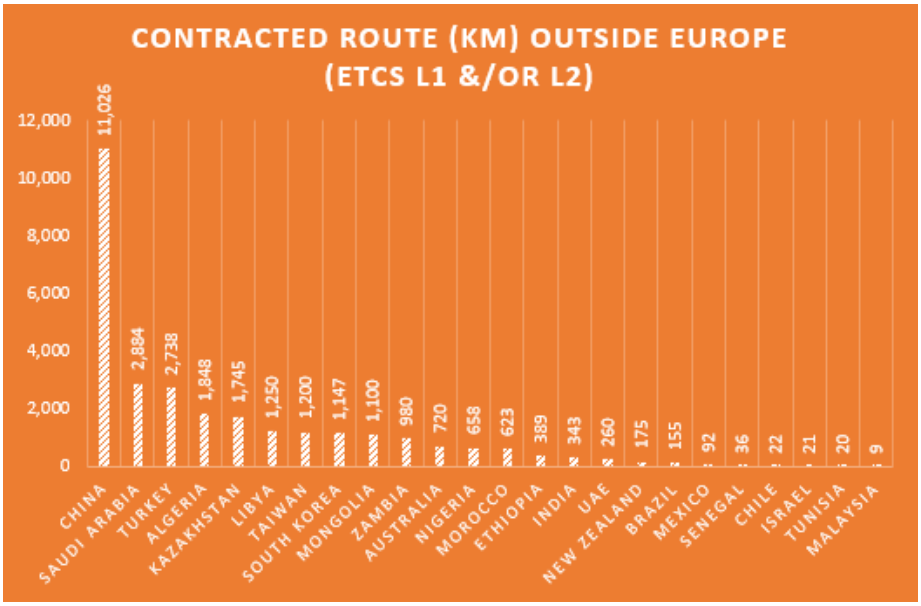


Chart: ERTMS.net

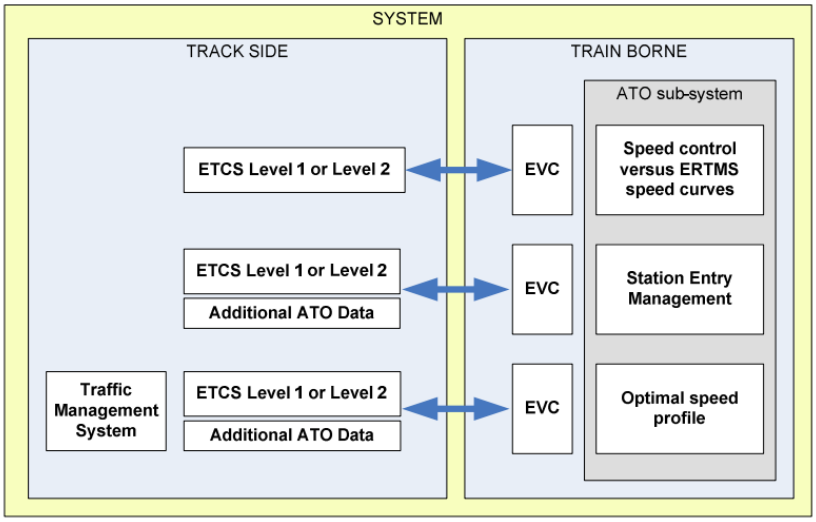
What's the situation in Europe?

In 2018 around 4.400 km of lines were operational on the CNC and almost 7.000 vehicles are equipped or contracted with ETCS, mostly co-funded by the EU.

Nearly the totality of the Italian and Spanish high-speed networks are supervised and protected by ERTMS, so are significant parts of the Swiss, Dutch and Belgian networks. The longest alpine tunnel is operated exclusively with ERTMS. The system is also in service in suburban lines with commuter traffic (e.g. Madrid).

In March 2018, Norway announced that it will carry out a country-wide overhaul of its rail signalling system over the next two decades based on ERTMS.

	Despite this progress much work is still required to achieve an EU-wide deployment of an interoperable system. Indeed, the ERTMS deployed so far do not constitute an interoperable system yet. This has different causes: ▪ Few suppliers: Since around 10 years, the rail supply industry is shrinking, due to ongoing mergers and take-overs. Today, there are some 5 suppliers in Europe, delivering ERTMS to rail infrastructure managers, with only 3 of them being European: Siemens, Alstom and Thales. The proposed merger between the market leaders Siemens and Alstom in 2018 also triggered an intensive debate in wider Europe regarding the European rail supply industry, the need for a European champion in rail supply and the EU competition, industry and trade policies. ▪ The design of ERTMS related products: For historical reasons there is no single version of ERTMS in the European market but rather many company-specific ones. This approach causes an increasing 'vendor-lock-in effect' on the buyers as they cannot buy from the shelf. However, this contrasts with the growing need for interoperable systems due to the development of the single European railway area ('SERA), the TEN-T deployment and the set-up of Rail Freight Corridors as well as the need of a fully harmonised basis for the future digitalisation technology (e.g. automatic train operations (ATO), digital traffic management, etc.). ▪ The fast pace of digitalisation: ERTMS suppliers face more and more the effects of their rail-specific proprietary technology which needs to be maintained over min 25 years. With new technology becoming much quicker obsolete due to shorter innovation cycles, ensuring backwards compatibility and proper maintenance of 25 years old technology heavily impacts the profit margins of the suppliers. On the buyer's side, IMs and RUs face increasing problems to capitalise for the increasing number and scope of upgrades, renewals, bug-fixings, etc. ERTMS faces the risk to increase costs via a lack of economies of scale. To speed up interoperability of the different systems, the ERA saw its mandate enlarged in 2016 to become the European ERTMS System Authority. Since then, the Agency has set up a variety of platforms, working parties and subgroups. Furthermore, the 4th Railway Package has introduced a new procedure for rail infrastructure managers to seek authorisation for their ERTMS track-side tenders from ERA (see section 4). ☝ Fast digitalisation and increasing needs for interoperability bring the sector to new technical, economic and commercial challenges. A faster development and more cost/ efficient deployment of ERTMS will depend on the ability of the sector to face successfully these "game changer".
How does ERTMS interface with Automatic Train Operations (ATO)?	ERTMS and ETCS are now the recognised worldwide interoperable solutions for Automatic Train Protection (ATP). The next evolution will consist in assisting the driver directly in driving the train, by adding Automatic Train Operation (ATO) to the ATP system. Because of the great diversity of trains and infrastructure in main line operations, an ATO system must be highly flexible. The ATO functional features depend on the signalling system implemented trackside. There are three steps to ATO: 1. The ATP system gives the maximum permitted speed for the train, the ATO is then able to assist the driver in performing automatic speed control at desired speed. 2. Further ATO features are achieved when the trackside equipment is able

	to send additional information related to platform configuration (opening the train doors, the platform length, the stopping position on platform etc.). This is possible with additional balises in level 1 while, in level 2, data could also be sent from the RBC. 3. Full ATO features are achieved when operational data from a Traffic Management System (TMS) are available to define the train's journey. The TMS must compute the arrival and departure times according to the time table and traffic regulation algorithms. Data could be communicated via the balises or the GSM-R connection. The figure below shows the three steps for functional ATO features:  Chart: Aspect IRSE © paper[15]
What are the challenges related to ATO?	ATO leads to more deterministic travel times, following optimal speed profiles which permit an increase in the operational traffic flow on existing lines and a reduction in energy consumption. Achieving ATO is challenging because of the diversity of trains, but also because of the complexity of the network. The challenge is now to implement ATO features on complex line configurations with the same level of interoperability as required for ERTMS.
What will happen after GSM-R has become obsolete?	All over the world, rail infrastructure managers and operators use GSM-R. It is the only fully interoperable radio communications network, which provides the data bearer (i.e. it transmits information) for ETCS. The first implementation of GSM-R started in 2000 and today over 75.000 km of lines are covered by GSM-R. Furthermore, it is a very stable system and there are no changes expected until the system's end of life. Still, the support for GSM-R is at risk after 2030 and prolonging the system beyond 2035 could prove extremely costly. However, the technology may still be in operation after that date in those countries which have deployed GSM-R at a later stage. The first target date of 2030 has alarmed the railway sector as it will need a new system from 2030 onwards which does not exist yet. Hence, the sector works since 2012 to identify a successor technology for GSM-R, called "Future Railway Mobile Communications System" (in short: FRMCS) under the supervision of the EU Agency for Railways.

[15] http://www.irse.org/knowledge/publicdocuments/2.06%20Bienfait%20-%20Automatic%20Train%20Operation%20for%20ETCS.pdf

What are the key challenges related to a new communications technology ?

Given the complexity of telecommunication technology, the following challenges need to be addressed:

- Spectrum: Needed for the future system as well as for GSM-R during the migration phase. There will be a massive competition for this spectrum;
- The need to keep GSM-R running alongside the FRMCS: this means that additional harmonised spectrum will be a vital requirement, and one the industry needs to start preparing for now;
- The timeline for migration: It will vary between countries, impacting on the interoperability of the system, as legacy and future systems are likely to coexist for many years.

In 2017, EIM and CER suggested that the 873-876MHz/918-921MHz band should be reserved in addition to the current GSM-R band for FRMCS. It was stated that this was the most favourable option to re-use infrastructure investment and allow a smoother migration.

Moving to FRMCS should not only be dictated by the future obsolescence of GSM-R. FRMCS will use broadband technology and offer a much higher communications capacity for railway applications. This will enable to optimise operations by leveraging this capacity for future signalling and / or business support systems. FRMCS will also ensure that there is a clear separation between the applications and the communication layer, allowing to prioritise the use of spectrum based on business criticality.

While this new technology should still contain ad-hoc specifications made for the railway sector (such as the emergency calls or group calls), the IMs would favour to deploy communication systems based on available market technology ('from the shelf') to avoid costly rail-specific proprietary technology.

The Agency is also preparing the introduction of the FRMCS system in the ERTMS standard (CCS TSI). The aim is to deliver the first functional requirement specification for the FRMCS in 2020 with the first FRMCS deployment (pilot) in 2023.

The chart below summarises the main activities linked to FRMCS:

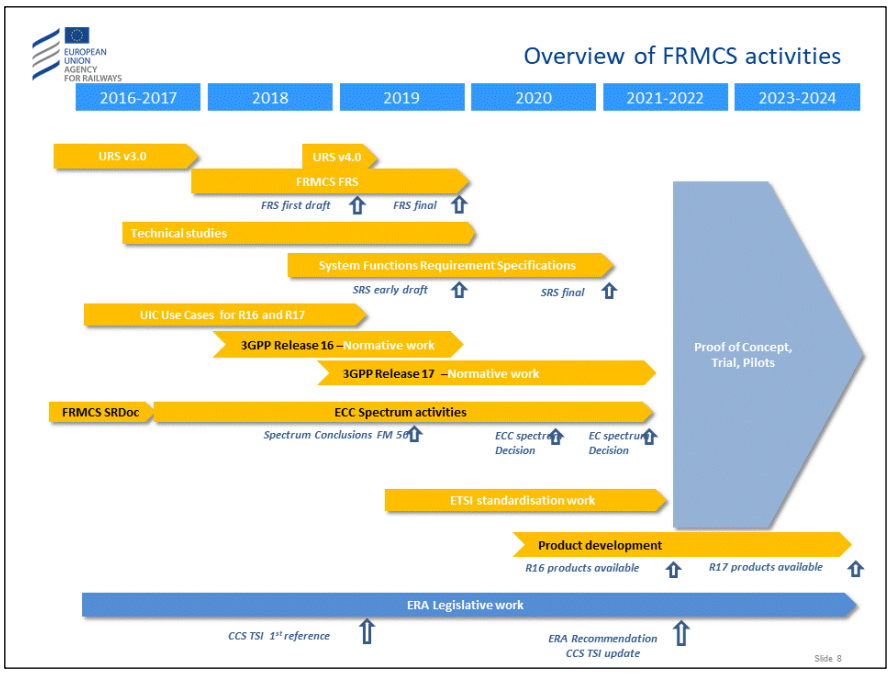


Chart: ERA

How does ERTMS interface with Galileo?	In 2016, Galileo, the European global navigation system launched its initial services. It is a European state-of-the-art system that provides highly accurate guaranteed global positioning and super precise timing. Once fully deployed in 2020, Galileo will consist of 24 operational satellites and 6 in orbit spares. Galileo is unique as it is under civilian control, while all other satellite systems are operated by military forces. In 2019, the EU Aviation Safety Agency (EASA) announced that 27 satellites of Galileo are in operation, improving the functionalities of GPS with a more accurate positioning at no cost for the users. The benefits of combining ERTMS and Galileo will not only improve the positioning and location of the railway, but also the reliability, safety and efficiency of railways operations. Galileo aims at being used as the positioning system for ERTMS. On 24th February 2017, for the first time a European rail test journey was completed in Sardinia (IT) using the positioning technology provided by Galileo. The test was an initiative of the Horizon 2020-funded Project "ERTMS on Satellite – Enabling Application Validation" (ERSAT EAV [16]). The test journey demonstrated the ability of Galileo to monitor and safely manage rail traffic on conventional secondary, local and regional rail lines with the aim to become an integral part of ERTMS. The advantages of this include: ▪ increase traffic capacity available to railway undertakings; ▪ guarantee high safety standards and punctuality; ▪ lower operating costs with new technological equipment that requires; less investments in installation and maintenance; ▪ maintaining a sustainable and competitive railway system. Although the European rail sector understands the potential of Galileo, its adoption is limited due to a lack of clear definitions and definitive testing. Before Galileo is fully adopted in rail, the sector needs to be confident that the train localisation based on the technology will satisfy European safety standards. One of the objectives of the ERSAT EAV Project is indeed to specify and standardise satellite positioning to ensure harmonisation with ERTMS standards.
What are the other main industry initiatives to boost interoperability?	Since 2014, several initiatives at industry level have emerged with the aim to boost interoperability among proprietary ERTMS technologies of the suppliers, so that to overcome some of the current shortfall limiting the ERTMS fast development and deployment. The main ones are: Reference CCS Architecture – (RCA[17]) The RCA is an initiative developed since 2016 by rail infrastructure managers within the scope of the ERTMS User Group. Its main aim is to develop a common system architecture platform with common interface specifications for the components of the Command-Control and Signalling (CCS). RCA aims for upwards and downwards compatibility of the common interfaces between suppliers' blocks operating under the system architecture to make them independent from any specific communications technology and free from IP rights. The RCA also targets a "low life cost" by introducing the concept of a modular architecture. This architecture approach is not limited to the ERTMS technology as such, but the entire CCS landscape. Indeed, the CCS components outside the

16 http://www.ersat-eav.eu/home.aspx
17 https://ertms.be/workgroups/ccs_architecture

	trackside safety part will be considered as far as relevant in order to define the interfaces with these components, with an overall view on CCS. Furthermore, the development of the RCA architecture is based on the definitions and principles included in the ERTMS TSI CCS, but also in the specifications defined by the EULynx consortium (see below). The ERTMS Users Group presented the RCA initiative in February 2019 and its members have reached out to the Shift2Rail Joint Undertaking to explore possible funding. EULynx[18] This initiative was also initiated in 2014 by rail infrastructure managers with the aim to standardise the interfaces and elements of the signalling systems and to complement the RCA initiative. EULynx seeks inclusive standards and mainly focuses on the interfaces between the interlocking and the field elements (level crossings, point machines etc.). It also foresees a security layer to be embedded in the future technology. As of today, EULynx remains an initiative mainly supported by infrastructure managers with limited support from the rail supply industry. Smart Rail 4.0[19] In 2017, the Swiss state railways SBB developed a new initiative to digitalise its CCS with the objective to prepare the Swiss railway system for the future 'game changers', such as ATO, ETCS level 3, the future rail mobile communication systems (from 2023 onwards), onboard location identification and the automation of the wider traffic management systems. Open CCS Onboard Reference Architecture – OCORA In 2018, several railway undertakings developed their own initiative, called OCORA. It is the successor approach to the former 'open ETCS' initiative. The goal of OCORA is to set common standards for the onboard modular architecture for the CCS functionality on the vehicle to reduce costs and workload for upgrades and extensions while simplifying homologation.

[18] https://www.eulynx.eu/
[19] https://smartrail40.ch/index.asp?inc=en/program.asp

ANNEXES

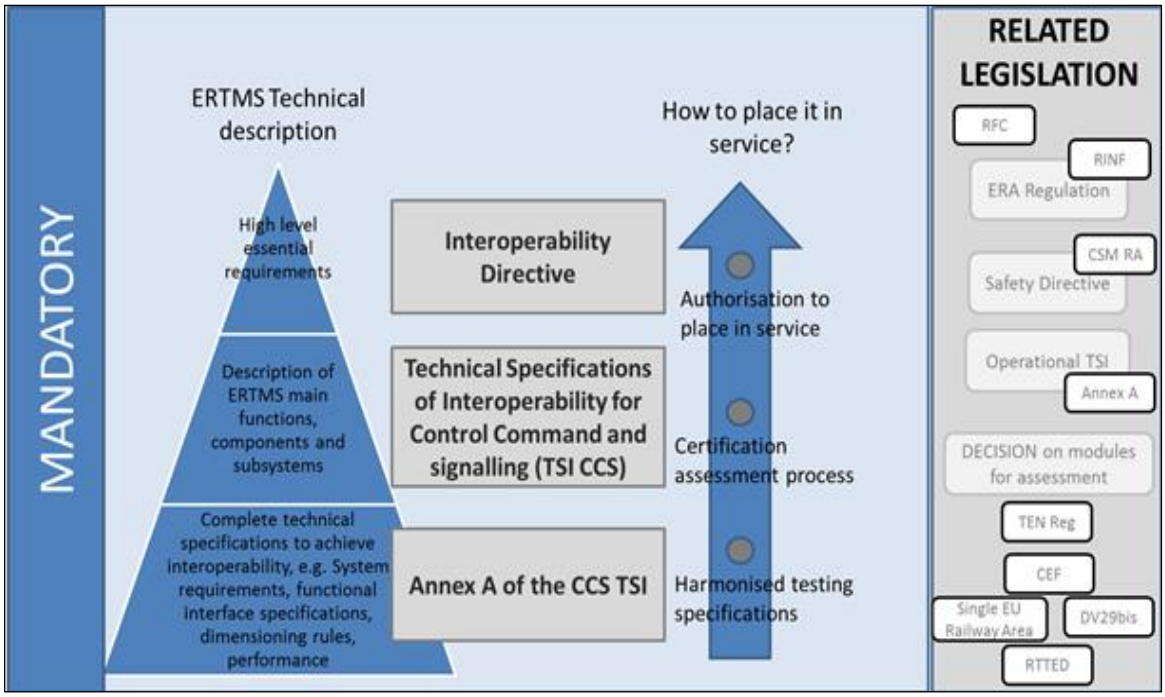
A1: List of national signalling systems

- Austria: INDUSI/PZB, LZB
- Belgium: Crocodile, TBL 1, TBL 2, TVM 430, TBL1+, KVB
- Bulgaria: EBICAB 700
- Croatia: INDUSI I60
- Czech Republic: LS
- Denmark: ZUB 123
- Estonia: ALSN
- Finland: ATP-VR/RHK
- France: Crocodile, KVB, TVM 300, TVM 430, KVBP, KCVP, KCVB, NEXTEO, DAAT
- Germany: PZB 90, LZB, GNT
- Hungary: EVM
- Ireland: CAWS, ATP
- Italy: BACC, RSDD/SCMT, SSC
- Latvia: ALSN
- Lithuania: ALSN
- Luxembourg: MEMOR II+
- Norway: ATC
- Poland: SHP, PKP radio system with Radiostop function
- Portugal: INDUSI, EBICAB 700
- Romania: INDUSI I60
- Slovenia Indusi/PZB
- Slovak Republic LS
- Spain: ASFA, EBICAB 900, LZB
- Sweden: ATC
- Switzerland: EuroSIGNUM, EuroZUB
- The Netherlands: ATB First generation, ATB new generation
- UK: GW ATP, RETB, TPWS, TVM 430, Chiltern-ATP, Mechanical Trainstops, KVB

NB: The fact that two or more Member States use the same of the legacy system does not imply that they are compatible.

A2: Legal basis for ERTMS

On a hierarchy scale, the highest documents related to Interoperability in the Railway frame are the EC Directives. Below there are EC Decisions that develop essential and technical requirements in more depth.



Source: EU Commission

The Interoperability Directive (2008/57/EC) is currently in force, and sets out a number of essential requirements to be met for interoperability which include safety, reliability and availability, health, environmental protection and technical compatibility along with others specific to certain sub-systems. The Directive also requires the production of mandatory Technical Specifications for Interoperability (TSIs).

The procedure for putting ERTMS systems into service is defined in the Interoperability Directive and has been further explained in an EEC recommendation, 2014/897/EC

The Technical Specifications of Interoperability for Control Command and Signalling (TSI CCS) Commission Regulation (EU) 2016/919 is the legal basis of ERTMS specification. It includes the definition of the essential requirements, the subsystem and interface functional and technical specifications, and also determines the necessary list of constituents and interfaces and procedures for their assessment. From the legal point of view, it is a Commission Regulation, thus directly applicable to all actors without a transposition to the national law. This also means that any actor can use the national courts to enforce this Regulation.

The European Union Agency for Railways (ERA), as ERTMS system authority, is in charge of the management, change and production of the specifications related to the ERTMS.

A3: List of Core Network Corridors (CNC)

The 9 core network corridors are illustrated below:

CNC	CNC Description
1- Rhine-Alpine (RALP)	Amsterdam-Zeebrugge-Antwerp/Rotterdam-Duisburg-[Basel]-Milan-Genoa
2- Scandinavian-Mediterranean (SCM)	Finland (Turku/Naantali-Kouvola-Hamina) Stockholm-Malmö-Copenhagen-Hamburg-Innsbruck-Verona-Roma-Napoli-Palermo
3- North Sea-Mediterranean (NSM)	UK (Glasgow-Edinburgh-Liverpool-Manchester-Birmingham-London-Dover)
	Rotterdam-Antwerp-Luxembourg-Metz-Dijon-Lyon/Basel-Marseille
4- Mediterranean (MED)	Algeciras-Valencia-Tarragona/Sevilla-Madrid-Zaragoza-Barcelona-Marseille-Lyon-Turin-Milan-Verona-Padua/Venice-Trieste/Koper-Ljubljana-Budapest-Zahony(Hungarian-Ukrainian border)/Budapest-Zagreb and Budapest-UA border
5- Rhine-Danube (RDN)	Prague-Horní Lideč–Žilina–Košice-Čierna nad Tisou (Slovak/ Ukrainian border)
6- North Sea-Baltic (NSB)	Bremerhaven/Rotterdam/Antwerp-Aachen-Utrecht/Hannover-Amsterdam/Berlin-Warsaw-Terespol (Poland-Belarus border)/Kaunas/Warsawa-Vilnus/Helsinki/Kaipeda/Ventspils
7- Baltic-Adriatic (BAC)	Gdynia-Katowice-Ostrava/Žilina-Bratislava/Vienna/Klagenfurt-Udine-Venice/ Trieste/Bologna/Ravenna/ Graz-Maribor-Ljubljana-Koper/Trieste
8- Atlantic (ATL)	Sines-Lisbon/Leixões-Madrid-Medina del Campo/ Bilbao/San Sebastian-Irun-Bordeaux-Paris/Le Havre/Metz Sines-Elvas/Algeciras
9- Orient/East-Med (OEM)	Rostock/Hamburg/Wilhelmshaven/Bremerhaven-Dresden-Prague-Bratislava/Vienna-Budapest Arad-Timisoara-Vidin-Sofia-Thessaloniki-Athens/ Igoumenitsa

Table: EU Commission

A4: Status of the CNC and ERTMS Deployment

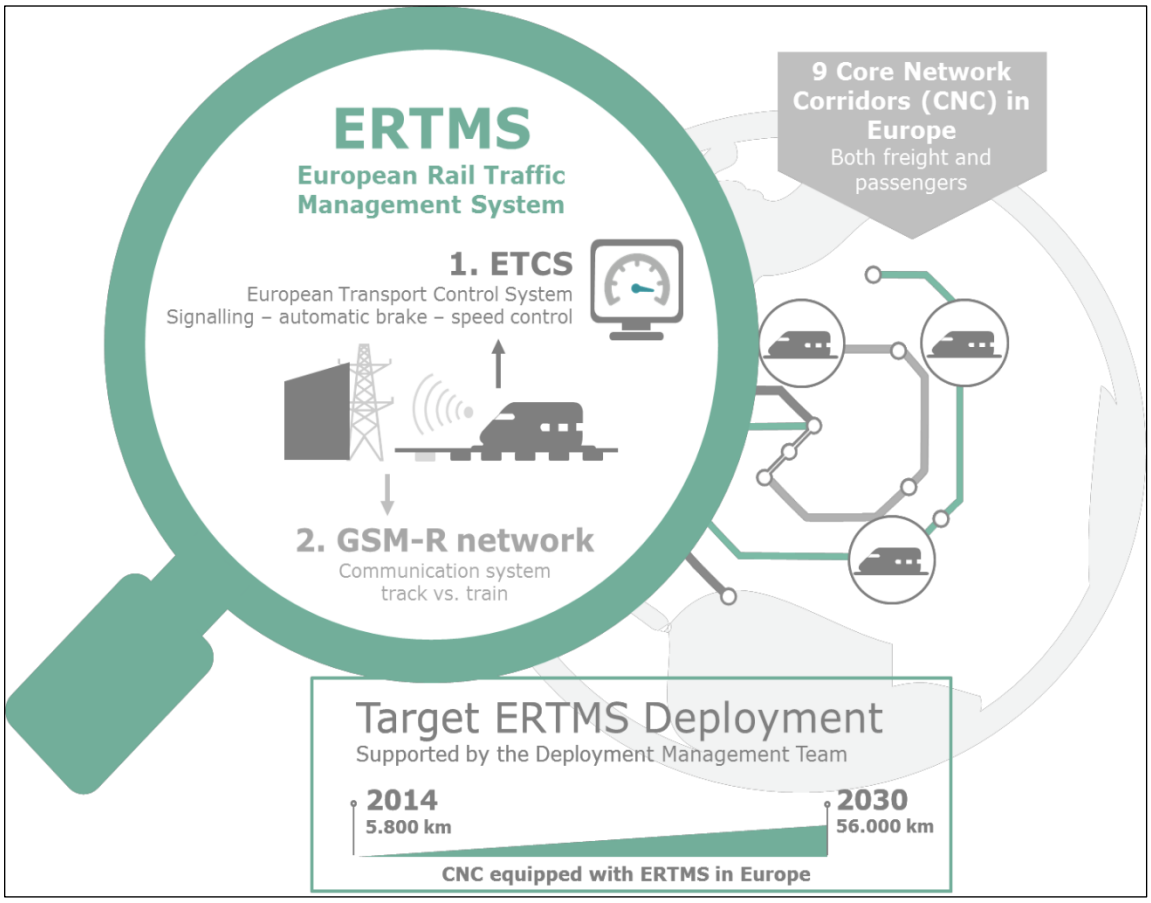


Chart: EU Commission

A5: Current status of the NIPs

According to the Commission Staff Working Document "Delivering an effective and interoperable European Rail Traffic Management System (ERTMS) – the way ahead", NIPs should have been submitted before July 2017 (article 7.4.4. of the Annex to Regulation (EU) 2016/919).

In addition, rail freight corridors should publish a plan for the deployment of the interoperable system ERTMS. Therefore, considering the compulsory basis of the European Deployment Plan for the core network corridors on the one hand and the rail freight corridor traffic on the other hand, the rail freight corridors are well placed to collect the data for the ERTMS roll-out on their principal, diversionary and connecting lines in order to provide a more complete overview relevant both for decision makers and RUs.

See below the responsibilities of each actor:

Action	Responsible	Involved	Timelines	Status
Implementation of the European Deployment Plan. Agreement between the affected infrastructure managers should be signed for cross-border sections (agreements should be notified to the Commission by Member States). List of cross-border sections can be found at Appendix B.	IMs, EC	DMT, ERA, MSs, NSAs, RFCs	Progressively: one year before the earlier of the deployment dates for the given cross-border section	24 countries have submitted the NIPs. 4 countries have not submitted the NIP: Greece, United Kingdom, Hungary and Romania
Notification of progress of implementation via TENtec	MSs	IMs	Progressively, one month after putting into operation	Unknown – not published
Synthesis of NIPs	EC	DMT, IMs	Publication of synthesis by end 2017	Published in March 2018 https://ec.europa.eu/transport/sites/transport/files/rail-nip/20180302-synthesis-report-on-nip.pdf
Report on implementation progress of European Deployment Plan	EC	DMT, IMs	First report to be published in the beginning of 2018, then on a yearly basis	Unknown – not published
Review and extension of European Deployment Plan for the CNC sections to be carried out between 2024 and 2030.	EC	MSs	Review procedure should be finalised not later than 31 December 2023, it should start in 2021	Planned for 2023

Table: EU Commission

A6: Memorandum of Understandings (MoUs)

Time	MOUs (actors, features, principles, elements, source)
2005	ERTMS MoU No 1 ▪ Actors: EC, manufacturers, IMs and Rus ▪ Feature: First comprehensive MoU on ERTMS ▪ Principle: Established first basic principles of an EU deployment strategy for the European Rail Traffic Management System (ERTMS). ▪ Main elements: Agreement of a main kernel for the ERTMS; National Implementation Plans (horizon 10-12 years); development of an EU Master Plan. Strategy from concept to delivery; set-up of an ERTMS system authority (former ERA) ▪ Source: https://ec.europa.eu/transport/sites/transport/files/modes/rail/ertms/doc/ertms-mou-2005.pdf
2008	ERTMS MoU No 2 ▪ Actors: EC, manufacturers, IMs and RUs ▪ Feature: Included past ERTMS experience of Member States ▪ Principle: Reference document for all stakeholders involved in ERTMS ▪ Main elements: Established the 1st reference version of the system; backwards compatibility principles (to protect investments/commitments already made); specified the next steps for the planned deployments; ensured the coordination in the updating of the specifications; added new functionalities and content of policy measures. ▪ Source: https://ec.europa.eu/transport/sites/transport/files/modes/rail/ertms/doc/ertms-mou-2008.pdf
2012	ERTMS MoU No 3 ▪ Actors: EC, manufacturers, IMs and Rus ▪ Feature: Define main objectives of cooperation between ERTMS stakeholders ▪ Principle: Principles of previous MoU No 2 were maintained ▪ Main elements: See MoU No 2 ▪ Source: https://ec.europa.eu/transport/sites/transport/files/modes/rail/ertms/doc/ertms-mou-2012.pdf
2016	ERTMS MoU No 4 ▪ Actors: EC, manufacturers, IMs and Rus ▪ Feature: Formalisation of integrated EU management process for ERTMS ▪ Principle: Framework for legal and technical certainty for trains equipped with the latest ERTMS release to run on any compatible line with an acceptable level of performance. ▪ Main elements: Mature management of software-based system with customers and suppliers; introduction of appropriate clauses for software maintenance in suppliers contracts; stronger commitment of sector to deploy a truly interoperable system based on a stable set of specifications (2nd release of baseline 3); contains definition of compatibility; consideration of results of long-term perspective; future game changers for the digitalization of the rail system; reflects new competences of the EU ERTMS system authority (i.e. EU Agency for Railways) ▪ Source: https://ec.europa.eu/transport/sites/transport/files/ertms-mou-2016.pdf

A7: EU Agency for Railways - ERTMS

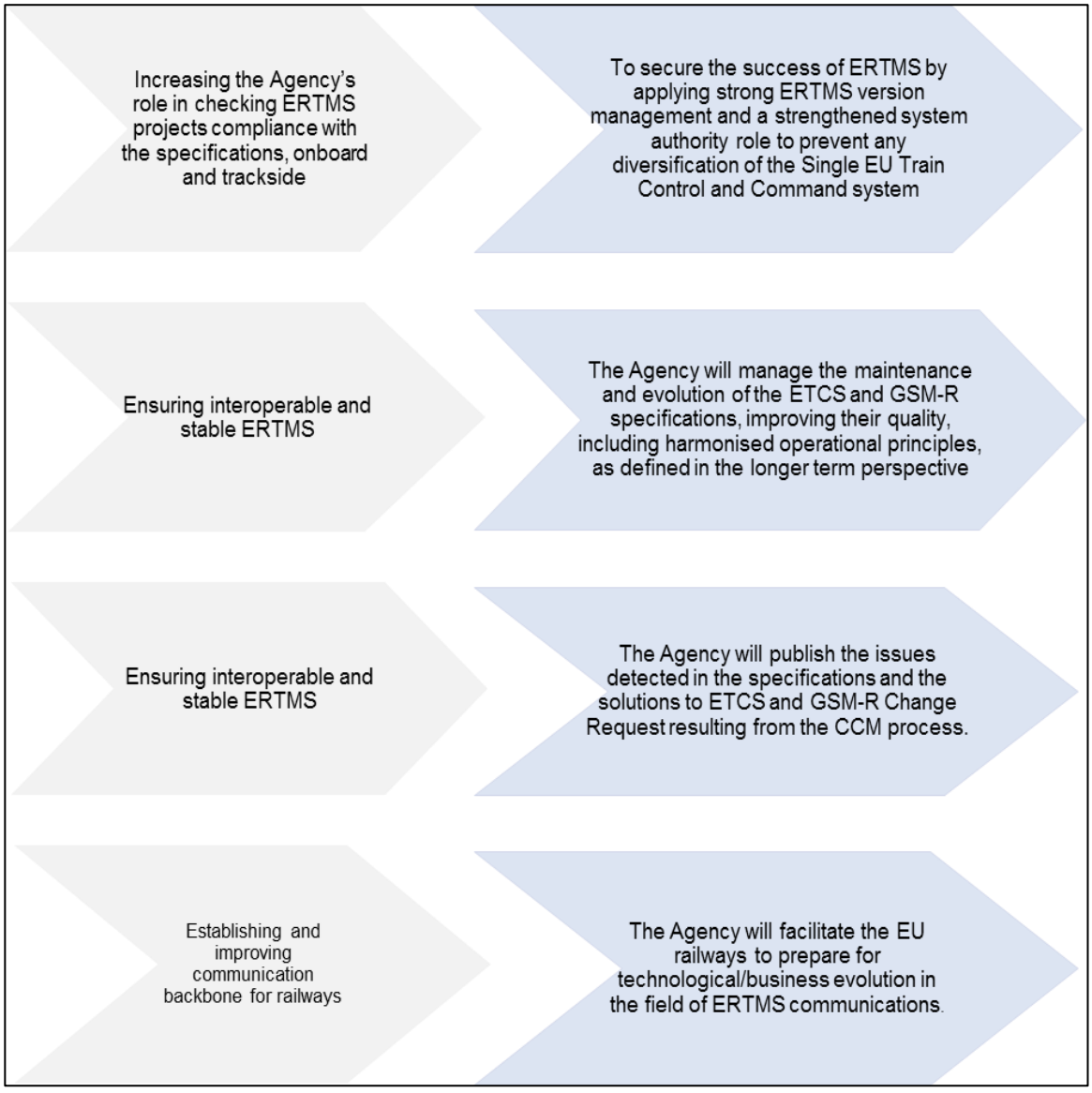


Chart: EIM

A8: ERTMS Trackside Approval – at a glance

European Rail Infrastructure Managers EIM
European year of rail 2021

ERTMS TRACKSIDE APPROVAL

APPLICATION GUIDE FOR ERTMS TRACKSIDE APPROVAL

WHAT IS THE ERTMS TA?

The ERTMS trackside approval is part of the application file for an authorisation for placing in service trackside control-command and signalling subsystems, involving the European Train Control System (ETCS) and/or the Global System for Mobile Communications – Railway (GSM-R) equipment.

WHO MUST APPLY FOR AN ERTMS TA?

The IM or other legal entity on behalf of the IM that requests the Agency approval of the technical solutions envisaged. The applicant can be the same entity that later will request the authorisation for placing in service fixed installations. The applicant should submit its request for application before any call for tenders relating to ERTMS trackside equipment.

HOW CAN APPLICATIONS BE MADE?

All applications for an ERTMS trackside approval must be electronically submitted through the ERA IT tool One-Stop Shop (OSS).

WHEN DOES THE ERTMS TA APPLY?

The ERTMS trackside approval **applies to any call for tenders relating to ERTMS trackside equipment** which are launched after (or were launched before but have not been closed on the date of) 16 June 2019 or, 16 June 2020 or 31 October 2020 (depending on the Member States transposition).

Even though the ERTMS trackside approval is requested for the authorisation of trackside subsystems involving ERTMS, as mentioned in Directive (EU) 2016/797, other transitional provisions are defined in Article 55 of this Directive. Due to these transitional provisions, and for the cases of any ERTMS trackside equipment which was not yet subject to an approval, the Agency must be informed before authorising the placing in service.

WHAT DOES IT CONTAIN?

- Project Description
- Relevant CCS TSI
- Project plan: deliverables, milestones and deadlines
- List of functions to implement (issue log)
- Address of risk impacting interoperability
- Engineering rules and operational scenarios
- Test strategy and test plan
- Conditions for technical and operational compatibility
- Previous ERTMS trackside authorisation or opinions by an NSA
- EC Certificates and EC Declarations of conformity of the interoperability constituents
- EC Certificates and EC Declarations of verification of the trackside subsystem
- National rules related to ERTMS
- Exemption from the application of one or more TSIs
- Previous approval(s) identification

FEES AND CHARGES

The amount of fees and charges shall be the total of the following:

- the number of hours spent by Agency staff and external experts, on the processing of the application multiplied by the hourly rate of the Agency; and
- the relevant costs of the NSAs resulting from the processing of the national part of the application.

The Agency shall apply an hourly rate of **EUR 130**.

This document is for information purposes, for official information go to https://www.era.europa.eu/applicants/applications-ertms-trackside-approval_en

European Rail Infrastructure Managers EIM European year of rail 2021

ERTMS TRACKSIDE APPROVAL

APPLICATION GUIDE FOR ERTMS TRACKSIDE APPROVAL

APPLICATION PROCESS

INITIAL ENGAGEMENT

OPTIONAL

The initial engagement (non-mandatory but highly recommended) is performed at applicant's request, starting before any call for tender relating to ERTMS trackside equipment and when the applicant informs the Agency of its intention to submit a request for approval.
The initial engagement stage is concluded with the signature of an arrangement between the Agency and the applicant which includes:

- The scope of the application;
- Schedule, including the dates of:
  - submission of each document listed in 'What does it contain?' section;
  - updates of the issue log;
  - deadline for decision;
- The issue log

Note: ERA will not charge during this stage

SUBMISSION AND VERIFICATION COMPLETENESS

The applicant should submit all the documents listed in 'What does it contain?' section. If any of those documents was previously submitted through the one-stop shop, the applicant may identify these documents and confirm that those documents remain applicable to the project without any modification or addition. In the event of any modifications or additions to those documents the applicant must submit the updated documents.

ASSESSMENT AND DECISSION

The Agency issues either a positive or negative decision within two months from the start of the assessment and decision stage on that part of the technical solutions that have not been previously covered by a positive decision for approval by the Agency.

The Agency shall issue:

- Positive decision if the previous stage ('Submission and Verification Completeness') is successfully completed and all the issues listed in the issue log have the status 'issue closed'.
- Negative decision if one or more issues listed in the Issue Log have the status 'issue closed but unacceptable' or if the assessment of the previous stage ('Submission and Verification Completeness') is finished but the file is not considered complete, relevant and/or consistent.
- Positive decision with conditions in the following cases:
  - One or more issues listed in the issue log have the status 'closed with conditions';
  - No issue has the status 'closed but it is not acceptable'.
  - It should provide an explanation of the conditions that need to be fulfilled by the applicant at a later stage and considered by the NSA and a summary of the final issues as recorded in the issue.

BOARDS OF APPEAL

IF NEEDED

The procedural rules applicable to an appeal against the Agency decision are detailed in the Commission Implementing Regulation (EU) 2018/867 laying down the rules of procedure of the Board(s) of Appeal of the European Union Agency for Railways.

Index

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