

European
Commission



CEF support to

ERTMS

May 2020

*Innovation
and Networks
Executive Agency*

Table of Contents

1. Introduction	3
1.1. Scope of the Report.....	3
1.2. Political and strategic EU background.....	3
2. State of play of the ERTMS Actions' portfolio.....	4
2.1. Track-side deployment	8
2.2. On-board deployment	14
2.3 Memorandum of Understanding.....	14
2.4 Financial Progress	15
3. Evolution of the ERTMS Actions' portfolio.....	16
3.1 Calls for proposals	16
3.1.1 ERTMS priority	16
3.1.2 Core Network Corridor priority	17
3.2 Financial evolution of the portfolio.....	17
3.3. Issues affecting the implementation	18
4. Conclusion.....	20
5. List of ERTMS Actions.....	21

1. Introduction

1.1. Scope of the Report

The purpose of this report is to give an overview on the European Rail Traffic Management System (ERTMS) Actions' portfolio benefitting from CEF Transport funding during the period 2014-2019.

Following the description of the basic political and strategic EU background of ERTMS deployment, the report highlights in Chapter 2 the state of play of the CEF support dedicated to ERTMS through the 2014-2018 calls for proposals. The report does not take into account the proposals submitted to CEF Transport 2019 Multi-Annual Programme Call (ERTMS on-board prototypes) and CEF Transport 2019 Blending Facility Call (ERTMS on-board and track-side deployment), since the respective evaluation procedures had not been completed by the time the report was elaborated. Chapter 3 focusses on the evolution of CEF Transport support to ERTMS and the main issues affecting the successful implementation followed by final conclusions.

The report is based on the data available in the Agency's tools used for the CEF Actions' monitoring.

1.2. Political and strategic EU background

The deployment of ERTMS is a major horizontal project resulting in an increase of the rail transport safety and interoperability and consequent improvement of the competitive position of the railways on the EU transport market. The ERTMS is a command and control system composed of the European Train Control System (ETCS), for continuous monitoring of the vehicle's speed, and the radio communication system GSM-R, for voice and data communication, used in the Level 2 of the system.

The system has been developed by the European industry since the end of the twentieth century. The comprehensive EU legislation as well as the EU-wide system deployment strategy intensified its implementation at the beginning of the twenty-first century.

Considerable political and strategic developments took place at the EU level during the previous financial framework (2007–2013). The adoption of the Directive on the Railway Interoperability, Technical Specifications for Interoperability for Control-Command and Signalling with Baseline 2 (B2, release 2.3.0d) and then Baseline 3 (B3), the European Deployment Plan (EDP) and the 3 Memoranda of Understanding paved the way for a structured deployment policy in EU.

With the latest re-cast of the Interoperability Directive¹ and the update of the technical specifications resulting in the adoption of B3 release 3.6.0², the system is now considered stable, mature, comprehensive and responding to the stakeholders needs, both on Infrastructure Managers (IM) and Railway Undertakings (RU) side. The ERTMS will be deployed in line with the updated EDP³. The document foresees the deployment of ERTMS on considerable parts of the Core Network by 2023.

In November 2017 the EC published the Commission Staff Working Document⁴ "Delivering an effective and interoperable European Rail Traffic Management System (ERTMS) – the way ahead". The document identifies the following principle drivers for successful ERTMS B3 deployment in EU: i) interoperable and compliant infrastructure, ii) standardisation of the on-board unit, iii) efficient testing and validation, iv) maintaining ERTMS in a reliable and consistent manner as well as v) funding/financing support .

¹ DIRECTIVE (EU) 2016/797 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Of 11 May 2016 on the interoperability of the rail system within the European Union

² COMMISSION REGULATION (EU) 2016/919 of 27 May 2016 on the technical specification for interoperability relating to the 'control-command and signalling' subsystems of the rail system in the European Union

³ COMMISSION IMPLEMENTING REGULATION (EU) 2017/6 of 5 January 2017 on the European Rail Traffic Management System European deployment plan

⁴ SWD(2017)375

The successful deployment of the system is a pre-requisite for interoperable, safe, efficient and competitive EU railways, taking a tangible step towards their digitalisation.

The level of political support to the deployment of ERTMS differs between the Member States. This has a clear impact on the associated investment decisions, the commitment to deliver particular projects and the contribution to the national and European deployment plans. EU has recognised an importance of the coordination of the system deployment at the European level. To this end the Commission appointed the European Coordinator for ERTMS in 2005, who aims, among others, at streamlining Member States' cooperation for a successful implementation of the system.

The absence of ERTMS is considered a bottleneck for the completion of Core Network. Along with the limitations to the allowed axle loads, access of 740 metre-long convoys and low operational speeds, this impacts negatively the operations of the Core Network Corridors.

The CEF Transport funding concentrates on railway projects, including 60 ongoing or completed Actions with ERTMS component getting the contribution of €802.9 million to date.

Though substantial progress towards the ERTMS deployment in EU has been achieved already in the previous financial framework, further effort is needed to successfully implement ERTMS in line with the EDP. Given the considerable experience gained by the sector during the 2007-2013 financial framework, as well as the already achieved stability and maturity of the system, it is expected that the CEF funding will significantly speed up ERTMS implementation progress by the end of the current financial perspective.

2. State of play of the ERTMS Actions' portfolio

Overall, 76 CEF ERTMS-related Actions were retained so far for funding under the general and cohesion CEF envelopes during the current Multiannual Financing Framework, including:

- 58 Actions retained under dedicated ERTMS calls' priority. These calls addressed predominantly ERTMS deployment, but covered also auxiliary necessary tasks such as interlockings' modernisation. The Actions were granted an initial total CEF Transport funding of €1.3 billion, including €1 billion for pure ERTMS deployment.
- 18 Actions retained under the Core Network Corridors (CNC) calls' priority. 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 components. These specific Actions were granted an initial CEF Transport funding of €3.7 billion, including €121.6 million for pure ERTMS deployment.

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

- 49 Actions retained under dedicated ERTMS calls' priority. The Actions are granted an actual total CEF Transport funding of €957.3 million, including €747.5 million for pure ERTMS deployment.
- 11 "combined" Actions retained under the CNC calls' priority with actual total CEF Transport funding of €2.6 billion, including €55.4 million for pure ERTMS deployment.

The decrease of number of respective Actions and related CEF Transport funding is due to the termination or the modification of the signed grant agreements, resulting in reduction or removal of CEF support to ERTMS activities. The reasons for terminations and reductions are elaborated in the paragraph 3.3. of the Report.

The Actions in subject contribute to the ERTMS deployment and cover the following activities: track-side or on-board physical deployment of the system, studies triggering contracting of suppliers for physical deployment and - so called - Memorandum of Understanding (MoU) tasks. The latter refer to Memoranda of Understanding signed between the EC and the sector stipulating, among others, proper maintenance and development of the system. The CEF supported Actions support Memoranda of Understanding

commitments by addressing horizontal tasks such as technical specifications, testing facilities, etc. Certain ERTMS Calls encompassed also other related tasks linked with track-side or on-board deployment, e.g. interlockings' modernisation, drivers' trainings, etc.

This report focuses solely on the ERTMS-deployment and the MoU component of the Actions.

In the period 2014-2019 the following areas of intervention were the three following priorities:

1. ERTMS **track-side** deployment, including:
 - a. **Retrofit**, i.e. first deployment of the system on a railway line section(s) already in operation and not equipped with the system before.
 - b. **Upgrade**, i.e. equipment of the legally binding baseline (e.g. B3) on a railway line section(s) already in operation and equipped with ERTMS compliant with a previous baseline.
 - c. **Preparatory actions**, i.e. activities needed to prepare project implementation. The preparatory actions should be a basis for launching a procurement procedure for the physical ERTMS deployment.
2. ERTMS **on-board** deployment, including:
 - a. **Retrofit**: deployment of the ERTMS B3-compliant system on an existing vehicle(s) already in operation and not equipped with the system before.
 - b. **Upgrade**: deployment of the ERTMS B3-compliant system on an existing vehicle(s) already in operation and equipped with pre-Baseline 3 compliant ERTMS equipment.
 - c. **Training activities**: specific ad-hoc expertise to follow up the project or other necessary support to small and medium-size 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 such elements as test campaigns (both in field and in laboratories), assistance to ERA regarding development and maintenance of ERTMS specifications, etc. The MoU Actions were only eligible under 2014 dedicated ERTMS call.

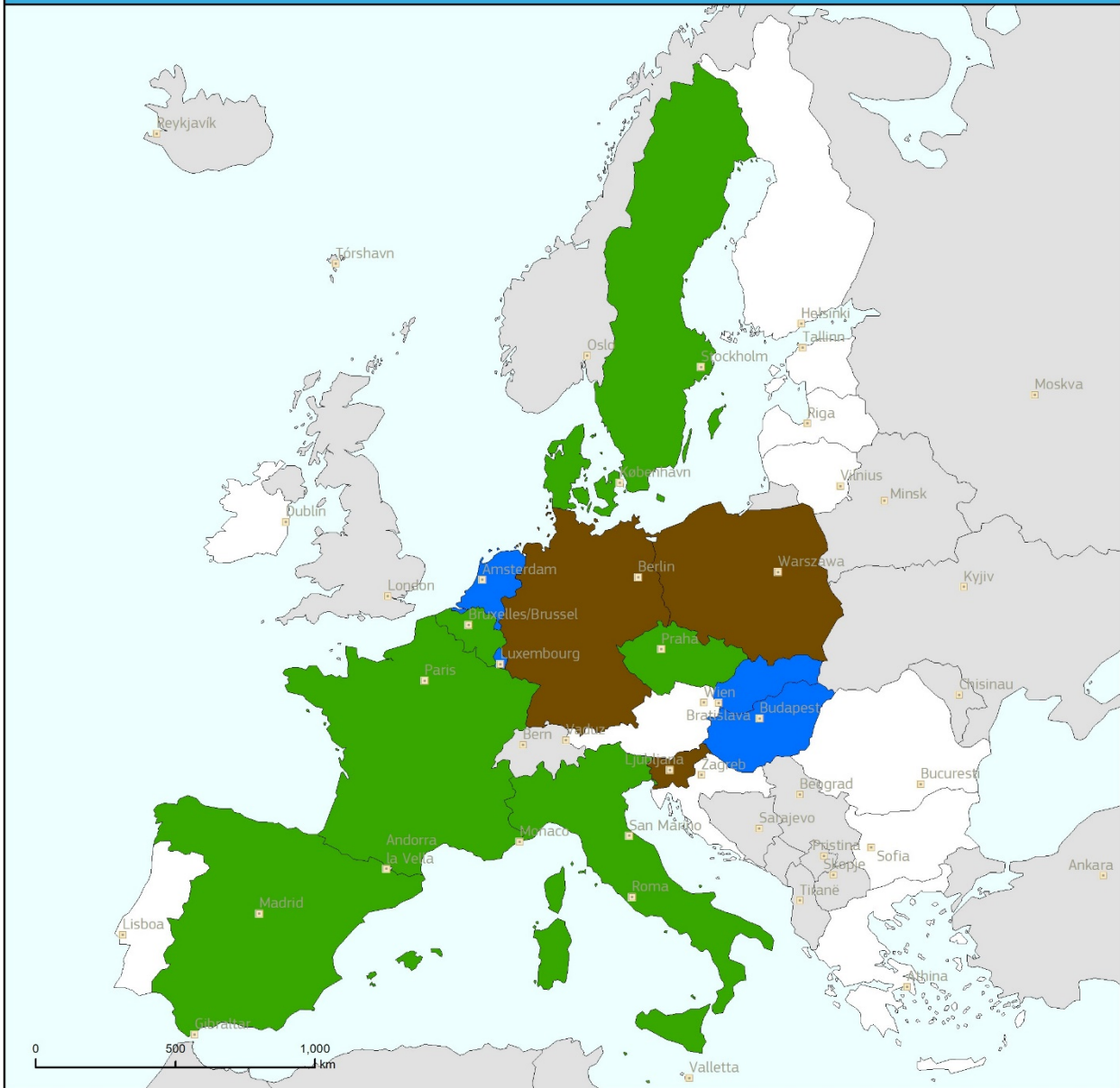
The map below presents the countries benefiting from CEF support of ERTMS on-board or track-side works (no studies or MoU included).



TEN-T NETWORK

Innovation
and Networks
Executive Agency

ERTMS CEF FUNDED ACTIONS BY AREA OF INTERVENTION



ERTMS dedicated calls, track-side and on-board works only




-  on-board
-  track-side
-  on-board and track-side

Figure 1 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 overwhelming part of CEF Transport funding, €564.8 million (70%), is allocated to track-side implementation, while the funding for on-board amounts to €232.5 million (29%). Activities related to MoU received €5.7 million (1%) of the CEF Transport funds allocated to ERTMS Actions.

Figure 1: Actual CEF Transport funding for ERTMS Actions per component, € million (number of Actions)

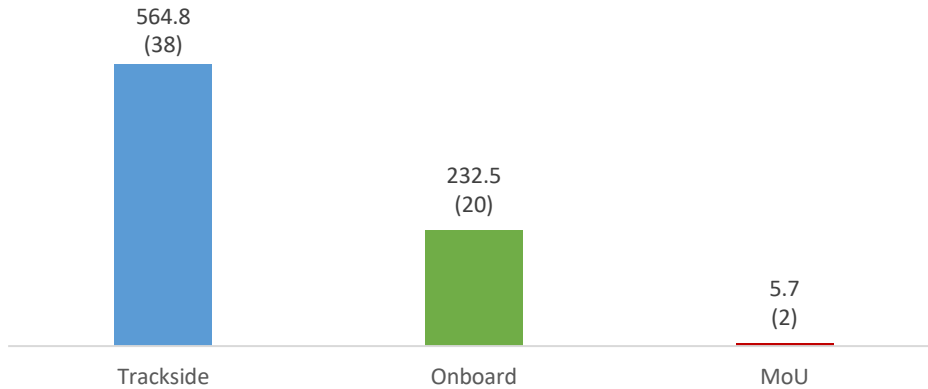
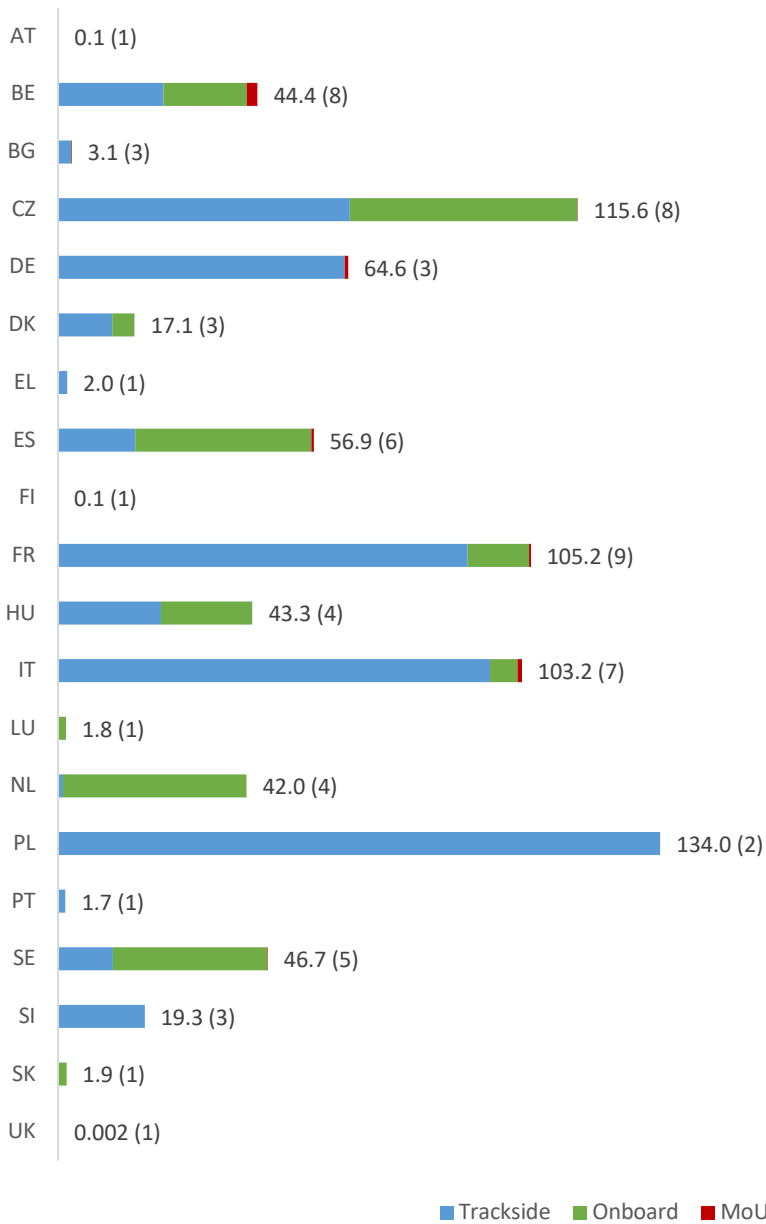


Figure 2 shows the distribution of CEF Transport grants at Member State level. One can observe certain tendencies applied by the Member States in using the CEF funding for different ERTMS components. Whereas Belgium, Bulgaria, Czechia, Germany, Denmark, Greece, France, Hungary, Italy, Poland, Portugal and Slovenia concentrate the CEF support on track-side deployment, Spain, Finland, Luxembourg, the Netherlands, Sweden and Slovakia focus on on-board deployment. A considerable part of MoU activities are implemented within multi-beneficiary Actions gathering stakeholders from different Member States.

Figure 2: Actual CEF Transport ERTMS funding per Member State and component, € million (number of Actions)



2.1. Track-side deployment

As far as the track-side component 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:

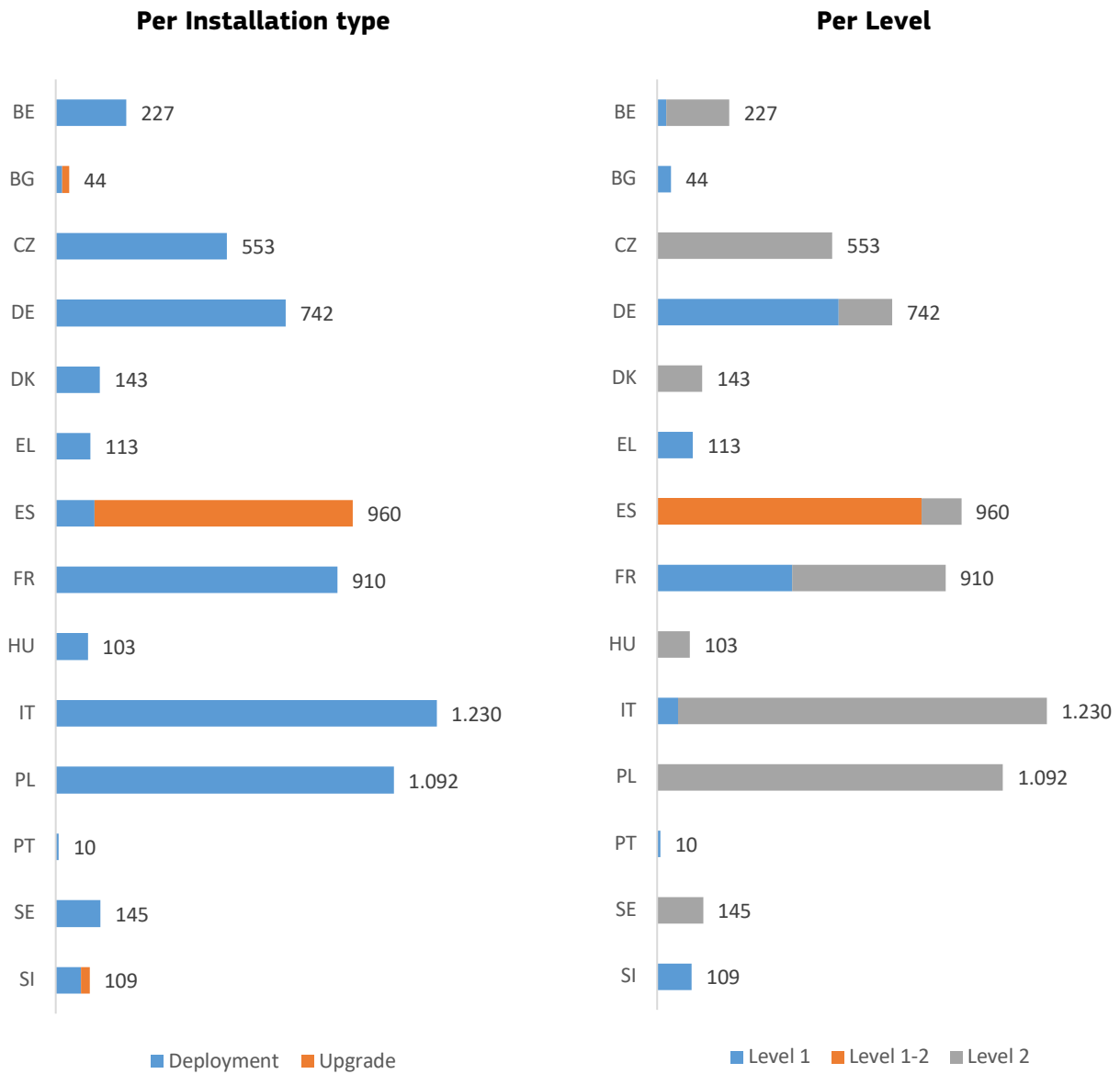
1. First deployment along lines (5,497 km, 86%)
2. Upgrade of already equipped lines (885 km, 14%)

Out of the 6,382 km of equivalent of double-track to be equipped/upgraded with ERTMS, 92% (5,899 km) is covered by Actions under the ERTMS priority and 483 km is supported within “combined” Actions. In the case of the latter type of Actions, the ERTMS deployment depends on the timely completion of the related railway works carried out on the same railway line section(s). This is due to the fact that ERTMS design takes into account comprehensive characteristics of the line. This represents a potential risk for the

successful ERTMS deployment when implementation challenges occur already at the stage of railway works.

Figure 3 and the maps show the ERTMS track-side geographical distribution by deployment type and the system level across the concerned 14 Member States. It can be noted that all Member States, aside from Bulgaria, Spain and Slovenia focus only on the first deployment of the system. More than 60% of the distribution of double-track lines equivalent (in km) is concentrated on level 2 (4,176 km). However, for a few countries level 1 is still dominant (Bulgaria, Germany, Greece, Portugal and Slovenia).

Figure 3: Double track (km) per Member State

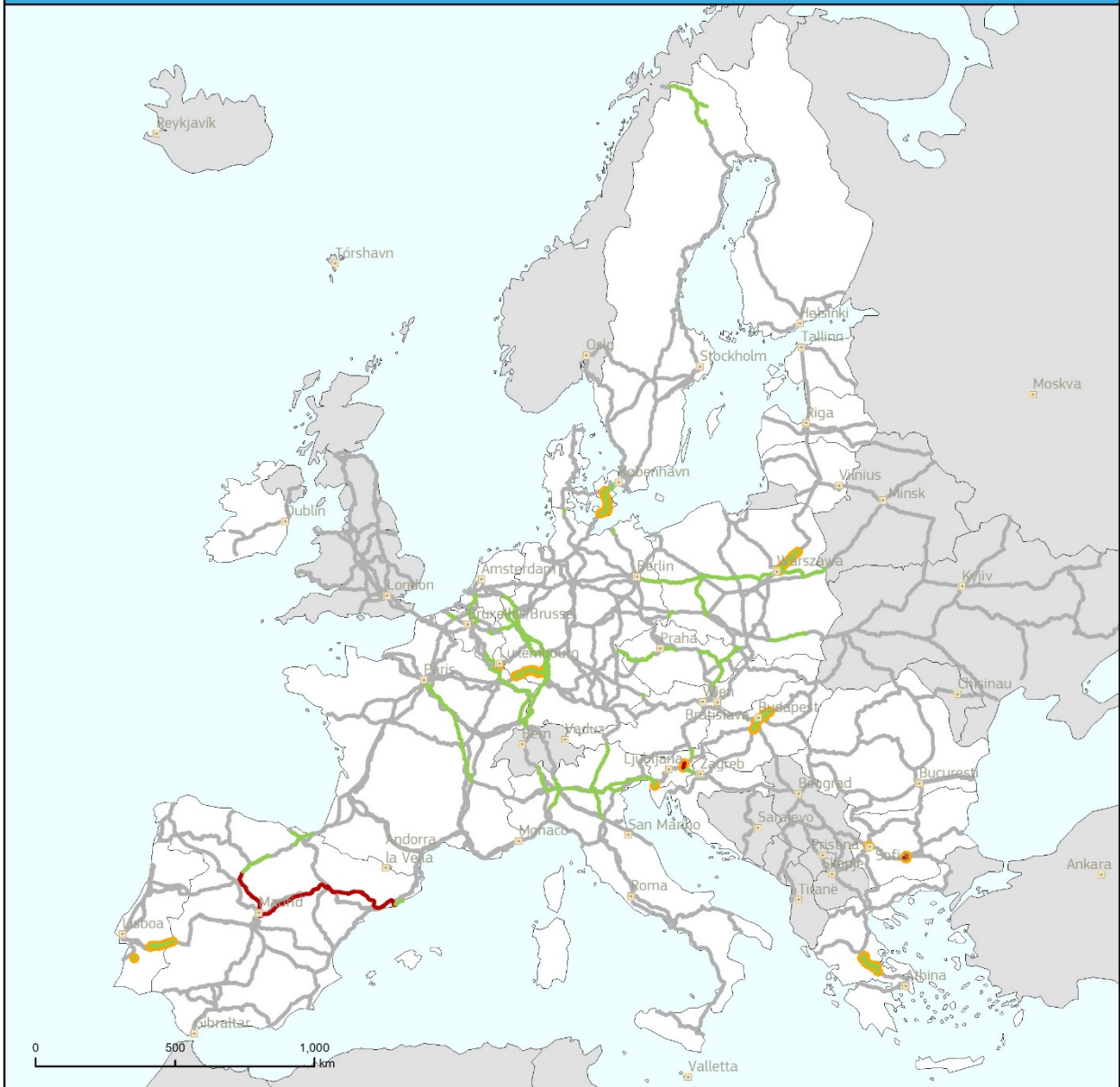




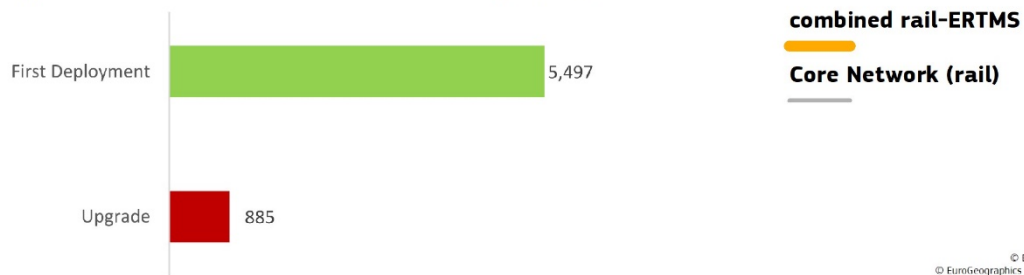
TEN-T NETWORK

Innovation and Networks Executive Agency

CEF FUNDED ERTMS ACTIONS BY TYPE OF INSTALLATION



Type of ERTMS installation and total length (km)

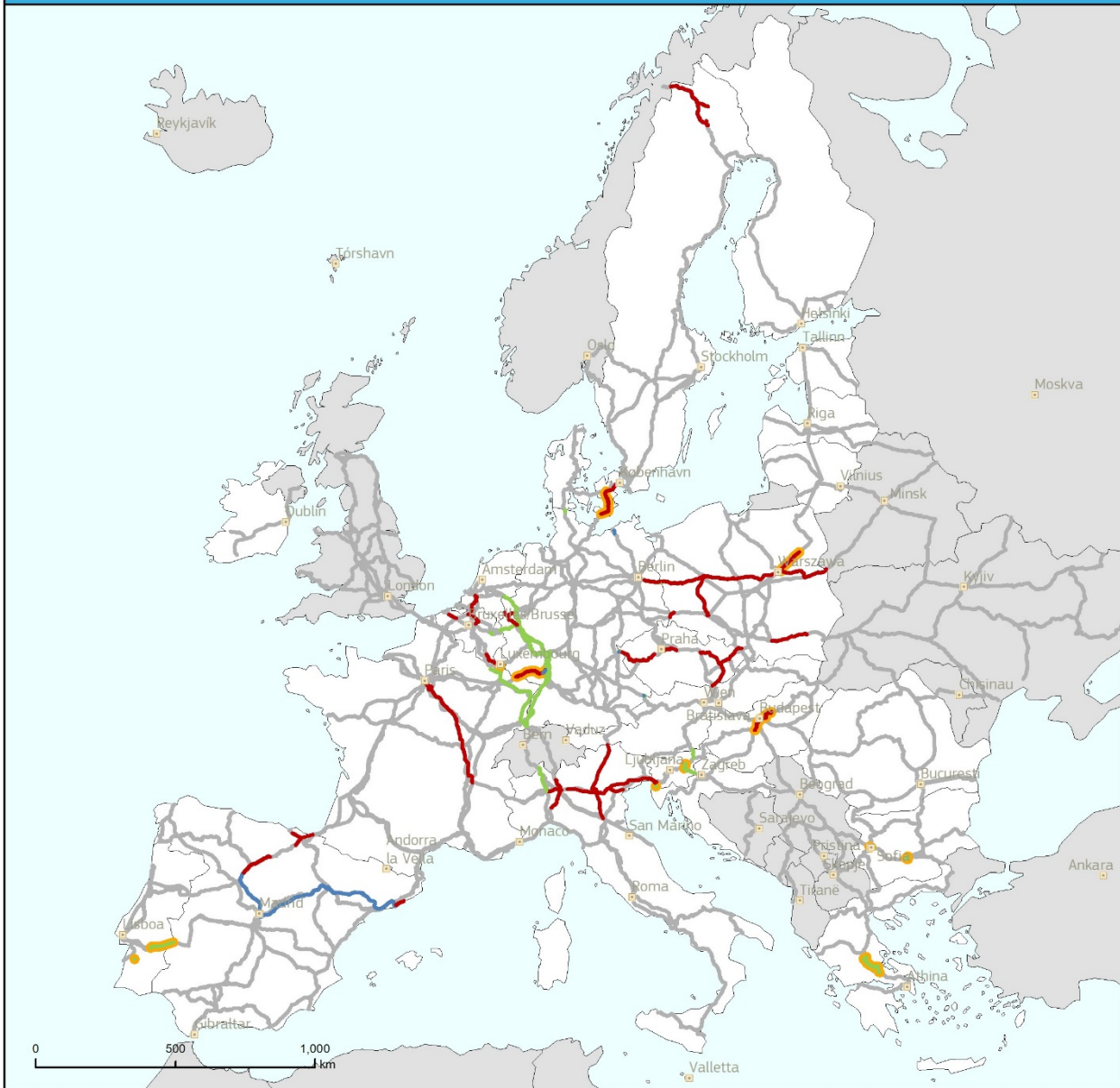




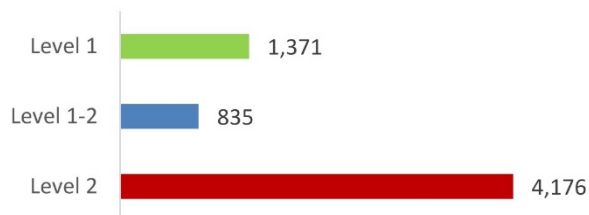
TEN-T NETWORK

Innovation
and Networks
Executive Agency

CEF FUNDED ERTMS ACTIONS BY LEVEL OF INSTALLATION



ERTMS level and total length (km)



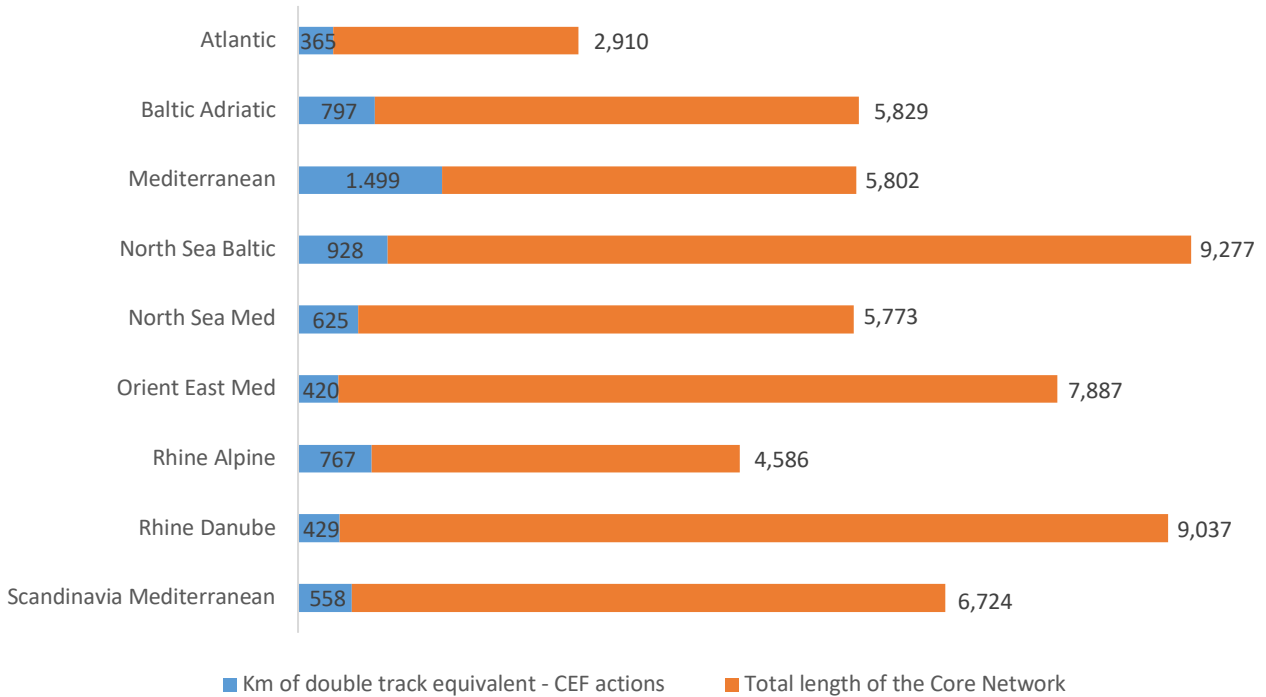
combined rail-ERTMS

Core Network (rail)

Cartography: INEA, May 2020
© EC, DG MOVE, TENtec for TEN-T network
© Eurogeographics 2001 for the administrative boundaries

98% of the 6,382 km of double-track lines equivalent (in km) on which ERTMS is being deployed with the CEF support are on the Core Network. The figure below shows that the Mediterranean Core Network Corridor will see more than 1,000 km of double-track line equivalent deployed with the system.

Figure 4: Double track (km) per CNC



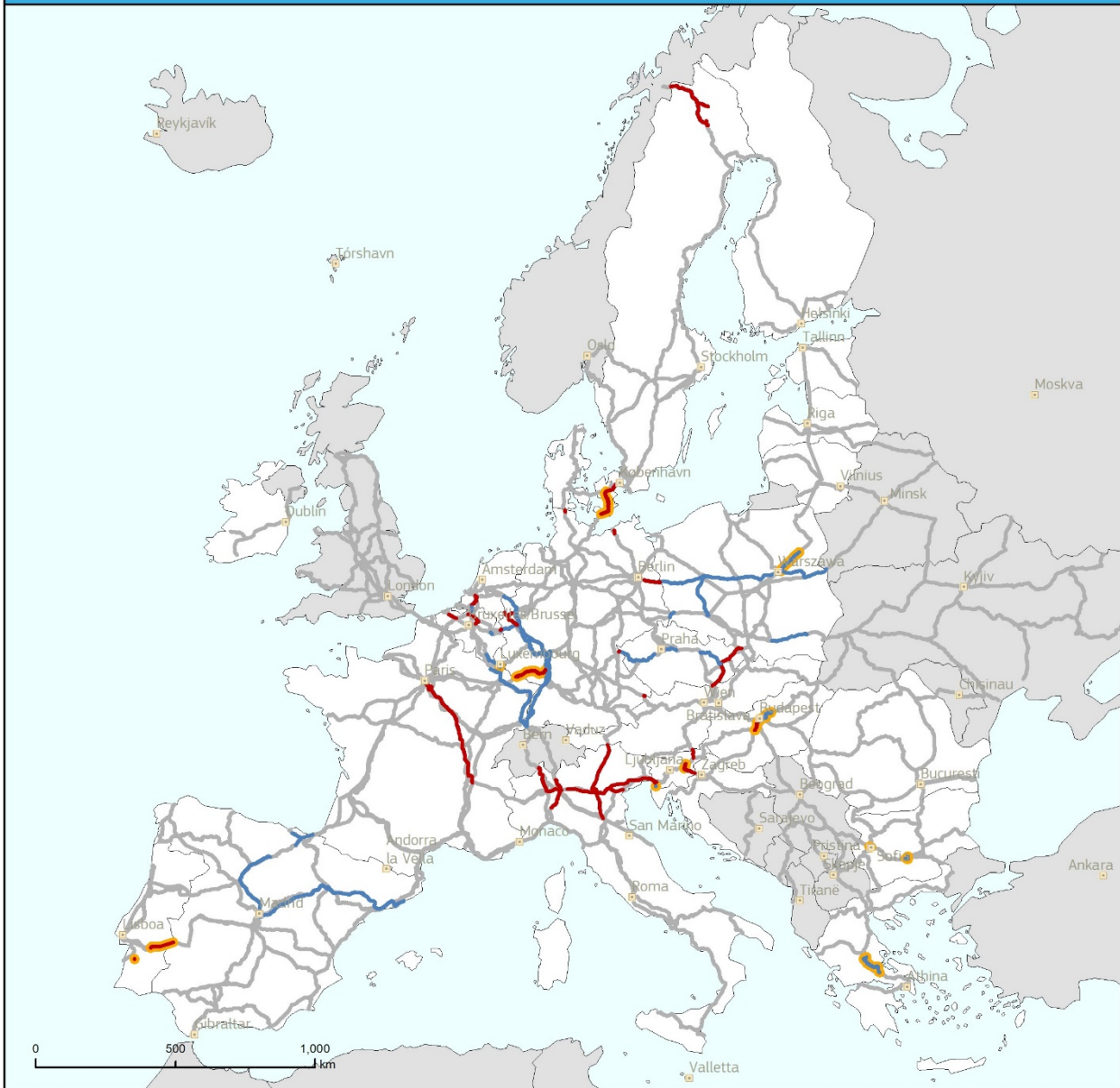
The Baseline 2 and 3 will almost equally be implemented within CEF Transport supported Actions, with a total of 3,116 km and 3,266 km of double-track line equivalent deployed with Baseline 2 and Baseline 3 respectively. This rate will be more favourable to the Baseline 3 in the future, since CEF support to Baseline 2 is excluded from recent CEF Calls.



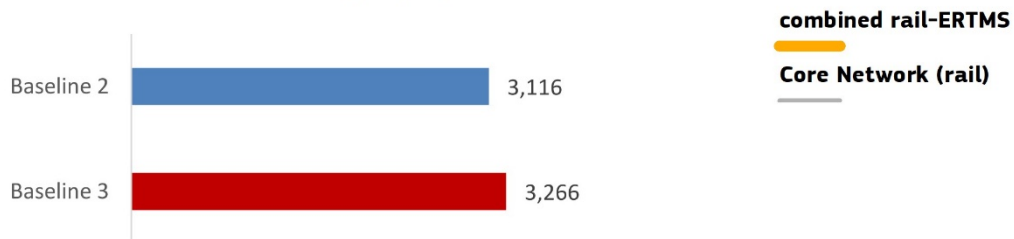
TEN-T NETWORK

Innovation
and Networks
Executive Agency

ERTMS CEF FUNDED ACTIONS BY BASELINE



ERTMS baseline and total length (km)



Cartography: INEA, May 2020
© EC, DG MOVE, TENtec for TEN-T network
© Eurogeographics 2001 for the administrative boundaries

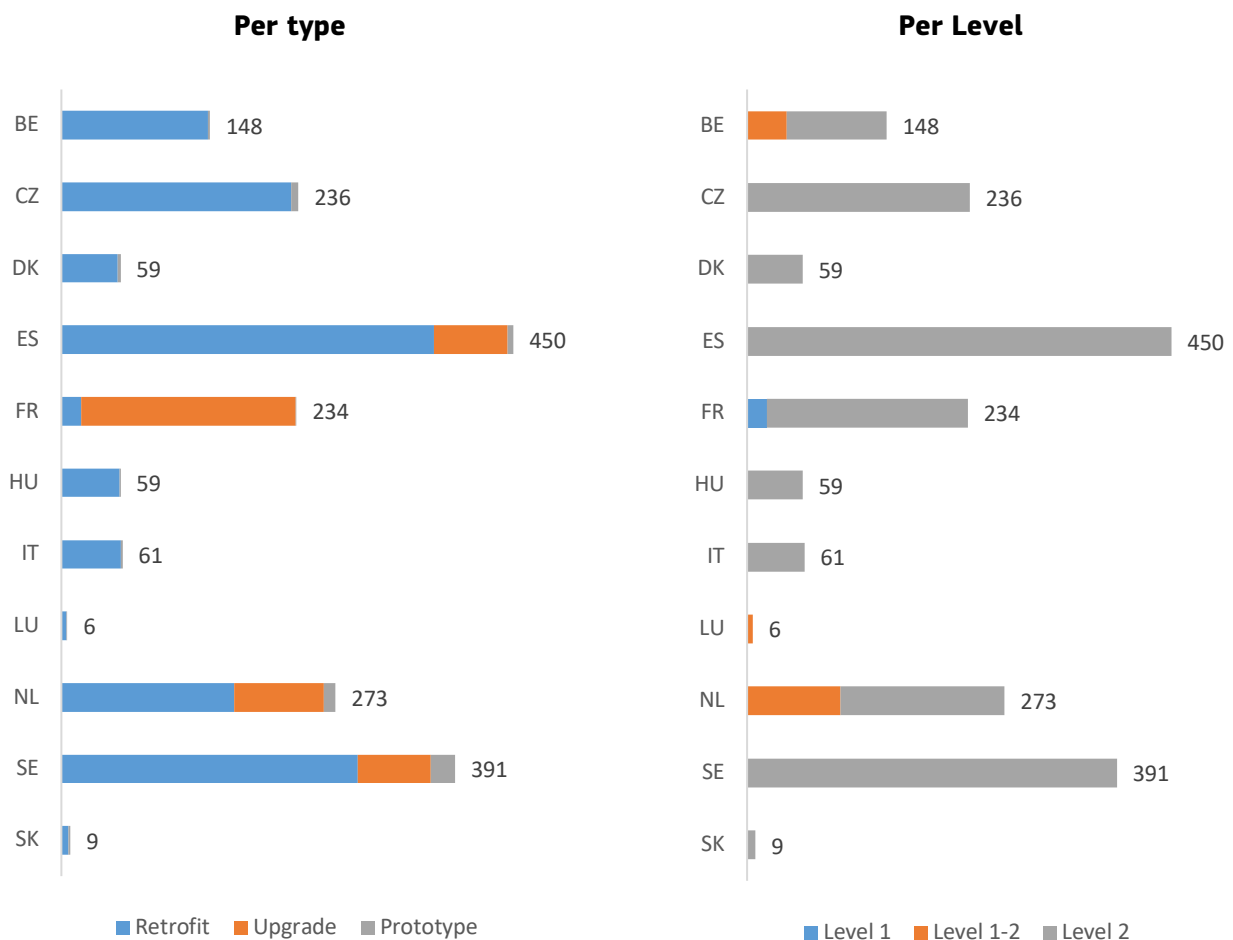
2.2. On-board deployment

As far as the on-board component is concerned, 20 Actions will contribute to the deployment of ERTMS on a total of 1,926 vehicles, classified as follows:

1. retrofitting (1,417, i.e. 74%)
2. upgrade (448, i.e. 23%)
3. prototype (61, i.e. 3%, both for retrofit and upgrade).

Figure 5 shows the geographical distribution of these interventions, based on Member States where the Beneficiaries are located. A total of 11 Member State will benefit from on-board activities, with the Netherlands, Sweden and Spain already covering more than half of the CEF-supported vehicles pool. For the total ERTMS portfolio, the distribution of vehicles per level is dominated by level 2.

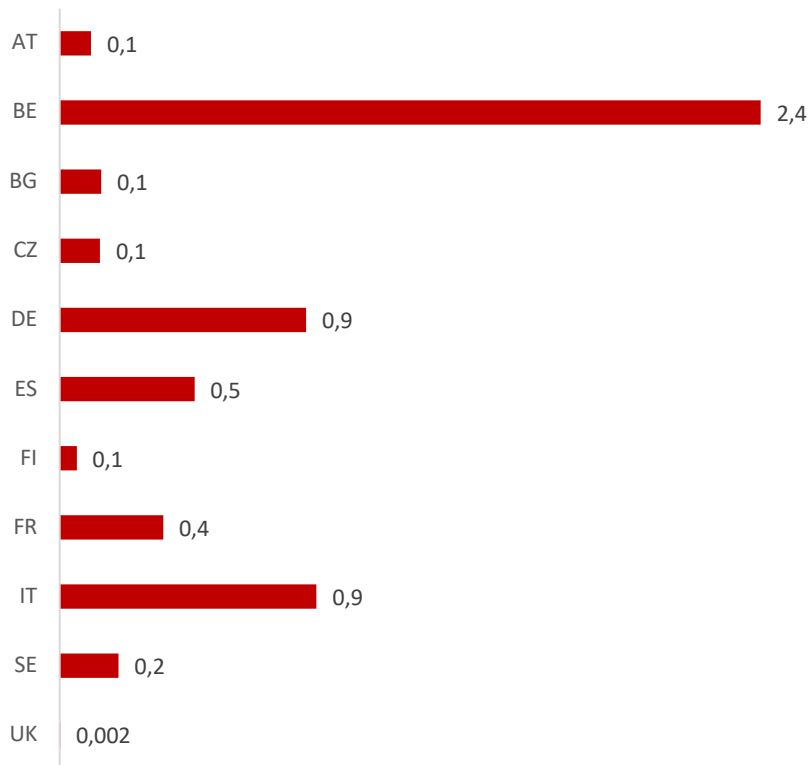
Figure 5: Number of vehicles per Member State



2.3 Memorandum of Understanding

Two Actions under this category include horizontal activities contributing to the consolidation of the ERTMS deployment, including development of specifications, running test campaigns, elaborating technical dossiers to be further processed by ERA (e.g. the Baseline 3). The total funding going to these activities is €5.7 million.

Figure 6: Funding per Member State involved in MoU activities (€ million)



It is to be noted, that MoU tasks were eligible only under 2014 dedicated ERTMS Call.

As indicated in the chart above, Belgium benefits from a considerably high share of the CEF budget supporting MoU type of Actions. This is due to the fact that one of the key beneficiaries within this domain, ERTMS Users Group, is located in this country. The ERTMS Users Group is a body gathering European IMs involved in the ERTMS track-side deployment. The organisation contributes, among others, to development and testing of the system specifications and products.

2.4 Financial Progress

CEF Transport funding of €1 billion was allocated to 58 Actions selected under the ERTMS priority and €121.6 million was allocated to the ERTMS part of 18 combined Actions. In total the 76 ERTMS Actions were initially⁵ allocated €1.1 billion, corresponding to €1.9 billion in eligible costs.

Following amendments, terminations and closures, €747.5 million is currently allocated to 49 Actions selected under the ERTMS priority and €55.4 million is allocated to the ERTMS part of 11 combined Actions. In total the 60 ERTMS Actions receive €802.9 million, corresponding to €1.4 billion in eligible costs based on the Grant Agreements in force. The Commission re-injected the recuperated CEF funding in the 2019 CEF Transport calls.

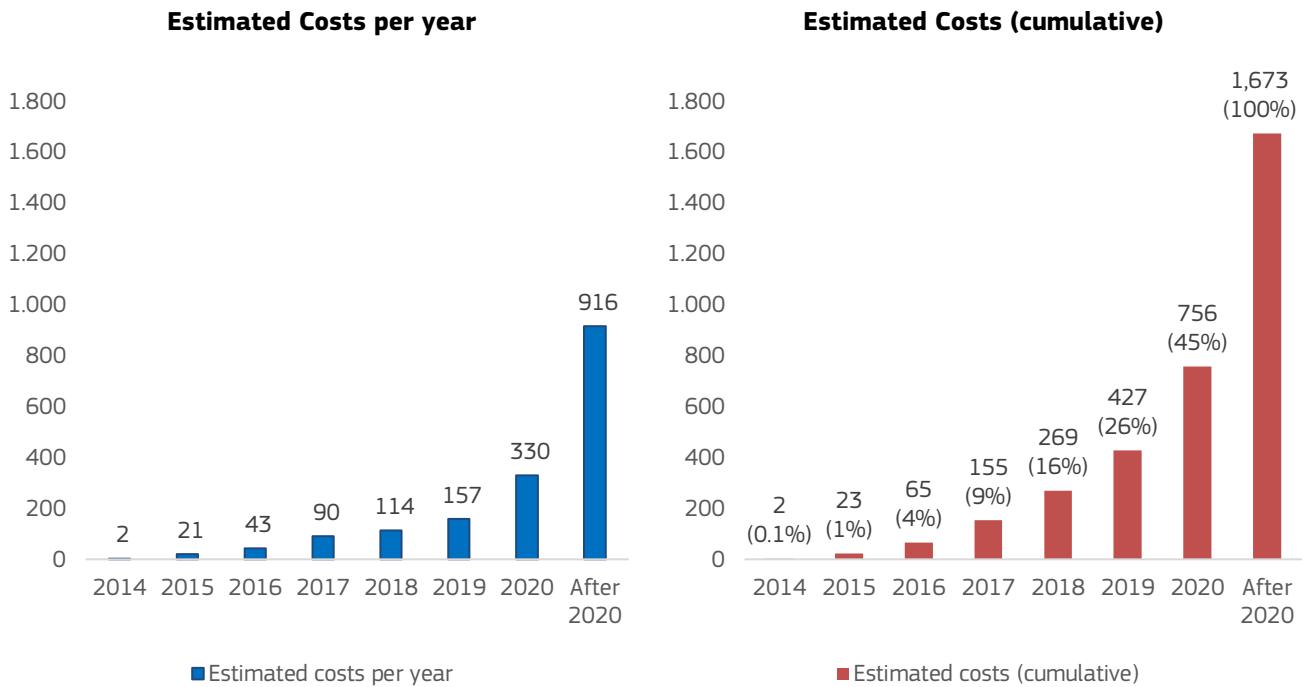
When taking into account the latest information available⁶, the costs necessary to implement the ERTMS Actions are estimated at €1.7 billion⁷. The figures below give an overview of the respective financial progress (in terms of estimated costs per year and cumulative) of the overall ERTMS portfolio. By the end of 2019 the financial progress reached was 26%.

⁵ i.e. grant agreement signature stage. For combined Actions this refers only to the share going to ERTMS.

⁶ i.e. to a possible extent, Action Status Reports and received but not yet approved final payment claims.

⁷ Higher estimated costs with respect to the initial or actual eligible costs are typically due to cost overruns reported in the ASRs.

Figure 7: Estimated budget implementation (€ million)



Whilst the above financial progress charts are based on cost estimates provided by the beneficiaries (updated annually in Action status reports), the budgetary absorption of the allocated funding can also be analysed by assessing the payments made and interim/final costs claims processed. With this approach, out of the €802.9 million of allocated funding:

- 30% or €241.2 million has already been paid (including pre-financing)
- 15% or €117.6 million of contribution has already been accepted following the introduction of interim/final cost claims by beneficiaries.

3. Evolution of the ERTMS Actions' portfolio

3.1 Calls for proposals

3.1.1 ERTMS priority

The multiannual programme and dedicated 2014 - 2018 ERTMS Calls set maximum ceilings of indicative eligible costs for certain categories of interventions, namely:

- Track-side deployment: The ceiling set is €260,000 per 1 kilometre of equivalent of double-track line (except of duly justified complex cases, e.g. marshalling yards, stations, etc.);
- On-board deployment (i.e. retrofit): the ceiling is €250,000 per ERTMS on-board unit.

For other categories of eligible interventions, e.g. track-side and on-board upgrade, track-side related preparatory Actions and infrastructure works (e.g. interlockings modernisation for ERTMS Level 2), on-board related ad hoc tasks (e.g. drivers' training, expertise for small and medium enterprises, etc.) the actual costs can be indicated. Depending on the call for proposals and its evaluation, the on-board prototype costs were limited (2015 and 2016) or not (2014, 2017) to the amount of the regular on-board deployment ceiling.

Co-financing rates for ERTMS components amount up to maximum of 50% of the indicative total costs. The rate for non-ERTMS track-side related infrastructure works, such as interlockings modernisation for ERTMS Level 2, amount up to maximum 40%.

In light of the above, the indicative eligible costs identified in individual grant agreements are not based, to a large extent, on actual estimated costs but on the applicable ceilings. The difference can be seen for prototyping activities, where actual costs reported in the given period were considerably higher compared to the ceiling.

Following the six dedicated ERTMS calls for proposals, 151 ERTMS proposals were submitted requesting €3.6 billion of CEF funding. Of these, 62 were selected (corresponding to CEF Transport awarded funding of €1.4 billion). 4 of these proposals were cancelled before the respective grant agreement was signed, while for another 10 Actions the awarded funding was slightly reduced in the initial grant agreement. In conclusion, grant agreements were signed for 58 ERTMS actions, corresponding to initial CEF Transport funding of €1.3 billion, out of which €1 billion was purely for ERTMS activities.

At the time of the Report finalisation, the Agency carries out evaluation of the proposals submitted under the CEF-T 2019 MAP Call, covering as one of the priorities the on-board prototypes. The CEF funding for this priority is calculated based on the Unit Contribution approach in line with the Decision authorising the use of unit contribution to support ERTMS deployment under the Connecting Europe Facility (CEF) - transport sector, dated 19 February 2019. It is expected that the grant agreements for the retained proposal(s) will be signed in the 2nd half of 2020

In 2019 EC/INEA opened a Blending Facility call for ERTMS, which combines private funding with CEF support. The concept aims at attracting private funding to the ERTMS ensuring at the same time the European leverage. The CEF support is based on the Unit Contribution, similarly to the CEF-T 2019 MAP Call, and the support is open to on-board and track-side deployment. At the time of the Report finalisation, the evaluation of the proposals submitted to the first “cut-off” date is being carried out. It is expected that the grant agreement(s) for the first retained proposal(s) will be signed in the 2nd half of 2020.

3.1.2 Core Network Corridor priority

Since first CEF call in 2014, CEF support for ERTMS track-side deployment could have been requested under the Core Network Corridor priority provided it covered the same section(s) as the railway works. In such applications “combining” ERTMS and other rail components, the ERTMS part needed to be clearly distinguished from the regular railway works’ scope for its proper evaluation. In case retained for funding, the ERTMS component was subject to the same rules as in other regular ERTMS track-side Actions, including application of the ceiling, definition of deliverables proving successful completion, etc.

The majority of the retained Actions merging both components come from the Cohesion Member States. In this type of Actions, the implementation of the ERTMS component is highly dependent on the progress of the rail works. This entails an additional risk to successful completion of the system.

As a result of the calls for proposals under the Core Network Corridor priority, 18 grant agreements were signed which contained ERTMS track-side activities. The initial CEF Funding allocated to these Actions was €3.7 billion out of which €121.6 million was for ERTMS activities.

3.2 Financial evolution of the portfolio

Overall, the initial CEF Transport funding to ERTMS activities was €1.1 billion, which is higher than the actual CEF Transport funding to ERTMS activities (€802.9 million), notably due to the termination of 9 actions and amendments of other actions.

1. The **termination** of 9 Actions (2014-AT-TM-0169-W, 2015-CZ-TM-0295-W, 2015-ES-TM-0118-W, 2015-NL-TM-0264-W, 2016-DE-TM-0128-W, 2016-NL-TM-0112-W, 2017-DE-TM-0006-W, 2017-DE-TM-0007-W, 2017-DE-TM-0011-W) corresponding to a CEF Transport funding reduction of €57.8 million, has led to a decrease in the number of Actions funded by the CEF Transport Programme (under the ERTMS priority) to 49.
2. Overall, 38 grant agreements with ERTMS component have been **amended** since 2014. In seven cases under the Core Networks Corridor priority the amendment resulted in a cancellation of the ERTMS part. The number of “combined” Actions decreased from 18 to 11, and the corresponding CEF support from €121.6 million to €55 million.
3. By the 1st quarter of 2020, 4 grant agreements with ERTMS component have been **closed**. This means the project had been implemented and the final payment processed. The actual CEF contribution to ERTMS covered by these Actions amounted to €9.1 million compared to €22.4 million foreseen in the initial grant agreements. Lower CEF contribution to these Actions results from partial completion or lower actual costs compared to initial estimation.

In conclusion, so far a total of €327.8 million of CEF Transport funding initially allocated to ERTMS Actions was not absorbed due to terminations, amendments and partial or less costly completion of Actions.

3.3. Issues affecting the implementation

Although in its advanced stage, the deployment of ERTMS with CEF support is still affected by a number of issues hampering its successful implementation. The most common ones are presented below, aggregated into 3 principle groups, i.e. technical, administrative and financial, with certain items fitting possibly to more than one group. These reasons were identified based on an analysis of the terminated and amended CEF grant agreements.

a) Technical:

- On-board: difficulty to include the vehicle’s manufacturer in the ERTMS equipment design phase, once the system is to be deployed by a different supplier.
- Track-side: difficulty in successful implementation of the ERTMS component due to delays in a precedent railway works on the same section. This is particularly applicable to “combined” actions. Completed or sufficiently advanced railway works determine completion of the ERTMS design and launch of the system deployment.
- Track-side: difficulty in ensuring compatibility of the system deployed across borders.
- Track-side: existence of national requirements to be taken into account while designing the system for a particular MS.
- On-board/Track-side: difficulty in upgrading the system, or in continuation of its deployment by a supplier different than the initial one.
- On-board/Track-side: not sufficient B3 implementations available for train-track tests.
- On-board/Track-side: limited capacity of laboratory tests to replace on-site testing.
- On-board/Track-side: difficulty in sharing the technical information (e.g. test report) by suppliers.

b) Administrative:

- On-board/Track-side: authorisation procedure requiring considerable amount of time and knowledge on the side of applicants (RUs and IMs).
- On-board/Track-side: (in)stability of National Deployment Plans.

- On-board/Track-side: complex and time-consuming procurement procedures.

c) Financial:

- On-board: considerable expenses related with ERTMS deployment without immediate operational savings or gains.
- On-board/Track-side: system maintenance/upgrade clause difficult to be included in a deployment contract, unless with high additional costs.

Some of the challenges are to be dealt by the railway sector representatives who operate under and are conditioned by a certain transport market situation. Nevertheless, the European institutions involved in supporting the ERTMS deployment in EU, notably EC, INEA, European Union Agency for Railways (ERA) together with the railway sector are committed to facilitate the implementation of the CEF-supported ERTMS Actions.

In this context, the beneficiaries can take the advantage of the Deployment Management Team (DMT, consortium of INECO and E&Y) contracted by the EC for the financial perspective 2014-2020. The contract covers DMT support not only to EC in monitoring of the ERTMS development but also to the ERTMS CEF-funded Actions' promoters. In particular, DMT can assist the beneficiaries during the implementation of ERTMS Actions in the areas such as the authorisation procedure, interoperability related issues, contacts with suppliers, etc.

In addition, ERA involvement into authorisation of ERTMS in line with the IV Railway Package, is expected to streamline the authorisation proceedings, notably for vehicles foreseen for international traffic.

Regarding follow-up of the CEF-supported Actions, INEA has undertaken a number of measures aiming at their successful implementation. On top of their regular monitoring, in 2018 INEA carried out the Mid-Term review of the CEF-supported Actions, including ERTMS portfolio. The exercise aimed at taking stock of the implementation progress of the Actions in the middle of the current multiannual financial framework. Thanks to the thorough screening applied by INEA to the ongoing Actions the key causes of delays were identified (including some listed above) and mitigating measures were proposed. 28 ERTMS Actions with CEF support granted through the dedicated ERTMS calls were subject of the exercise. As a result, a number of Actions were modified, including adaptation of the scope and CEF grant. Monitoring of Actions by INEA aims at successful implementation of the technical scope of the ERTMS portfolio ensuring an optimum use of the CEF support for this priority.

In addition, in November 2018 INEA organised a dedicated ERTMS Workshop. The principle objective of the event was to enable open sharing of knowledge and lessons learnt regarding the technical implementation among the beneficiaries of the CEF-supported ERTMS Actions. The Workshop gathered principle stakeholders involved into the CEF Actions, notably Railway Undertakings, Infrastructure Managers, Ministries, EC, EU Coordinators, ERA and DMT. The event was appreciated by the participants and its regular organisation would be appreciated.

Since 2019 EC/INEA introduced a Unit Contribution concept into ERTMS Calls as opposed to the ceiling-based EU grants combined with a fixed co-funding rate. INEA contributed to the preparation of the decision for Unit Contribution by providing the data and analysis. This approach is expected to result in a major simplification of the payment procedures, hence increasing an attractiveness of the CEF support for ERTMS deployment. The actual Unit Contributions should be revised for their adaptation depending on the actual market conditions.

In order to attract private funding for ERTMS deployment, the Blending Facility call for ERTMS was opened in 2019.

The lack of long term planning and stability of CEF calls' priorities was raised by the sector as a factor hampering preparation of projects' pipeline and submission of mature applications by the Infrastructure Managers (track-side) and Railway Undertakings (on-board). This will be addressed under CEF2, where EC considers defining at least 3-years long calls' plan informing applicants well in advance about funding opportunities.

It is expected that due to the undertaken measures, the CEF ERTMS Actions will deliver considerably better than the TEN-T ones (see report dated 2018).

4. Conclusion

This is the second report of INEA describing the contribution of CEF to the implementation of the ERTMS. It takes stock of the implementation of CEF-funded actions and demonstrates how the sector is delivering so far. ERTMS deployment, considered the backbone of the railway transport digitalisation, remains a key priority of the EU railway policy. Its roll-out is closely followed by EC, ERA and INEA with the support of DMT.

Concerning CEF funded Actions, it is still too early to draw conclusions as the vast majority of the Actions are ongoing, and the only completed are predominantly the ones related with MoU activities or track-side studies.

It is expected that following the terminations and the scope reductions concluded so far, the remaining portfolio of the Actions will be stable and deliver successfully over the coming years. This assumption is based on the fact that i) the system is mature, ii) the applicants are experienced and aware both of the system specifications as well as the legal and administrative environment and iii) additional technical support on the EU side is provided (DMT). Nevertheless, the Covid-19 pandemics in the EU may have a negative impact, on the overall implementation of the CEF Actions including the ERTMS ones.

5. List of ERTMS Actions

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2014-BE-TM-0655-S	ERTMS	Trackside	Ongoing	ETCS: development of the generic design Level 2, key catalyst for the roll-out of ETCS 2 in Belgium	Studies	31/08/2020	15,348,900	15,348,900	32	-
2014-BE-TM-0660-W	ERTMS	Trackside	Closed	Deployment of ETCS Level 1 on the rail section Ans - Angleur	Works	01/05/2018	2,367,500	2,367,500	30	-
2014-CZ-TMC-0308-M	ERTMS	Trackside	Ongoing	ETCS Petrovice u Karviné – Ostrava – Přerov – Břeclav	Mixed	30/06/2020	20,519,708	20,519,708	204	-
2014-DE-TM-0057-W	ERTMS	Trackside	Ongoing	ERTMS Deployment on the German part of the Core Network Corridor Rhine - Alpine	Works	31/12/2020	43,936,573	43,936,573	514	-
2014-DK-TM-0183-W	ERTMS	Trackside	Ongoing	ERTMS Trackside deployment along the section Copenhagen H – Køge Nord – Ringsted in East Denmark	Works	09/12/2020	10,998,469	7,800,000	60	-
2014-DK-TM-0300-W	ERTMS	Onboard	Ongoing	Retrofitment of vehicles with ERTMS baseline 3 - level 2	Works	31/12/2019	7,966,100	4,961,014	-	59
2014-ES-TM-0510-W	ERTMS	Trackside	Ongoing	ERTMS DEPLOYMENT ON BARCELONA COMMUTER LINES	Works	31/12/2021	5,200,000	5,200,000	40	-
2014-ES-TM-0512-W	ERTMS	Trackside	Ongoing	Upgrade of Spanish High Speed Lines to version 2.3.0.d. of ERTMS (ETCS+GSMR) 2nd Phase	Works	31/12/2020	4,190,000	4,190,000	835	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2014-ES-TM-0514-W	ERTMS	Trackside	Ongoing	ERTMS deployment on the section Valladolid – Burgos	Works	31/12/2021	7,783,767	7,783,767	85	-
2014-EU-TM-0128-S	ERTMS	MoU	Closed	ERTMS HIPPOPS (ERTMS Harmonised & International Procedures for Placing into Operation of Products & Subsystems)	Studies	30/11/2017	720,000	529,801	-	-
2014-EU-TM-0279-S	ERTMS	MoU	Closed	Support to the implementation of ERTMS	Studies	31/12/2017	5,738,197	5,143,589	-	-
2014-FR-TM-0090-W	ERTMS	Onboard	Ongoing	Multiannual program to upgrade to ERTMS Baseline 3 the 213 high speed trains TGVs already fitted with ETCS on board	Works	31/10/2020	8,504,000	8,504,000	-	213
2014-FR-TM-0545-W	ERTMS	Trackside	Ongoing	ETCS Deployment on the French part of the Antwerp-Basel route	Works	31/12/2020	55,497,000	55,497,000	427	-
2014-HU-TMC-0611-W	ERTMS	Onboard	Ongoing	Deployment of ETCS L2 onboard units on 59 FLIRT (EMUs) electric multiple units	Works	31/12/2020	25,075,000	20,454,603	-	59
2014-IT-TM-0058-W	ERTMS	Trackside	Ongoing	ERTMS Deployment on the Italian part of the Rhine - Alpine Core Network Corridor	Works	31/12/2020	13,691,000	13,691,000	133	-
2014-LU-TM-0410-W	ERTMS	Onboard	Ongoing	Retrofitment of Locomotives with ETCS Baseline 3	Works	31/05/2019	7,304,192	1,776,434	-	6

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2014-NL-TM-0230-S	ERTMS	Trackside	Closed	Preparatory Study for deployment of ERTMS on the railway line section Kijfhoek (Port of Rotterdam) – Roosendaal – Belgian border – Core Network Corridor / Rail Freight Corridor North Sea – Mediterranean	Studies	31/03/2018	2,350,000	1,069,068	-	-
2015-BE-TM-0122-W	ERTMS	Onboard	Ongoing	Deployment of ETCS Bsl3 L2 on 106 AM Break motor units - Retrofit action to promote safety and cross border transport	Works	31/12/2020	13,250,000	13,250,000	-	106
2015-CZ-TM-0057-W	ERTMS	Onboard	Ongoing	Deployment of ERTMS/ETCS on-board components compliant with ETCS Baseline 3 in ČD CARGO, a.s. vehicles on the Rail Freight/Core Network Corridors	Works	31/12/2022	74,241,582	27,544,689	-	128
2015-CZ-TM-0136-W	ERTMS	Onboard	Ongoing	Deployment of ERTMS/ETCS on-board components compliant with Baseline 3 in ČESKÉ DRÁHY, a.s. vehicles on the Core Network Corridors	Works	31/12/2022	141,426,466	21,196,350	-	99
2015-CZ-TM-0174-M	ERTMS	Trackside	Ongoing	ETCS Beroun-Plzeň-Cheb	Mixed	31/12/2020	27,147,770	27,147,770	182	-
2015-CZ-TM-0238-M	ERTMS	Trackside	Ongoing	ETCS Cesky Brod - Praha Junction (including)	Mixed	31/12/2020	7,442,839	5,295,500	59	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2015-CZ-TM-0377-M	ERTMS	Trackside	Ongoing	ETCS Prerov - Ceska Trebova	Mixed	31/12/2020	11,889,222	11,889,222	108	-
2015-DE-TM-0363-W	ERTMS	Trackside	Ongoing	Design and equipment of ERTMS for six border crossing corridor sections as well as two gap closings on German TEN core network corridors	Works	31/12/2020	19,756,411	19,756,411	228	-
2015-ES-TM-0011-W	ERTMS	Onboard	Ongoing	Retrofitting and Upgrading of on-board ERTMS in Renfe's vehicles	Works	31/12/2021	27,992,000	27,992,000	-	289
2015-FR-TM-0258-M	ERTMS	Onboard	Ongoing	Project to install ERTMS Baseline 3 on the Regional trains linking France and Luxembourg	Mixed	31/12/2020	5,125,000	5,125,000	-	21
2015-IT-TM-0168-W	ERTMS	Trackside	Ongoing	ERTMS trackside equipment on Italian sections of the ERTMS/Core Network Corridors in compliance with the Breakthrough Program	Works	31/12/2020	45,710,000	45,710,000	512	-
2015-NL-TM-0328-W	ERTMS	Onboard	Ongoing	ERTMS L2 B3 On-board deployment on NS vehicles for operation on – CNC North Sea - Mediterranean	Works	31/12/2020	17,100,000	17,100,000	-	174
2015-SE-TM-0371-W	ERTMS	Onboard	Ongoing	Deployment of ERTMS On-board in Sweden	Works	31/12/2020	10,331,500	10,331,500	-	165

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2015-SI-TM-0111-W	ERTMS	Trackside	Ongoing	Deployment of ERTMS/ETCS on the Dobova-Zidani Most and Pragersko-Maribor-Šentilj railway lines	Works	31/12/2020	6,374,999	6,374,999	82	-
2016-BE-TM-0297-W	ERTMS	Onboard	Ongoing	Deployment of ETCS Bsl3 L1+L2 on 42 HLE 13 locomotives – retrofit action to promote safety and cross-border transport	Works	31/12/2020	5,250,000	5,250,000	-	42
2016-BE-TM-0298-W	ERTMS	Trackside	Ongoing	ETCS L2 track-side deployment on 2 cross border sections of the Core network Corridors	Works	30/06/2020	2,355,000	2,355,000	86	-
2016-CZ-TMC-0293-W	ERTMS	Onboard	Pre-terminated	ERTMS in RegioJet	Works	31/12/2020	1,912,500	1,912,500	-	9
2016-ES-TM-0027-W	ERTMS	Onboard	Ongoing	Retrofitting of on-board ERTMS in Renfe's vehicles	Works	31/12/2021	11,250,000	11,250,000	-	161
2016-FR-TM-0147-S	ERTMS	Trackside	Ongoing	Track-side deployment of ERTMS Level 2, Baseline 3 on the Paris-Lyon HSL: preparatory actions	Studies	30/09/2020	7,600,000	7,600,000	-	-
2016-IT-TM-0244-W	ERTMS	Trackside	Ongoing	ERTMS on strategic sections of 3 CNCs	Works	31/12/2020	27,250,000	27,250,000	475	-
2016-PL-TMC-0136-W	ERTMS	Trackside	Ongoing	Deployment of ERTMS/ETCS on the TEN-T core network lines	Works	31/12/2023	116,631,696	125,425,636	990	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2016-SE-TM-0140-W	ERTMS	Onboard	Ongoing	Deployment of ERTMS On-board in Sweden 2017-2020	Works	31/12/2022	20,640,146	10,218,146	-	94
2016-SK-TMC-0224-W	ERTMS	Onboard	Ongoing	Delivery and installation of ETCS into motive power units of 361 series for ZSSK	Works	30/06/2022	1,912,500	1,912,500	-	9
2017-FR-TM-0030-W	ERTMS	Trackside	Ongoing	Track-side deployment of ERTMS Level 2, Baseline 3 on the Paris-Lyon HSL	Works	31/12/2023	15,460,000	15,460,000	483	-
2017-IT-TM-0003-W	ERTMS	Onboard	Ongoing	Rail Freight Strengthening Project – Retrofit of Mercitalia Rail locomotives E405/E412 with ETCS/ERTMS L2 Baseline 3	Works	30/06/2023	6,150,500	6,150,500	-	61
2017-NL-TM-0046-W	ERTMS	Onboard	Ongoing	ERTMS Baseline 3 upgrade on-board units (OBU's) Rhine-Alpine freight locomotives	Works	31/12/2023	32,461,200	17,741,250	-	44
2017-NL-TM-0101-W	ERTMS	Onboard	Ongoing	ERTMS Baseline 3 upgrade on-board units (OBUs) Rhine-Alpine freight locomotives - II	Works	31/12/2023	6,073,507	6,073,507	-	55
2017-SE-TM-0022-W	ERTMS	Onboard	Ongoing	Deployment of ERTMS On-board in Sweden 2017-2023	Works	31/12/2023	13,708,525	13,708,525	-	132
2018-BE-TM-0101-W	ERTMS	Trackside	Ongoing	ETCS L2 track-side deployment on 4 sections of the Core Network Corridors	Works	30/11/2022	3,425,000	3,425,000	80	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2018-FR-TM-0098-S	ERTMS	Trackside	Ongoing	Track-side deployment of ERTMS in the Channel Tunnel and interfaces with neighbouring networks : preparatory actions	Studies	27/11/2020	661,400	661,400	-	-
2018-FR-TM-0132-S	ERTMS	Trackside	Ongoing	Marseille -Ventimiglia Phase 1: Preparatory actions for deployment of ERTMS L2 (Baseline 3)	Studies	18/12/2023	11,950,000	11,950,000	-	-
2018-IT-TM-0059-W	ERTMS	Trackside	Ongoing	ERTMS deployment on the SCANMED Corridor (Verona – Bologna section)	Works	31/12/2023	9,469,000	9,469,000	110	-
2018-SE-TM-0018-W	ERTMS	Trackside	Ongoing	ERTMS cross border deployment on the Iron Ore Line	Works	31/12/2023	12,220,689	12,220,689	145	-
TOTAL ERTMS Priority (49)							951,359,858	747,520,051	5,899	1,926
2014-BG-TMC-0133-W	Core Network Corridors	Trackside	Ongoing	Development of Sofia Railway Junction: Sofia - Voluyak Railway Section	Works	31/12/2020	2,095,081	2,095,081	21	-
2014-EL-TMC-0651-W	Core Network Corridors	Trackside	Ongoing	Completion of the new, double, high speed, electrified railway line Tithorea-Lianonkladi-Domokos, 106km long	Works	30/06/2020	2,092,839	2,025,195	113	-
2014-HU-TMC-0493-W	Core Network Corridors	Trackside	Ongoing	Upgrading the Kelenföld-Pusztaszabolcs railway line, Stage I (Upgrading the Kelenföld-Százhalombatta	Works	31/12/2022	4,530,500	4,530,500	21	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
				section and installation of ETCS level 2)						
2014-PL-TMC-0182-W	Core Network Corridors	Trackside	Ongoing	Works on the E75 railway line Sadowne – Czyżew section, along with the remaining works on the Warszawa Rembertów - Sadowne section	Works	31/12/2020	8,602,282	8,602,282	102	-
2014-PT-TM-0627-M	Core Network Corridors	Trackside	Ongoing	Ligação Ferroviária Sines/Elvas (Espanha): Troço Évora-Caia e Estação Técnica ao km 118 da Linha do Sul (Railway connection Sines/Elvas (Spain): Évora-Caia Section and Technical Station at km 118 of the South Line)	Mixed	31/12/2019	1,704,200	1,704,200	10	-
2014-SI-TMC-0301-M	Core Network Corridors	Trackside	Ongoing	Bottleneck rehabilitation in the area of Bivje on the Divača–Koper railway line	Mixed	01/06/2019	323,765	742,495	1	-
2015-HU-TM-0003-M	Core Network Corridors	Trackside	Ongoing	Upgrade of the Százhalombatta - Pusztaszabolcs railway section, including installation of ETCS Level 2	Works	31/12/2022	6,928,350	6,928,350	31	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	Km of ERTMS	Number of Vehicles
2015-HU-TM-0158-M	Core Network Corridors	Trackside	Ongoing	Upgrade of the Budapest, Rákos – Hatvan railway section, including installation of ETCS Level 2	Mixed	31/12/2022	11,403,600	11,403,600	52	-
2015-SI-TM-0228-W	Core Network Corridors	Trackside	Ongoing	Upgrade of the Zidani Most - Celje railway line	Works	31/12/2020	12,153,052	12,153,052	27	-
2016-BG-TMC-0047-M	Core Network Corridors	Trackside	Ongoing	Development of Plovdiv Railway Node	Mixed	15/12/2020	862,345	862,345	23	-
2017-DK-TM-0008-W	Core Network Corridors	Trackside	Ongoing	Implementing the Scan-Med Corridor - upgrading the Danish railway access line to the Fehmarnbelt tunnel (Phase 1)	Works	31/12/2023	4,316,000	4,316,000	83	-
TOTAL Core Network Corridors Priority (11)							55,012,014	55,363,100	483	-
TOTAL ERTMS and Core Network Corridors priorities (60)							1,006,371,872	802,883,151	6,382	1,926

List of terminated Actions and combined Actions without initial ERTMS component⁸

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	(initial) Km of ERTMS	(initial) Number of Vehicles
2014-AT-TM-0169-W	ERTMS	Onboard	Terminated	Upgrade of Austrian vehicles to ERTMS Baseline 3	Works	31/12/2019	4,487,298	-	-	175
2015-CZ-TM-0295-W	ERTMS	Onboard	Terminated	Leo express ETCS B3 retrofit – Leo B3	Works	31/07/2019	1,296,250	-	-	5
2015-ES-TM-0118-W	ERTMS	Trackside	Terminated	ERTMS (ETCS+GSMR) deployment on Atlantic Corridor. Section Vitoria – Bilbao – San Sebastián	Works	31/12/2020	11,652,500	-	163	-
2015-NL-TM-0264-W	ERTMS	Trackside	Terminated	Deployment of ERTMS level-2 (only) trackside at the railway line Kijfhoek-Roosendaal- Belgian border	Works	31/12/2020	11,275,000	-	58	-
2016-DE-TM-0128-W	ERTMS	Onboard	Terminated	ERTMS on-board deployment for interoperable freight traffic on the Scandinavian-Mediterranean Core Network Corridor	Works	31/12/2020	2,125,000	-	-	17
2016-NL-TM-0112-W	ERTMS	Onboard	Terminated	ERTMS baseline 3 upgrade of TEN-T freight locomotives	Works	31/12/2020	5,291,500	-	-	63

⁸ ERTMS is excluded from the combined Actions as a result of the Grant Agreement amendment.

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	(initial) Km of ERTMS	(initial) Number of Vehicles
2017-DE-TM-0006-W	ERTMS	Onboard	Terminated	ERTMS-BR186: Interoperable international freight traffic along four TEN-T corridors across Belgium, France and Germany	Works	31/12/2023	9,816,000	-	-	65
2017-DE-TM-0007-W	ERTMS	Onboard	Terminated	ERTMS-BR185.1: Interoperable international freight traffic along the Rhine-Alpine Core Network Corridor	Works	31/12/2023	5,766,000	-	-	57
2017-DE-TM-0011-W	ERTMS	Onboard	Terminated	ERTMS-DE6400: Interoperable international freight traffic along three TEN-T corridors across Belgium and the Netherlands	Works	31/12/2023	6,000,000	-	-	38
Total ERTMS Priority (9)							57,709,548	-	221	420
2014-DE-TM-0138-M	Core Network Corridors	Trackside	Ongoing	Upgraded line 23 Saarbrücken – Ludwigshafen (POS Nord), Upgrade of the Neustadt – Boehl-Iggelheim and Landstuhl – Kaiserslautern route sections for v = 200 km/h, planning of ETCS (European Train Control System)	Mixed	31/12/2019	4,004,800	-	125	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	(initial) Km of ERTMS	(initial) Number of Vehicles
2014-LU-TM-0257-W	Core Network Corridors	Trackside	Ongoing	North Sea-Mediterranean. Section Brussel-Luxembourg-Strasbourg "EuroCap-Rail". Luxembourg rail network. WORKS regarding the construction of a new section providing a direct link between Luxembourg Station and Bettembourg Station.	Works	31/12/2022	350,000	-	7	-
2014-PL-TMC-0198-W	Core Network Corridors	Trackside	Ongoing	Works on the E 59 railway line, Poznań Główny-Szczecin Dąbie section.	Works	31/12/2020	14,177,239	-	118	-
2014-RO-TMC-0639-W	Core Network Corridors	Trackside	Ongoing	THE REHABILITATION OF THE BRASOV – SIMERIA RAILWAY COMPONENT OF THE RHIN - DANUBE CORRIDOR, FOR CIRCULATION WITH MAXIMUM SPEEDS OF 160 KM/H; SECTION: BRASOV – SIGHISOARA. SUBSECTIONS: 1. BRASOV – APATA and 3. CATA – SIGHISOARA.	Works	31/12/2022	18,386,664	-	85	-
2015-EU-TM-0347-M	Core Network Corridors	Trackside	Ongoing	Development of a 1435 mm standard gauge railway line in the Rail Baltic/Rail Baltica (RB) corridor through Estonia, Latvia and Lithuania (Part II)	Mixed	31/12/2020	12,818,000	-	58	-

Project Code	Call Priority	Deployment Type	Project Status	Title	Type	End Date	Initial ERTMS funding	Actual ERTMS funding	(initial) Km of ERTMS	(initial) Number of Vehicles
2015-PL-TM-0002-W	Core Network Corridors	Trackside	Ongoing	Works on the E75 railway line, Czyżew - Białystok section (phase I)	Works	31/12/2022	6,619,314	-	71	-
2016-PL-TMC-0135-W	Core Network Corridors	Trackside	Ongoing	Works on the E75 railway line, Białystok – Suwałki – Trakiszki (state border) section, Stage I Białystok - Ełk section	Works	29/12/2023	10,228,064	-	104	-
TOTAL Core Network Corridors Priority (7)							66,584,081	-	568	-
TOTAL ERTMS and Core Network Corridors priorities (16)							124,293,629	-	789	420

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of the following information.

© European Union, 2020

Reuse is authorised provided the source is acknowledged. The reuse policy of European Commission documents is regulated by Decision 2011/833/EU (OJ L 330, 14.12.2011, p.39).

For any use or reproduction of photos or other material that is not under the EU copyright, permission must be sought directly from the copyright holders.

Pdf: EF-01-20-457-EN-N - ISBN: 978-92-9208-092-1 - DOI: 10.2840/80258