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Retrack

REorganization of Transport networks by advanced RAil freight Concepts

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Author(s)	Roberto Palacín (UNEW)
Co-author(s)	Roland Mauck (EUB)
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TABLE OF CONTENTS

TABLES

FIGURES

Executive Summary.

The objective of this report is to provide an overview of the available train control systems by country along the proposed RETRACK corridor Rotterdam (NL)-Constanza (RO). The report also gives a brief comprehensive overview of the European Rail Traffic Management System (ERTMS) as well as assessing the extent of the deployment of ERTMS in Europe and along the proposed RETRACK corridor.

The proposed RETRACK corridor runs along five different countries (six if a brief incursion into Slovakia is considered) encountering five different Control-Command systems including ERTMS/ECTS. Chapter 2 summarises the main characteristics of these Command Control (CC) systems per country.

The Dutch CC system is known as ATB. It has two main versions, the first generation or ATB-EG and a modern version known as ATB-NG. While ATB-EG provides discrete (i.e. at signals) speed supervision, the ATG-NG provides continuous speed supervision. Both systems are incompatible, needing an additional interface (ATB-L). ATB-L is the on board ATB-NG system capable of managing ATB-EG information. The German system is known as PZB with a more advanced version of the system known as LZB for continuous speed supervision. The Austrian CC system uses the same systems as the German network, the PZB and the LZB. The Hungarian CC system is called EVM and is based on a technology very similar to the Dutch ATB-EG. However, EVM is not capable to stop the train before a reference point. Romania uses the PZB system, similar to the German and Austrian systems.

The proposed RETRACK corridor runs through the Netherlands using the dedicated freight line “Betuweroute”, which is fitted with ERTMS/ECTS level 2 exclusively. Joining the Betuwe route, between Rotterdam and Kijfhoek, the line is equipped with ATB-EG although it is planned to be equipped with ERTMS/ETCS level 1 by spring 2008. The connection to the German network is made on track equipped with PZB changing to LZB for the German section. The Austrian section (Passau - Linz - Vienna- Hegyeshalom), is fitted with a combination of PZB, LZB and ERTMS/ECTS Level 1 systems, although ERTMS/ECTS Level 1 will be in service for the whole of the Austrian section by the end of 2008. Running across Hungary (Hegyeshalom-Budapest-Curtici), the route is fitted with ERTMS/ETCS level 1 from Hegyeshalom to Budapest, switching to EVM system from Budapest to Curtici on the Romanian border. Finally, the Romanian section (Curtici-Bucharest-Constanza), is fitted with PZB from Curtici to Campina. The section between Campina and Bucharest has ERTMS/ETCS level 1 already in commercial service running alongside PZB during the migration phase while the Bucharest-Constanza section currently uses PZB although ERTMS/ETCS Level 1 is already being fitted and will be fully operational by 2008.

Chapter 3 gives a comprehensive overview of ERTMS. The systems consists of two main distinctive features, namely, GSM-R for data exchange between trackside and onboard and the European Train Control System (ECTS) in which a train-based computer controls the train speed according to the operational characteristics of the track. ECTS and GSM-R together form ERTMS.

ERTMS has three levels. ERTMS/ECTS Level 1 which can also be used as an overlay to existing signalling systems. Track integrity and position is provided by track circuits and the movement authority is received via Eurobalise (track-mounted). ERTMS/ECTS Level 2 does not require trackside signalling. The movement authority to the vehicle is now received via radio (GSM-R) from the control centre. This allows constant update of speed and position, making the trackside signals redundant. This also allows increase the capacity of the network. ERTMS/ECTS Level 3 which in addition to level 2 features, now the train can check its integrity and position by itself becoming effectively a moving block system where trains constantly talk to each other and the control centre adapting their speed profiles to their surrounding convoys allowing more trains on the network.

A Memorandum of Understanding (MoU) signed in 2005 by the European Commission and all the rail stakeholders marked the start of the real implementation of ERTMS which has been planned and developed for the last two decades. To allow this implementation, a coordinated deployment of an ERTMS network of corridors has been defined. Six corridors have been selected and studied, namely:

- Corridor A: Rotterdam – Genoa;
- Corridor B: Stockholm-Naples;
- Corridor C: Antwerp-Basel-Lyon;
- Corridor D: Valencia-Lyon-Ljubljana-Budapest;
- Corrdidor E: Dresden-Prague-Budapest;
- Corridor F: Duisburg-Berlin-Warsaw

These six corridors represent 6% of the total Trans-European Network of Transport (TEN-T) but 20% of the total freight traffic. Each of the corridors has specific individual targets and objectives and often involves not only fitting ERTMS/ETCS equipment but also upgrading the existing infrastructure as well as harmonising the operational rules.

The final chapter of this report provides conclusions about the corridor control systems as well as highlighting the main benefits and drawbacks of ERTMS and its deployment. ERTMS is seen as an essential tool for realising the interoperability of the European railway system and improving the competitiveness of the European railway sector. However, it is encountering compatibility issues on its migration from existing systems. Technical compatibility issues between trainbourne and trackbourne equipment are also slowing some projects although this is something to be expected when introducing new technologies in such complicated environments as the railways and it should disappear after the initial stages.

1 Introduction

The single European Rail System is in working progress, with increasing levels of harmonisation and interoperability being achieved by the introduction of an array of measures including Standards (TSIs-Technical Specifications for Interoperability) and technical developments such as the all important European Rail Traffic Management System (ERTMS). However, until this particular development is widely available every new cross border rail service will have to carefully consider and assess the different train control systems to be encountered along the route.

The objective of this report is to provide an overview of the available train control systems by country along the RETRACK corridor Rotterdam (NL)-Constanza (RO). The report will also assess the extent of the deployment of ERTMS along the corridor, both current and approved for future implementation, particularly for the 2008-09 period. Also depending on the technology that is used prior to ERTMS, the gain in capacity may be significant. For international planning of railfreight it is of great importance to know if existing bottlenecks will disappear at a certain time or whether alternatives due to the lack of capacity are needed.

2 Control Systems by Country

The pilot demonstration of an innovative new rail freight service on the Rotterdam–Constanza corridor is essential to RETRACK. Running for 2650 km along the following route:

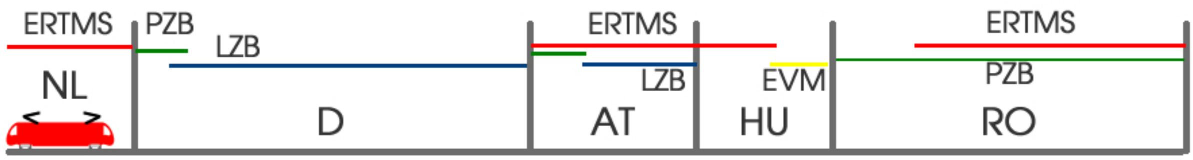
Rotterdam (NL)- Zevenaar (NL) – Emmerich (DE) – Duisburg (DE) – Rheinstrecke (DE) - Aschaffenburg (DE)- Passau (DE) - Linz (AT)- Vienna (AT)- Hegyeshalom (AT) - Budapest (HU) - Curtici (RO) – Bucharest (RO) – Constanza (RO)

The European railways currently operate over 20 different Control-Command (CC) systems based on a number of versions of 6 core technologies. The proposed RETRACK corridor crosses 5 different countries encountering 5 different CC systems, including ERTMS. Table 1 gives an overview of the CC systems on the corridor and fig.1 represents them graphically.

Table 1. Summary of the CC systems encountered along the RETRACK corridor.

RETRACK corridor section		country	CC system
Rotterdam-Zevenaar	**Roterdam- Kijfhoek**	The Netherlands	ATB (ERTMS 1 from 2008)
	Kijfhoek-Zevenaar	The Netherlands	ERTMS 2
Zevenaar-Emmerich-Duisburg-Rheinstrecke-Aschaffenburg-Passau		Germany	PZB
Passau-Linz-Vienna	**Passau-Wels**	Austria	PZB (ERTMS 1 from 2008)
	Wels-Linz-Vienna	Austria	LZB (ERTMS 1 from 2008)
Vienna-Hegyeshalom		Austria	LZB + ERTMS 1
Hegyeshalom-Budapest		Hungary	ERTMS 1
Budapest-Curtici		Hungary/Romania	EVM
Curtici-Bucharest	**Curtici-Campina**	Romania	PZB
	Campina-Bucharest		PZB + ERTMS 1
Bucharest-Constanza		Romania	PZB (ERTMS 1 from 2008)

Fig. 1. Distribution of CC systems along the corridor on the 2008 horizon.



The following sections of this chapter give an overview of the CC systems in the countries crossed by the corridor and in the specific sections of the corridor in that country. These are currently in use or will be in use by the time the RETRACK pilot demonstration is expected to take place (end 2008).

2.1 The Netherlands.

The Dutch rail traffic protection system is called ATB (**A**utomatische **T**rein**B**eïnvloeding-*automatic train influencing*) which originates in the 1950s and is still in use as ATB-EG (**E**erste **G**eneratie- *first generation*). This technology uses low frequency track-circuits for the data transmission between track and train. Electric alternating current at 75 Hz is pulsed into the rails and the number of pulses is then recognised by the locomotive antenna (coils) which transmits the signal to the cab where the maximum allowed speed is displayed to the driver. Speed limits vary from 40km/h, 60km/h, 80 km/h, 130 km/h or full speed 140 km/h. If the driver does not take the appropriate action, the ATB system overrides the train controls with an emergency brake intervention able to be released at full stop only. The major disadvantages of ATB-EG are the inability to intervene at speeds below 40 km/h.

To overcome the limitations of the ATB-EG, an improved version called ATB-NG (**N**ieuwe **G**eneratie-*new generation*) has been developed and rolled out. While ATB-EG provides discrete speed supervision (i.e. at signals), the ATG-NG provides continuous speed supervision. The ATB-NG technology uses spot (i.e. non-continuous) transmission with electronic transponder device working in low frequency range. However, the two systems are totally incompatible, which means a train equipped with ATB-NG needs the ATB-EG onboard system to feed the ATB-NG onboard system. ATB-NG can operate in steps of 10 km/h in the range between 0 km/h and 200 km/h. To overcome this incompatibility, the ATB-L system was provided. This is an on board ATB-NG system capable of managing ATB-EG information.

The section of the proposed RETRACK corridor running through the Netherlands will use the dedicated high-speed freight Betuwe route, which is fitted with ERTMS/ECTS level 2 exclusively. The connection to the German network is made on track equipped with PZB system (See section 2.2. Germany for more details), while at the beginning of the Betuwe route, between Rotterdam and Kijfhoek, the line is equipped with ATB-EG exclusively although it is to be replaced with ERTMS/ETCS Level 1 exclusively by spring 2008. Within the Kijfhoek marshalling yard, no ERTMS is installed.

2.2 Germany

The main CC system used in Germany is the PZB90 (**P**unktförmige **Z**ug**b**eeinflussung Version 19**90**), mandatory on every main line locomotive. This is a discrete speed supervision system that uses spot transmission in conventional technologies such as galvanic contacts or inductive coils, i.e. it is an inductive system with its intelligence built in the onboard computer. Three different types of trackside magnets communicate to the counterpart on the vehicle. The trackside magnets are connected to the respective signals and react to the actions of the train driver. If a vehicle goes too fast or does not slow down when it is supposed to, the train driver has to confirm that he is aware of the situation within 4 seconds by pressing a “receipt button” on the cab console. Failing to do this will result in the train being automatically stopped. To ensure that the train will stop at the right point, the onboard computer calculates and monitors the individual braking curve comparing it with the speed profile to decide whether emergency braking is required.

The main disadvantage of a system using fixed points, such as the PZB is that the vehicle cannot accelerate before it has passed the next magnet, as this is the only way to update the onboard computer. For this reason a more advanced LZB (**L**inien**z**ug**b**eeinflussung) system has been developed and installed in all high speed lines and main conventional lines.

The LZB system uses cable loops technology for the data transmission between track and train. Compared with the PZB system, the driver now receives additional information on a display indicating the distance to the next target point and the required speed that the train should have at that point. If the onboard computer decides that based on the individual trains braking characteristics the target speed cannot be reached, it overrides the driver and initiates an emergency stop.

Two other systems are used in Germany but only marginally and do not affect the RETRACK corridor. These systems are the AFB (**A**utomatische **F**ahr- und **B**remssteuerung-*automatic driving and braking control)* and the CIR-ELKE II (**C**omputer **I**ntegrated **R**ailroading – **E**rhöhung der **L**eistungsfähigkeit im **K**ernnetz der **E**isenbahn).

Regarding the section of the RETRACK corridor running across Germany from Emmerich on the Dutch border to Passau on the Austrian border (Emmerich-Duisburg-Rheinstrecke-Aschaffenburg-Passau), the route is fitted with the PZB system.

2.3 Austria

The Austrian and German systems are very similar. The main CC system in Austria is also the PZB, installed on all main lines with the only exception of the Vienna–Wels–Salzburg route equipped with LZB. The main difference between the two countries lays on the level and scope of ERTMS/ECTS deployment. Where Germany is only rolling out ERTMS/ECTS on new-built high speed lines, Austria is already installing ERTMS/ETCS level 1 on all it’s A-Mainline network and it is expected to have 60% in service and a third of the whole network fitted with ERTMS/ETCS level 1 by the end of 2008 (see chapter 3 of this report).

Regarding the section of the RETRACK corridor running across Austria from Passau on the German border to Hegyeshalom on the Hungarian border (Passau-Linz-Vienna-Hegyeshalom), the route is fitted with a combination of PZB, LZB and ERTMS/ECTS Level 1 (See table 1), although ERTMS/ECTS Level 1 will be in service for the whole of the Austrian section of the RETRACK corridor by the end of 2008 (see chapter 3 for more details).

An alternative routing to this corridor considers a brief incursion into the Slovak Republic. Slovakia uses a CC system known as LS which is similar to the Hungarian EVM (see 2.4).

2.4 Hungary

The Hungarian CC system is called EVM. This discrete speed supervision system is based on a technology very similar to the Dutch ATB-EG using low frequency track circuits to transmit date from infrastructure to vehicle. However, EVM is not capable to stop the train before a reference point. EVM is the only system used in the country (excluding ERTMS).

Regarding the section of the RETRACK corridor running across Hungary from Hegyeshalom through Budapest onto Curtici on the Romanian border (Hegyeshalom-Budapest-Curtici), the route is fitted with ERTMS/ETCS level 1 from Hegyeshalom to Budapest, switching to EVM system from Budapest to Curtici on the Romanian border.

2.5 Romania

Romania uses the PZB system, similar to the German and Austrian systems. PZB is installed in all Romanian main lines. However, contrary to the approach in Germany and Austria, the limitations of the PZB have not been taken forward with the introduction of the more advanced version, LZB.

Regarding the section of the RETRACK corridor running across Romania from Curtici to Bucharest onto the final destination Constanza (Curtici-Bucharest-Constanza), the route is fitted with PZB from Curtici to Campina. The section between Campina and Bucharest has ERTMS/ETCS level 1 already in commercial service running alongside PZB during the migration phase while the Bucharest-Constanza section currently uses PZB although ERTMS/ETCS Level 1 is already being fitted and will be fully operational by 2008.

3 Deployment of ERTMS along the Corridor

3.1 What is ERTMS?

ERTMS is the European Rail Traffic Management System set up by the railway operators, the supply industry and the European Commission to overcome the fragmented European Rail System, where there are up to six different navigation systems currently in operation. ERTMS can be defined as the European single signalling and train control system for interoperability. It aims at standardising signalling and train control across Europe to promote interoperability and reduce journey times (no border stops) as well as maintenance and operational costs. It has two key basic components:

- ECTS, the European Train Control System;
- GSM-R, the dedicated radio system for voice and data communication.

ECTS can be defined as the new European CC system in which a train-based computer controls the train speed according to the train characteristics, national (operational) values and the operational characteristics of the track.

GSM-R is based on GSM technology using dedicated frequencies exclusive to the railways with the addition of a number of advanced functions. ECTS and GSM-R together form ERTMS.

3.1.1 Further improvements

A management layer known as ETML acting as third layer to ERTMS is being developed and tested on the Rotterdam-Milan corridor under the EU-funded project EUROPTIRAILS with the potential for future evolution to cover commercial opportunities such as:

- Tracking and tracing;
- Estimated time of arrival (static initially, dynamic later);
- Electronic calculation of Bonus/Malus system along corridors as part of a European Performance Regime
- Real time path assembly during perturbation on International corridors.

This is an information system in real time for traffic management which will optimise the monitoring of the railway traffic in Europe, obtaining information on time and reducing train delays. It does not replace the existing domestic systems, providing bilateral data exchange based on UIC-Leaflet 407-1 but assures a centralised interface. Through the corridors it will allow the monitoring of the international trains, identified by a reference number unlike the current methods.

Moreover, EUROPTIRAILS is one of the components of the information systems developed by the European Infrastructure Managers together with Pathfinder and EICIS tomorrow which will bring information about the price of the international paths.

3.2 Legal basis.

3.2.1 History

In 1990 the first European working group of experts was created to draft the requirements of ETCS. The following year industry and railway undertakings agreed to cooperate in the development of the requirement specifications of ETCS as a base for commercial development.

The EU Council Directive 96/48/EC of 23 June 1996 on the interoperability of the European high speed system set the basis for the development of the technical specifications for interoperability (TSIs) and consequently the need for a common rail traffic management system. The subsequent Directive 2001/16/EC set the basis for the interoperability of the trans-European conventional rail system.

The ERTMS functional requirement specification and system requirement specification Class 1 was signed on 25 April 2000 meaning the arrival of ERTMS. In 2002 the current version Baseline 2.3.0 was agreed and accepted by all parties. This is now part of the TSI for Control-Command (adopted on 7 November 2006, Com(2006)5211) and the current legal version of ERTMS. A future version 3.0.0 is currently being developed by the European Railway Agency (ERA) which has been designated as the ERTMS systems authority. It is expected to enter into force in 2011 after the adoption procedure is completed. This version will be fully compatible with baseline 2.3.0[1].

3.2.2 Legal references

A number of EU Decisions and Directives have been published dealing with the specifications of ERTMS. In particular:

- The 2001/260/EC Commission Decision of 21 MARCH 2001 on the basic parameters of the command-control and signalling subsystem of the trans-European high-speed rail system referred to as "ERTMS characteristics" in Annex II to aforementioned Directive 96/48/EC.
- Commission Decision 2002/731/EC of 30 May 2002 concerning the TSI relating to the control-command and signalling subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Council Directive 96/48/EC. This decision is modified by Commission Decision 2004/447 of 29 April 2004, modifying Annex A, and establishing the main characteristics of Class A system (ERTMS) of the control-command and signalling subsystem of the trans-European conventional rail system referred to in Directive 2001/16/EC.

3.3 How it works.

ERTMS/ECTS has three different levels, namely:

3.3.1 ERTMS/ECTS Level 1.

Level 1 is designed as an add-on or overlay to a conventional line equipped with line side signals and train detection equipment which locates the train. Balises (see fig.2) containing pre-programmed track data are installed on the track and linked to the control centre. The train detection equipment sends the position of the vehicle to the control centre which determines the new movement authority sending it back to the balise. When the train passed over it receives the new movement authority and track data. The onboard computer then

[1] ERTMS systems architecture is designed so it can keep up with technology developments and therefore any subsequent versions will be fully compatible with each other.

uses this data to calculate the speed profile for the movement authority and the next breaking point, displaying it to the driver.

Fig. 2. in-track mounted eurobalises.

To improve the capacity of the line, and infill can be added. Loops are installed ahead of the balises so information from the next balise can be sent into the loop and transmitted to the train as it passed over. The onboard computer therefore receives advanced information of the next movement authority and the characteristics of the track ahead. This advanced information indicates the new breaking point to the driver which avoids the train braking too soon, significantly improving journey times.

Fig. 3. diagram showing the basics of ERTMS/ECTS Level 1 without infill loop.

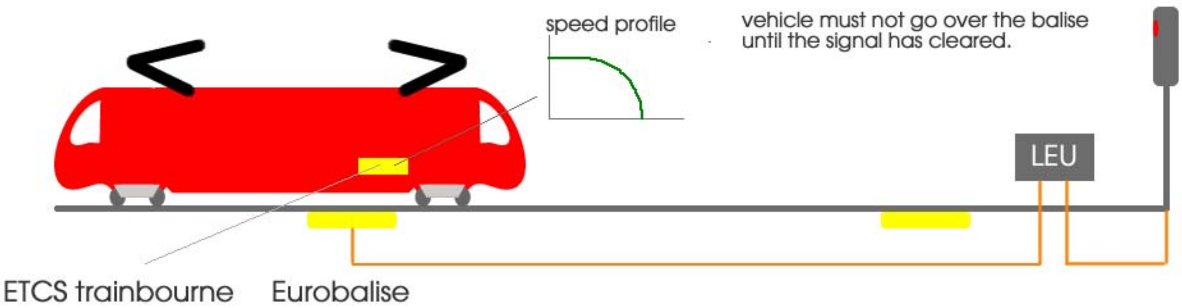
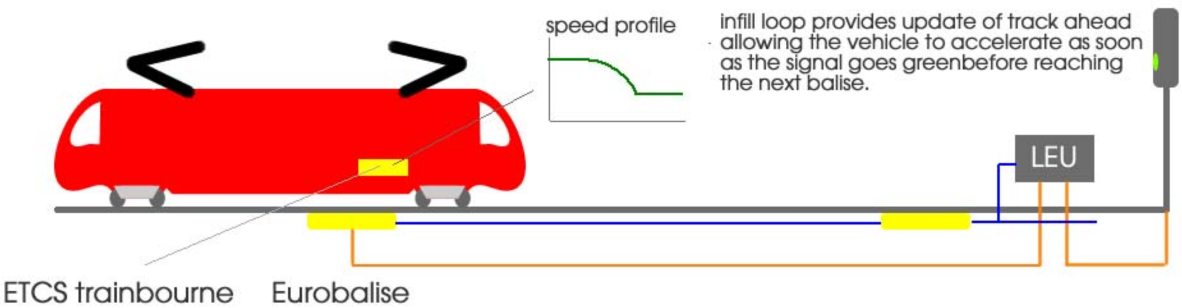


Fig. 4. Diagram showing the basics of ERTMS/ECTS Level 1 with infill loop.

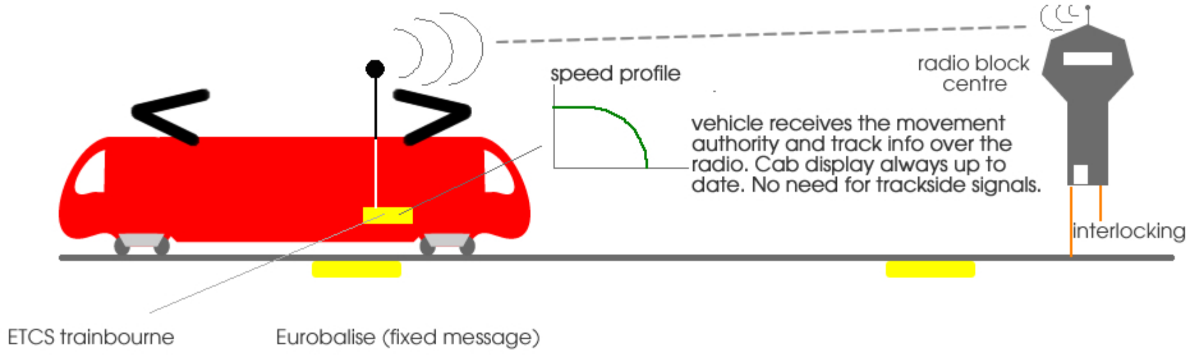


3.3.2 ERTMS/ECTS Level 2.

Level 2 does not require line side signals but still need train detection equipment along the track. It has on onboard radio system allowing the onboard computer to communicate with the control centre instead of the balises in level 1. These balises are now autonomous, acting as electronic position markers with the track characteristics now pre-programmed in the onboard computer.

The train detection equipment sends the position of the vehicle to the control centre which determines the new movement authority sending it back to the train using the radio system (GSM-R). As with level 1, the onboard computer then calculates the speed profile for the movement authority and the next breaking point, displaying it to the driver. The train passes over the balise receiving a new position indicator. To ensure safety, the onboard computer continuously determines the train position and checks that the current speed is correct for the distance travelled.

Fig. 5. Diagram showing the basics of ERTMS/ECTS Level 2.



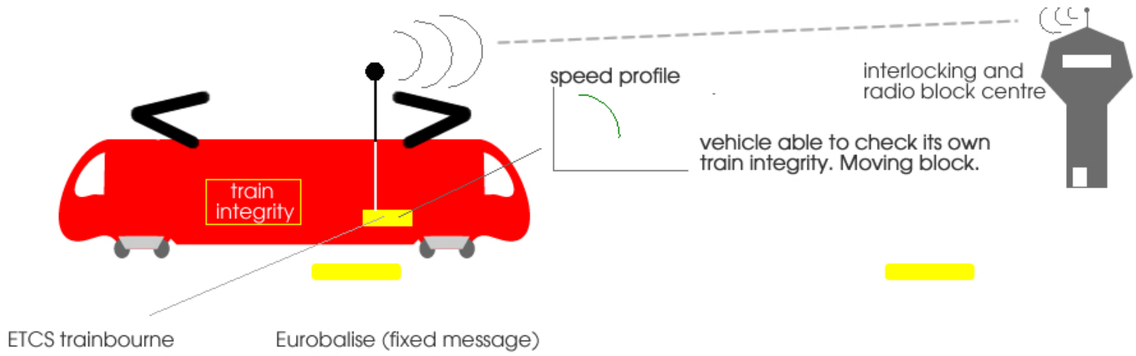
3.3.3 ERTMS/ECTS Level 3

As a step forward from level 2, level 3 has an onboard train integrity system which monitors that the train is complete (train integrity) and therefore there is no requirement for train detection equipment that can now removed from the track. Level 3 equipment still requires an onboard radio system allowing the onboard computer to communicate with the control centre. It also requires the use of autonomous balises which are now simply electronic kilometre markers, with the track characteristics being pre-programmed into the onboard the computer.

The train passes over the balise receiving a new position indicator allowing the onboard computer to determine the train position and checking that the current speed is correct for the distance travelled. The train radios its position to the control centre which then determines the new movement authority sending it back via radio to the train. The onboard computer then calculates the speed profile for the movement authority and the next breaking point, displaying it to the driver.

The possibility of frequent updates of the movement authority through radio transmission enables trains to run closer together and the line capacity increases quite significantly. ERTMS/ECTS level 3 is effectively what is now as a moving block CC system.

Fig. 6. Diagram showing the basics of ERTMS/ECTS Level3.



3.4 ERTMS deployment across the whole network

Tests are completed and European deployment of the system across different routes is a major step forward in the implementation of ERTMS.

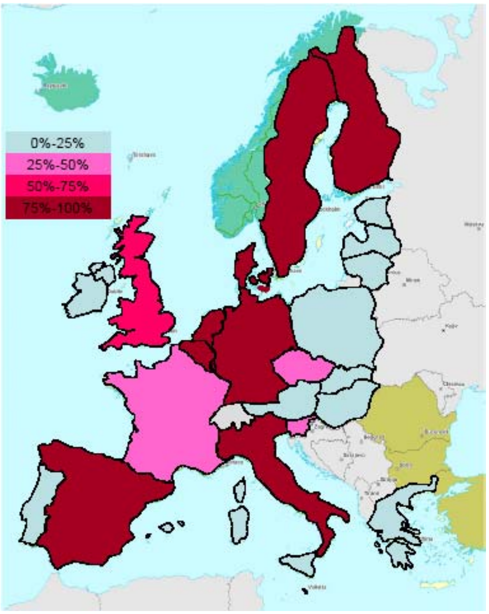
In March 2005 a key milestone was achieved for this purpose. A Memorandum of Understanding (MoU) was signed between the European Commission and the European rail associations (CER, UIC, UNIFE and EIM)[2]. This document establishes the basic principles for the definition of an EU deployment strategy for ERTMS (see annex). One of the key aspects of this document is the coordinated deployment and migration strategies as well as the creation of an ETCS network parallel to the development of major international interoperable corridors (see section 3.4.5 for more details)

3.4.1 GSM-R deployment

GSM-R deployment is well under way. Most EU members are already replacing their obsolete analogue radio technology with GSM-R. The following figure (Fig.7) illustrates this rapid deployment. It is expected that by 2010 at the latest, the main railway lines in the EU should be fitted with GSM-R.

Fig. 7: Percentage of EU25 main lines equipped with GSM-R by the end of 2008 (Source: European Commission).

[2] CER: Community of European Railways; UIC: International Union of Railways; UNIFE: European Association for the Railay Supply Industry; EIM: European Rail Infrastructure Managers.



3.4.2 ECTS deployment

ECTS deployment is not as fast as GSM-R. The main reason for this lays on the safety-critical nature of signalling equipment that leads to longer specification process, need for integration with existing equipment and other system facilities as well as complex validation and certification process. The longer lifetime of the ECTS equipment both onboard and trackside also contributes to slower deployment of ECTS compared with GSM-R.

3.4.3 Migration strategy

The railway sector stakeholders have all agreed on a “rapid” migration strategy, corroborated by the signature of the Memorandum of Understanding in 2005. This rapid strategy is based on natural renewal and selective and coordinated retrofitting to achieve interoperability faster on key routes as well as reaching a critical mass of ERTMS equipment. This is planned to take place during a 10-12 year period plan from the signing on the MoU, although the expected delivery of the complete ETCS corridors (see 3.4.5) is 2012-2015. During this time a number of studies on a corridor by corridor basis are taking place before commencing the deployment and migration between the current national systems and the ECTS system. It is seen as an essential need to have a coordinated[3] deployment.

An EU master plan on ERTMS migration will be prepared. The EU Member States are expected to submit their national migration plans by October 2007. The European Commission together with the Member States and the MoU partners will consolidate these national plans to produce a EU master plan.

From a practical point of view, the progressive implementation of sections of corridors with ERTMS/ETCS means that rolling stock running on those lines will have to be equipped to run on both ERTMS and non-ERTMS lines, which still rely on national CC systems. To make this possible a Specific Transmission Module (STM) is essential to be fitted on the ERTMS/ETCS onboard equipment (also known as EuroCab).

3.4.4 Cost.

It is expected that the total cost of the deployment of ERTMS on the selected corridors to reach critical mass by 2015 will be in the region of €5 billion (€400-500M per year) with an

[3] Mr Karel Vinck, former director of the Belgian Railways, was appointed European Coordinator for ERTMS by the EC in 2006.

estimated 50% funding by the EC. The rest of the funding is expected to be provided by national governments and key stake holders.

The financial support of the Trans-European Transport Network (TEN-T) is vital to the implementation of ERTMS following a rapid migration strategy. The Multi-Annual Programme of the TEN-T for 2007-2013 includes €500M exclusively dedicated to ERTMS investments split fifty-fifty between onboard and trackside investments.

Funding from Structural and Cohesion Funds particularly for new Member States can be very significant. Fitting ERTMS/ECTS is mandatory in the case of financial support from such funds reaching 30% or more of the upgrade total cost[4]. This could significantly speed up the implementation of ERTMS in the new Member States as their rail infrastructure is in most cases in need of urgent upgrading.

In terms of the actual equipment, ECTS equipment consists of two modules, namely onboard and trackside. The cost of the onboard module depends on the type of vehicle or convoy. It can range from something in the region of €100,000 when fitted on a new vehicle to €200,000-300,000 when retrofitting or upgrading existing rolling stock. Regarding the trackside equipment, it is extremely dependent of the track conditions and traffic density and therefore it can vary from €30,000 to €300,000 per kilometre. It is worth mentioning that the costs are falling sharply as the number of trains fitted with ETCS increases, allowing withdrawing the expensive-to-run existing systems. Also, economies of scale are starting to be introduced.

Both trackside and onboard equipment qualify from EC funding. For instance, retrofitting existing locos qualifies for €200,000 in the 2007 cal, lowering to €150,000 in subsequent calls. New locos could qualify to a maximum of €100,000 per set of ERTMS/ECTS equipment.

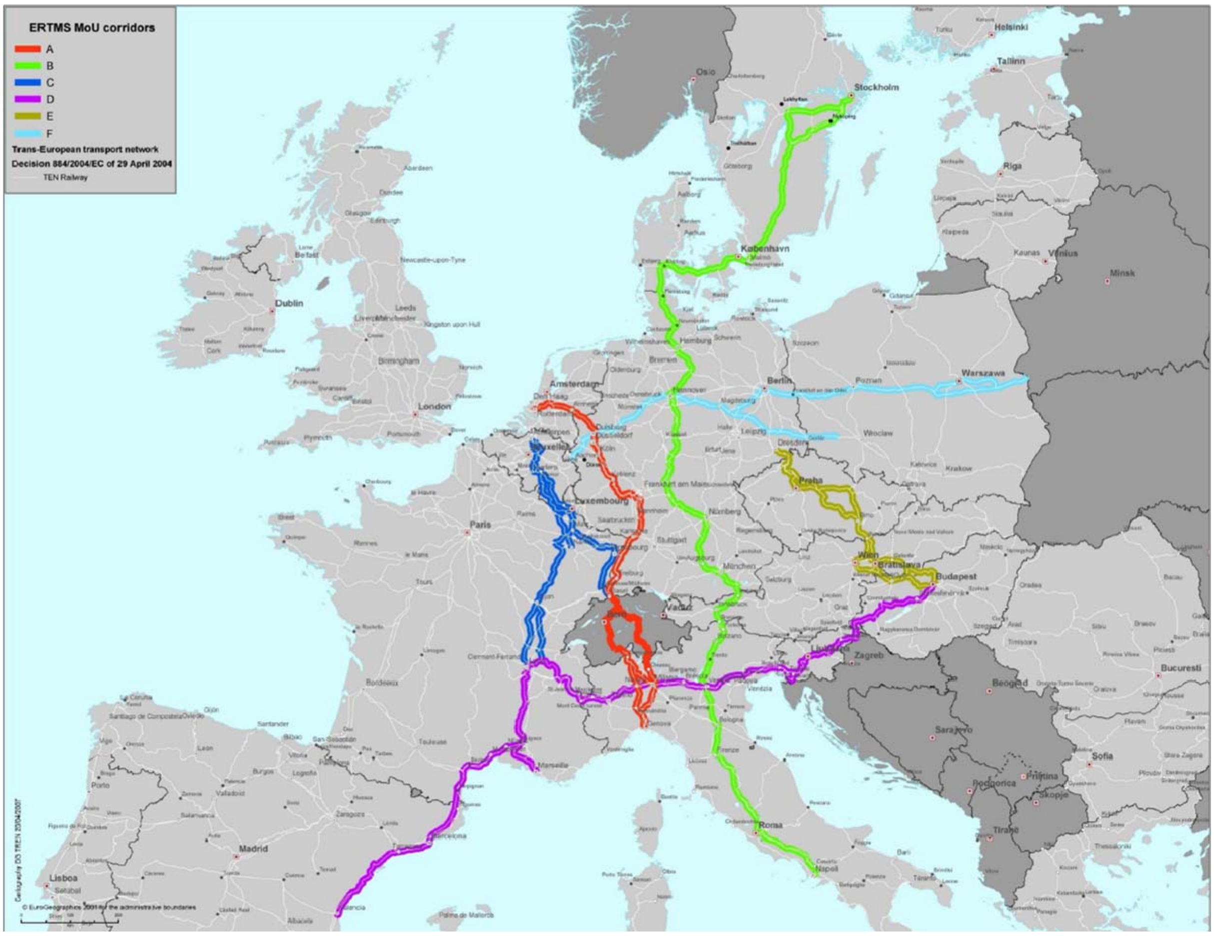
3.4.5 ERTMS freight corridors

The deployment of ERTMS will be carried out by developing an ERTMS/ECTS network.

As result of the Memorandum of Understanding, for the horizon of 2012-15 the main objective is to upgrade a network of six major freight corridors (see fig.8) by deploying ERTMS/ETCS.

Fig. 8. Map showing the six corridors for ERTMS deployment (source: EC)

[4] Commission decision C(2006)964 of 28 March 2006.



These six corridors represent 6% of the total trans-European network but 20% of the total freight traffic. Each of the corridors has specific individual targets and objectives and often involve not only fitting ERTMS/ETCS equipment but also upgrading the existing infrastructure as well as harmonising the operational rules. In other words, the corridor approach is made in two strategic dimensions: improving interoperability by introducing additional measures and creating a total service concept and the introduction of ERTMS/ECTS.

The following table gives an overview of these six corridors and their expected implementation timeframe.

Table 2. Details of the six ERTMS corridors and expected implementation timetable (source: EC)

Corridor	section	ERTMS/ETCS level	Implementation date
Corridor A: Rotterdam-Genoa	**Rotterdam-Oberhausen**	Level 2	2012
	Oberhausen-Mannheim	Level 2	2015
	Mannheim-Genoa	Level1/2	2012
Corridor B: Stockholm-Naples	**Stockholm – German Border**	Level 1/2	2015
	Flensburg – Hannover	Level 2	After 2020
	Hannover - München	Level 2	After 2020
	München – Kufstein	Under examination	under examination
	Wörgl – Innbruck	Level 2	2012
	Innsbruck – Verona – Naples	Level 1/2	2014
Corridor C: Antwerp-Basel-Lyon	**Antwerpen – Bettembourg**	Level 1	2012
	Bettembourg – Basle	Level 1	2009/10
	Athus – Dijon	Level 1	2014
	Dijon – Lyon	Level 1	2016/17
Corridor D: Valencia-Lyon-Ljubljana	**Valencia – Tarragona – Port-Bou**	Level 1	2014
	Tarragona – Perpignan	Level 2	2009
	Perpignan – Lyon	Level 1	2012/16
	Lyon – Modane – Torino	Level 1	2014
	Torino – Milano	Level 1	2012
	Milano – Ljubljana	Level 1	2013/14
Corridor E: Dresden-Prague-Budapest	**Dresden – Děčín**	Level 2	2020
	Děčín – Praha – Břeclav	Level 2	2010/11
	Břeclav – Bratislava – Budapest	Level 1	2015
Corridor F: Duisburg-Berlin-Warsaw-Terespol	**German section**	Level 2	2020
	Polish sections to be confirmed		

The following table gives an overview of the targeted performance improvements regarding travel time reduction on the six ERTMS corridors. Other performance improvements expected include, for instance, a capacity increase between 2 and 20 % in the selected corridors.

Table 3. Targeted performance improvement for the ERTMS corridors: Travel time reduction (Source: EC).

	Travel time 2006	Travel time 2012-15	Time reduction
Corridor A	**22h 00m**	18h 00m	-18%
Corridor B[5]	**51h 09m**	49h 00m	-4%
Corridor C (Basle)	**11h 05m**	8h 45m	-26%
Corridor C (Lyon)	**13h 30m**	10h 45m	-21%
Corridor D	**37h 00m**	31h 00m	-15%
Corridor E	**18h 00m**	14h 00m	-22%
Corridor F	**N/A**	N/A	N/A

Besides this coordinated deployment of ERTMS over six freight corridors, ERTMS is also being deployed in an increasing higher number of high speed and conventional rail corridors across Europe. Examples include the Spanish, German and French high speed Networks.

3.5 ERTMS deployment along the RETRACK corridor

The proposed RETRACK corridor runs along five different countries, all of which are implementing ERTMS onto their networks at different rate and pace. Section 2 of this report gives an overview of the current CC systems in these countries making also references to the ERTMS implementation and projects.

Regarding the ERTMS corridors defined in chapter 3, there are some overlaps with sections of the RETRACK corridor, the most obvious one being the Betuweroute, part of Corridor A.

The following table gives a summary of the expected ERTMS implementation on the RETRACK corridor by section and the correspondence with the all ERTMS Corridors.

Table 4. Overview of ERTMS/ECTS expected implementation along the proposed RETRACK corridor.

RETRACK corridor section		ERTMS Corridor overlap	ERTMS/ETCS
Rotterdam-Zevenaar	**Roterdam- Kijfhoek**	Corridor A	ERTMS 1 from 2008
	Kijfhoek-Zevenaar	Corridor A	ERTMS 2 in service
Zevenaar-Emmerich-Duisburg-Rheinstrecke-Aschaffenburg-Passau	**Zevenaar-Emmerich-Duisburg-Rheinstrecke**	Corridor A	ERTMS 2 from 2012
	Aschaffenburg-Nurnberg	Corridor B	ERTMS 2 after 2020
	Nurnberg-Passau	-	-
Passau-Linz-Vienna	**Passau-Wels**	-	ERTMS 1 from 2008
	Wels-Linz-Vienna	-	ERTMS 1 from 2008
Vienna-Hegyeshalom		Corridor E	ERTMS 1 (+ LZB) in service[6]
Hegyeshalom-Budapest		Corridor E	ERTMS 1 in service[7]
Budapest-Curtici		-	-
Curtici-Bucharest	**Curtici-Campina**	-	-
	Campina-Bucharest	-	ERTMS 1 (+LZB) in service
Bucharest-Constanza		-	ERTMS 1 from 2008

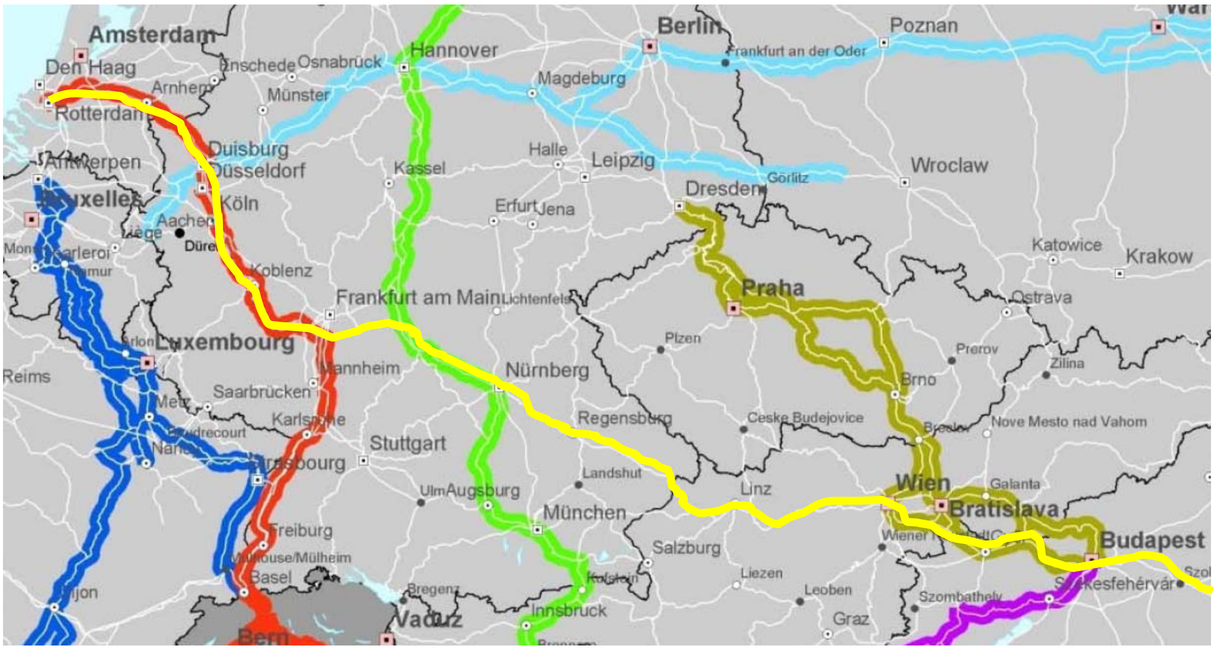
The following figure shows a magnified section of the ERTMS Corridors map (see fig. 8). The RETRACK proposed corridor is represented by the yellow line.

5 Reduction of time loss due to border procedures is not included. If included the travel time could be reduced from 55-58 hours to 49 hours, i.e. 11-16%

6 ERTMS freight corridor E: ERTMS 1 from 2015

7 ERTMS freight corridor E: ERTMS 1 from 2015

Fig. 9. Map of the ERTMS corridors and the RETRACK proposed route.



4 Conclusions

The objective of this report is to provide an overview of the available train control systems by country along the RETRACK corridor Rotterdam (NL)-Constanza (RO). The report also assesses the extent of the deployment of ERTMS in Europe and along the corridor.

The proposed RETRACK corridor runs along five different countries (six if a brief incursion into Slovakia is considered) encountering five different Control-Command systems including ERTMS/ECTS.

A Memorandum of Understanding (MoU) signed in 2005 by all the European Commission and all the rail stakeholders marked the start of the real implementation of ERTMS which has been planned and developed for the last two decades. To allow this implementation, a coordinated deployment of an ERTMS network of corridors has been defined. Six corridors have been selected and studied. These six corridors represent 6% of the total Trans-European Network of Transport (TEN-T) but 20% of the total freight traffic. Each of the corridors has specific individual targets and objectives and often involves not only fitting ERTMS/ETCS equipment but also upgrading the existing infrastructure as well as harmonising the operational rules.

ERTMS has a number of clear benefits such as being an essential tool for making the interoperability of the European railway system a reality, but also improving the safety and security of the system as well as improving cost-effectiveness. At operational level, the main benefit of ERTMS above all, is the increased security for train drivers by ensuring continuous monitoring during train operation. All of which contributes to making the railways more competitive.

However, ERTMS has its drawbacks, the migration from existing signalling systems being the most complicated issue. Also, implementing ERTMS on its own is not enough. To really obtain tangible worthwhile results on the selected freight corridors additional measures need to be taken in addition to deploying ERTMS. Improvements in capacity, reliability, travel time and cost require additional measures such as removal of infrastructure bottlenecks harmonisation of procedures and simplification of operational rules.

Technical compatibility issues between trainbourne and trackbourne equipment are also slowing some projects although this is something to be expected when introducing new technologies in such complicated environments as the railways and it should disappear after the initial stages.

The proposed RETRACK corridor overlaps with three ERTMS corridors along different sections of the route. Namely corridor A and the RETRACK corridor overlap for the whole of the Betuweroute into Germany until Rheinstrecke, corridor B overlaps briefly up to Nurnberg and RETRACK corridor overlaps Corridor E from Vienna to Budapest.

Although by the time of the RETRACK demonstration these overlaps will not be fully available it is worth exploring the potential future benefits as well as considering any fine-tuning alternatives to the route to maximise the benefits of ERTMS by assessing the potential of using ERTMS corridors where possible, particularly corridors A, B and E.

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6 Annex