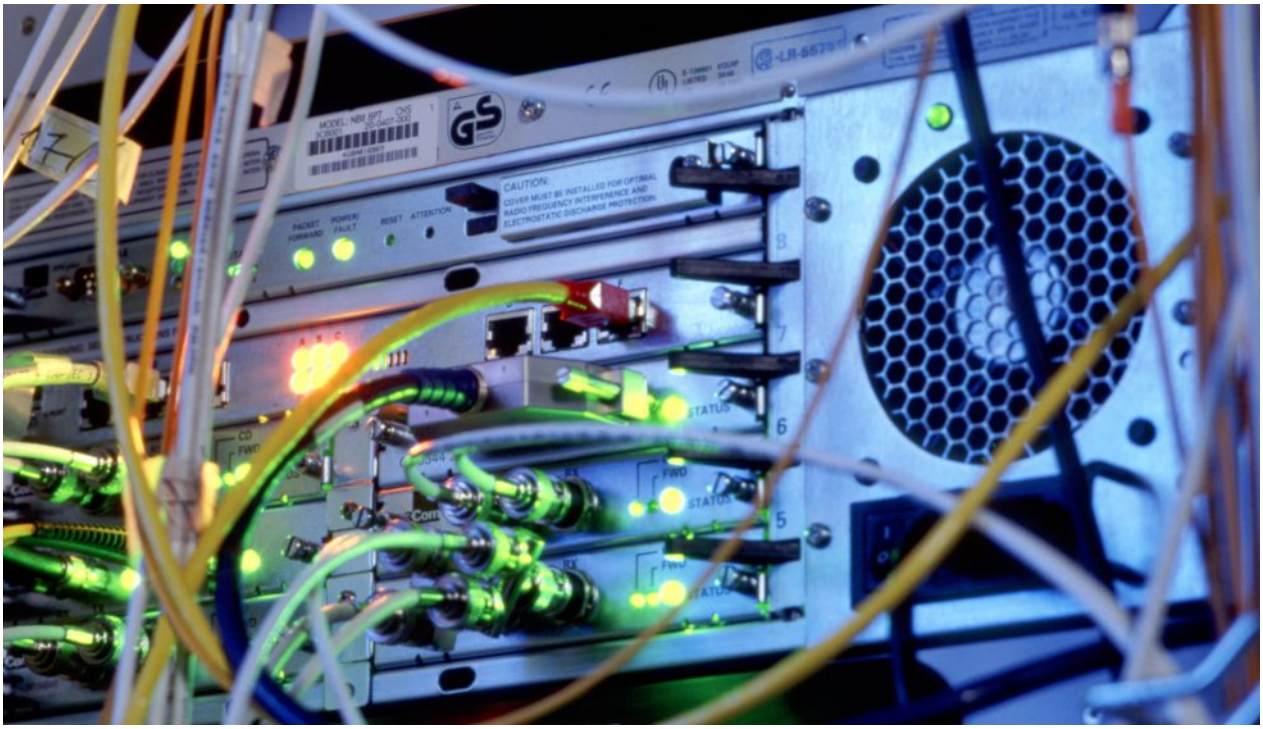
Kapsch CarrierCom

White Paper
European Railway Traffic Management System - ERTMS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RADIO FREQUENCY INTERFERENCE AND
ELECTROSTATIC DISCHARGE PROTECTION

ERTMS: A common signaling and communication system.

Railways operate in a competitive environment and have to ensure operational safety, international interoperability, growth of transport capacities, and the reduction of travel time and reduction of life-cycle costs for equipment. Today, European railways have to deal with at least six different types of railway electrification and about 20 different train control-command systems. Each of these is extremely costly to maintain and operate, takes up space on-board the locomotives and adds complexity and cost for border crossing traffic. A train crossing European countries must switch operating standards when crossing the borders. Adding multi-system equipment to locomotives for border crossing operations can add up to 30% to the price of a locomotive.

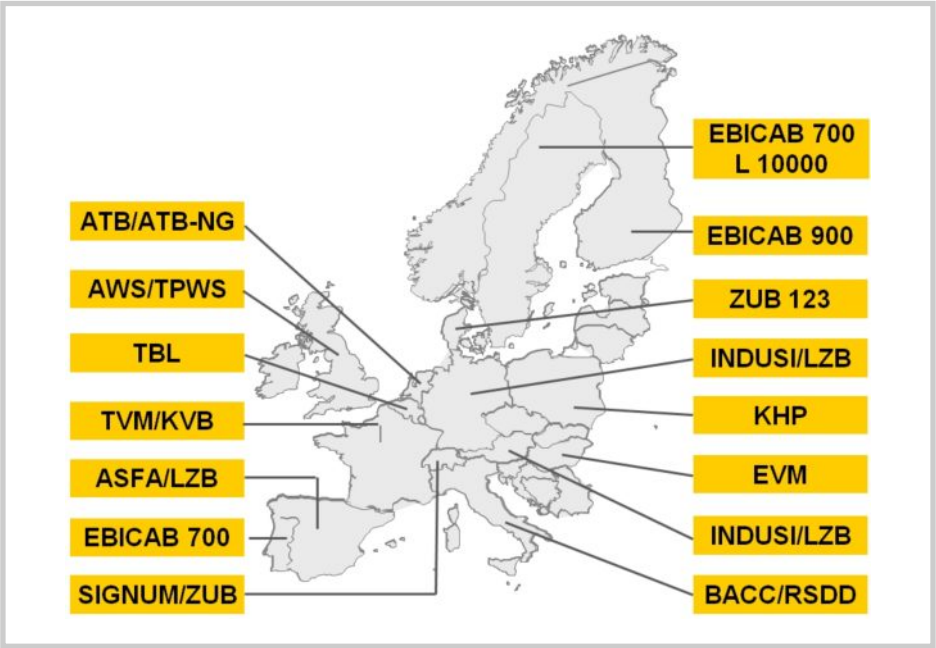

Figure 1: A diversity of implemented national train communication and signaling systems today.

- 32 State owned European railway organizations.
- ~ 200.000 railway kilometers.
- ~ 100 different communication variants (based on 17 national systems).
- 23 different national signaling systems.

To bear with the high cost of the different signaling and communication systems, the European Commission started a project back in the early 1990s to analyze the problems provoked by the operation of the different train control-command systems. Two different groups of experts worked out basic strategies on how these problems could be solved. One working group looked at the definition of a new communication system and the other one analyzed the definition of a new signaling standard.

The result of their work was the definition of GSM for Railways (GSM-R) as the new digital radio system for railway internal voice and data communication, and the European Train Control System (ETCS) as the new control-command system. The combination of ETCS and GSM-R form a new signaling and communication system, the European Railway Traffic Management System (ERTMS). The ERTMS system addresses the following major functional aspects:

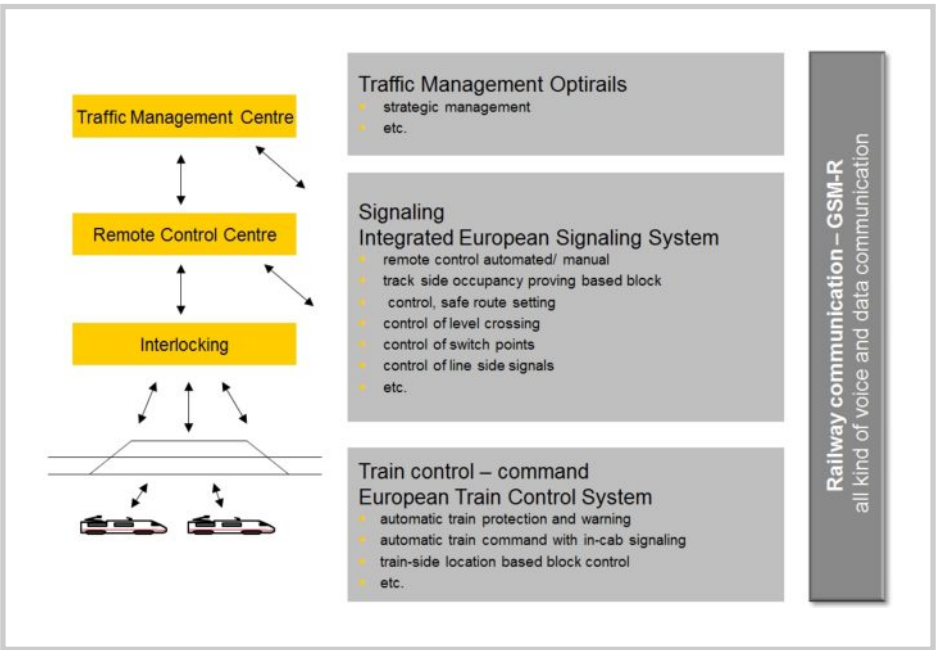

Figure 2: ERTMS - Importance of Train Control Command and Communication in Railway Traffic.

European Train Control System (ETCS).

The ETCS train control-command system was specified by the International Union of Railways (UIC) in cooperation with the railway signaling industry and railway operators. ETCS offers a uniform signaling system and is opening the way for seamless cross-border operations for high speed and conventional trains as well as freight hauling. By optimizing safety while increasing the maximum capacity on railway lines, the system is making a vital contribution to rail network efficiency.

Traffic capacity is limited by infrastructure and rolling stock characteristics. Improving capacity with new tracks is very expensive and can involve considerable time for planning and implementation; improving capacity with ETCS is far more cost-efficient.

Better availability and knowledge of track conditions enables increased train speeds and reduced headway (the time difference between two trains on a track). Both measures can increase the capacity. ETCS provides a rich functionality to railways that allows advanced supervision of rail track equipment and rolling stock.

ETCS Level 1	ETCS Level 2	ERTMS - REGIONAL	ETCS Level 3
Eurobalise without infill ■ Overlay to Existing Signaling System ■ Movement Authorities through Eurobalise ■ Train Integrity & Position by Track Circuit **Eurobalise + infill (euroloop, radio, or extra balises)** ■ Overlay to Existing Signaling System ■ Movement Authorities through Eurobalise ■ Train Integrity & Position by Track Circuit	**Eurobalise** **+ Euroradio (GSM-R)** **+ Radio Block Center** ■ No more Trackside Signals Required ■ Movement Authorities through GSM-R ■ Train Position via Eurobalise	**Eurobalise** **+ Euroradio (GSM-R)** **+ TCC (traffic controller center)** **+ object controller** ■ Movement Authorities through GSM-R ■ Train Position via Eurobalise ■ Train Integrity Onboard ■ Additional object controller ■ GSM-R islands possible	**Eurobalise** **+ Euroradio (GSM-R)** **+ Radio Block Center** ■ Movement Authorities through GSM-R ■ Train Position via Eurobalise ■ Train Integrity Onboard ■ Moving Block

Figure 3: ETCS Levels.

ETCS Level 1.

ETCS Level 1 has been designed as an add-on to an existing line having line sight signals and train detection equipment which locate the train. In ETCS Level 1, Eurobalises are installed to the track and linked to the control center. The balises contain preprogrammed track data. The train detection equipment sends the train position to the control center.

The control center (which receives the information about the positions of all trains on the line) determines the new movement authority and sends it to the balise. The train receives the new movement authority and track data when it passes over the balise. The ETCS balises and legacy optical signals are connected via LEUs (Lineside Electronic Unit).

The on-board computer then calculates the speed profile for the movement authority and the next braking point. This information is displayed to the train driver.

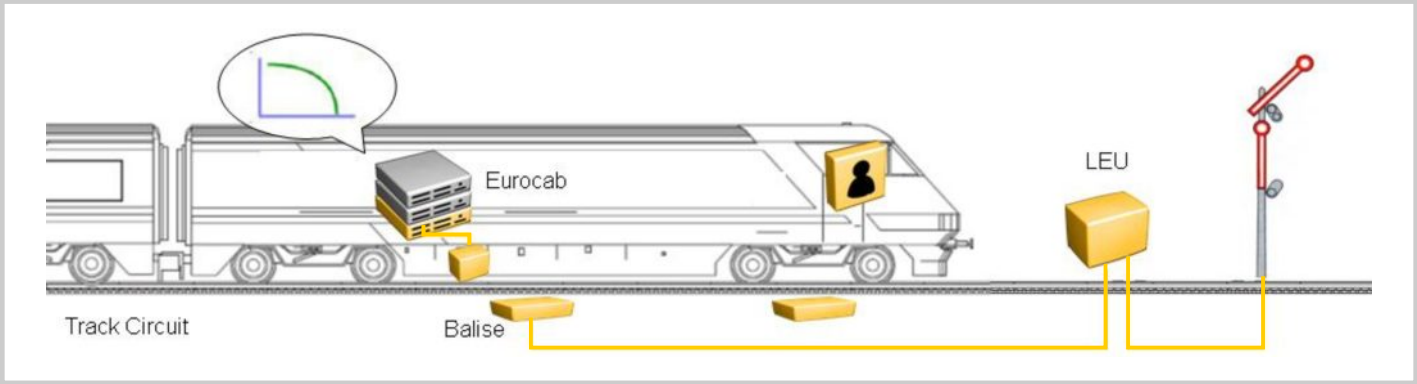

Figure 4: ETCS Level 1 without Infill.

The line capacity of lines equipped with ETCS Level 1 can be improved by using additional loops ahead of the balises. Information from the next balise is then sent into the loop and transmitted to the train as it passes over the loop.

The on-board computer receives advanced information of the next movement authority and the characteristics of the track ahead.
This advanced information helps with calculating the breaking point by optimizing the so-called braking curve (a speed-distance curve calculated from train and infrastructure data). This procedure helps to avoid breaking too soon, and reduces travel time significantly.

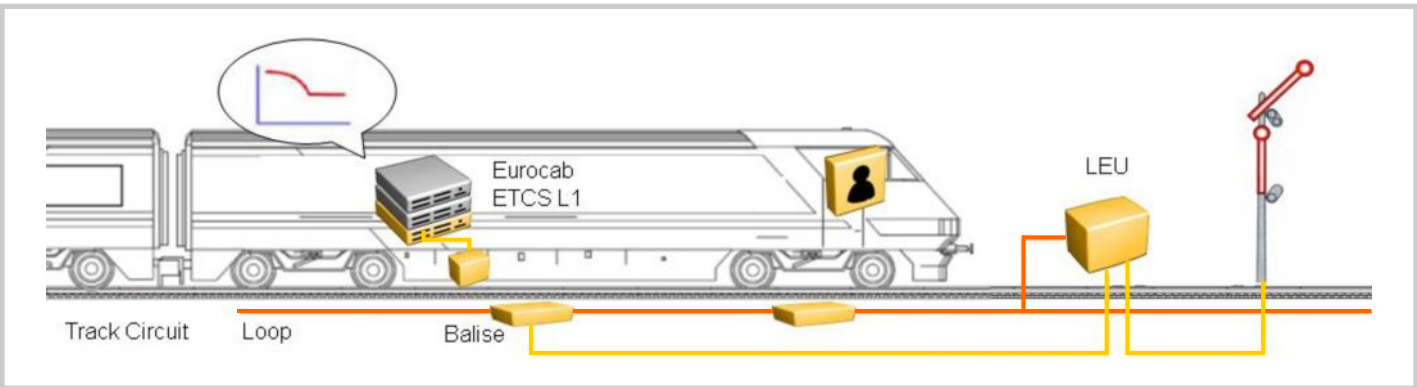

Figure 5: ETCS Level 1 with Infill.

ETCS Level 2.

ETCS Level 2 does not require line sight signals but still needs train detection equipment on the track. ETCS Level 2 uses GSM-R as a board radio system allowing communication between the on-board computer and the control center, the Radio Block Center (RBC). The RBC is a database that is connected to the trackside signaling equipment. The RBC is continuously updated by an on-board system.

The balises on the track become autonomous and are only used as electronic position markers. The track data is preprogrammed into the on-board computer.

The train detection equipment sends the train's position to the control center which receives the position of all trains on the line. The train control center determines the new movement authority to the train.

The on-board computer then calculates the speed profile for the movement authority and the next breaking point. This information is displayed to the driver. As soon as the train passes over the balise it receives a new position indicator.
To ensure safe travel the on-board computer continuously determines the train position and checks the current speed.

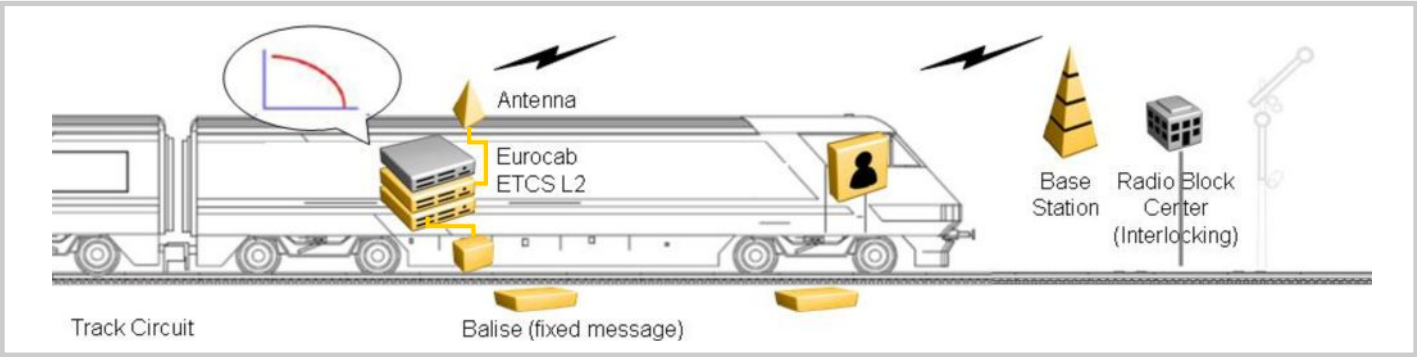

Figure 6: ETCS Level 2.

ERTMS – Regional (ERTMS-R).

ERTMS – Regional is a complement to the above described levels. The objective of ERTMS-R is to reduce the amount of track side equipment, line side signals and traditional interlocking equipment, to minimize cables by controlling objects via radio. An additional Train Control Centre takes over functions including interlocking, object controller, etc. ERTMS-R is based on the ERTMS operating rules and some additional operational guidelines for an ERTMS-R application.
This approach targets to maximize the re-usage of existing on-board equipment and to minimize maintenance efforts and cost significantly. ERTMS-R will be used in particular on tracks with less traffic (secondary tracks).
The train detection equipment sends the train position to the traffic control center. The control center receives the position of all trains on the line and controls all signaling objects along the trackside (switches, level crossings, etc.) through the object controller.

The status information is send from the object controller via radio to the traffic controller center (TCC) and to the locomotive onboard signaling unit. The on-board computer then calculates the travel profile for the movement authority and the next breaking point. This information is displayed to the driver. As soon as the train passes over the balise it receives a new position indicator. To ensure safe travel the on-board computer continuously determines the train position, checks the current speed and train integrity.

Only on critical locations track circuits and axle counter are necessary for train integrity control. ERTMS-R is currently in an early project phase.

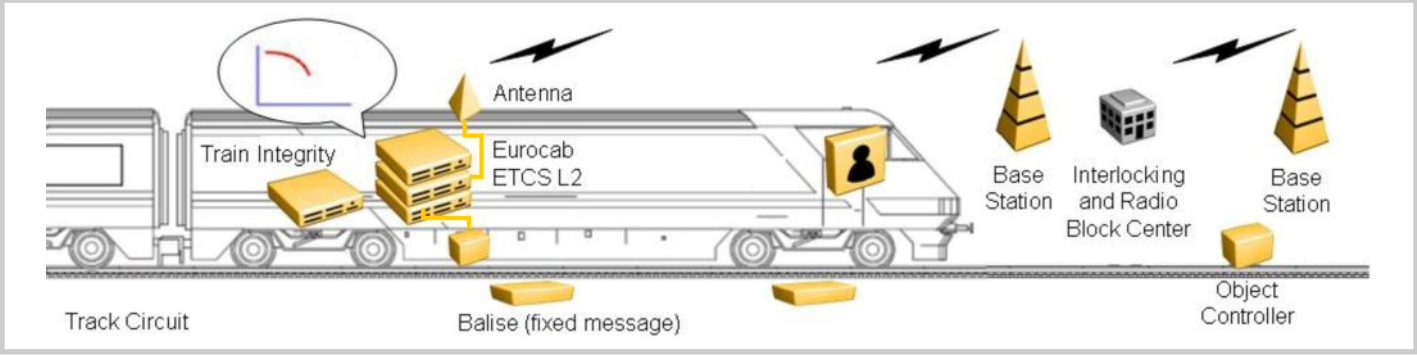

Figure 7: ERTMS - R.

ETCS Level 3.

ETCS Level 3 has an on-board train integrity system which monitors the train. There is no requirement for train detection equipment, which can be removed from the track. ETCS Level 3 equipment still requires an on-board radio communication system to allow the on-board computer communication with the control center and electronic balises as kilometer markers.

The track characteristics are pre-programmed into the on-board computer. When the train passes over a balise, it receives a new position indicator. The on-board computer determines the train position and checks if the current speed is correct for the distance traveled.

The train sends its position via radio signals to the control center, which receives all train positions, determines the new movement authorities and sends it via radio to the train. The on-board computer calculates the speed profile for the movement authority and the next breaking point, which is displayed to the driver. The possibility for frequent updates of the movement authority through radio transmission allows trains to run closer together and the line capacity to be increased significantly.

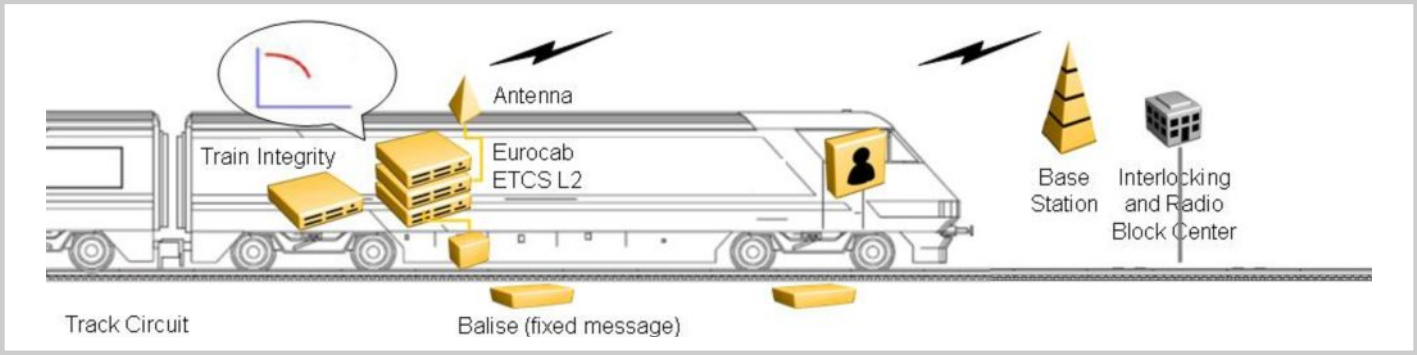

Figure 8: ETCS Level 3.

GSM-R is the result of years of collaboration between the various European railway companies, the railway communication industry and the different standardization bodies. In order to achieve interoperability across Europe using a single communication platform, the GSM-R standard combines all key functions and past experiences from the 35 analog systems used previously across Europe. GSM-R provides a secure platform for voice and data communication between the operational staff of the railway companies including drivers, dispatchers, shunting team members, train engineers, and station controllers. It delivers advanced features such as group calls, voice broadcast, location based connections, and call pre-emption in case of an emergency, which significantly improves communication, collaboration, and security management across operational staff members.

GSM-R is part of the ERTMS standard and carries the signaling information directly to the train on-board signaling unit, enabling higher train speeds and traffic density with a high level of safety.

GSM-R is based on public GSM and provides a rich set of features addressing the specific needs of railway operators. The following diagram is the architectural framework of the services that can be offered by the GSM-R network:

- Standard GSM features such as point-to-point voice and Short Messaging Service (SMS) between in-cab radios, handheld radios inside trains, signalers, controllers, shunting crew, and track-side workers. In addition, the platform can also support supplementary services such as call waiting, call forwarding, etc.
- Advanced Call Speech Items (ASCI): Call Pre-emption, Voice Group Calling Service, Voice Broadcast Service.
- Railway Specific Features: Functional Addressing, Access Matrix, and Location Based Addressing.
- Railway Applications: voice applications, data applications.

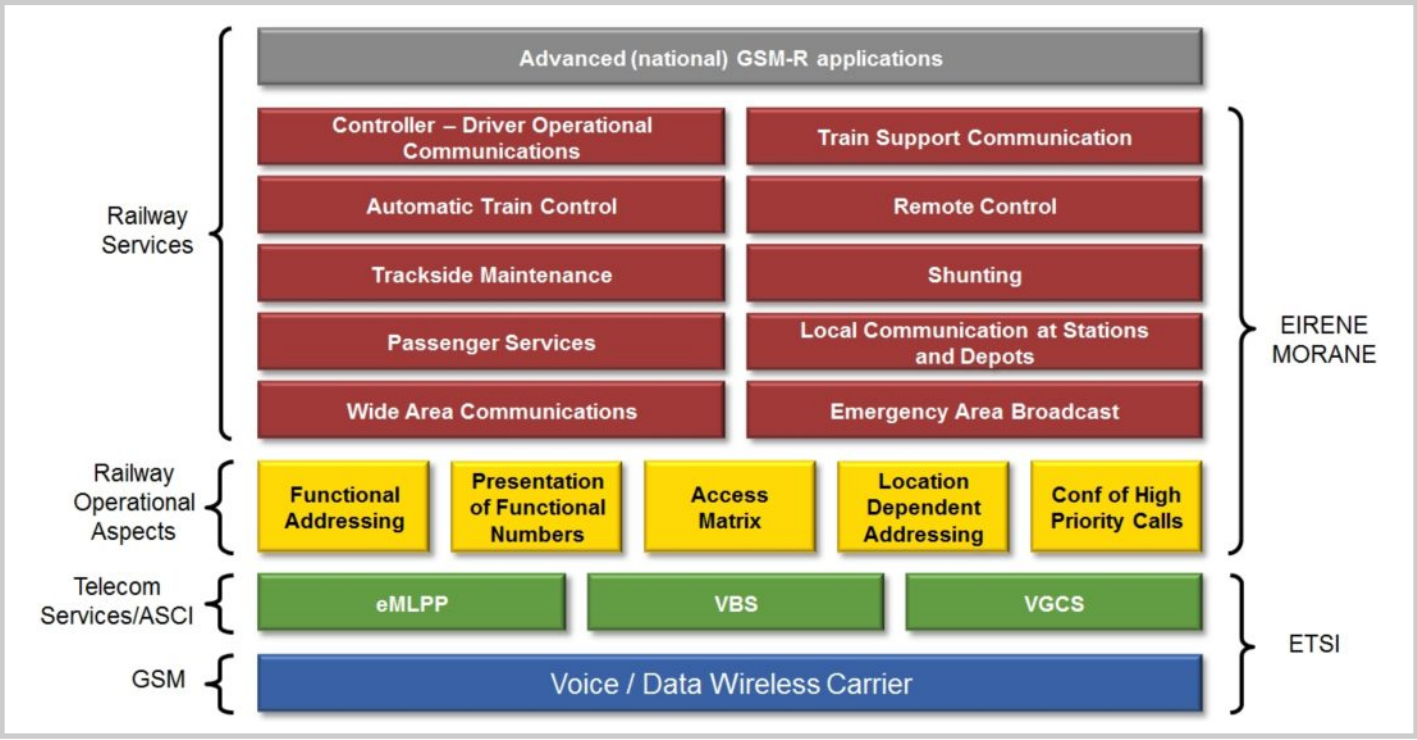

Figure 9: GSM-R Applications.

GSM-R is a proven technology, currently being implemented in a growing number of countries worldwide. While GSM-R specifications were finalized in 2000, it has already been selected by 35 countries across the world, including all member states of European Union, and a growing number of countries in Asia, Africa and South America. This number is increasing every month, making GSM-R one of the fastest growing wireless markets.

Kapsch CarrierCom's unrivaled experience in GSM-R services and technology has made us the leading provider for GSM based radio communication to railway networks around the world. Kapsch CarrierCom has been awarded the largest GSM-R networks in Europe, Africa and Asia covering the major part of railway tracks among the over 115,000 km awarded to date.

Kapsch CarrierCom has already been selected to deploy GSM-R networks, including national contracts in Austria, France, Germany, Lithuania and the UK, and track based GSM-R contracts in Algeria, Bulgaria, China, Czech Republic, Italy, India, Spain, Turkey and in Slovakia.

GSM-R – ETCS Interfaces.

GSM-R uses its data transmission capability as bearer system for the ETCS level 2 applications. The interfaces between GSM-R and ETCS and the data capacity (2.4, 4.8 & 9.6 kbit/s) are standardized. The NSS and the RBC are connected via the PRI interface as defined in the ETSI standards. The GSM-R cab radio – Eurocab (onboard signaling equipment) interface is connected as described in the FFFIS / Euroradio standard documents. Beyond these two main standards, there are some other specific parameters fixed or in progress which specify additional system or interface aspects, like Key Performance Indicators (KPI) or Quality of Service (QoS) for the whole network.

Implementing the European Train Control System.

A cost-benefit analysis, worked out by the UIC ETCS Migration Strategy Group, stated: “There is technical consensus around the ETCS solution for the long-term and the force of European Commission (EC) Directives will ensure the future evolution in this direction. It is reasonable to assume that a unified signaling system will bring economies of scale in an area which is fragmented and specialized.”

EU ERTMS strategy: Dedicated ERTMS Corridors.

The EU together with UIC and ERA have selected 6 corridors. The 6 corridors represent about 6% of the total network but 20% of the total freight traffic. Both parties agreed in a Memorandum of Understanding to implement ERTMS for interoperability reasons during the next few years. These corridors, which cross Europe from north to south and east to west, are as indicated in the diagrams below:

Figure 10: ERTMS corridors .

	Roterdam-Genova	Naples-Hamburg-Stockholm	Antwerp-Basel-Lyon	Sevilla-Lyon-Torino-Trieste-Ljubljana	Dresden-Prag-Brno-Wien-Budapest	Duisburg-Berlin-Warsaw
Country	A	B	C	D	E	F
Austria		kapsch			kapsch	
Belgium			NSN			
Czech Rep.					kapsch	
Denmark		NSN				
France			kapsch	kapsch		
Germany	kapsch	kapsch			kapsch	kapsch
Hungary				Not yet decided	Not yet decided	
Italy	NSN	kapsch & NSN		NSN		
Netherlands	NSN					
Poland						kapsch
Slovakia					kapsch	
Slovenia				Not yet decided		
Spain				kapsch & NSN		
Sweden		NSN				
Switzerland	NSN		NSN			

Figure 11: Status of GSM-R implementation projects.

Corridor A: Rotterdam - Genova
Corridor B: Stockholm - Naples
Corridor C: Antwerp - Basel - Lyon
Corridor D: Valencia - Lyon - Ljubljana - Budapest
Corridor E: Dresden - Prague - Budapest
Corridor F: Aachen - Berlin - Warsaw - Terespol

Moving Forward.

ERTMS/ETCS/GSM-R opens the market for signaling and communication systems to a level never achieved before. Competing suppliers are now available to bid in all countries. As ERTMS, ETCS and GSM-R are based on open specifications; additional suppliers can enter the market, which is something that has not been possible previously due to the proprietary character of the systems installed so far.

The new openness requires also a higher level of cooperation and integration. Kapsch CarrierCom is committed to deliver an open and standard compliant GSM-R solution to railways and to work with railways and the different standard bodies to continue developing the solution as the needs of railways evolve. This commitment is underlined by our strong engagement in different UIC and ERA working groups looking into aspects of Quality of Service, ETCS over GPRS and other topics. Kapsch CarrierCom is also actively participating in different working groups for the integration of the GSM-R system, e.g. for border crossing.

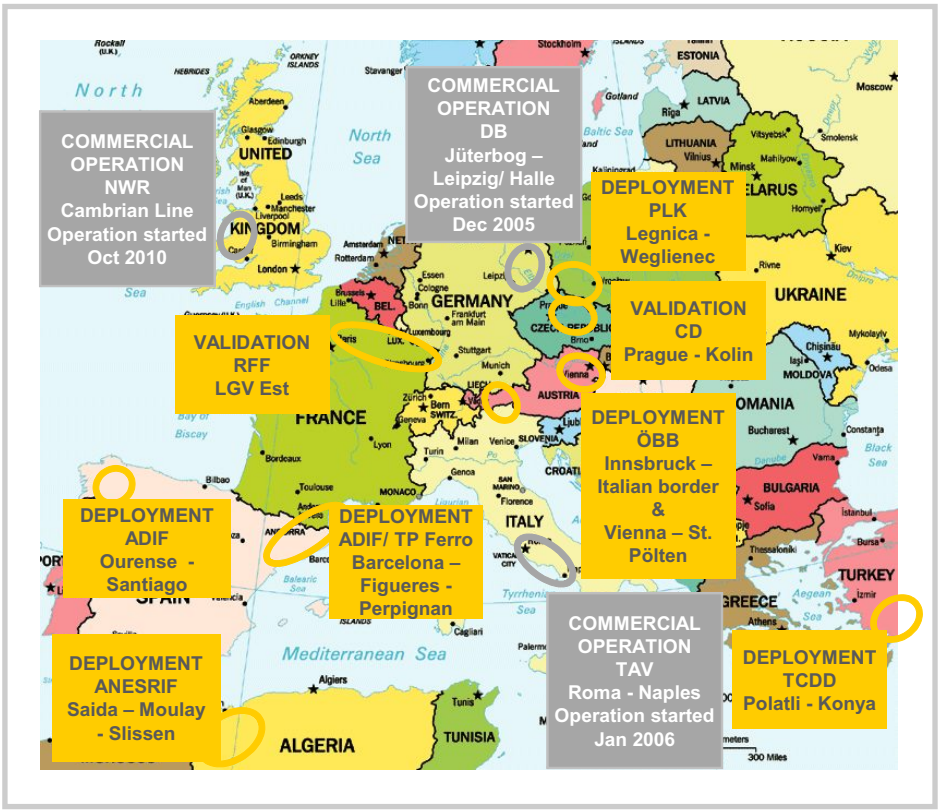

Figure 12: Kapsch CarrierCom ETCS L2 involvement.

Today Kapsch CarrierCom is engaged in a number of ERTMS projects across Europe and committed to deliver an open and standard compliant GSM-R solution to railways and to work with railways and the different standard bodies to continue developing the solution as the needs of railways evolve.

The deployments realized so far demonstrate the high level of commitment of the industry but also the level of maturity ERTMS has already achieved. The deployment of the systems is continuing in different countries and there is a willingness to accelerate the deployment in a coordinated way across Europe. ERTMS is one important milestone on the way to an integrated European railway area and its deployment will help to improve the performance of rail in Europe and to increase the usage of railways for passengers and for freight transport.

Abbreviations.

- **ASCI**
  Advanced Call Speech Items
- **GSM**
  Global System for Mobile Telecommunications
- **GSM-R**
  GSM for Railways
- **EC**
  European Commission
- **EIRENE**
  European Integrated Railway Radio Enhanced Network
- **ETCS**
  European Train Control System
- **ETSI**
  European Telecommunications Standards Institute
- **eMLPP**
  Enhanced Multi-level Precedence and Pre-emption
- **ERA**
  European Railway Agency
- **ERTMS**
  European Railway Traffic Managements System
- **ERTMS-R**
  ERTMS-Regional
- **ETSI**
  European Telecommunications Standards Institute
- **KPI**
  Key Performance Indicators
- **LEU**
  Line side Electronic Unit
- **MORANE**
  Mobile radio for Railways Networks in Europe
- **QoS**
  Quality of Service
- **RBC**
  Radio Block Center
- **SMS**
  Short Messaging Service
- **TCC**
  Traffic Control Center
- **UIC**
  International Union of Railways
- **VBS**
  Voice Broadcast Service
- **VGCS**
  Voice Group Call Service

About Kapsch CarrierCom

Long term experience, outstanding technology and a strong customer focus set Kapsch CarrierCom apart as the world´s leading supplier, integrator and maintainer of end-to-end GSM-R and GSM solutions. With 52% market share in terms of track-kilometers covered by GSM-R infrastructure Kapsch CarrierCom is primed to strengthen its position as the GSM-R market leader over the next few years. For more information visit **www.kapschcarrier.com**

Kapsch Group

The Kapsch Group and its entities – Kapsch TrafficCom AG, Kapsch CarrierCom AG and Kapsch BusinessCom AG – are specialised in the future-oriented market segments of Intelligent Transportation Systems (ITS) and Information and Communication Technology (ICT). Kapsch. Always one step ahead.

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