LECTURE

11

Railway telematics

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Lecture 11 – Overview

- Railway telematics
- ERTMS
  - ETCS
  - GSM-R
  - Legal support
- (Automatic Train Operation)

Railway telematic applications

Railway telematics

- Similar systems to other modes of transport
  - Information systems
  - Fleet management systems
  - Goods monitoring systems
  - Diagnostic systems
  - Passenger navigation systems

- Special – control systems
  - Interlocking systems

Sensor functions and possible application inputs

- Sensors on the railway carriage can monitor:
  - Valves opening or opening of cargo space than can be block in some geographical areas
  - Vehicle weight (either absolute weight of cargo shifting)
  - Cargo state control (pressure, temperature, impermeability, thefts, etc.)
  - Customs seals
  - Impact detection for analysing potential damages occurred during the transport

Telematics in intermodal and multimodal transport

- Basic requirements on telematic systems of logistics centres
  - Information linkage to systems in European space
  - Ensured information interoperability in particular transport modes
  - Position of logistic centres in national laws
  - City logistics and multimodal transport centres
  - Position in the architecture of cities, regions, transporters, infrastructure operators, etc.
- Telematics systems are necessary condition for advancements in intermodal and multimodal transport

Legal framework – Telematics in passenger transport

- **Commission Regulation (EU) No 454/2011 of 5 May 2011 on the technical specification for interoperability relating to the subsystem 'telematics applications for passenger services' of the trans-European rail system** includes following applications:
  - (a) systems providing passengers with information before and during the journey;
  - (b) reservation and payment systems;
  - (c) luggage management;
  - (d) issuing of tickets via ticket offices or ticket selling machines or telephone or Internet, or any other widely available information technology, and on board trains;
  - (e) management of connections between trains and with other modes of transport.

Legal framework – Telematics in railway cargo transport

- Using telematics in railway cargo transport is specified by the Appendix 2 of the Directive 2001/16/EC
  - Contains mainly
    - Usage in cargo transport including information systems (monitoring of cargo and position)
    - Systems of shunting (train ordination)
    - Booking systems, meaning booking train routes
    - Ensuring communication with other means of transport and using electronic documents
- Commission Regulation (EC) No 62/2006 of 23 December 2005 concerning the technical specification for interoperability relating to the telematic applications for freight subsystem of the trans-European conventional rail system
  - regulates data exchange on European level among all transport participants

ERTMS
European Railway Traffic Management System

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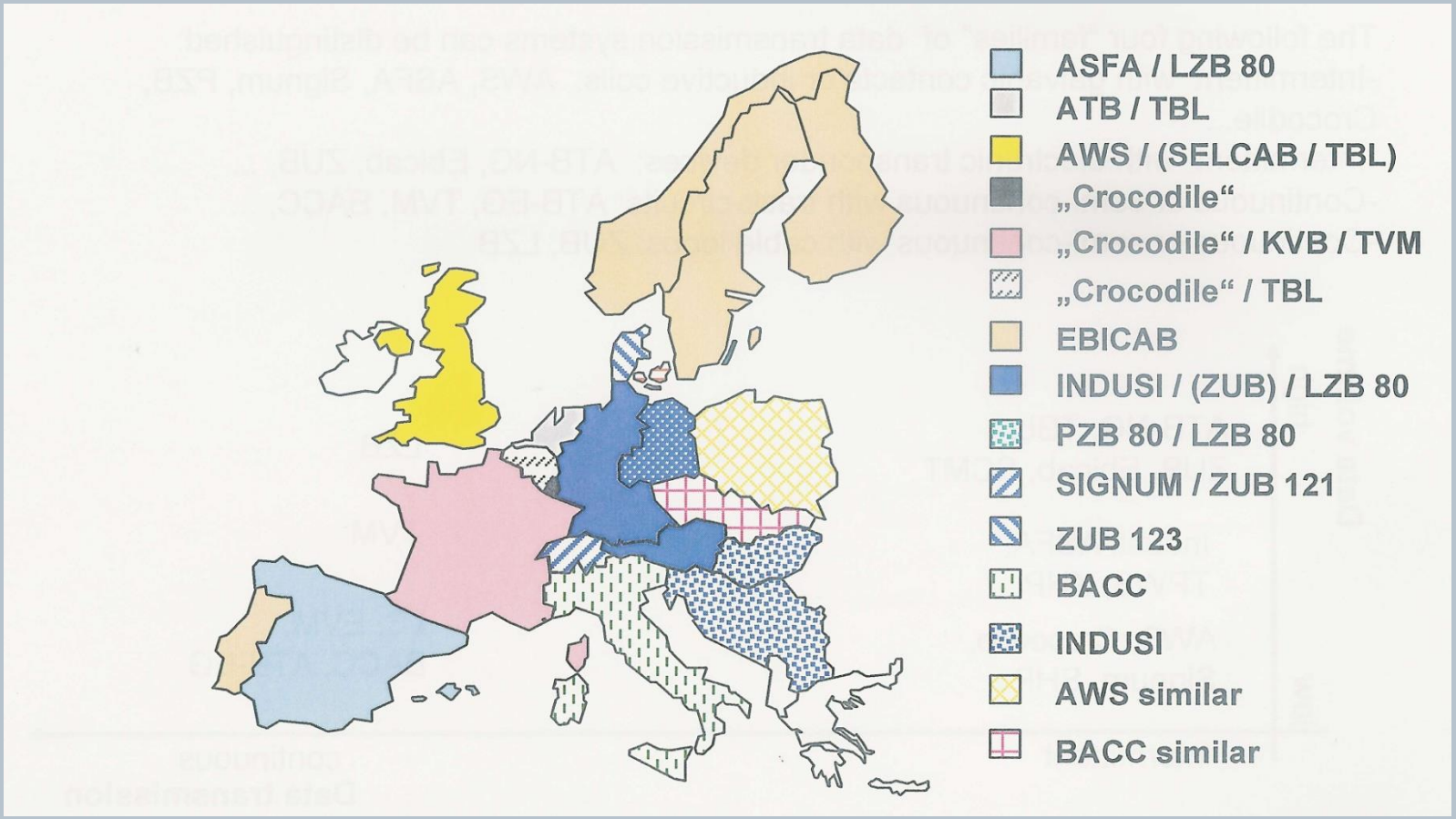
ERTMS (European Railway Traffic Management System)

- There are several railway control systems in Europe
- Need of unified solution
- European Railway Traffic Management System (ERTMS)
  - major industrial project developed by six UNIFE members – Alstom Transport, Ansaldo STS, Bombardier Transportation, Invensys Rail Group, Siemens Mobility and Thales
  - in close cooperation with the European Union, railway stakeholders and the GSM-R industry.

Railway control command systems in Europe



Source: UIC ERTMS platform

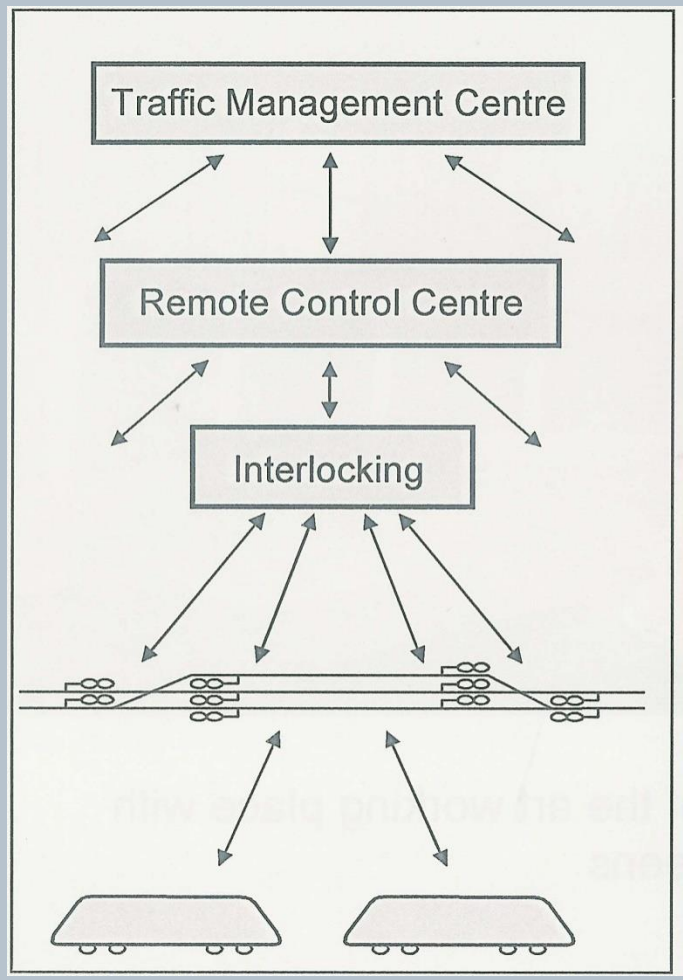
ERTMS goals

- ERTMS aims at replacing the different national train control and command systems in Europe.
- Deployment of ERTMS will enable the creation of a seamless European railway system
- Enabling interoperability throughout the European Rail Network
- Increase European railway's competitiveness

ERTMS components

- ERTMS has two basic components
  - ETCS, the European Train Control System, is an automatic train protection system (ATP) to replace the existing national ATP-systems;
  - GSM-R, a radio system for providing voice and data communication between the track and the train, based on standard GSM using frequencies specifically reserved for rail application with certain specific and advanced functions.

Functional structures of ERTMS and related European activities



Traffic Management Layer: *Europtirails*
- *Strategic planning, time tabling*
- *Information, Monitoring, pass assembling*
- *etc.*

Signalling: *INESS Integrated European Signalling System*
- *Remote control automated/manual*
- *Track-side occupancy proving based block control, safe route setting*
- *Control of level crossings*
- *Control of Switch points, ...*
- *Control of line side signals*
- *etc.*

Train control-command: *ETCS European Train Control System*
- *Automatic train protection and warning*
- *Automatic train command with in-cab signalling*
- *Train-side location based block control*
- *etc.*

Railway communication: *GSM-R*
All kinds of voice and data communication

Source: UIC ERTMS platform

Scope of ERTMS deployment

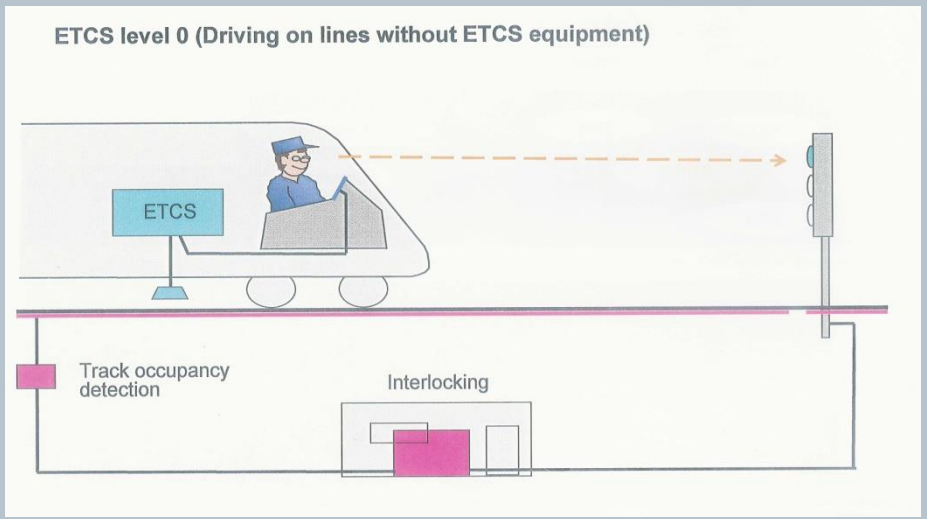
- Project ERTMS/ETCS/GSM-R is applied on all types of lines:
  - High-speed lines
  - Conventional lines
  - Regional lines
- Due to the high costs of implementation nowadays ERTMS is implemented only at the high-speed coridor lines

ETCS levels

- ETCS has three levels enabling step-by-step deployment
  - Level 1 can be superimposed on the existing signalling system
  - Level 2 digital radio-based signal and train protection system with existing block section with track occupancy reporting
  - Level 3 full radio-based train spacing,

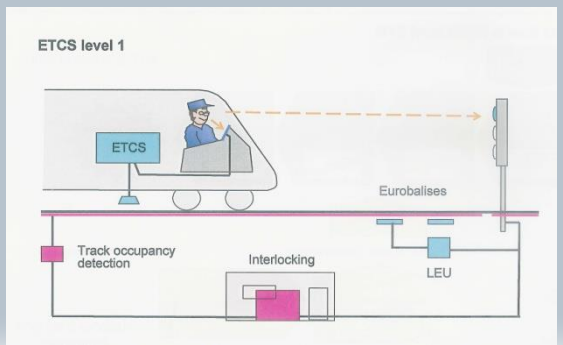
ECTS level 0

- lines without ETCS equipment
- driver gets his target information from the line side signals

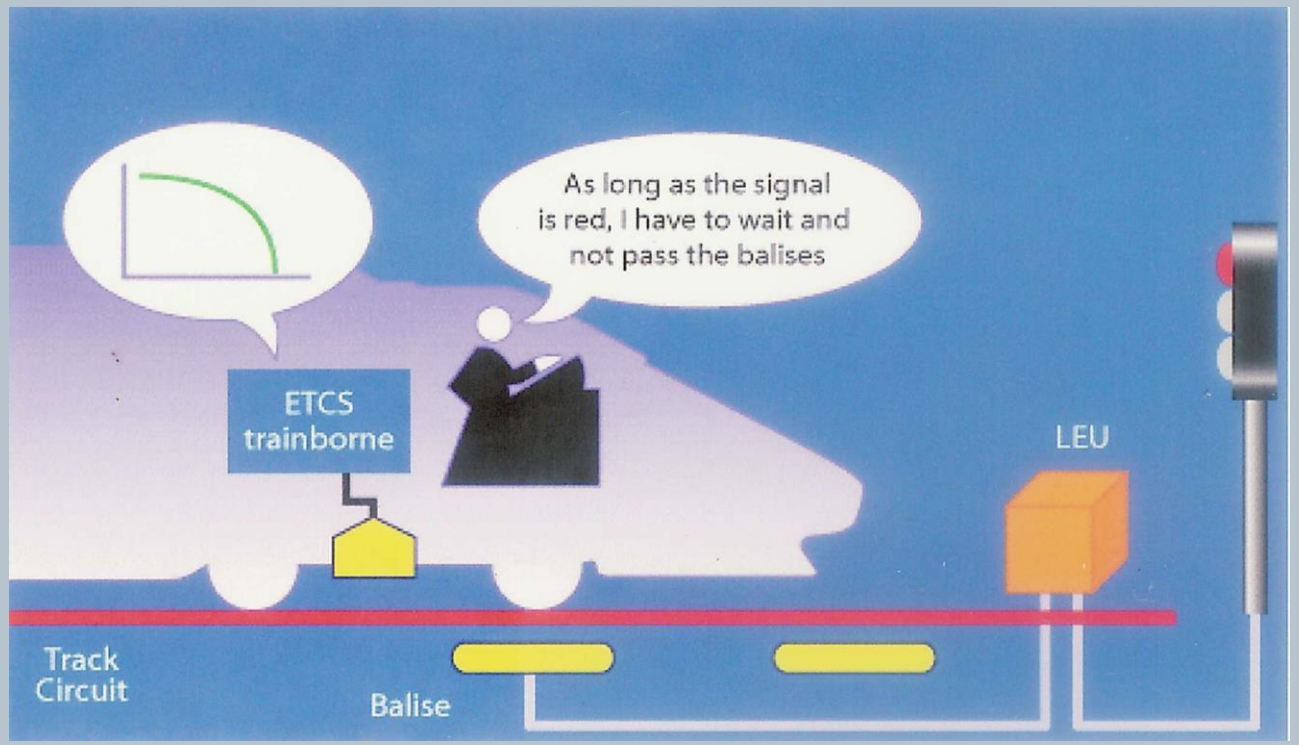


ETCS level 1

- Can be superimposed on the existing signalling system
- Communication between tracks and trains ensured by “Eurobalise”
- radio beacons pick up signal aspects from the trackside signals and transmit them to the vehicle as a movement authority together with route data at fixed points.
- ETCS calculates the maximum speed of the train and the next braking point if needed main benefits interoperability and safety



ETCS level 1


As long as the signal is red, I have to wait and not pass the balises
ETCS trainborne
LEU
Track Circuit
Balise

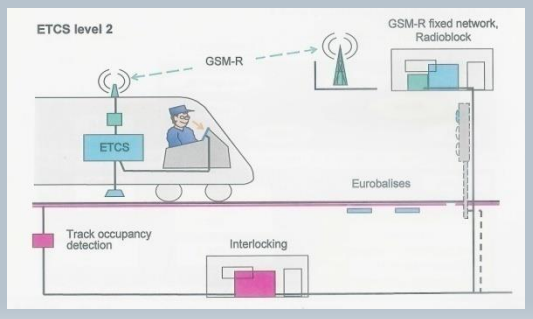
Eurobalise

- Typically needs no power source
- Responding to the radio broadcast from the train
- Designed for trains speed up to 500 kmph
- Typically transmitted data
  - Location,
  - geometry of the line,
  - speed restrictions

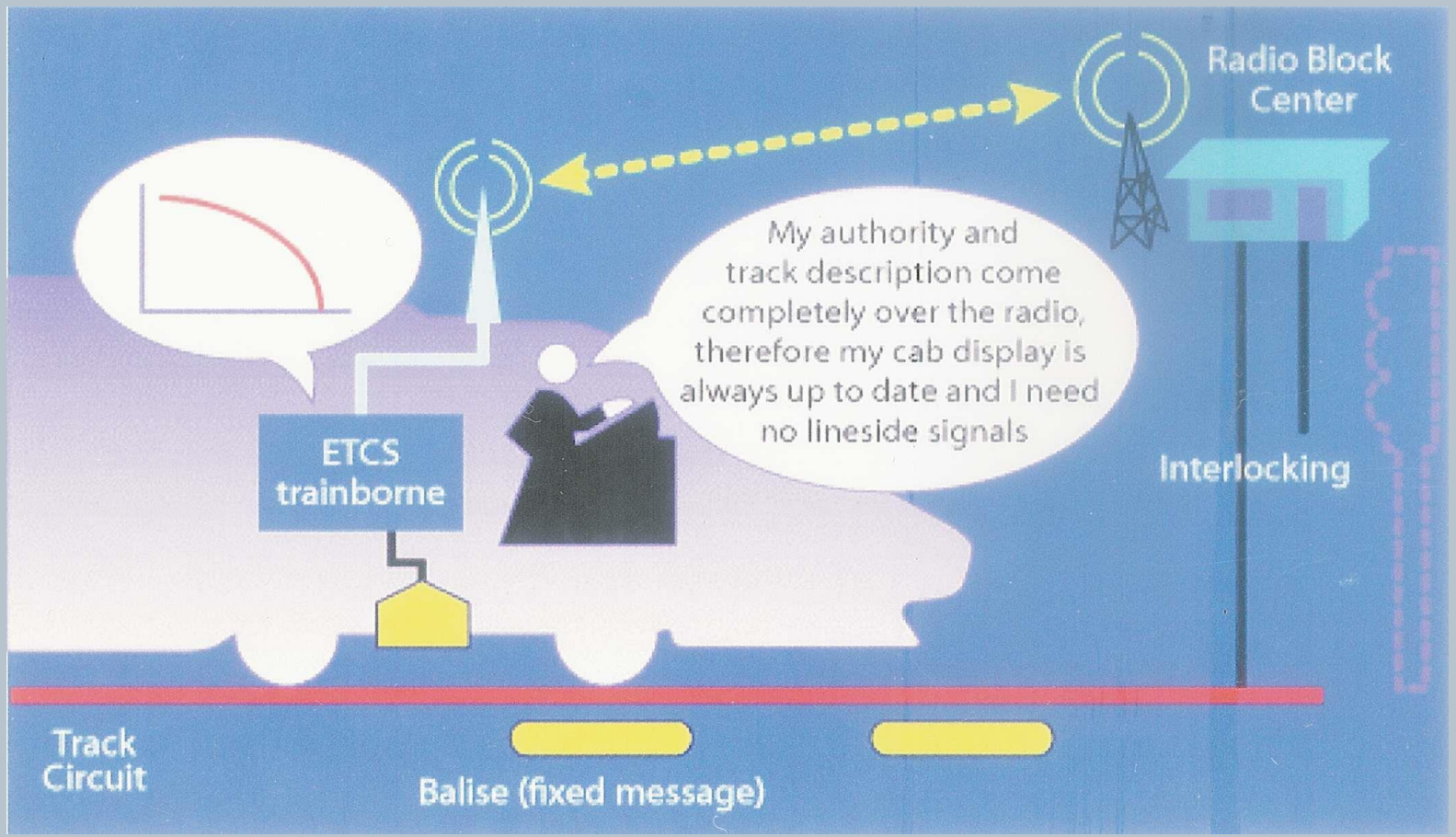
A Siemens Eurobalise in Germany
Source: Wikipedia.org

ETCS level 2

- Digital radio-based signal and train protection system
- Does not require lineside signals
- Remain existing block section with track occupancy reporting
- Movement authority is communicated directly from a radio block centre to the on-board unit using GSM-R
- Eurobalise" radio beacons pick up signal aspects from the trackside signals
- Advantages: reducing costs (does not require lineside signals), capacity increase

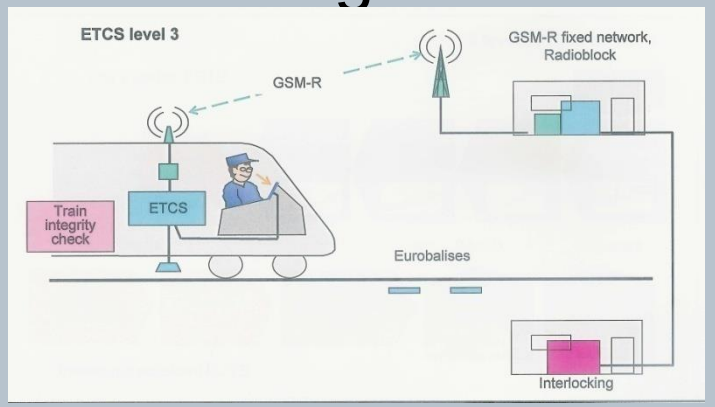


ETCS level 2

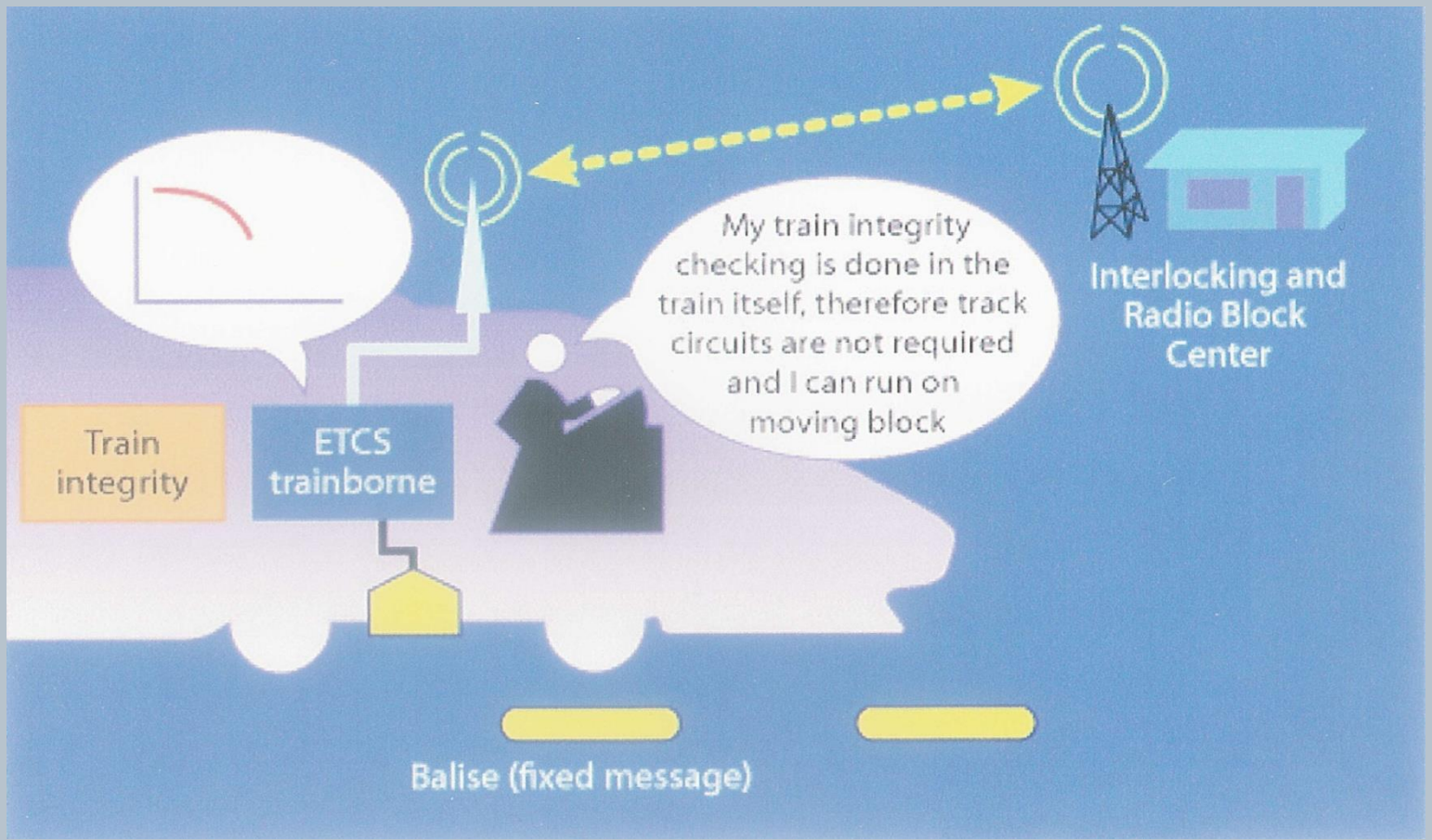

Radio Block Center
My authority and track description come completely over the radio, therefore my cab display is always up to date and I need no lineside signals
ETCS trainborne
Interlocking
Track Circuit
Balise (fixed message)

ETCS level 3

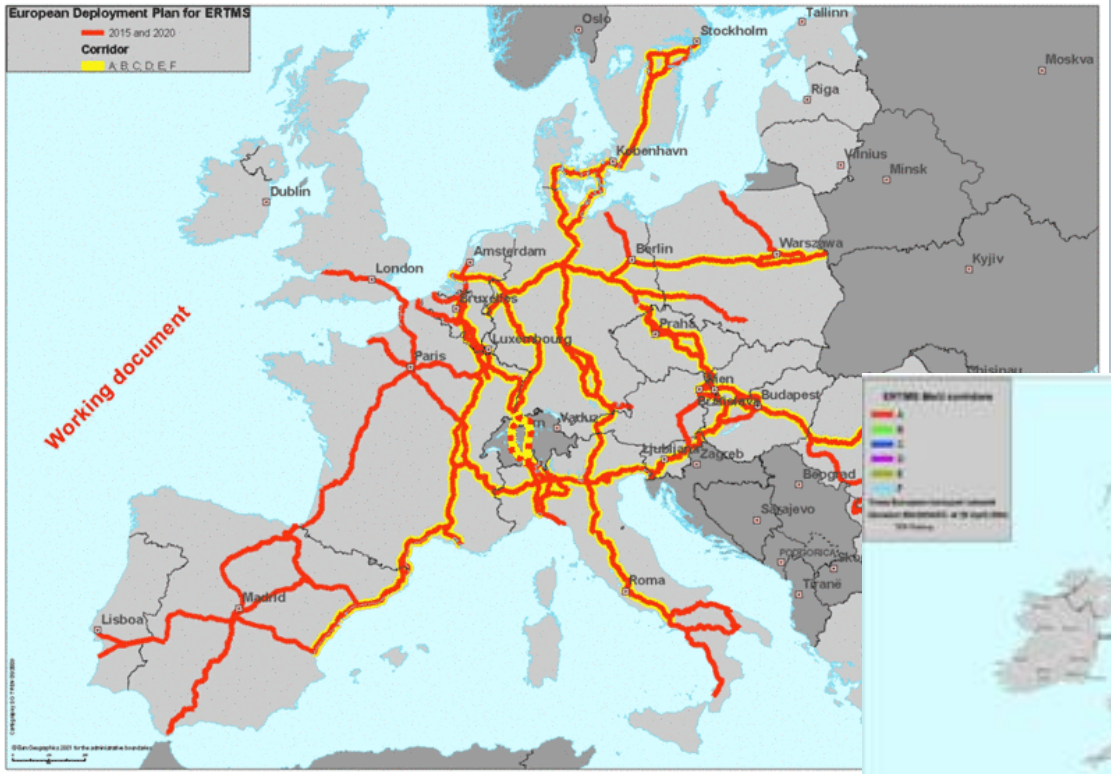
- Line side signals as well as the track-side occupancy checking devices are replaced
- Location or the train determined by the train-side odometry and reported via the GSM-R
- Completeness of the train checked by on train device
- In radio-centre data regarding train movements are gathered and ride approvals given.
- In connection with the interlocking level safety rides can be achieved



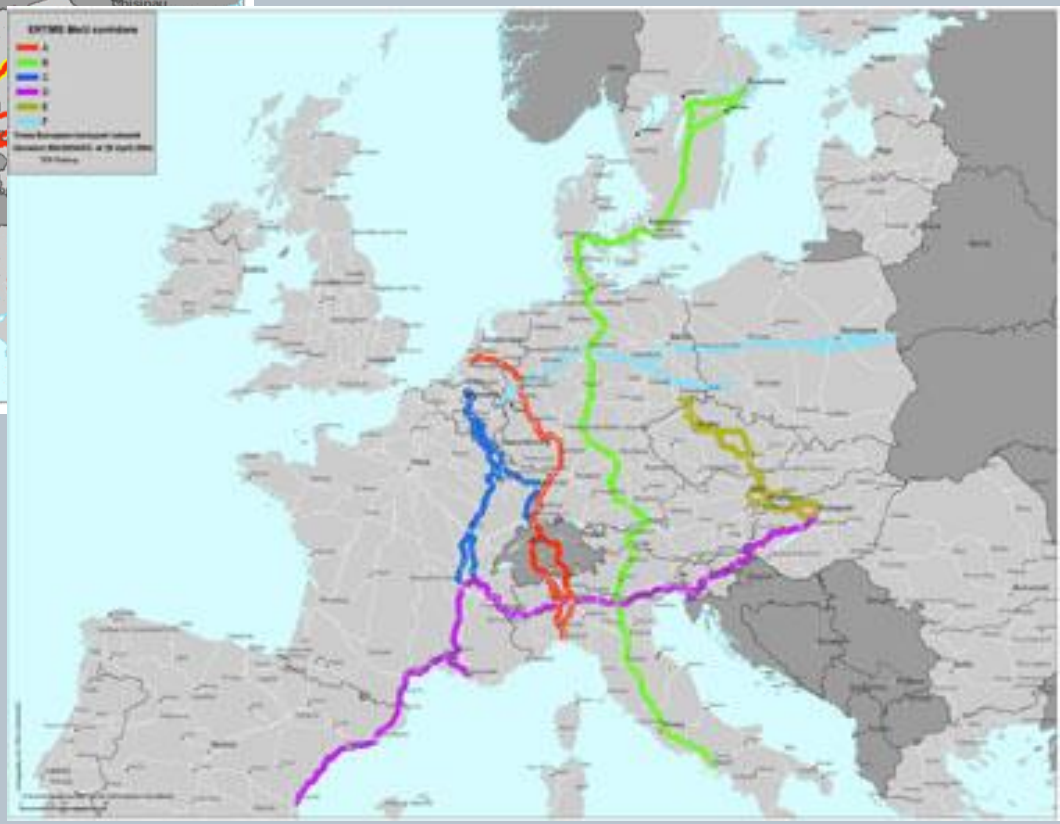
ETCS level 3


My train integrity checking is done in the train itself, therefore track circuits are not required and I can run on moving block
Interlocking and Radio Block Center
Train integrity
ETCS trainborne
Balise (fixed message)

ERTMS in Europe



Source: http://www.rff.fr/en/the-network/europe-on-rails/european-network/major-cross-border-projects



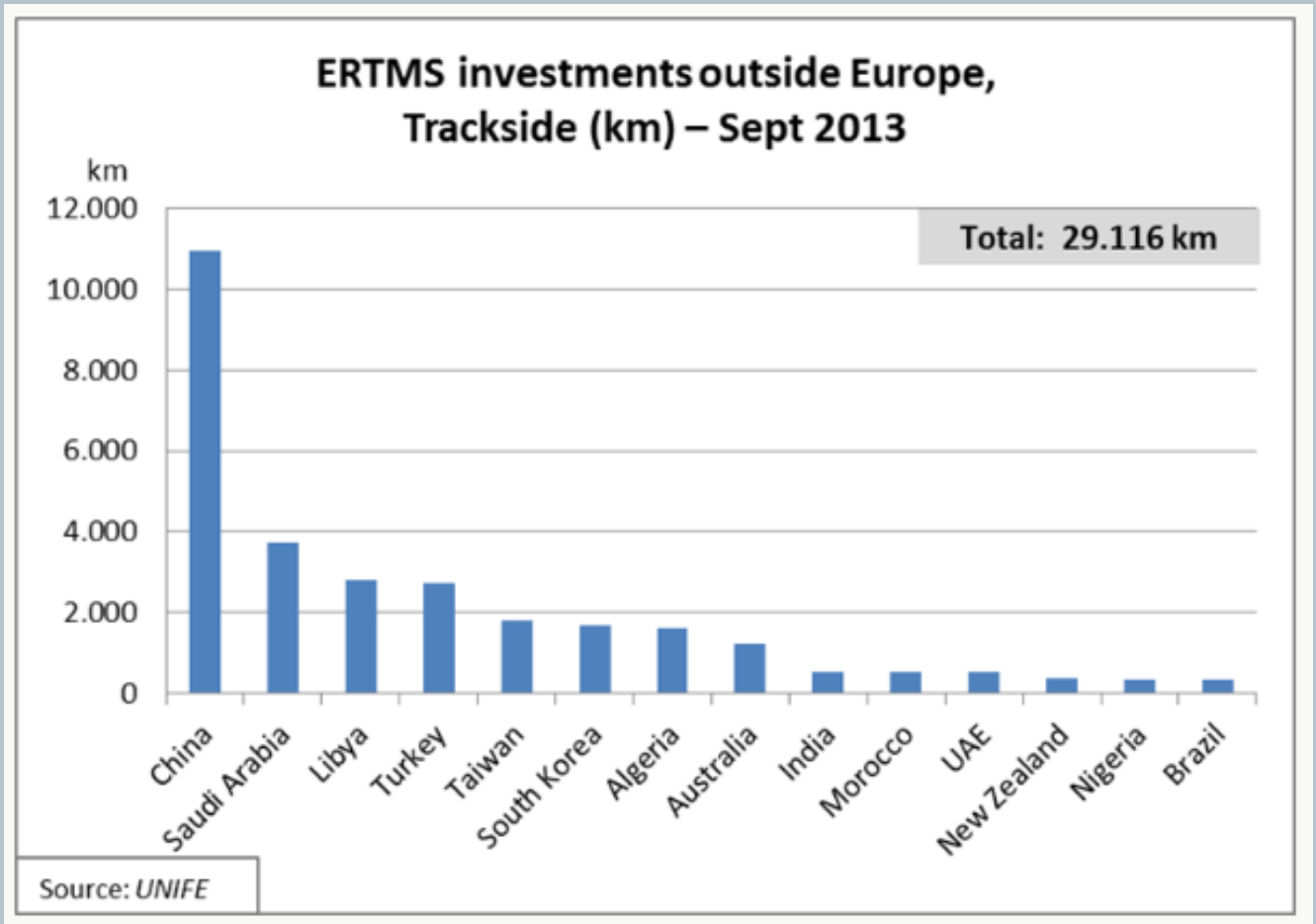
6 European freight corridors
A: Rotterdam - Geneva
B: Stockholm – Naples
C: Antwerp - Basle - Lyon
D: Valencia – Lyon – Ljubljana - Budapest
E: Dresden – Prague - Budapest
F: Duisburg – Berlin – Warsa

Source: http://www.railwaygazette.com/news/single-view/view/ec-sets-out-ertms-deployment-deadlines.html

ERTMS worldwide

Source: http://www.ertms.net

ERTMS worldwide

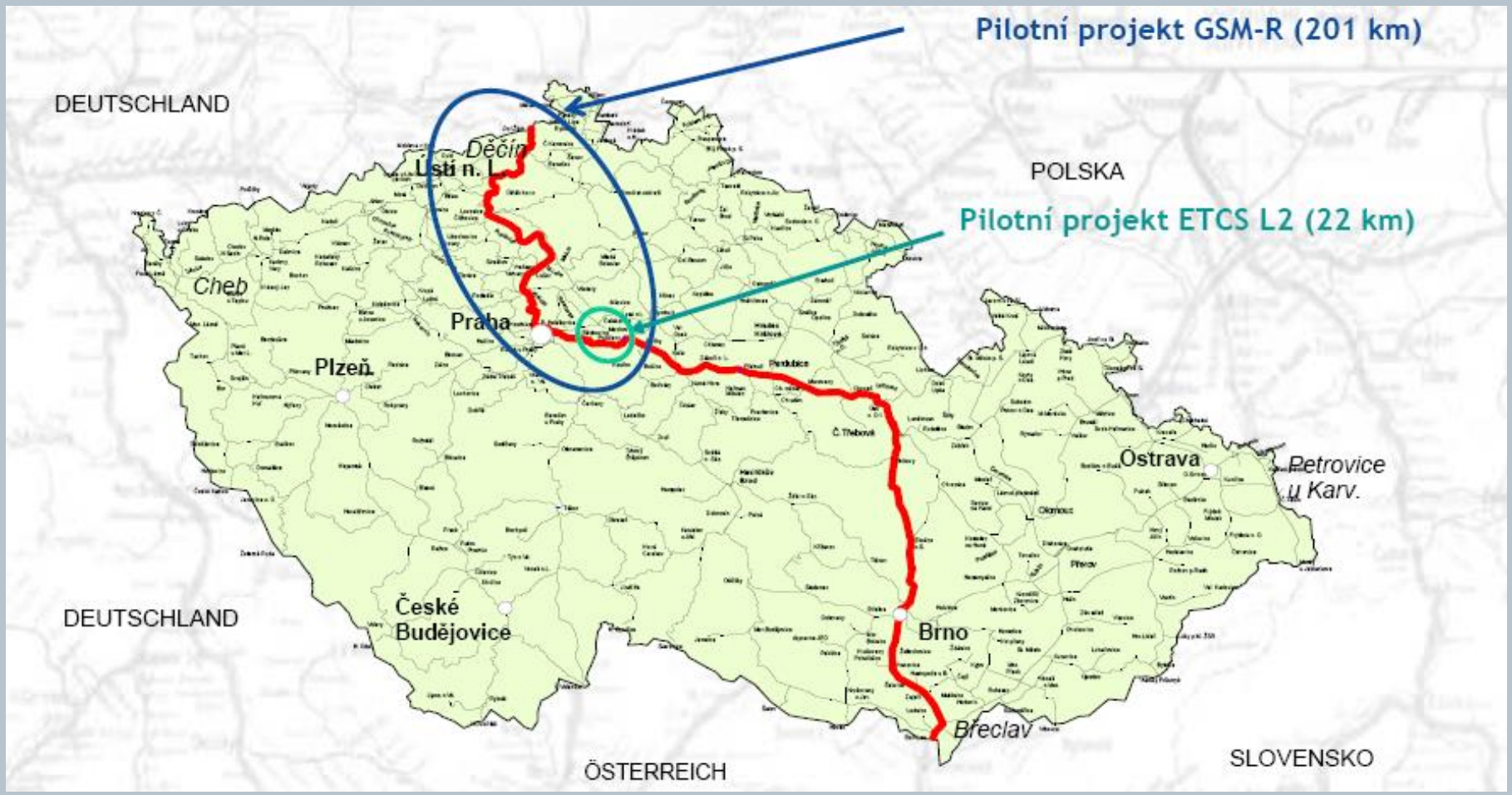


Source: www.ertms.net

ETCS in the CR

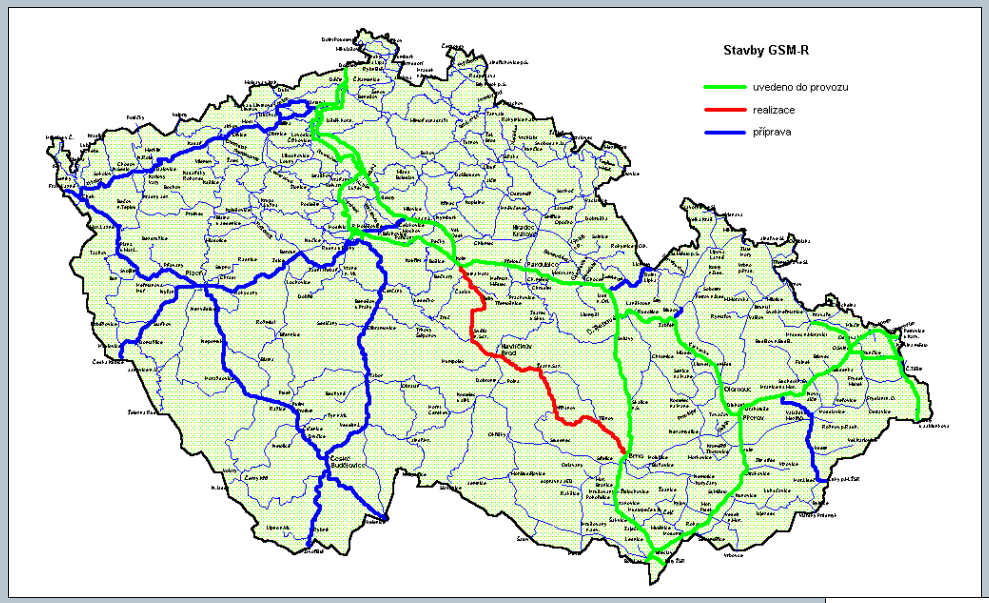
- Lines
  - Poříčany – Kolín – ERTMS level 2, Pilot line 22 km
- CR uses the support from the TEN-T program (for trans-European railway networks)
- Support for the 2nd part of realization of the part Děčín st. hranice - Praha - Kolín
- Support for the 1st phase of realization Kolín - Česká Třebová - Brno - Břeclav national border

ERTMS in the Czech Republic – pilot project



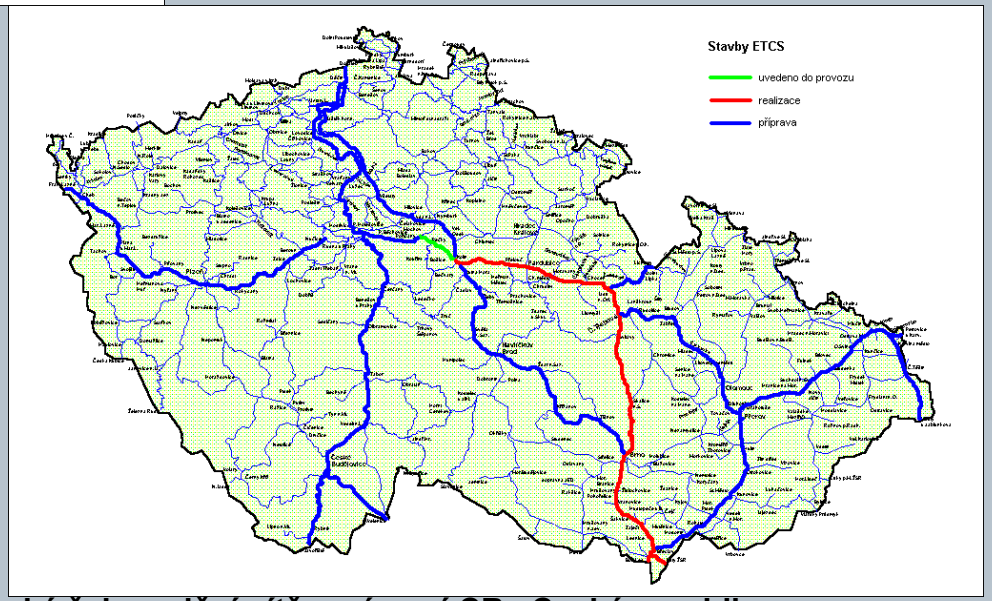
Source: Varadinov P. Zavádění ERTMS v České republice

ERTMS in the Czech Republic - 2014



- 2014 GSM-R network covers ca 1100 km (mainly 1. and 3. national railway corridor) ,
- More then 1300 vehicles equiped

- ETCS system in planning and building phase



Source: SŽDC. Modernizace evropské železuzniční sítě na území CRv Ceské republice

Legal support of ERTMS

- E.g. Directive 2001/16/EC on the interoperability of the conventional rail system
- deals with the following areas:
  - the essential requirements to be met by the system;
  - the technical specifications for interoperability (TSIs), which have to be adopted in accordance with the procedures laid down by the Directive;
  - all the other European specifications, including European standards from the European standards bodies: CEN, Cenelec and ETSI.
- and many others

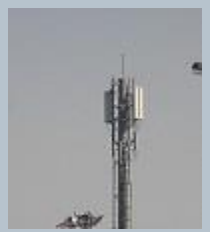
Legal support of ERTMS

- In July 2009, the European Commission announced that ETCS is now mandatory for all EU funded projects which include new or upgraded signalling and GSM-R is required when radio communications are upgraded
- In September 2010, a logo was adopted for ERTMS.

GSM-R

- Started in 1993 thanks to UIC (International Union of Railways)
- Operates under EIRENE standard (European Integrated Railway Radio Enhanced Network) that is developed in cooperation with ETSI
- Czech Republic joined the activity via Czech Railway company in 1997 by signing EIRENE Memorandum of Understanding





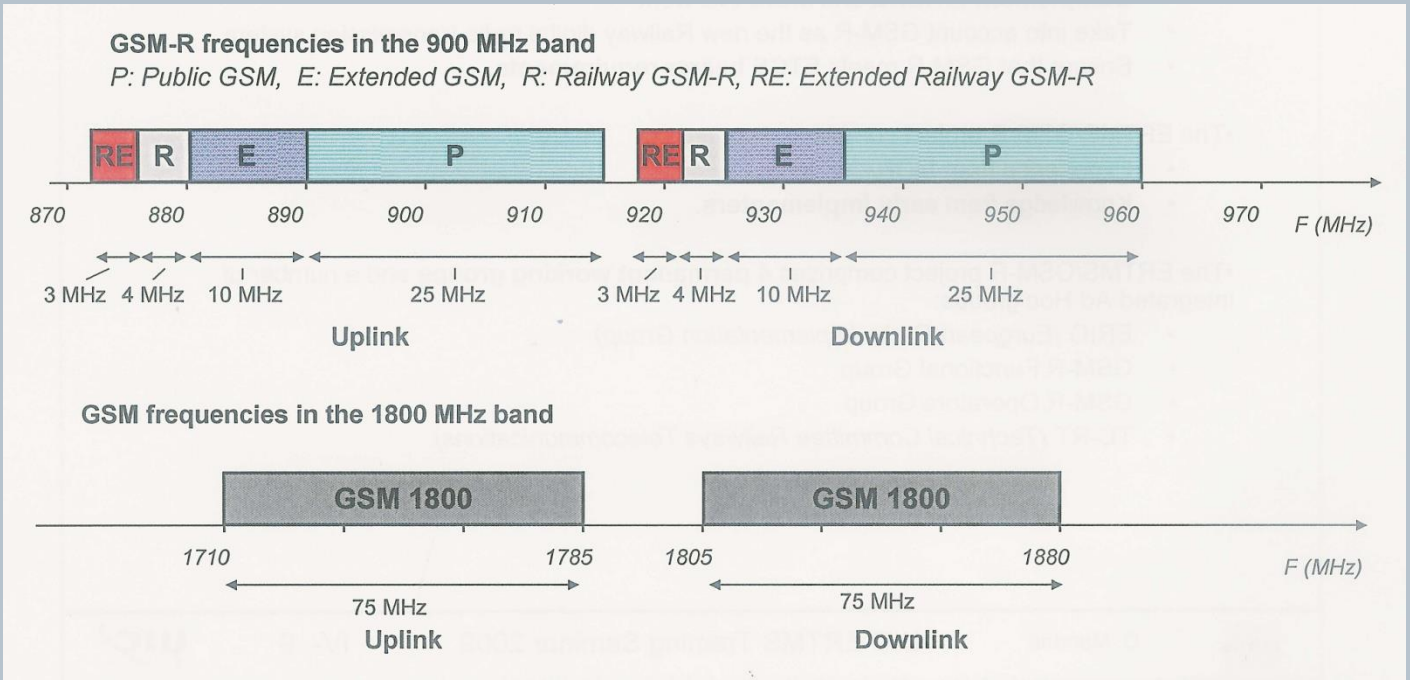
Source: www.gsmweb.cz

GSM-R differences from GSM

- Main differences in comparison to GSM are related with safety
- GSM-R signal **covers only areas along the tracks**, but without any silent zones (even in tunnels, deep valleys, etc.)
- GSM-R cells are long but narrow
- Uses directional antennas on high pylons
- Enables setting of communication priorities
- Provides group connection, meaning communication with pre-defined group of users

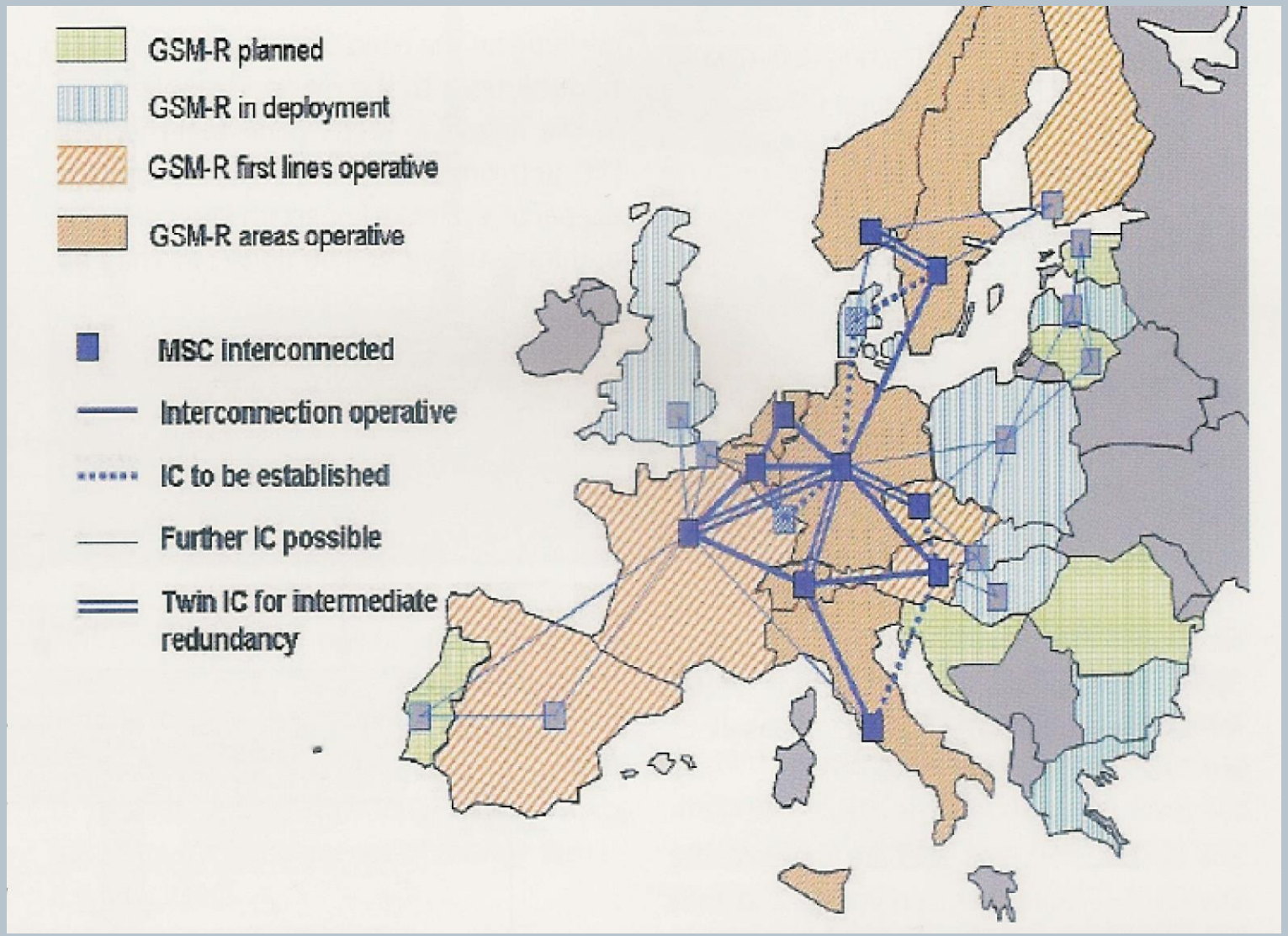
GSM-R frequencies

- GSM-R has been allocated with specific frequencies (R+RE)



Source: ERTMS/GMS-R 3 Focus, March 2009

GSM-R in Europe



Source: ERTMS/GMS-R 3 Focus, March 2009

Automatic Train Operation

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Automatic train operation

- Designed for automatic target braking and the energy optimisation of train operation
- Basic part central vehicle regulator (CRV) ensuring automatic speed regulation, regulation of traction agregate, brakes control and multiple control of vehicles in the train
- Automatic vehicle control part serves for the target braking and energy optimization
- This whole system ensures the automatic train operation (ATO)

Automatic train operation

- Since 60s regulators for goal braking were developed - algorithms verified by 35 years of operation
- Increase of operation safety
- Modular structure for different automation degrees
- Readiness for international operation
- Cooperation with ERTMS/ETCS
- Multilingual model

Automatic train operation

- Automatic train operation system offers several levels of automation enabling:
  - Manual vehicle control
  - Manual vehicle control with automatic speed regulation
  - Control in the mode of goal braking and train control
  - Multiple vehicle control

Parts of automatic train operation system

- CRV&AVV consists of three parts
  - Functional – composed from control computer and sensors of track information points
  - Railyard – set of information points
  - Data – track descriptions, data from timetables stored in the computer memory

Central vehicle regulator

- Main task is apperiodic achieving of required speed
- To reach required speed power regulation or brake regulation is used (Priority use of dynamic brake, automatic air brake control)
- Contains target braking regulator and running time regulator

Target braking regulator and running time regulator

- Respecting of line, scheduled and signalised speed
- Automatic braking to reduced speed points and to stopping points
- Automatic stopping of high precision at platforms of relevant stations and halts
- High level of time keeping along with optimum energy saving during coasting to target
- Traction energy saving
- Radio transmission of dispatcher‘s data commands for train
- Requires data transmission from line

Railyard part

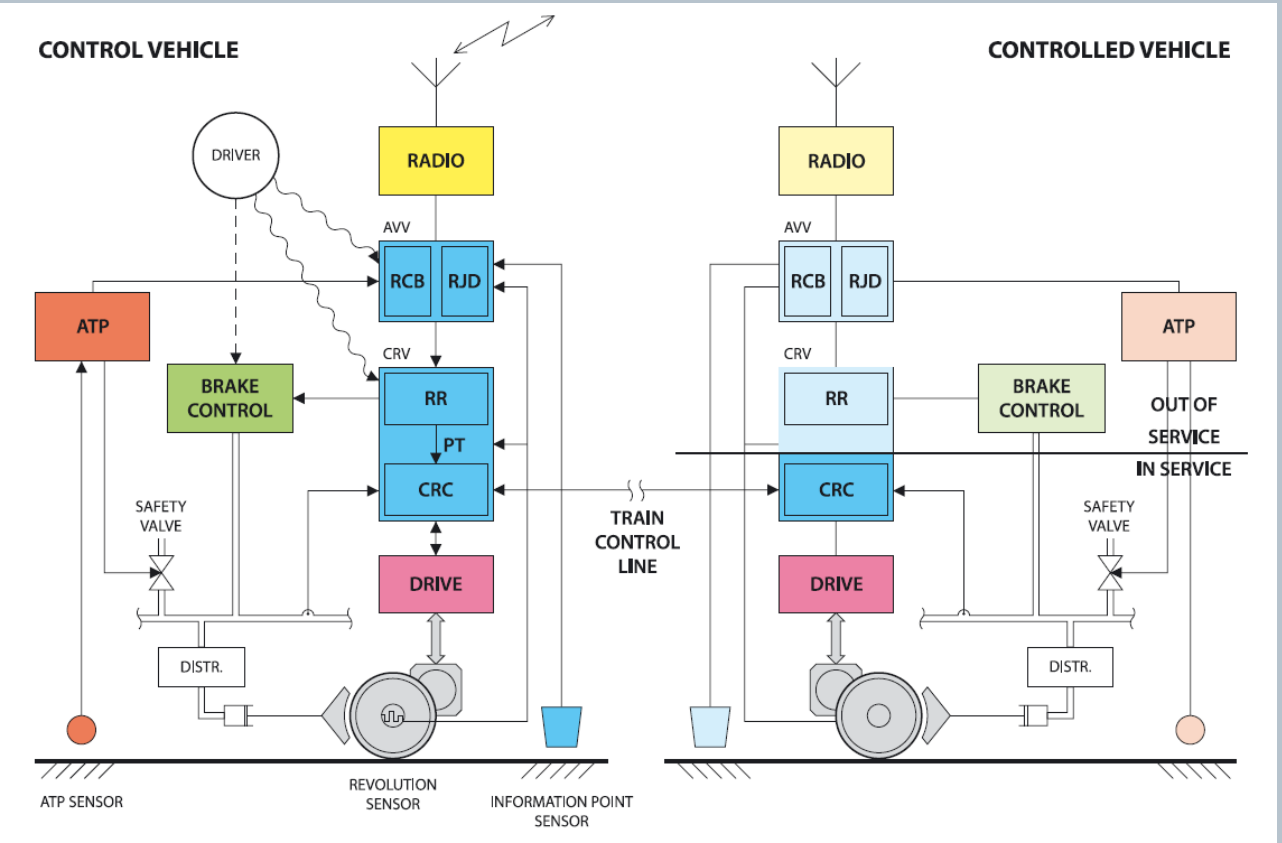
- Consist of railyard information points located at the track
- Information point is made of two wooden or plastic squared logs of length app. 6 m laid lengthwise in the railyard
- They contain 8 permanent magnets located according special algorithm – that gives more than 30 000 different code combinations
- Information code gives precise information about vehicle location
- Information about permitted speed, etc. Contains the functional part
- System is resistant to not-reading some information points – after this the engine-driver is called on the manual control
- Information points have to be located at each track branch

Information points

- Magnetic information point at the track in station Poříčany
- E.g. Line Praha – Kolín contains 162 magnetic information points, that is app. 2,6 points per 1 km

Automatic train operation - diagram

RCB – target braking block
(blok cílového řízení)
RJD – running time control block
(blok řízení jízdní doby)
AVV – automatic train operation
(automatické vedení vlaku)
RR – speed regulator block
(blok regulátoru rychlosti)
CDC – central control element
(blok centrálního řídicího členu)
CRV – centralize regulator
(centrální regulátor vozidla)
PT – relative traction
(signál „poměrný tah“)



Source: www.azd.cz

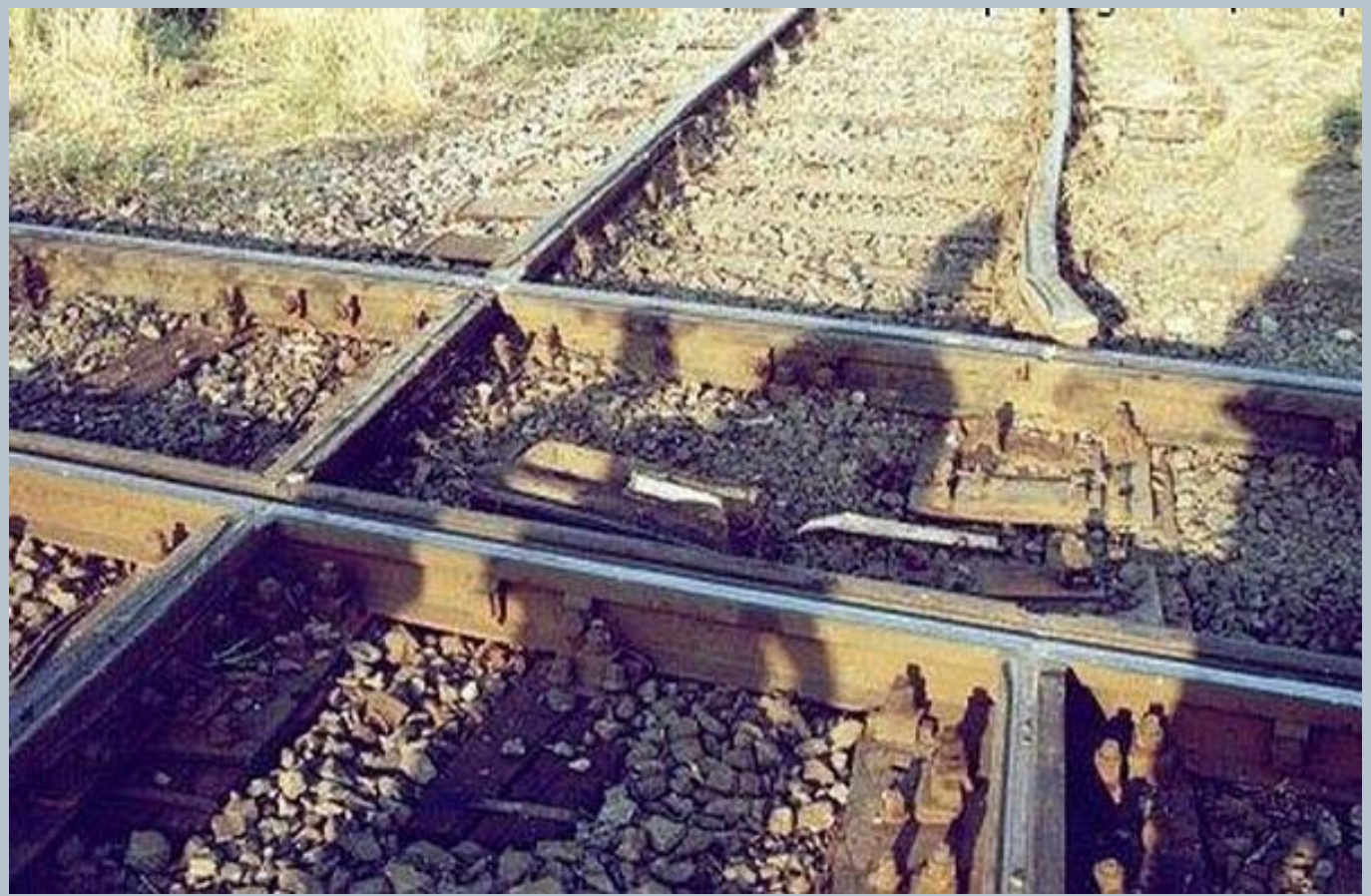
Railway vehicle diagnostic system

- Ensures **collection, evaluation and display of data** from CRV, AVV and from other systems (drive, auxiliary drives, door computers, heating, WC, fire switchboard and other)
- Transmission of signals to/from additional train carriages
- Carriage facility control (interior lighting, information system, doors, etc.)
- Detection and display of a train set, calculation of length, weight and train braking percentage
- Black box function for storage of failure messages and selected operating data
- Interface for service PC
- Multilingual design

Basic technical parameters of the automatic train control system

Speed keeping accuracy	± 1 kmph
Stopping path accuracy	± 2 m
Arrival time accuracy	Typically ± 10 s
Traction energy saving	Typically 20 to 50 %
Number of controlled vehicles in train	unlimited

Thank you for your attention



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