Czech Republic
Ministry of Transport

Czech Republic

ERTMS

NATIONAL IMPLEMENTATION PLAN

2017

This document represents also the national implementation plan of technical specification for interoperability of "Control-command and signalling" subsystems defined in point 7.4.4 of the Annex to 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.

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Definition of terms

For the purpose of this document following terms have the meaning as follows:

A. General terms

ATO Automatic Train Operation

An automation device for automatic train driving in terms of observing track speed limits, signal aspects, automatic target braking, optimum movement mode in relation to observing the train schedule and consumption of traction energy; it is not designed as a interlocking equipment.

ATP Automatic Train Protection

Train protection equipment enabling transfer of information concerning the movement authority to a driver. ATP either requires the driver to monitor the information or to observe speed limits or signal aspects. It consists of a trackside and on-board part.

ATS Automatic Train Supervision

An automation device for automatic train transport control by means of automatic route setting based on train schedule and anticipating and solving conflicts of current train routes in an optimized way.

ATD Automatic Train Driving

Highly automated system of train transport control that interconnects ATO and ATS systems. Train protection is ensured by the ATP system.

ERTMS European Rail Traffic Management System

European Rail Traffic Management System. Aggregate title for the joint European system of the rail traffic management, consisting of two basic parts – the GSM-R communication system (see below) and the European Train Control System (ETCS) (see below).

Migration period

Migration period is a predefined span of time needed to completely switch from the Class B system (national system) to the Class A system (ERTMS/GSM-R, ERTMS/ETCS).

Class A System

The Class A system is an integrated interoperable system specified in the TSI CCS, Annex A – in the area of communication it is the GSM-R system and in the area of the train protection it is the ETCS system.

Class B System

Class B system is a national system for radio communication with the train or the national train protection system that is included in the European Railway Agency's technical document List of Class B Systems "Control-command and signalling", ERA/TD/2011-11, version 3.0. In case of railways in the Czech Republic it is the trackside radio system of the TRS type and the Automatic train protection system called "LS".

TEN Trans-European Network

Priority transport network established by Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU. Trans-European Network consists of two planning layers, i.e. comprehensive network and core network. Comprehensive

network comprises all existing and planned railway infrastructure of trans-European railway network. Core network consists of those parts of comprehensive network that have the greatest strategic significance for the achievement of objectives of the trans-European railway network's development.

TSI Technical Specifications for Interoperability

Technical specifications for interoperability of individual subsystems adopted on the basis of Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community, or 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.

B. Radio communications systems

Dual-mode on-board radio station

On-board radio station for voice communication in GSM-R digital radio network and TRS analog radio network, or other analog radio networks.

EIRENE European Integrated Railway radio Enhanced Network

Network technical specifications.

GSM-R Global System for Mobile communications – Railway

Digital radio system on GSM platform based on EIRENE system requirements, extended to include specific railway requirements.

TRS Trackside radio system

Analog national trackside radio system for communication with the trains of the Class B. At the level of controlling signals, the TRS system is fully compatible with mandatory requirements UIC 751-3. Therefore it is possible to realize the requested communication, standard and emergency communications with TRS and similar systems made by other manufacturers. Communication is accomplished on four internationally co-ordinated frequencies in the band 450 MHz.

C. Train protection systems

ETCS European Train Control System

The European train protection system enabling transfer of information about the movement authority to a driver and enforcing the observance of speed limits and movement authorities. It consists of a trackside and on-board part.

The system has three application levels that can be characterized as follows:

Level 1 (ETCS L1):

Trackside functionalities:

- Assigning movement authorities according to data from trackside signalling equipment (signal boxes etc.)
- Sending movement authorities and track description to a specific train, especially when switchable Eurobalises are used

On-board functionalities:

- Receiving movement authorities and track description associated with an appropriate balise group

- Calculating a dynamic speed profile
- Comparing the train's current speed against the maximum authorised speed and, if necessary, activating the brakes
- On-board (cab) signalling for the driver

Level 2 (ETCS L2):

Trackside functionalities:

- Registering of each ETCS-fitted train in the Radio Block Centre (RBC)
- Monitoring of each ETCS-fitted train's position in RBC (on the basis of the train's report of its position) in relation to a given balise group
- RBC assigns the movement authority according to data from trackside signalling equipment (signal boxes etc.) individually for each train
- Sending movement authorities individually to each train and continuously via GSM-R

On-board functionalities:

- Each train sends the data about its position in relation to a given balise group to RBC
- Calculating a dynamic speed profile
- Comparing the train's current speed against the maximum authorised speed and, if necessary, activating the brakes
- On-board (cab) signalling for the driver

Level 3 (ETCS L3):

Trackside functionalities:

- Registering of each ETCS-fitted train in the Radio Block Centre (RBC)
- Monitoring of each ETCS-fitted train's position in RBC (on the basis of the train's report of its position) in relation to a given balise group
- Cancelling the ends of routes based on the information from trains
- Assigning movement authorities according to data from trackside signalling equipment (signal boxes etc.) individually for each train
- Sending movement authorities individually to each train and continuously via GSM-R

On-board functionalities:

- Each train sends the data about its position in relation to a given balise group to RBC
- The train monitors its integrity and sends relevant information to RBC
- Calculating a dynamic speed profile
- Comparing the train's current speed against the maximum authorised speed and, if necessary, activating the brakes
- On-board (cab) signalling for the driver.

ETCS equipment versions

The ETCS version refers to the version of the System Requirements Specification (SRS) that describes the system behaviour in detail. At present, TSI CCS definitions are as follows:

- Set of specifications # 1 (ETCS Baseline 2),
- Set of specifications # 2 (ETCS Baseline 3 – Maintenance Release 1)
- Set of specifications # 3 (ETCS Baseline 3 – Release 2)

Operating modes of the ETCS on-board system

- FS Full Supervision
- OS On Sight
- SR Staff Responsible

- UN Unfitted
- SN STM National
- SL Sleeping
- NL Non Leading
- TR Trip
- PT Post Trip
- RV Reversing
- SF System Failure
- IS Isolation (ETCS closure)
- NP No Power
- SB Stand By
- SH Shunting
- LS Limited Supervision

  Note: ETCS LS operating mode has no connection with the Class B Czech national train protection system of the type LS.
- PS Passive Shunting

ETCS LS ETCS Limited Supervision

ETCS application which uses the ETCS on-board system of vehicles in a simplified way. Trackside system transmits only limited amount of information to the vehicle. Based on these data, the on-board system ensures (via direct check or only background check) the train is observing the speed limit and not overriding the previously established place. If speed limit is exceeded or predefined place overridden, braking is activated. The driver has to watch and observe signals. Limited Supervision can be used only below a specified speed limit.

LS Line System – type of the Czech train protection system

Train protection system used on the railways in the Czech Republic. It is a system using the continuous transmission of simplified signal aspects by means of subsequently coded track circuits. In case of transmission of restrictive or prohibitive aspects it controls the specified reaction of a driver. If the reaction is absent, it automatically starts braking. According to TSI CCS it is a national train protection of Class B (see below).

RBC Radio Block Centre

Radio Block Centre (ETCS Level 2 (3) centre) gathers information from station, track and crossing safety devices and also controller commands within the circuit of the given RBC. RBC will process these data into the movement authorities for the ETCS-fitted train logged in its circuit and transmit them to the train via GSM-R. The same route is used to receive the necessary information from the train. These can be then displayed for the controller's need.

STM Specific Transmission Module

Specific transmission module communicates with an on-board part of the ETCS and uses the ETCS system to emulate the national system of train protection. An on-board ETCS, equipped with STM module, enables the movement of a train on lines fitted with the national train protection system in the same way as if the train was equipped with the national system. One on-board ETCS device can communicate with multiple STM modules.

Abbreviations

AC	Alternating current
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATD	Automatic Train Driving
ATS	Automatic Train Supervision
CEF	Connecting Europe Facility
	(programme of funding of European projects between 2014 and 2020)
ČD	Czech Railways, j.s.c. (České dráhy, a. s.)
ČR	Czech Republic
DB	DB Netz AG
DC	Direct current
EDP	European Deployment Plan (European ETCS implementation plan)
EIRENE	European Integrated Railway radio Enhanced Network
EK	European Commission
EMC	Electromagnetic compatibility
EP	European Parliament
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ETCS LS	ETCS Limited Supervision
ETCS L1	ETCS Level 1 (application level)
ETCS L2	ETCS Level 2
ETCS L3	ETCS Level 3
EU	European Union
GNSS	Global Navigation Satellite System
GSM-R	Global System for Mobile communications – Railway
GVD	Train Schedule (Theoretical graph of train running)
HW	hardware
kV	kilovolt
LS	Line System – type of the Czech train protection system
LZB	Linienförmige Zugbeeinflussung – type of continuous train protection system
MÁV	Magyar Államvasutak (Hungarian Railways)
MD ČR	Ministry of Transport of the Czech Republic
MSC	Mobile Switching Centre
NIP	National implementation plan
ÖBB	Österreichische Bundesbahnen – Infrastruktur AG
ProRail	State organisation for the administration of railway infrastructure in the Netherlands
PZB	Punktförmige Zugbeeinflussung – type of intermittent train protection
RBC	Radio Block Centre
SFDI	State Fund for Transport Infrastructure
SRS	System Requirements Specification

STM	Specific Transmission Module
SW	software
SWOT	Strengths Weaknesses Opportunities Threats
SŽDC	Railway Infrastructure Administration, state organization
TEN	Trans-European Network
TEN-T	Trans-European Network - Transport
TRS	Trackside radio system
TSI	Technical Specifications for Interoperability
TSI CCS	TSI for "control-command and signalling" subsystems
TŽK	National transit railway corridor
VRT	High-speed line
ŽSR	Železnice Slovenskej republiky (Slovakian Railways)

1 Introduction

Historically established systems of train protection that are still used in individual member states of the European Union are characterised by type differentiation, technological obsolescence and different and usually inferior level of functionality and safety. And this is what gave birth to the idea of the EU's new and uniform system of train protection showing significantly higher level of quality and safety. In 1995 the European Commission defined a global strategy for the development of the European Rail Traffic Management System (ERTMS) with the objective to prepare its future implementation on the European railway network and incorporated it into the interoperability directive and subsequently into the Technical Specifications for Interoperability of the control-command and signalling subsystems both for high-speed and conventional European railway system.

1.1 ERTMS

ERTMS is a project dealing especially with the following areas:

- **communication – EIRENE project** (European Integrated Railway Radio Enhanced Network) within which functional and system specifications were created that led to the GSM-R (Global System for Mobile communications – Railway) system. The GSM-R system, as any radio communication tool, consists of an infrastructure part and a mobile part, represented by mobile terminals of the user.
- **ETCS project – the European Train Control System** facilitates transferring information about the movement authority to a driver and continuously checks that the driver drives safely and does not override the place where the movement authorisation ends (e. g. signal at stop). At the same time, the system ensures that the train stops before this place even in case of failure and that the train does not exceed maximum authorised speed. Observance of maximum authorised speed is checked by means of data transmitted from trackside to on-board ETCS.

1.2 Technical Specifications for Interoperability – TSI

Commission Regulation (EU) 2016/919 of 27 May 2016 issued the TSI relating to the control-command and signalling subsystems of the rail system in the European Union (hereinafter referred to as TSI CCS) which specifies a set of obligatory specifications to ensure interoperability of the Class A system.

TSI CCS establishes requirements necessary to ensure interoperability of trans-European rail system and to demonstrate the compliance with the basic requirements.

The control-command and signalling subsystems include the following parts:

1. Train protection;
2. Voice radio communication;
3. Data radio communication;
4. Train detection.

The Class A train protection system is ERTMS/ETCS.

The Class A radio system is ERTMS/GSM-R.

For Class A train detection the TSI specifies the requirements for the interface with other subsystems in "Interface Document – ERA/ERTMS/033281" (updated version 3.0 from 4 December 2015), the

compatibility with the Rolling Stock Subsystem being the most important requirement. TSI CCS's requirements for track circuits are open to discussion and have not been defined yet.

Class B systems are a limited set of train protection legacy systems and radio means of the existing control-command and signalling systems that were in use in the trans- European rail network before 20 April 2001 and in other parts of the EU railway system before 1 July 2015. The list of Class B train protection systems is established in the European Railway Agency's technical document "List of CCS Class B systems", ERA/TD/2011-11, updated version 3.0 from 4 December 2015.

TSI CCS establishes that the following versions of mandatory requirements are valid for ETCS:

1. ETCS Baseline 2;
2. ETCS Baseline 3 – Maintenance Release 1;
3. ETCS Baseline 3 – Release 2;

All ETCS construction activities in the Czech Republic must comply at least with Baseline 2, version 2.3.0d. Newly started structures from 2017 onwards must comply also with Baseline 3. Document ERA_BCA_B3R2, version 1.1.0 from 13 May 2016, requires full backward and forward compatibility between devices produced according to ETCS Baseline 3 – release 2 and ETCS Baseline 3 – Maintenance Release 1. Running of vehicles equipped with on-board ETCS as per ETCS Baseline 2 on lines equipped with trackside ETCS as per ETCS Baseline 3 – Release 2 can be realized by using the system version 1.1., although in such case some new functionalities introduced in ETCS Baseline 3 - Release 2 are inaccessible. This system version is required for lines managed by SŽDC.

1.3 Overview of railway lines in the Czech Republic that are included in the EU rail system

1.3.1 Railway lines included in trans-European transport network

In particular the lines of trans-European railway network TEN-T have to meet interoperability objectives that include safety, reliability, health protection, environmental protection and technical compatibility. The introduction of ERTMS in accordance with TSI CCS is one of the preconditions of meeting these objectives.

This applies particularly to the part of national railway corridors that are included in the core TEN-T network, as well as to the rest of national corridors, alternative branches of corridor lines and important conventional connecting lines that belong to global TEN-T network in the Czech Republic. Although the lines of the TEN-T network where ERTMS must be installed and used without fail represent about 26 % of the whole Czech railway network, they produce over 80 % of all railway transport output in the Czech Republic. The TEN network lines are important not only for international, but also domestic transport. In particular the suburban sections of transit corridors are overloaded by the concurrence of long-distance transport (passenger and freight) and regional transport. With an appropriate arrangement of infrastructure and train protection system, the ETCS can be an effective and useful tool of increasing the capacity of railway infrastructure.

Regulation (EU) No 1315/2013 of the European Parliament (hereinafter referred to as EP) and of the Council specifies that trans-European railway network in the Czech Republic will in future include also ca 500 km of new high-speed railway lines that, at the same time, represent the basis of the network of Rapid Service connections (hereinafter referred to as RS) proposed by the Ministry of Transport of the Czech Republic (hereinafter referred to as MD).

The lines of the core TEN-T network should be equipped with ERTMS in compliance with Commission Implementing Regulation (EU) 2017/6 of 5 January 2017 on the European Rail Traffic Management

System (ERTMS) European deployment plan. For these lines and associated stations and junctions, the Implementing Regulation sets out **implementation dates by which ERTMS (GSM-R and ETCS) should be implemented and put into operation**. By these dates at the latest, vehicles equipped only with ERTMS **must have access to these lines without needing the Class B system in addition to ERTMS**. On railway lines with implementation dates beyond 2023 the plan must be fulfilled by 2030, taking into account that ETCS, in particular Level 2, should be implemented on lines that were previously upgraded.

Fitting of the comprehensive TEN-T network lines should be scheduled in continuity with their upgrading or optimization in order to finish this process by 2030, but no later than by 2050

The geographic overview is presented in Figure 1.

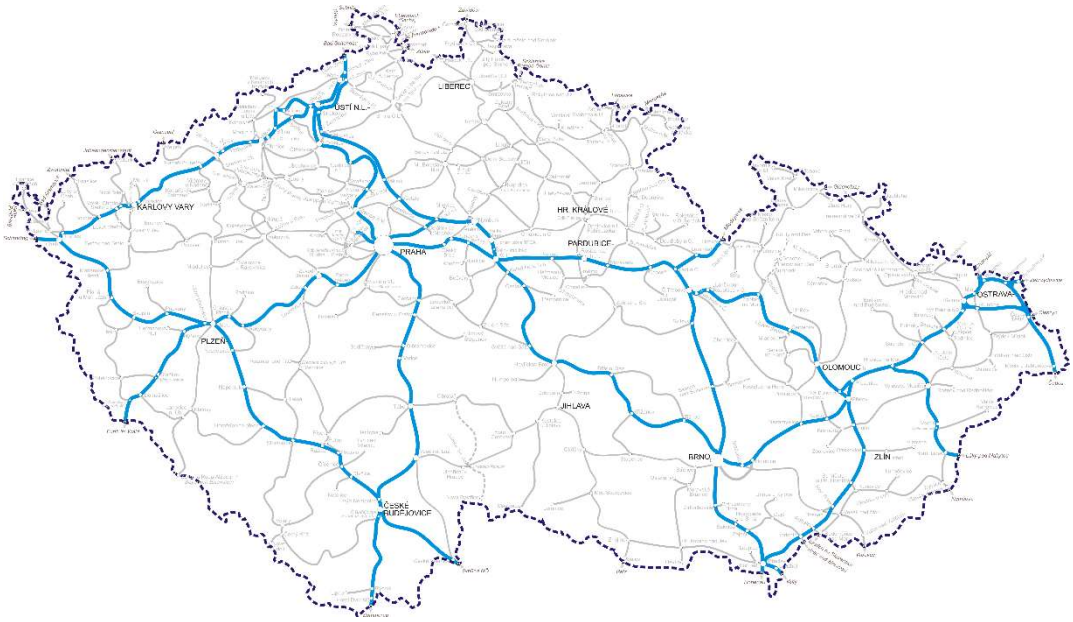

Figure 1: Overview of railway lines included in the TEN-T network with mandatory implementation of ERTMS

Mandatory implementation of ERTMS on Czech lines included in TEN-T applies to about 2550 km of existing conventional lines. They are numbered according to "The Network Statement on nationwide and regional rail networks" valid for 2017 and shown in Table 1.

Implementation of ERTMS will also be mandatory for about 500 km of high-speed lines as per Regulation (EU) No 1315/2013 of the EP and of the Council whose construction is being planned in the Czech Republic.

Table 1: Conventional lines in the Czech Republic included in the Trans-European transport network (TEN-T)

Number:	Line:
380, 400, 420, 421	Germany/Czech state border - Děčín main st. - Ústí nad Labem main st. - Kralupy nad Vltavou - Praha junction
422, 440, 441, 560	Děčín - Prostřední Žleb - Děčín východ - Ústí nad Labem-Střekov/Ústí nad Labem západ - Mělník - Nymburk main st. - Kolín
120, 140, 160, 169,	Ústí nad Labem main st./Ústí nad Labem jih - Chomutov - Karlovy Vary - Cheb
165	Bílina - Ústí nad Labem West
545, 546	Ústí nad Orlicí - Letohrad – Lichkov - Czech state border/Poland
520, 540	Praha junction - Kolín - Pardubice main st. - Česká Třebová
100, 104, 340, 360	Praha junction - Beroun - Plzeň main st. - Mariánské Lázně – Cheb - Czech state border/Germany
200	Plzeň main st. - Domažlice - Česká Kubice - Czech state border/Austria
220	Plzeň main st. - Strakonice - České Budějovice - České Velenice - Czech state border/Austria
240	České Budějovice - Horní Dvořiště - Czech state border/Austria
446	Praha junction - Lysá nad Labem
280, 300	Praha Junction - Tábor - Veselí nad Lužnicí - České Budějovice
680, 700	Kolín - Havlíčkův Brod - Brno junction
720	Brno Junction - Břeclav – Lanžhot - Czech state border/Slovakia
740	Česká Třebová - Brno junction
760, 816	Česká Třebová - Přerov, including Dluhonice connecting track - Prosenice
780, 817	Přerov - Bohumín
820	Hranice na Moravě - Vsetín - Horní Lideč - Czech state border/Slovakia
752, 753, 806	Brno junction - Holubice - Nezamyslice - Přerov
860, 861, 880, 881, 884	Bohumín - Petrovice u Karviné - state border/Karviná main st. - Mosty u Jablunkova Czech state border/Slovakia, including Koukolná connecting track - Závada
793, 794	Bohumín/Bohumín Vrbice - Bohumín - Czech state border/Poland
791, 883, 882	Polanka nad Odrou/Ostrava-Svinov - Havířov - Český Těšín
732, 800	Přerov – Břeclav - Czech state border/Slovakia
520, 321, 380, 324, 381, 382,332, 329, 348, 333, 334, 349, 335, 301, 302	Lines of Praha junction: Praha-Běchovice – Praha-Libeň – Praha-Holešovice – Praha-Bubeneč, Praha-Libeň - Praha Masaryk station., St. 4 – Praha-Bubny – Praha-Bubeneč, Praha-Běchovice – Praha-Malešice – Praha-Vršovice marshalling yard – Praha-Krč – Praha-Radotín, Praha-Hostivař – Praha-Malešice – Praha-Libeň, Praha-Smíchov – Praha-Vršovice passenger station – Praha-Hostivař, Praha-Bubny – Praha-V. Havel Airport
722, 725, 806	Lines of Brno junction: Brno-Maloměřice – Brno-Židenice - Brno dolní nádraží – Brno-Horní Heršpice, Brno-Slatina – Brno-Židenice

1.3.2 Other lines included in the EU rail system

Besides lines listed in 1.3.1, all Czech lines[1] defined by Act No 266/1994Coll., as amended (hereinafter referred to as "Act on rail systems") are included in the trans-European rail system. On these lines the interoperability objectives must be fully implemented, including TSI CCS requirements – in particular the construction of Class A systems.

1.4 European freight corridors

European freight corridors are defined in Regulation (EU) No 913/2010 of the EP and of the Council of 22 September 2010 concerning a European rail network for competitive freight, as amended by Regulation (EU) No 1316/2013 of the European Parliament and of the Council of 11 December 2013. The principal objective of European freight corridors is to increase the share of environmentally friendly railways on the freight market. The Regulation defines the main corridors and stipulates the process and conditions of their implementation, including requirements on their technical standards. It is a comprehensive support of freight transport development whose aim is to establish an infrastructure with homogenous key parameters from the point of freight transport (loading gauge, axle load, train length and speed) and to create the system of appropriate guaranteed routes in train traffic schedule. ERTMS is an integral part of technical equipment of these corridors.

Czech Republic is affected by four of nine freight corridors defined by the Regulation, as they pass through its territory. They are the following corridors:

- RFC 5 (Baltic-Adriatic);
- RFC 7 (Orient-East Mediterranean);
- RFC 8 (North Sea-Baltic);
- RFC 9 (Rhine-Danube, until 2020 Czech-Slovak).

[1] They are all *nation-wide rail systems* and also all *regional rail systems* according to the transposition of Directive (EU) 2016/797 of the EP and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union and geographical scope defined in 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.

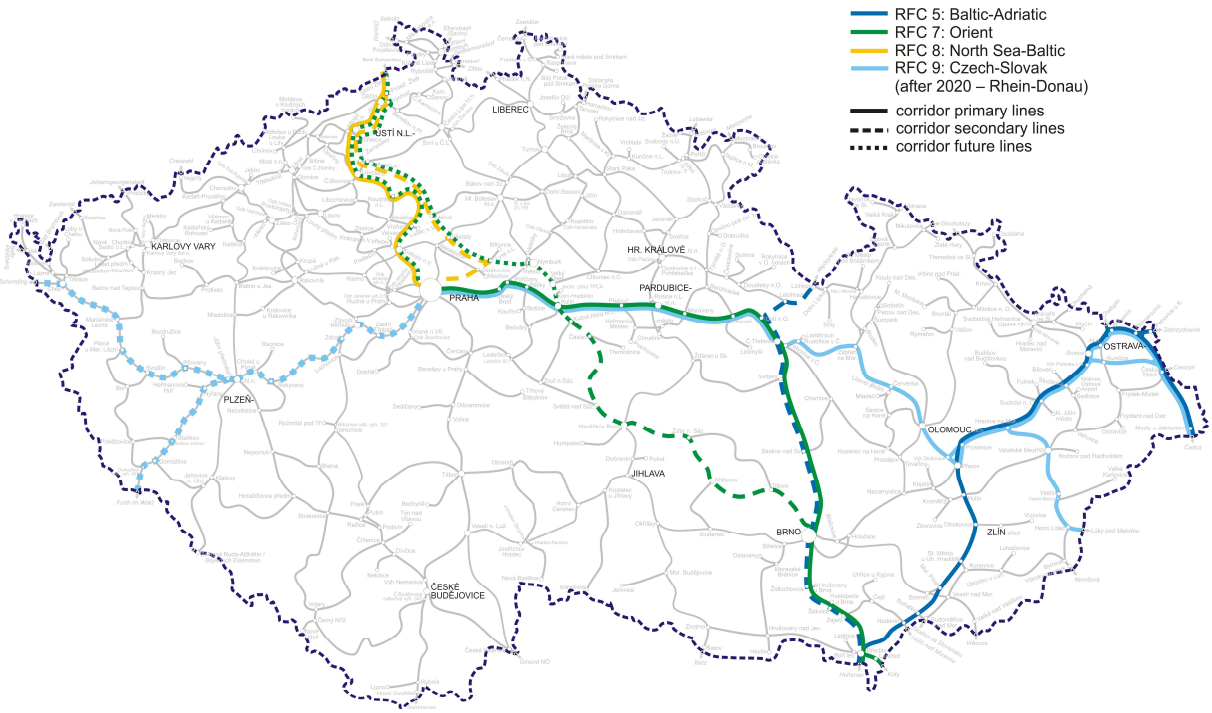

Figure 2: Routes of European freight corridors in the Czech Republic

1.5 Proportion of trackside and on-board ERTMS

The precondition of functional railway is the balance of its structural subsystems. Full functionality of ERTMS and all its benefits is based on the compliance of trackside ERTMS with on-board ERTMS equipment of vehicles. This is true both for GSM-R vehicle radio stations and for on-board ETCS. Therefore we need to know the number of vehicles necessary to ensure the operation of a given line.

Specific number of vehicles per 1 unit of the line's length expresses the gradient of number of vehicles necessary to ensure the operation of the line.

$n = N/L = 2 . N_v / (v_o . T_i . k_e . k_d)$

n … gradient of the number of on-board GSM-R or ETCS (1/km),

N … number of on-board GSM-R or ETCS

L … line length (km),

2 … number of directions of movement (forward and back),

N_v … number of on-board GSM-Rs, or ETCSs in a train (impact of driving trailers, double-headed trains, double multiple units etc.),

v_o … turn round speed (proportion of the length of the served line and the time of the whole turn round of vehicle),

T_i … interval between trains in peak hours (h),

k_e … relative length of the use of GSM-R, or ETCS (proportion of the length of fitted section and the length of the whole served line),

k_d … availability coefficient.

Approximate boxed value of length gradient of the number of on-board GSM-Rs, or ETCSs, in networks with long continuous sections of GSM-R or ETCS (which is going to be true in the Czech Republic in several years):

$n = 2 \times N_v / (v_o \times T_i \times k_e \,.\, k_d) = 2 \times 1.2 / (60 \times 0.1 \times 0.8 \times 0.85) = 0.6\ km^{-1}$

This is an approximate characteristic value that can be made more specific for the particular lines with the use of specific timetables and rolling stock rosters.

2 Control-command and signalling subsystems in the Czech Republic

2.1 Class B systems in the Czech Republic

Railway radio communication system TRS is designed for the operational duplex communication between the running engine driver and a dispatcher or a signaller by means of the ribbon network along the track. TRS is fully compatible at the control signals level in accordance with mandatory recommendation UIC 751-3. Communication is accomplished on four internationally co-ordinated frequencies in the band 450 MHz. TRS features coded transmission in the form of a short telegram FFSK 1 200 bps. One of commands is assigned to the train remote stop that can be activated by a dispatcher or a signaller and causes vehicle emergency braking (if appropriate driver vigilance equipment is present on-board). At present, the TRS radio system is used on about 4,200 km of railway network in the Czech Republic. On-board equipment is available in about 2,350 railway vehicles.

National train protection system LS consists of trackside part and on-board part placed in leading rail vehicle. Trackside part of the system consists of low-frequency track circuits. The code is transmitted by amplitude modulation of carrier frequency 75 Hz (or 50 Hz in older applications). The data transmission between coded track circuits and on-board equipment is via inductively coupled air coil pickup antennae above the rails. One of four different codes is transmitted to the vehicle. Depending on the received code, on-board equipment displays via cab signalling simplified on-board signal aspects. Systematic control of driver vigilance is ensured by active pressing the vigilance button. Driver vigilance control (driver is required to press the button) depends on the currently transmitted code and the speed of train. Trackside part of the ATP LS system is today installed on about 1,850 km of railway network in the Czech Republic and on-board parts are usually installed only in vehicles with design speed over 100 km/h.

Obviously, national train protection system LS which is product of its time (i.e. the middle of the last century) no longer meets modern requirements for these systems. One of the LS system's benefits is the fact that it transmits, ahead of the length of a block section, simplified information about the signal aspect the train is approaching to. This train protection system causes vehicle emergency braking only in case that the driver does not confirm his or her vigilance when receiving the information about a prohibitive or restrictive signal. LS system however does not verify whether the driver is slowing down in order to be able to stop before a signal at stop or before a speed restriction signal. Neither it activates brakes in case the train is approaching to a prohibitive aspect at excess speed or it has overridden a prohibitive signal.

In recent years, travel speed of trains has significantly raised (by tens of percent in passenger trains and hundreds of percents in freight trains), which means that the probability of accident due to failure of driver is increased by the following four factors:

- shorter time of visibility of signals,
- longer braking distances,
- shorter time intervals between signals,
- drivers cover longer distance during their shift and therefore they must perceive and register more signals.

And what's more, recent progress of rational transport technologies minimizes the level of supervision of driver's work by other employees (dispatcher, train crew head).

Many European states (Germany, Austria, Switzerland etc.) have extensively implemented national train protection system of the Class B that ensure relatively high level of railway operation safety (they

almost rule out accidents caused by overriding a signal at stop, e.g. PZB) and show high level of functionality (they can be used at higher speeds, enable automatic train operation according to a speed profile, e.g. LZB).

ETCS is useful for these states in particular in terms of European uniformity (practical effects: easier conversion of transit freight transport from roads to railway, productive utilization of rail vehicles in international transport). For the Czech Republic, **changeover to ERTMS is much more important, particularly because of improved safety of railway transport** and other functional parameters of ETCS (speed over 160 km/h, higher line capacity, energy savings etc.). Therefore ERTMS in the Czech Republic is a programme for the whole railway, which will be of course realized in prioritized steps. The ETCS-oriented approach, especially at ETCS Level 2, indicates that ERTMS in the Czech Republic is understood as a coordinated implementation of GSM-R and ETCS.

2.2 The current state of GSM-R development in the Czech Republic

GSM-R system was used on 1660 km of lines as of 1 January 2017, see Figure 3 and Table 2. GSM-R network has two mobile switching centres (MSC) in Prague and Přerov. During the construction process they are gradually upgraded in order to be able to ensure the operation of newly equipped lines and, at the same time, back up each other. SŽDC's GSM-R network is interconnected with GSM-R of DB, ÖBB and ProRail, which enables mutual roaming in these networks. Interconnection with GSM-R of ŽSR and MÁV is being prepared right now (it should be put into operation in 2017). Today, national roaming in the network of national public operator is being verified in test mode.

The construction of trackside GSM-R and equipment of vehicles with on-board GSM-R devices is implemented simultaneously. In the transitional period (digital-analog) GSM-R/TRS dual-mode on-board radio stations are being used. In 2017, SŽDC issued a total of 2945 SIM cards for GSM-R on-board radio stations for the purpose of voice communication. The number of vehicles operated in the SŽDC network that can communicate in GSM-R system increased to include vehicles of foreign railway undertakings, or vehicles owned by companies that rent traction units communicating in SŽDC's network via roaming. The national railway undertaking alone (ČD and ČD Cargo, a. s.) had 1784 vehicles equipped with GSM-R communication system, which were in fact all vehicles operated on lines fitted with GSM-R. All newly acquired vehicles will be equipped with GSM-R too. This was achieved mainly thanks to the vehicle equipment support program (managed by the Ministry of Transport of the Czech Republic) with the use of EU funds.

Successful installation of radio stations in vehicles laid the groundwork for the requirement for mandatory equipment of vehicles with on-board radio system to gain access to particular railway lines – see the current version of "The Network Statement on nationwide and regional rail networks" published on the SŽDC's Rail Operation web portal. For the sake of railway operation fluency and safety, SŽDC grants access to the listed lines only to vehicles that are fitted with radio station compatible with a trackside part (in this case GSM-R).

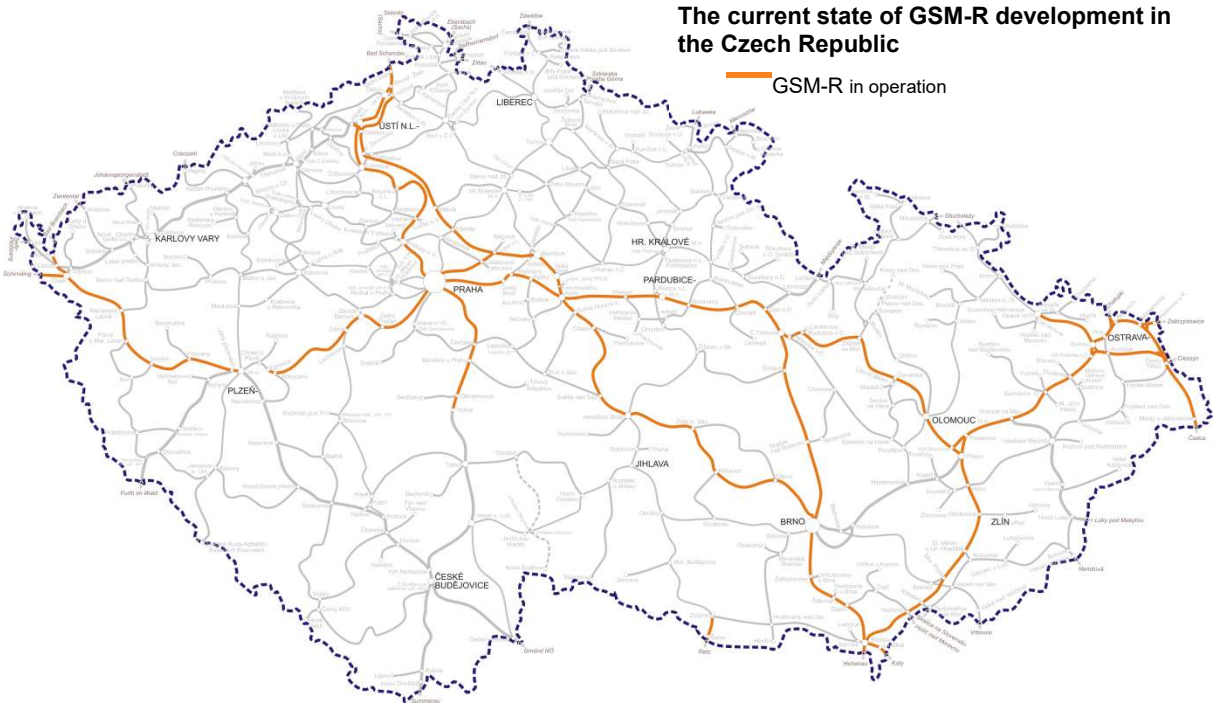

Figure 3: The current state of GSM-R development in the Czech Republic as of 1 January 2017

Table 2: Lines equipped with GSM-R as of 1 January 2017[2]

Pos.	Line	Length[3] (km)
1	State border Czech Rep./Germany – Děčín – Praha – Kolín – Česká Třebová – Brno – Břeclav – state border Austria/Slovakia	470
2	Břeclav – Petrovice u Karviné – state border Czech Rep./Poland; Bohumín – state border Czech Rep./Poland	220
3	Česká Třebová – Přerov/Prosenice	120
4	Dětmarovice – Mosty u Jablunkova – state border Czech Rep./Slovakia	60
5	Polanka nad Odrou – Český Těšín	50
6	Praha – Lysá nad Labem	30
7	Kolín – Lysá nad Labem – Ústí nad Labem-Střekov – Děčín-Prostřední Žleb	160
8	Ostrava-Svinov – Opava east	30
9	Kolín – Havlíčkův Brod – Křižanov – Brno	200
10	Praha – Benešov u Prahy – Votice	70
11	Znojmo – Šatov – state border Czech Rep./Austria	10
12	Praha – Beroun – Plzeň – Cheb – Cheb state border Czech Rep./Germany / Vojtanov – state border Czech Rep./Germany[4]	240
	Total	**1660**

[2] Detailed description of individual line sections can be found in "The Network Statement on nationwide and regional rail networks" valid for 2017

[3] Approximate values

[4] Except for the section Ejpovice – Plzeň that will be put into operation after completion of the Ejpovice railway tunnel.

2.3 Development of ETCS Level 2 in the Czech Republic

In 2001, initiatives aimed at the implementation of ETCS under the conditions of Czech Republic were started. It was decided that further developemnt of radio system and train protection system would head towards ERTMS. The Railway Research Institute prepared a study on the application of ETCS in the Czech railway network. The implementation of pilot project ETCS L2 in the section Poříčany – Kolín (outside) was started in 2005 with the support of the EU cohesion fund. The pilot project ETCS L2 was realized in version 2.3.0 and put into test operation. During further construction of ETC L2 in the section Kolín – Praha – Kralupy nad Vltavou the system will be upgraded to updated version of mandatory specifications and included in the system of the whole section.

The evaluation of experience with the implementation of ETCS L2 during the pilot project became a groundwork for ordering the construction "ETCS – Corridor I, section Kolín – Břeclav state border Austria/Slovakia" that was started in 2012.

In 2016 the implementation of ETCS L2 on the line Břeclav – Přerov – Ostrava – Bohumín – Petrovice u Karviné – state border Czech Republic/Poland was started. In 2017 other structures should be started: Kolín – Praha – Kralupy nad Vltavou, Přerov – Česká Třebová, Praha-Uhříněves – Votice.

3 ERTMS national implementation plan

3.1 General principles

The aim of the ERTMS national implementation plan is to develop both trackside and on-board ERTMS on the railway in the Czech Republic in a coordinated way. From the point of time schedule, the most important think is installation and utilization of ERTMS on existing upgraded or optimized conventional lines in the Czech Republic that are included in trans-European railway network.

ERTMS must be also installed and utilized on newly constructed conventional and high-speed lines and this way it will become an integral part of their constructional design. ERTMS will be gradually extended to include other railway lines in order to develop integrated operation lines, both from the perspective of traffic management and turn round of vehicles. **ERTMS will always be implemented on lines where it is possible to increase speed limit established by Decree No 173/1995 Coll. of the Ministry of Transport, as amended.**

Considering the Czech Republic's emphasis on ETCS L2, ERTMS will be tested in two consecutive steps: first GSM-R and then ETCS. In order to harmonize life-cycles of successive technical equipment and to minimize costs, necessary upgrading of station, track and level crossing interlocking devices (to the extent needed to develop rational interfaces) must be performed prior to ETCS installation. **All upgrading projects of station, track and level crossing interlocking devices, also on the lines where dates of ERTMS installation have not been determined yet, have to be performed in such a manner as to facilitate installation of ERTMS in future.**

The inclusion of a large part of the Czech railway network in European structures alone means that ERTMS will be implemented on about 3,000 km of railway lines of TEN network. This is ca 30 % of the total network length (9,500 km of conventional lines and ca 500 km of future high-speed lines) which will represent more than 85 % of all transport output. It follows that GSM-R and ETCS will become integral parts of all vehicles as well as basic tools of rail traffic management.

Facts associated with the realization of ETCS:

- **All lines** (so far unfitted with the national ATP system LS) **where the speed limit can be increased to more than 100 km/h** must be equipped with a train protection system, as required by Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended, before the track speed is increased over 100 km/h. As on these lines the train protection system will be installed for the first time, it will be mandatorily fitted with ETCS in accordance with TSI CCS. This involves lines such as Velký Osek – Hradec Králové – Choceň, Pardubice – Hradec Králové, Pardubice – Chrudim, Znojmo – Břeclav, Olomouc – Nezamyslice, Olomouc – Uničov, Brno – Veselí nad Moravou, Nymburk – Mladá Boleslav, Veselí nad Lužnicí – České Velenice, Česká Lípa – Liberec, Praha – Kladno and others. This requirement applies also to lines that are currently equipped with the national ATP system LS and that are going to be reconstructed or upgraded.
- TSI CCS also requires that ERTMS is installed on **lines leading from European corridors to principal European ports, marshalling yards, freight terminals and freight transport areas**.
- After trackside parts of GSM-R and ETCS will be finished, **it is logical that other adjacent lines will be continuously connected to them in order to utilize synergic effects of previously constructed trackside equipment as well as to take operational advantages** – the best use of on-board parts of GSM-R and ETCS that will become a mandatory standard on vehicles.
- The crucial point is that **the lower intensity of operation on a given line, the lower costs of construction of ETCS** (i.e. less operating points and smaller trackage, longer block sections, low number of vehicles). **ETCS of an appropriate level is therefore suitable also for obsolete lines with very low degree of train protection where they can be cost-competitive with traditional**

concept of train protection technology (i.e. construction of main signals and warning signals), provided however that vehicles are fitted with on-board ETCS.

Overall, it can be said that ERTMS may be reasonably applied to the whole railway network where it is necessary to construct train protection equipment, gradually in prioritized steps, within the meaning of Decree No 173/1995 Coll. of the Ministry of Transport that issues track traffic rules, as amended. Here we do not talk about the present state, but about future economically meaningful scope of the Czech railway network. The lines will be equipped either with ERTMS, or they will be not part of really functioning railway network system. This is true for all lines where interoperability, and thus also ERTMS, is absolutely essential as required by 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.

TSI for subsystems "control-command and signalling" for railway system in the EU deals in Chapter 7 with the process and methods for transition from national Class B systems to interoperable Class A systems. At the same time, it sets mandatory rules for GSM-R and also ETCS systems implementation.

The objective of the ERTMS European Deployment Plan is to ensure that, gradually, locomotives, electric and diesel traction units and other railway vehicles equipped with ERTMS gain access to an increased number of lines, ports, terminals and marshalling yards without needing national equipment in addition to ERTMS. The final goal is the implementation of ERTMS on a larger scale according to the needs of national railway network operation, which is the subject of the national implementation plan. Basic mandatory requirements for the structure of a national implementation plan are stipulated in point 7.4.4 of the Annex of TSI CCS.

National implementation plans must above all set the following parameters:

1. **Target lines** – unambiguous identification of national lines designated for the implementation of radio communication system and train protection equipment, i.e. ERTMS, within a given timeframe.
2. **Technical requirements** – definition of the fundamental technical requirements for the implementation, e.g. GSM-R Voice/Data, ETCS application level, concurrent operation of the national train protection system.
3. **Implementation strategy and planning** – proposal for the implementation plan including the procedure and work schedule.
4. **Transition strategy** – the strategy of transition from national systems of Class B to the systems of Class A, including the planned closure of Class B system.
5. **Potential restrictions** – overview of potential factors which could have impact on the implementation progress.

Migration period for a given track (track section) starts when Class A system is put into operation and ends when exclusive operation of Class A system begins (and all vehicles on a given section are fitted with Class A equipment) and, at the same time, B class system is put out of operation. The strategy of transition from national Class B systems to Class A systems consists of the following stages:

Stage 1 – before the start of migration period – the use of B Class system and the baseline state of Class A system (ERTMS).

Characterization:

- Mixed operation of Class A and Class B systems
- The use of the existing B Class system (TRS, train protection system LS)
- Partial use of Class A system (GSM-R, or ETCS[5]), if available

[5] This applies only to the pilot ETCS project on the line section Poříčany – Kolín and the construction of ETCS on the line section Kolín – Břeclav – state border Austria/Slovakia.

- Traction units of railway undertakings can use the systems without restrictions
- It is possible to start the refurbishment of the Class B system only on tracks where this Class B system was operated prior to the investment or non-investment project. At the same time, the Class A system has to be put in routine operation as soon as the investment/non-investment project is started in test operation or the application for final inspection approval is submitted.

Stage 2 – migration period in progress – the use of Class A and Class B and transition to Class A.

Characterization:

- Mixed operation of Class A and Class B systems
- The use of the existing B Class system (radio communication system TRS, train protection system LS)
- Using Class A system (GSM-R) and newly completed ETCS L2, or newly completed ETCS L1 only
- Traction units of railway undertakings can still use the systems without restrictions
- It is possible to start the refurbishment of a Class B system, but only if it is completed or put into operation 1 year before the start of stage 3 of migration. This refurbishment may be done only on tracks where this Class B system was operated before the start of investment or non-investment project.

Stage 3 – after the end of migration period – final state, Class A is used only, Class B is not used at all.

Characterization:

- Class A system is used only
- The existing B Class system is not used any more (TRS, train protection system LS)
- Using only Class A system (GSM-R) and newly completed ETCS L2, or only newly completed ETCS L1
- Traction units of railway undertakings must use Class A system
- Class B system must not be refurbished and operated

3.2 GSM-R national implementation plan

The undermentioned information can be presented within the meaning of Regulation (EU) No 1315/2013 of the EP and of the Council, Directive (EU) 2016/797 of the EP and of the Council, Commission Implementing Regulation (EU) 2017/6 and general principles for creation of ERTMS implementation plans, and on the basis of the ERTMS National Implementation plan approved in 2014 and the previous experience with ERTMS implementation.

3.2.1 Target lines designated for GSM-R system implementation before 2023 – with a view to 2030

Primarily they are lines defined in chapter 1.3.1. A total length of these lines is about 2,550 km.

Basic characteristics of these lines:

- Mixed operation (passenger and freight transport).
- Largely double-track lines.
- The lines electrified with the AC 25 kV 50 Hz or DC 3 kV system.
- Current maximum track speed of 160 km/h (up to 200 km/h in future).
- At present, the national radio TRS system is usually available, but the plan is to abandon it in future.

GSM-R implementation will also concern all nation-wide rail systems (about 3,100 km), depending on the progress of reconstruction and upgrading of these lines and with respect to the construction of necessary cabling and transmission systems – the lines so far unfitted with radio system must have the highest priority. After nation-wide rail systems, GSM-R will be installed on adjacent regional rail systems, gradually according to operational and economic priorities (uninterrupted served lines, intensive traffic, safety etc.). Special attention will be paid to cross-border and borderline sections to ensure interoperable radio communications.

3.2.2 Technical requirements for GSM-R implementation

- In the view of the intention to establish gradually ETCS Level 2 on target lines, GSM-R system has to be able to provide both voice and data transfer services. It appears from this that the coverage of the railway lines with the GSM-R signal must be ensured in the quality for the lines equipped with ETCS Level 2 and 3 and on conventional lines for speed up to 220 km/h according to the EIRENE specifications. On cross-border sections the signal must reach also the territory of a foreign railway to ensure fluent transition of trains between ETCS systems of neighbouring railways.
- On lines (where full installation of trackside multiple-aspect signals is not present any more) that are operated solely under supervision of ETCS L2 the appropriate measures must be taken to improve reliability and availability of GSM-R signal so that adequate reliability and safety of rail transport operation is ensured.
- Concurrent operation of national analog radio system TRS will not be maintained on lines fitted with GSM-R system. Therefore vehicles and employees has to be equipped with mobile GSM-R terminals. This applies to railway undertakings as well as to the area of ensuring operation and operability of railway infrastructure. Given the limited number of available connections in GSM-R, the communication of employees who ensure the operability of railway infrastructure can be done also via other available radio networks (e.g. in large junctions or stations with

extensive shunting activity). These networks however cannot be used as line communication means in a given line section.

3.2.3 GSM-R implementation strategy and planning

- Implementation strategy is based on the fact that GSM-R represents communication environment which is necessary for the operation of ETCS L2. Considering the intention to equip TEN-T railway lines primarily with ETCS L2, it is necessary to in advance build GSM-R in quality needed for its operation on conventional lines as required by EIRENE specifications.
- The first stage of GSM-R implementation focuses on national transit railway corridors and their basic by-pass routes, subsequently on other target lines. As the construction of GSM-R in many cases depends on the completion of line upgrading (especially in more extensive relocations), it is not always possible to equip corridors first. The implementation plan including the presumed workflow is presented in Table 3.
- In the next step, all ca 3,100 km of nation-wide rail systems should be covered to ensure interoperability within the meaning of Directive (EU) 2016/797 of the EP and of the Council, and then regional rail systems should be covered. This is nevertheless contingent on implementation of further investment projects in the area of infrastructure upgrading, above all extension of transmission routes network including laying optical fibre cables. The highest priority will be given to lines that have not been fitted with radio system yet and where the radio communication part of a Control-Command and Signalling Trackside Subsystem will be installed for the first time as required by point 7.3.1 of the Annex of TSI CCS. The order of other nation-wide and regional rail systems to be equipped with GSM-R will be prioritized on the basis of operational requirements in order to develop integrated areas, or served lines, enabling uniform communication in GSM-R network. Special attention will be paid to the development of GSM-R network on cross-border and borderline sections in order to ensure interoperable radio communication with vehicles of foreign railway administrations entering the Czech Republic.
- When building individual GSM-R facilities it is necessary to provide radio signal coverage not only on the backbone line, but also sections on connected branch lines in order to ensure railway operation safety when switching between radio systems, or, in the next phase, to ensure the function of the access of trains to the area fitted with ETCS. Previous experience shows that coverage should be assured of such a length of connected branch line section that corresponds to a two-minute run of the train at line speed. Alternatively, the signal should reach to the nearest operating point on a given line. Kilometric lengths of the fitted sections demonstrated in Table 3 are therefore only approximate. Considering the abovementioned requirements, the actual lengths of line sections covered by GSM-R radio signal within the construction projects will not be known until detailed technical, safety and transport and technological analyses will be performed during project preparation.
- For objective reasons the socioeconomic benefits of projects ensuring the implementation of trackside GSM-R cannot be fully monetized. Therefore it is not appropriate to evaluate cost-effectiveness by standard CBA method in every case. If cost-effectiveness is not demonstrated by CBA[6], other method of economic assessment (as per implementing guidelines for evaluation of effectiveness of transport infrastructure projects) will be used according to the

[6] Only if it has been proved that the project is not cost-effective due to the construction of GSM-R. However, this procedure cannot be directly applied to projects of reconstruction, upgrading etc. of lines where the construction of GSM-R is just one of the project's components. For details see implementing guidelines for evaluation of effectiveness of transport infrastructure projects issued by the Ministry of Transport of the Czech Republic.

directive of the Ministry of Transport No V-2/2012 *"Directive governing the procedures of the Ministry of Transport, investor organizations and the State Transport Infrastructure Fund during the preparation of investment and non-investment activities of the transport infrastructure, financed without the participation of the state budget"*. Funding gap will be established only by means of financial analysis of the project. If an alternative without project cannot be defined, or if GSM-R implementation is mandatory and results from the EU mandatory legal regulations or from this implementation plan, then only balance sheet of investment and operating costs (including material profits generated by the project during the economic life cycle of the investment) will be developed.

- The development of trackside GSM-R on TEN network lines in the planning period 2017–2023 will be primarily funded from CEF fund (core network lines), or within the Operational Programme Transport or SFDI (State Transport Infrastructure Fund). The plan of funding of future development will be updated based on the current budgetary considerations of the EU/Czech Rep.
- In the planning period 2017–2023 only new vehicles will need to be fitted with GSM-R on-board radio stations.

Table 3: GSM-R implementation plan

Pos.	Line	Length*) (km)	Workflow		Note
			End of preparation	Realization	
1.	České Velenice state border Czech Rep./Austria – České Budějovice – Horní Dvořiště state border Czech Rep./Austria	110	2017	2018 – 2019	Preparation
2.	Plzeň – České Budějovice	140	2017	2018 – 2019	Preparation
3.	Ejpovice – Plzeň	10	2014	2014 – 2019	Realization 1)
4.	Ústí nad Orlicí – Lichkov state border Czech Rep./Poland	40	2016	2017 – 2018	Preparation
5.	Votice – České Budějovice	100			Preparation 2)
6.	Hranice na Moravě – Horní Lideč state border Czech Rep./Slovakia	70	2019	after 2023	
7.	Ústí nad Labem – Oldřichov u Duchcova/Úpořiny – Kadaň-Prunéřov – Karlovy Vary – Tršnice – Cheb/Františkovy Lázně, branch Dolní Rybník – Jirkov, Úpořiny – Řetenice, Oldřichov u Duchcova – Louka u Litvínova – Litvínov/Most new st. – Most/Třebušice, Kadaň-Prunéřov – Kadaň	260	2018	2019 – 2021	Preparation
8.	Pardubice – Hradec Králové	30	2019	2022 – 2023	3)
9.	Zábřeh na Moravě – Šumperk	15	2019	2022 – 2023	
10.	Praha-Bubny – Praha-Ruzyně – Praha-V. Havel Airport/Kladno	40	2020	after 2023	3)
11.	Brno – Přerov	90	after 2020	after 2023	3)
12.	Plzeň – Domažlice state border Czech Rep./Germany	80	after 2020	after 2023	3)
13.	Velký Osek – Hradec Králové - Choceň	100	after 2020	after 2023	3)
14.	Protivín – Písek – Písek město, Putim – Ražice	30	before 2023	2023	4)
15.	Boskovice connecting track	5	2019	2021 – 2023	5)
16.	Blažovice – Veselí n. Moravou	70	2020	after 2023	6)
17.	Šakvice – Hustopeče u Brna	7	2018	2020 – 2021	7)
18.	Židlochovice – Hrušovany u Brna	3	2018	2020 – 2021	8)
19.	Pardubice – Žďárec u Skutče	40	2019	after 2023	9)
20.	Olomouc – Uničov	30	2018	2023	10)
21.	Uničov – Šumperk	30	after 2020	after 2023	
22.	Otrokovice – Zlín – Vizovice	30	2019	after 2023	11)
	Total	**1330**			

1) The remaining part of the construction "GSM-R Corridor III Beroun – Plzeň – Cheb" depends on the completion of the Ejpovice tunnel.

2) A possible prolongation the derogation granted by Commission Decision No 2010/691/EU until 31 December 2018 is now being negotiated

with relevant EU bodies.

3) The stated GSM-R constructions will be realized depending on the progress of upgrading of a given line section.

4) Based on the approved feasibility study – the date depends on the progress of constructions built to optimize the line.

5) Depends on the progress of construction of Boskovice connecting track.

6) Based on the approved feasibility study – the date depends on the progress of individual structures of the reconstructed line section Blažovice – Veselí n. M.

7) The intention of the construction project "Upgrading and electrification of the line Šakvice – Hustopeče u Brna" was approved.

8) The intention of the construction project "Upgrading and electrification of the line Hrušovany u Brna – Židlochovice" was approved.

9) Depends on the progress of construction of Ostřešany connecting track.

10) Depends on the progress of realization of the construction "Electrification and capacity upgrading of the line Uničov (inclusive) – Olomouc".

11) Based on the approved feasibility study – the date depends on the progress of the construction "Upgrading and electrification of the line Otrokovice – Vizovice".

*) Approximate values

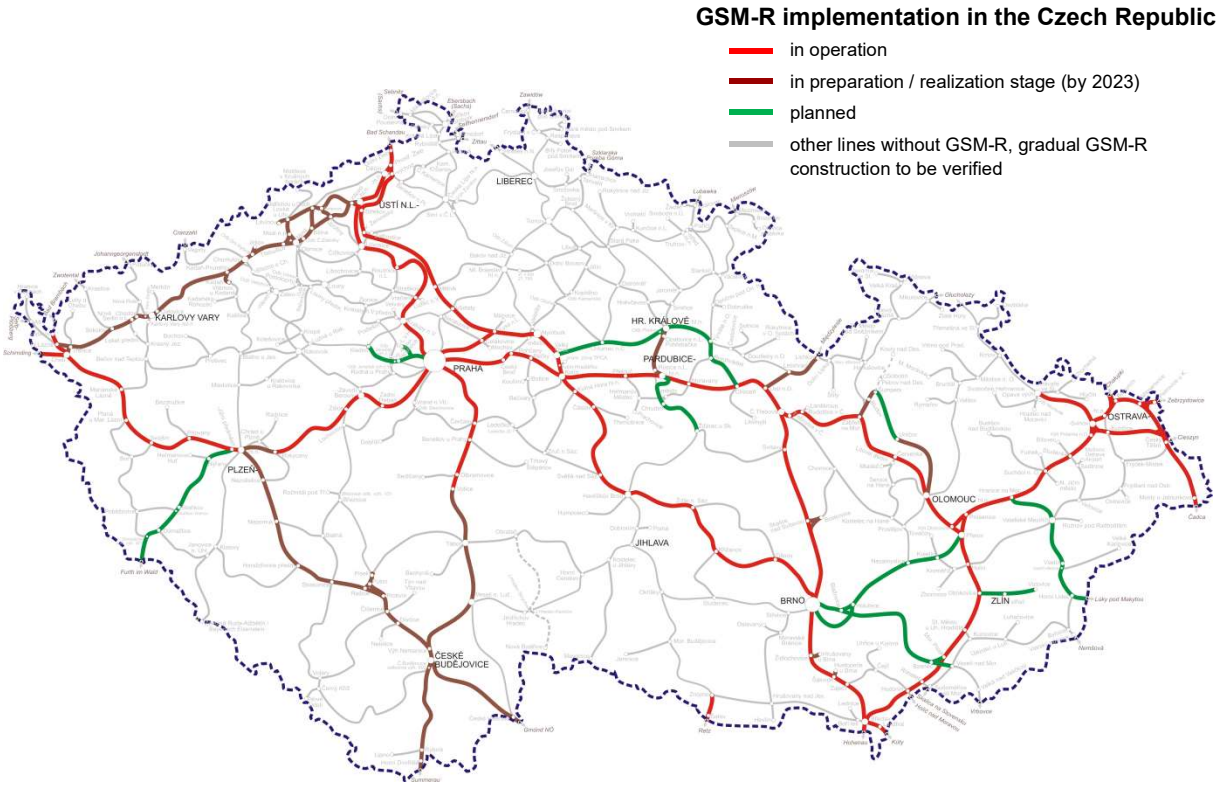

Figure 4: The planned stages of GSM-R implementation from 2017 onwards

3.2.4 Strategy of transition from the national TRS system to GSM-R

The following facts and principles were taken into account when developing the strategy of transition from Class B radio communication system (analog voice TRS in the Czech Republic) to uniform and mandatory use of Class A system (GSM-R) and when developing the procedure of installation of radio system on lines that have not been fitted yet:

- To ensure and improve safety – to cover a greater part of railway network with radio communication system as compared with previous TRS coverage.
- Higher functionality of the new system.
- To prepare the ground for ETCS L2 implementation.
- European uniformity.
- Problems with parallel operation of two systems (GSM-R and TRS) on one line.

- Problems with organization of parallel operation of two systems (GSM-R and TRS) from the perspective of communicating vehicles.
- Specific costs of trackside GSM-R per 1 km of line (approximately CZK 3 million per km[7]).
- Costs of on-board GSM-R (approximately CZK 0.5 million per vehicle).
- The amount of on-board GSM-R per 1 km of the line equipped with trackside GSM-R:
  - up to 1.2/km (initial period, small part of the network is covered by signal, which indicates little coverage of the vehicle's operation line,
  - up to 0.6/km (later period, great part of the network is covered by signal, which indicates good coverage of the vehicle's operation branch.
- Proportion of specific costs of on-board parts – ca CZK 0.3 to 0.6 million per 1 km of the line fitted with GSM-R, i.e. ca 9 % to 17 % of all specific costs of GSM-R (both trackside and on-board) amounting to CZK 3.3 to 3.6 million per km.

Considering these fact the following principles of migration to GSM-R were adopted:

- Short migration period, particularly in relation to problems with parallel operation of analog and digital stationary parts of radio communication.
- The effort to keep the migration as short as possible is based on the following rationale:
  - to take advantages of GSM-R as soon as possible,
  - to grasp an economic return on the investment by using it meaningfully during its depreciation period,
  - to minimize the period of operational complications associated with parallel operation of two different systems.
- In the beginning the vehicles should be fitted with radio stations very intensively, i.e. in higher numbers than just proportionately to target length of lines currently covered by GSM-R signal. This is relevant in terms of initially lower share of sections covered by GSM-R signal in the total length of served lines as well as in terms of minority share of costs of on-board part in the total costs of EIRENE system.

This strategy proved successful in the past. Moreover, it turned out that migration period can be reduced to several months and that such reduction brings real benefits.

- Strategy of transition from national Class B radio system (TRS) to Class A system (GSM-R), based on the ERTMS National Implementation Plan 2014, suggests that initial investments in trackside and on-board equipment are combined concurrently so that it would be possible to implement full (net) GSM-R operation on long continuous line sections shortly after installation of trackside part, see Figure 5.
- The merits of this approach above all rest upon the following facts:
  - as the first one the most exposed backbone line in the railway network in the Czech Republic, the transit railway corridor I (which was not continually equipped with the national TRS radio system) was fitted, and subsequently transit railway corridor II and the line Česká Třebová – Přerov were fitted; almost concurrently, vehicles were equipped thanks to the GSM-R vehicle fitting support programme,

[7] This is only an estimate based on experience with previously realized projects. Actual costs can be estimated with the help of tools defined by Act No 134/2016 Coll. on Public Procurement, as amended (e.g. market consultation).

- on these lines the prevailing part of vehicles that are designed for the operation on corridor and other main lines of the Czech railway network are used; therefore it was necessary to install on-board equipment on a proportionally large number of vehicles (ca 1.2/km) – this objective was achieved,
- the number of vehicles which necessarily have to be equipped for the operation on other lines in the course of GSM-R implementation is relatively small compared to the initial investments (less than 0.6/km).

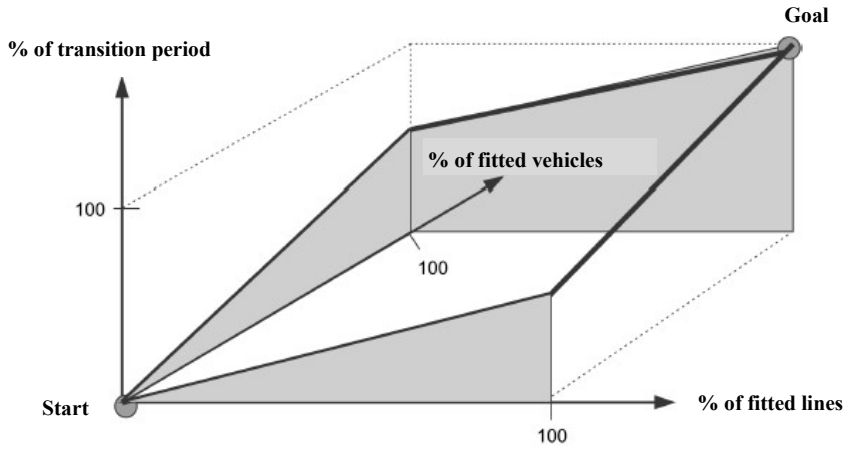

Figure 5: Strategy of transition from TRS to GSM-R

- Strategy of migration to GSM-R relies on the use of dual equipment in vehicles that makes it possible to operate GSM-R also in the national analog system TRS. This enables the transition of vehicles to lines that will be fitted with GSM-R in the long term and facilitates the service of drivers in transition period – drivers will not have to work with two different equipments when running along lines with different systems.
- **The existing trackside parts of the national analog radio system TRS, if available, on the lines newly fitted with trackside GSM-R will be operated concurrently (migration period) for no more than 2 months after GSM-R is put into operation – this will allow for coordination of transition to the new radio system. Specific date of putting the original train radio equipment on a given line out of operation will be announced on the SŽDC's Rail Operation portal at least two months before the actual date.** Vehicles and employees should be equipped with on-board terminals during the construction of trackside GSM-R to keep migration period as short as possible (thus taking advantage of investments in trackside part and keeping complications associated with concurrent operation of two systems to a minimum).

Overview of potential factors which might have impact on the implementation progress:

- The pilot GSM-R project was realized in the Czech Republic to identify the risks, their minimization or elimination; the obtained findings and experience were evaluated and used for further GSM-R system implementation in the Czech Republic.
- The critical factor is the funding of GSM-R system development in the area of trackside and on-board equipment and portable terminals:
  - The development of trackside GSM-R on TEN network lines in the planning period 2017–2023 will be primarily funded from CEF fund or within the Transport operation programme or SFDI fund; the plan of funding of future development will be updated based on the current budgetary considerations of the EU/Czech Rep.,

- dynamic development of GSM-R network is contingent on the existence of the GSM-R vehicle fitting support programme that can be used by railway undertakings (e.g. fitting vehicles for other lines that are newly equipped with trackside GSM-R); this is very important for the selected migration strategy also in future – obviously, if the programme will not be available in the next planning period, fitting of other vehicles with on-board GSM-R will significantly slow down and the objectives will not be met.

- The delays in the selection of the contractor within the public commercial tender caused by protests of the unsuccessful applicants represent further factor with negative impact on the time schedule of the GSM-R implementation; the intended implementation schedule could be delayed for months or years due to this factor.

- Delays of the infrastructure upgrading constructions, within which the fundamental conditions for following line construction of the GSM-R system are prepared (laying optical fibre cables, providing power supply for the base radio stations etc.) may also have a negative influence on the GSM-R implementation schedule.

3.2.5 GSM-R implementation – Summary

In the planning period 2017–2030 the implementation of GSM-R in the railway network of the Czech Republic should continue up to the maximum extent allowed. Priority should be given to TEN-T network lines that represent approximately 26 % of all railway lines in the Czech Republic. This intention primarily depends on co-financing of these constructions from CEF fund or the Operational Programme Transport (2017–2030). The plan of funding of future development will be updated based on the current budgetary considerations of the EU/Czech Rep.

The schedule of fitting TEN-T railway lines with GSM-R must allow its completion by 2030. At the same time, we have to keep in mind that upgrading of certain lines (e.g. Plzeň – Domažlice state border Czech Rep./Germany or Brno – Přerov) may remain uncompleted by this date.

The long-term aim of the Czech Republic is to gradually install GSM-R on all nation-wide rail systems and their adjacent regional rail systems according to operational and economic priorities. This is nevertheless contingent on implementation of further investment projects in the area of infrastructure upgrading, above all extension of transmission routes network including laying optical fibre cables, but also completion of upgrading of lines associated with relocations.

According to point 7.3.1 of the Annex of TSI CCS, GSM-R installation is mandatory when installing for the first time the radio communication part of a control-command and signalling trackside subsystem, or when upgrading the radio communication part of a control-command and signalling trackside subsystem already in service in such a way that it changes the functions or the performance of the subsystem. Interoperability is mandatory on nation-wide and regional lines and GSM-R is its integral part.

As far as equipment with GSM-R is concerned, priority will be given to lines so far unfitted with a radio system. The order of other nation-wide and regional rail systems to be equipped with GSM-R will be prioritized on the basis of operational requirements in order to develop integrated areas, or served lines, enabling uniform communication in GSM-R network. Special attention will be paid to the development of GSM-R network on cross-border and borderline sections in order to ensure interoperable radio communication with vehicles of foreign railway undertakings.

3.3 ETCS national implementation plan

The undermentioned information can be presented within the meaning of Regulation (EU) No 1315/2013 of the EP and of the Council, Directive (EU) 2016/797 of the EP and of the Council, Commission Implementing Regulation (EU) 2017/6 and general principles for creation of ERTMS implementation plans, and on the basis of the ERTMS National Implementation Plan approved in 2014 and of the previous experience with ERTMS implementation.

3.3.1 Lines designated for ETCS system implementation before 2023 – with a view to 2030

Priority will be given above all to TEN-T lines defined in chapter 1.3.1.

Basic characteristics of these lines:

- Mixed operation (passenger and freight transport).
- The goal is to operate exclusively ETCS-fitted trains including special powered vehicles.
- Largely double-track lines.
- The lines electrified with the AC 25 kV 50 Hz or DC 3 kV system.
- Current maximum track speed of 160 km/h (up to 200 km/h in future).
- At present, the Class B national train protection system LS is usually available, but the plan is to abandon it in future.
- The lines are currently equipped with signals for traffic control (the plan is to reduce their number).
- There is an intention to reduce the length of block sections (section signals will not be used any more) on lines having problems with capacity and to ensure shorter intervals between train movements under supervision of ETCS.

The ETCS implementation will concern also nation-wide rail systems, depending on the progress of their reconstruction and upgrading, especially in cases when speed limit will be increased to exceed 100 km/h and when – in accordance with Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended – the trackside part of train protection system will have to be installed. ETCS will be similarly installed on selected regional rail systems, gradually according to operational and economical priorities (uninterrupted served lines, traffic intensity, safety etc.). Special attention will be paid to cross-border and borderline sections to ensure interoperability.

3.3.2 Technical requirements for ETCS implementation

- On the basis of studies prepared in 2001 by the Railway Research Institute (Výzkumný ústav železniční, a.s.) for the purpose of the pilot project specification for the ETCS system implementation in conditions on the railways in the Czech Republic, it was decided to equip national railway corridors, i.e. the most exposed lines of the conventional railway system on the territory of the Czech Republic, with ETCS Level 2. This way also the ETCS pilot project was commissioned and implemented in the Poříčany – Kolín section.
- For the project "ETCS – Corridor I, section Kolín – Břeclav state border Austria/Slovakia" ETCS L2 version 2.3.0d is implemented. The ongoing project "ETCS Břeclav – Přerov – Ostrava – Petrovice u Karviné state border Poland" is implemented with ETCS L2 3.6.0. ETCS L2 on other structures will be primarily implemented according to Baseline 3 (depending on the availability of products and above all on the stability of Baseline 3). Vehicles have to be equipped with on-

board ETCS according to Baseline 3 (or according to Baseline 2, but with the option to upgrade it to Baseline 3).

- Fitting of lines with GSM-R, which is necessary for the function of the ETCS Level 2, is already established on the part of the lines concerned and on the rest it will be performed beforehand in accordance with the GSM-R implementation plan. The GSM-R system is and will be realized on the stated lines in accordance with the requirements of the EIRENE specifications for ETCS data transmission.
- On the infrastructure of the lines stated the upgrading was already performed or would be finalized before the ETCS implementation and a new signalling equipment was established (except for certain junctions whose upgrading is being prepared or is already under way). New signalling devices are full-electronic or with the electronic controlling level enabling cooperation with ETCS L2. In those exceptional cases where new interlocking equipment is not available ETCS L2 can be provisionally connected to the existing interlocking equipment, usually to a limited extent (e.g. main train routes only, or other routes significant for transport) – it should be noted that other parts of trackage will be connected when upgrading station signalling equipment. This connection of ETCS L2 will however cause the change of RBC software when the existing signalling equipment will be replaced. Costs of software upgrade have to be included in the future construction of signalling equipment.
- ETCS is considerably dependent on specific parameters, railyard configuration and signalling and traffic control system. Construction activities therefore have to be carefully coordinated to avoid changes of these parameters when ETCS is being installed on a given line section. If this requirement is ignored, it can seriously affect implementation deadlines and cause additional costs or lead to violation of the contract for work.
- **When designing reconstruction or upgrading of railway infrastructure, it is necessary to take into account parameters of ETCS (of adequate application level) that is or will be installed on a given line and to tailor the infrastructure – according to transport and technology requirements – in such a manner as to allow close monitoring of benefits arising from the exclusive operation of ETCS-fitted vehicles and to minimize possible operational restrictions associated with ETCS. Here we have in mind the division of track sections in operating points and open line sections, placement of platforms relative to main signal etc. Design of station and track signalling equipment must take account of exclusive operation of trains under supervision of ETCS. This requirement has to have preference even in cases when a given line section will be temporarily operated with vehicles unfitted with on-board ETCS and the infrastructure will be for the given purpose equipped with trackside signals in stations and open line sections (e.g. until the upgrading of a continuous line section is completed). In such cases the components of signalling equipment needed for the operation of vehicles unfitted with ETCS (allocation of trackside signals etc.) should be adapted to the infrastructure that has been already optimized for the operation controlled by ETCS. The basic idea here is to design railway infrastructure and interlocking equipment (station, track, level-crossing) in holistic way in order to minimize limitations arising from the character of the ETCS system.**
- In the Czech Republic the requirement is to use vehicles equipped with two data GSM-R terminals for the purposes of ETCS. If a vehicle has only one GSM-R data terminal or if one of the two terminals is broken, there is a risk of significant restriction of operation when handing over a vehicle between two RBCs.
- In justified cases (e.g. in cross-border sections, or short or separated sections where ETCS L2 systems cannot be connected due to technical or space constraints) the ETCS L1 system or ETCS with Limited Supervision operational mode (ETCS LS) can be used in the Czech Republic.

- Shunting of vehicles in stations will continue to be controlled with the use of existing technological procedures and previously established means, including the possibility to introduce trackside multiple-aspect signals relevant for shunting, even in sections with exclusive operation of ETCS-fitted vehicles where no trackside multiple-aspect signals relevant for train routes are installed.
- In accordance with point 7.4.3 par. 2 of the Annex of TSI CCS and par. 5 of part II of the Annex 3 of Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended, all new vehicles intended for national service on lines fitted with trackside ETCS must be equipped with functional on-board ETCS.
- Point 7.4.3 par. 2 of the Annex of TSI CCS also requires that on-board ETCS be mandatory for all new vehicles intended for national service on lines that include more than 150 km of a section to be equipped with trackside ETCS within 5 years after the authorisation for placing in service of those vehicles.
- Vehicles have to be equipped with on-board ETCS according to Baseline 3 or at least according to Baseline 2, but with the option to upgrade it to Baseline 3.
- In the Czech Republic, as per point 6.5 of Commission Regulation (EU) 2016/919 and par. 5 of part II of the Annex 3 of Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended, the requirement is to perform compatibility tests of on-board and trackside parts of ETCS (On-board Control-command and signalling and Trackside Control-command and signalling subsystems defined in points 2.3 and 2.4 of Directive (EU) 2016/797 of the EP and of the Council) in order to check technical compatibility between the vehicle and the network of the area of use (on lines fitted with ETCS L2).

3.3.3 Implementation of trackside ATP Class B (system LS) in the Czech Republic

Considering the following facts:

- Trackside and on-board Class A systems (ETCS) must be installed without fail in all Member States, which is required by legislation of the Czech Republic and the EU;
- Introduction of Class B systems significantly hinders interoperability, which is directly contrary to the targets of transport policy of the Czech Republic and the EU and, at the same time, the construction of national Class B system cannot be co-financed from EU funds;
- The level of functionality and safety of Class B train protection system LS used in the Czech Republic is far below that of Class A system (ETCS); ETCS is therefore to be seen in the Czech Republic as a direct replacement of the national ATP system LS;
- Designing infrastructure and signalling equipment (station, trackside and level-crossing) for operation with national Class B system – only with the option to install ETCS later – does not enable optimization of the infrastructure for the operation with ETCS; such an approach leads to a decrease in railway infrastructure capacity, which is, in particular on TEN lines, totally undesirable and inconsistent with the stated objectives of upgrading;
- We cannot require railway undertakings that they equip their vehicles with national system on interoperable lines. In accordance with TSI CCS, new vehicles equipped only with ETCS will be gradually put into operation;
- Parallel installation of Class B system besides mandatory ETCS would mean unjustifiable investments in trackside Class B system and would increase operating costs associated with maintenance of its serviceability;

- Parallel installation of trackside Class B system substantially devalues investments in the construction of trackside ETCS as well as operating costs associated with maintenance of the system serviceability (due to its poor utilization);
- If only Class B is installed, railway undertakings cannot gain full benefits from using railway vehicles fitted with on-board ETCS, on the grounds of:
  - mandatorily installed on-board ETCS not used;
  - additional costs of installation of on-board B Class system or acquisition of STM modules;
  - additional costs of certification of on-board B Class system and testing of vehicles;
- Parallel use of two train protection systems based on radically different operating principles significantly decreases the level of railway operation safety; when running on a line equipped with Class A system (ETCS), different technological procedures are used as well as there are completely different sources of information needed to ensure safe train control as compared with lines fitted with B class system; there is for example different method of driver vigilance control, which poses a risk of undesirable subconscious operation of the equipment in sections fitted with Class B system;

the following principles for the Class B system have been adopted in the Czech Republic

- On tracks that are being fitted with ETCS, **concurrent operation of the existing national Class B train protection system LS is permitted only until the end of migration period** in order to maintain the level of signalling equipment functionality and ensure fluent railway transport with mixed operation of ETCS-fitted and unfitted vehicles. **Trackside Class B system LS must be put out of operation upon the end of migration period** (i.e. right after exclusive operation under supervision of ETCS is launched).
- **In all cases of the first installation of a trackside train protection system (irrespective of line speed):**
  1. **Class A system (ETCS) must be installed exclusively;**
  2. **Class B system (dually with ETCS system) or any other system incompatible with vehicles fitted with on-board ETCS must not be newly installed;**
  3. before the introduction of exclusive operation under supervision of ETCS, the vehicles unfitted with on-board ETCS will be operated in full accordance with effective Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended, at maximum speed of 100 km/h; before the introduction of exclusive operation under supervision of ETCS, the infrastructure will be equipped with appropriate trackside signals, in compliance with infrastructure manager's effective rules, to allow for operation of these vehicles.

  As of 1 September 2017 the abovementioned conditions shall apply without exception to all newly launched investment and non-investment projects.

  The projects under way will be handled as follows: the abovementioned conditions shall apply to all projects whose initiators cannot demonstrate they concluded before 31 August 2017 a contract for processing the documentation for: notification of structure, issuance of the building permit, announcement in summary proceedings or structure realization. The list of projects under way to which the abovementioned conditions do not apply shall be submitted to the Ministry of Transport by 31 October 2017 and each project shall be appropriately justified.

The first installation of trackside train protection system within the meaning of TSI CCS means any installation of trackside train protection equipment on a line section where, as of 1 September 2017, was not built or was not put into operation trackside part of Class B system LS (i.e. sections that are not highlighted green in Figure 6).

In such cases the status quo is not deteriorated in terms of poorer safety and fluency of railway transport – on the contrary, the safety significantly improves thanks to ETCS.

- In order to maintain previous level of signalling equipment functionality and to ensure fluent railway transport until the end of migration period**, the Class B trackside system LS can be refurbished within an investment (of any extent) or non-investment project[8] (hereinafter referred to as "projects") concerning railway infrastructure – but only when the following conditions are met. Fulfilment of these conditions must be clearly demonstrated within the approval process led by the Ministry of Transport.**

  All conditions stated in paragraphs A to C are applicable without exception to all projects newly launched from 1 September 2017.

  The projects under way will be handled as follows: these conditions shall apply to all projects whose initiators cannot demonstrate they concluded before 31 August 2017 a contract for processing of documentation for: notification of structure, issuance of the building permit, announcement in summary proceedings or structure realization. The list of projects under way to which the conditions stated in paragraphs A to C do not apply shall be submitted to the Ministry of Transport by 31 October 2017 and each project shall be appropriately justified.

  A.

  Generally applicable conditions:

  1. **Refurbished trackside Class B system LS may be put into operation one year before the end of migration period at the latest.**

  2. If the date of putting the refurbished trackside Class B system is sooner than one year before the end of migration period, the Class B system must not be realized. Investors have to continuously verify this condition when preparing the project and, if required, remove their request for installation of the Class B system in advance.

  3. All projects that include the construction of a trackside train protection equipment with the date of planned completion and putting into operation after the end of migration period on a given line must be ordered and prepared in such a way that, at the moment of their completion, **only ETCS system could be put into operation and exclusive operation under supervision of ETCS could be launched**.

  4. All refurbishment projects must fulfil the requirement that the trackside of the ATP system LS may be **refurbished only in such a manner as to preserve the system's purpose and extent of operation it had before the refurbishment project**. It means that **Class B system must not be in any way extended to stations, parts of stations or line sections where it was not established and operated before the project was started.** The documentation submitted to the Ministry of Transport for approval must clearly describe the extent to which the Class B system was established and operated at the

[8] As far as non-investment projects are concerned, this does not apply to repairs of existing trackside Class B system LS:
- in sections of a total length below 1 kilometre, or
- for the purpose of quick recovery of operation after accidents or natural disasters.

start of the project and univocally demonstrate that the system will not be extended in any way.

B.

On line sections:

- State border Czech Rep./Slovakia – Břeclav – Brno – Česká Třebová – Pardubice main st. – Kolín – Praha-Libeň – Praha-Holešovice – Kralupy n. Vlt. – Lovosice – Ústí n. L. main st. – Děčín main st. – state border Czech Rep./Germany (except to sections so far unfitted with the Class B system);
- State border Czech Rep./Poland – Petrovice u Karviné – Dětmarovice – Bohumín – Ostrava main st. – Ostrava-Svinov – Hranice na Mor. – Přerov – Otrokovice – Břeclav;
- Česká Třebová – Olomouc main st. – Dluhonice – Prosenice/Přerov;

the refurbishment of the Class B system LS may be considered only in:

a) projects that meet conditions A 1 to 4 and
b) cases where the refurbished trackside Class B system LS will be put into operation by 31 December 2023[9].

The above must be clearly demonstrated when submitting the project for approval by the Ministry of Transport.

C.

On line sections:

- Kolín – Velký Osek – Nymburk main st. – Lysá n. L. – Všetaty – Ústí n. L.-Střekov – Ústí n. L. west (discontinuously equipped section);
- Kolín – Havlíčkův Brod – Křižanov – Tišnov – Brno-Maloměřice;
- State border Czech Rep./Slovakia – Mosty u Jablunkova – Český Těšín – Dětmarovice;
- Branching-off point Koukolná – branching-off point Závada;
- Český Těšín – Havířov – Ostrava-Kunčice – Ostrava centre – Ostrava main st.;
- Ostrava-Kunčice – odbočka Odra – overtaking station Polanka n. O./Ostrava-Svinov;
- Hranice n. M. town – Horní Lideč – state border Czech Rep./Slovakia;
- Beroun – Plzeň – Mariánské Lázně – Cheb;
- Cheb – Tršnice – Sokolov – Chodov;
- Karlovy Vary – Hájek;
- Kadaň-Prunéřov – branching-off point Dubina;
- Branching-off point Chomutov town – Třebušice – Most – Bílina – Řetenice – Ústí n. L. west – Ústí n. L. main st./Ústí n. L. main st. south;
- Oldřichov u Duchcova – Osek;
- Plzeň main st. – Nýřany – Stod (existing line);
- Havlíčkův Brod – Jihlava;

[9] Based on the end of migration period on given lines according to par. 3.3.6.

- Česká Lípa (outside) – overtaking station Žizníkov – Zákupy; overtaking station Žizníkov – Srní u Č. Lípy;
- Předměřice n. L. (outside) – Smiřice (outside);
- Stéblová – Opatovice n. L.-Pohřebačka (outside);
- Přelouč – Heřmanův Městec – Prachovice;
- Studénka – Sedlnice – Mošnov, Ostrava airport;
- Opava-west – Krnov;
- Boří Les – Valtice;
- Designated sections in junction Praha as per Figure 6;
- Designated sections in junction Brno as per Figure 6;

the refurbishment of the Class B system LS may be considered only in:

a) projects that meet condition A 1 to 4 and, at the same time,
b) in case that the trackside Class A system (ETCS) will be activated on a given line section no later than at the moment when the application for test operation[10] or the application for final inspection approval of the installation that includes refurbishment of Class B system LS is submitted. That means that the projects whose part is the refurbishment of the trackside Class B system LS must not be put into test operation or undergo final inspection before the trackside Class A system is put into operation on a given line section (irrespective of the ETCS application level).

The above must be clearly demonstrated as early as when submitting the project for approval by the Ministry of Transport.

Investors who prepare any project on lines as per paragraph C that include building trackside train protection equipment shall in advance request the Ministry of Transport to specify the date of the end of migration period on a given line (line section), based on the expected date of the project completion conveyed by the investor to the Ministry of Transport. The investor shall adjust the conditions of assignment according to actual findings. Migration period for a given line (line section) shall not be longer than 5 years.

The project extent should always be set in such a way so that the project is technically and economically feasible and enables activation and subsequent operation of trackside ETCS. An appropriate length of a given section allowing for construction of ETCS should be selected and continuity with other sections fitted or being fitted with ETCS should be ensured in order to:

- minimize costs of necessary upgrade of ETCS hardware and software when connecting other sections being fitted with ETCS,
- operate ETCS in continuous section – above all to minimize the number of entrances/exits of trains in/from the ETCS area.

Construction of trackside ETCS may be realized as an independent project.

D.

[10] This is not applicable in case of "premature structure utilization" as defined by Act No 183/2006 on town and country planning and building code (Building Act), as amended.

Construction of the trackside Class B system LS may be completed during upgrading of transit railway corridor IV on the line section Praha-Hostivař – Benešov u Prahy – Tábor – České Budějovice – a derogation was granted for this section by Commission Decision No 2010/691/EU. If the date of putting a trackside Class B system into operation (when upgrading any line section) moves in the interval of one year before the end of migration period, the Class B system must not be realized.

- Considering the necessity to ensure desirable railway infrastructure capacity and to minimize ETCS's operational constraints, all projects stated in paragraphs B and C **must be designed in such a way as they allow for exclusive operation of vehicles under supervision of ETCS of selected application level. Station and track signalling equipment shall be designed with respect to exclusive operation of trains under supervision of ETCS even in cases when a given line section will be temporarily (in the migration period) operated with vehicles both fitted and unfitted with on-board ETCS. Components of signalling equipment needed for operation of vehicles without ETCS (allocation of trackside multiple-aspect signals etc.) should be preferentially adapted to operation supervised by ETCS.**
- **Until the exclusive operation under supervision of ETCS is launched, the vehicles unfitted with Class A nor Class B on-board systems will be operated on all line sections stated in paragraphs B to D in full accordance with effective Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended, at maximum speed of 100 km/h.** Before the exclusive operation under supervision of ETCS begins, the infrastructure will be equipped with appropriate trackside multiple-aspect main signals and single-aspect signals, in compliance with effective infrastructure manager's rules, to allow operation of these vehicles.
- As long as trackside multiple-aspect signals will be operated on a line equipped with trackside ETCS, trains fitted with on-board ETCS will be allowed to override a signal at stop, as per effective infrastructure manager's rules. In order to allow for specific conditions of mixed operation of vehicles both fitted and unfitted with on-board ETCS, infrastructure managers and railway undertakings will take appropriate technical and administrative measures to ensure railway transport safety.
- On lines fitted with ETCS Level 2, trackside multiple-aspect signals may be fully operated until the introduction of exclusive operation of vehicles under supervision of ETCS (i.e. until the end of migration period).
- **Since the abovementioned constraints arising from operation of trains fitted and unfitted with systems of Class A and Class B are undesirable, in particular with respect to infrastructure capacity and operational safety, it is imperative to keep the period of migration to exclusive operation under supervision of the Class A system (ETCS) as short as possible. Every effort must be devoted to installation of the Class A system, especially to fitting vehicles with on-board ETCS. All funds saved due to the fact that Class B was not established nor operated, should be directed to the abovementioned area.**
- **As Class B systems significantly hamper the interoperability, it is important to avoid creating additional obstacles to interoperability by, for example, altering these Class B systems (national ATP system LS) or by introducing new systems which are not compatible with on-board Class A system.** Any other approach would be in conflict with TSI CCS.

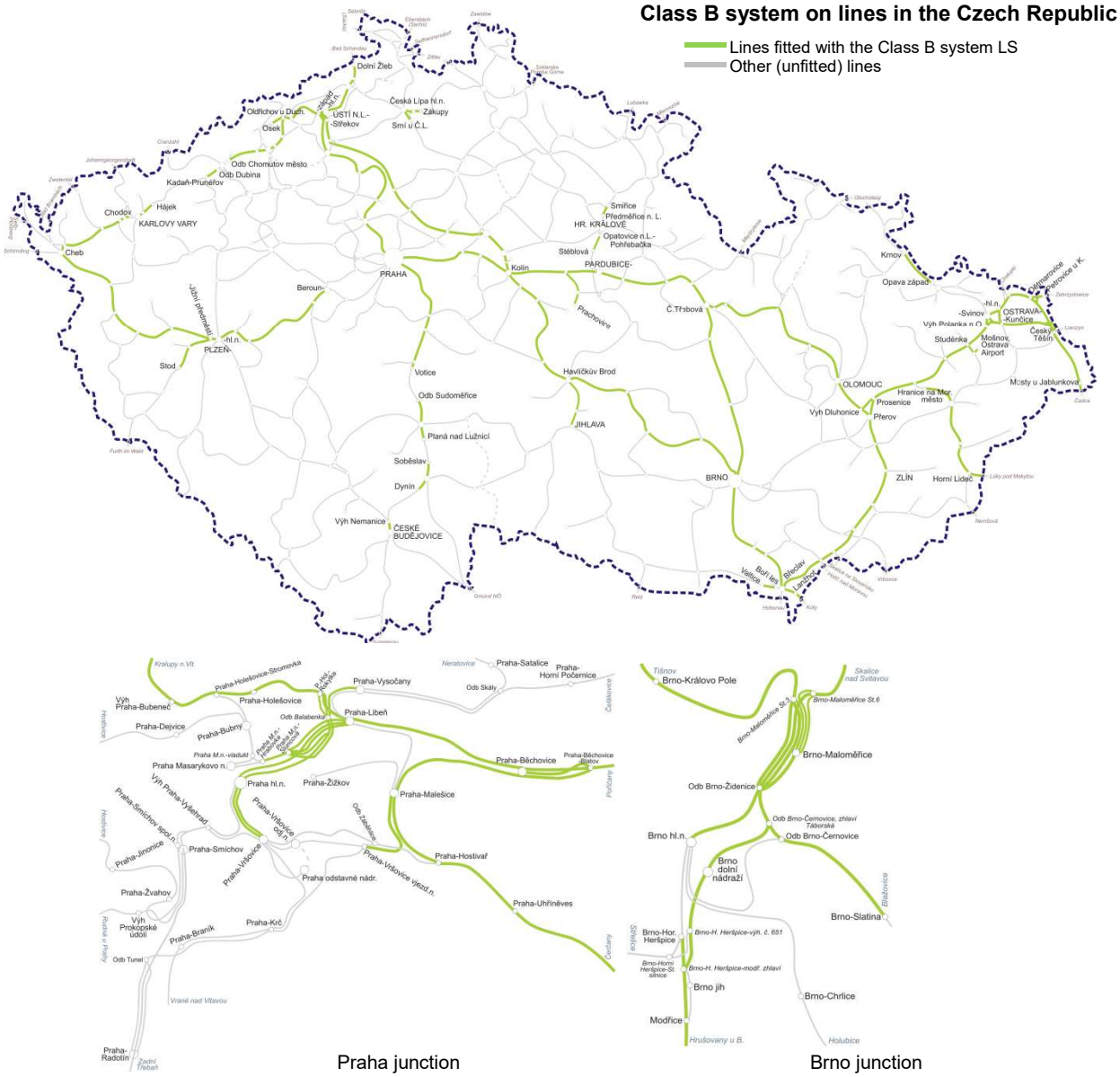

Figure 6: Distribution of the trackside Class B system LS in the Czech railway network (as of 1 September 2017)

3.3.4 Availability of Specific Transmission Modules (STM) in the Czech Republic

- Specific Transmission Modules (STM) enable Class A on-board systems to operate on Class B infrastructure. Point 7.4.4 requires that NIP ERTMS must include information about availability of STM in each Member State.
- For the national Class B system LS which is today operated in the Czech Republic specific transmission module STM LS and the interface between on-board ERTMS/ETCS and the Class B system LS based on devices MIREL VZ1 and MIREL STB are available. The transition between ETCS and Class B train protection is not realized via standardised interface described in point 4.2.6.1 of the Annex of TSI CCS (Notified body opinion No 1714 ref. VUZ KAO-192/2016 from 29 June 2016 declares that the device has no other requirements for the control-command and signalling trackside subsystem in the Czech Republic as per point 4.2.6.1 of TSI CCS).

- Considering the fact that the national Class B system will not be refurbished or extended any more in the Czech Republic, the need for STM modules will decrease.

3.3.5 ETCS implementation strategy and planning

- Implementation strategy is based on the fact that ETCS will be implemented mainly in order to improve operation safety and, in connection with appropriate infrastructural measures and arrangement of station and track signalling equipment, to increase line capacity in congested sections.
- The implementation rate is based first of all on the accessible volume of financial means, not only in the trackside part, but above all in the area of vehicles equipment with on-board part of the system.
- In the view of ETCS implementation expensiveness it is necessary to focus the implementation effort in this planning period, in accordance with TSI CCS, in particular on lines of the core European railway network that shall be equipped as required by Commission Implementing Regulation (EU) 2017/6. From the point of international transport this is the most important part of lines to be equipped with ETCS in the Czech Republic.
- Like in GSM-R system, the construction of trackside ETCS and equipment of vehicles with on-board ETCS should be implemented simultaneously in order to significantly improve safety of train transport and avoid wasting investments in infrastructure by not using it or not taking its other advantages (e.g. higher line capacities due to shorter block sections, line speed exceeding 160 km/h, application of advanced automation system of train transport operation and train movement control). **The goal is to keep period of migration to exclusive (100 %) operation of ETCS as short as possible so that the benefits of ERTMS could be soon reaped**. This will also facilitate putting the national train protection system LS out of operation and shutting down low-frequency 75 Hz or 50 Hz track circuits that do not meet future interoperability requirements regarding EMC.
- For operational reasons in the view of reaching the target state of ETCS implementation it will be necessary to equip also alternative branches of freight corridors or by-pass routes of individual sections of transit railway corridors. This applies for example to the lines Kolín – Nymburk – Mělník – Děčín east – Děčín-Prostřední Žleb and Kolín – Havlíčkův Brod – Brno. However, these lines have to be first upgraded or optimized before ETCS will be launched.
- The next step is the installation of ERTMS (GSM-R and ETCS L2) on lines of European freight corridors that are outside the network of national transit railway corridors (e.g.: Plzeň – Domažlice, Hranice na Moravě – Horní Lideč etc.), and on upgraded lines with speed limit exceeding 100 km/h (Pardubice – Hradec Králové, Velký Osek – Hradec Králové – Choceň etc.) and, generally, on all upgraded lines. The implementation plan including the presumed workflow is presented in Table 4. In justified cases (e.g. in cross-border sections, or short or separated sections) where ETCS L2 systems cannot be connected due to technical or space constraints, less expensive ETCS L1 with appropriate operational properties will be alternatively used.
- **For future equipment of further lines with speed limit below 100 km/h less expensive ETCS L1 will be again implemented, possible with the option to use Limited Supervision operational mode (ETCS LS) whose specification is part of Baseline 3. This step may, beside the achievement of interoperability, bring significant increase of railway transport safety on these lines, as mostly they are not equipped with the national ATP system LS.**
- As soon as the European Commission approves new TSIs that include ERTMS components based on so far unused technologies (e.g. safe localization of trains using GNSS, new

generation radio system etc.), these components – prior to putting them into routine operation – shall undergo pilot verification. An appropriate legislation has to be prepared too.

- Similarly, after the respective specification will be approved in future, the utilization of ETCS L3 can be considered on functionally separated lines where only independent traction vehicles or traction units (i.e. trains whose integrity can be easily checked) are used. These progressive trends could not be implemented until on-board ETCS equipment will be common part of vehicles (only in this way they can become usable on nation-wide and regional rail systems in the Czech Republic).
- For objective reasons the socioeconomic benefits of projects ensuring the implementation of trackside ETCS cannot be fully monetized. Therefore it is not appropriate to evaluate cost-effectiveness by standard CBA method in every case. If cost-effectiveness is not demonstrated by CBA[11], other method of economic assessment (as per implementing guidelines for evaluation of effectiveness of transport infrastructure projects) will be used according to the directive of the Ministry of Transport No V-2/2012 *"Directive governing the procedures of the Ministry of Transport, investor organizations and the State Transport Infrastructure Fund during the preparation of investment and non-investment activities of the transport infrastructure, financed without the participation of the state budget"*. Funding gap will be established only by means of financial analysis of the project. If an alternative without project cannot be defined, or if ETCS implementation is mandatory and results from the EU mandatory legal regulations or from this implementation plan, then only balance sheet of investment and operating costs (including material profits generated by the project during the economic life cycle of the investment) will be developed.
- The development of ETCS on TEN network lines in the planning period 2017–2023 will be primarily funded from CEF fund (core network lines), or within the Operational Programme Transport or SFDI (State Transport Infrastructure Fund). The plan of funding of future development will be updated based on the current budgetary considerations of the EU/Czech Rep.
- Co-financing of equipment of rail vehicles with on-board ETCS will amount up to 85 %. Details will be established by respective calls of the Ministry of Transport of the Czech Republic.

[11] Only if it has been proved that the project is not cost-effective due to the construction of ETCS. However, this procedure cannot be directly applied to projects of reconstruction, optimization, upgrading etc. of lines where the construction of ETCS is just one of the project's components. For details see implementing guidelines for evaluation of effectiveness of transport infrastructure projects issued by the Ministry of Transport of the Czech Republic.

Table 4: ETCS implementation plan

Pos.	Line	Length ***) (km)	On-board parts *) (pcs)	Workflow		Mandatory deadline of ERTMS application **)	Note
				End of preparation	Realization		
1.	Kolín – Břeclav - state border Austria/Slovakia	280	250	2012	2012 - 2018	31/12/2018	Realization
2.	Kralupy nad Vltavou (outside) – Praha – Kolín	110	100	2015	2018 - 2020	31/12/2020[13)]	Preparation
3.	State border Czech Rep./Germany – Dolní Žleb – Kralupy nad Vltavou	120	100	2020	2021 - 2023	31/12/2023	Preparation
4.	Petrovice u Karviné state border Czech Rep./Poland – Přerov – Břeclav	210	130	2016	2017 - 2020	31/12/2020	Realization
5.	Praha-Uhříněves – Votice	60	40				1)
6.	Votice – České Budějovice	110	50				1)
7.	Česká Třebová – Přerov	110	50	2017	2018 - 2021	31/12/2021	2)
8.	Plzeň – Cheb state border Czech Rep./Germany	120	40	2018	2019 - 2021	31/12/2022[14)]	
9.	Beroun – Plzeň	70	40	2019	2020 - 2022	31/12/2030	3)
10.	Dětmarovice – Mosty u Jablunkova state border Czech Rep./Slovakia	60	20	2019	2020 - 2022	31/12/2030	4)
11.	České Velenice state border Czech Rep./Austria – České Budějovice – Horní Dvořiště state border Czech Rep./Austria	120	50	2020	2021 - 2022		
12.	Ústí nad Orlicí – Lichkov state border Czech Rep./Poland	40	20	2020	2021 - 2022		4)
13.	Kolín – Nymburk – Mělník – Děčín east – Děčín-Prostřední Žleb	160	100	after 2020	after 2023	31/12/2030	4)
14.	Kolín – Havlíčkův Brod – Brno	200	100	after 2020	after 2023		4)
15.	Praha – Lysá nad Labem	40	30	2020	2021 - 2023	31/12/2030	4)
16.	Praha-Bubny – Praha-Ruzyně – Praha-V. Havel Airport/Kladno	40	20	after 2020	after 2023		4) 5)
17.	Praha – Beroun	50	30	after 2020	after 2023	31/12/2030	4)
18.	Plzeň – Domažlice – state border Czech Rep./Germany	80	40	after 2020	after 2023	31/12/2030	4) 18)
19.	Pardubice – Hradec Králové	30	20	after 2020	after 2023		4)
20.	Plzeň – České Budějovice	140	50	after 2020	after 2023		4) 12)
21.	Brno – Přerov	90	60	after 2020	after 2023	31/12/2030	4)

Pos.	Line	Length ***) (km)	On-board parts *) (pcs)	Workflow		Mandatory deadline of ERTMS application **)	Note
				End of preparation	Realization		
22.	Hranice na Moravě – Horní Lideč – state border Czech Rep./Slovakia	70	30	after 2020	after 2023	31/12/2030	4)
23.	Praha junction (completion)	40	20	after 2020	after 2023		4)
24.	Český Těšín – Ostrava-Svinov	50	20	after 2020	after 2023		4)
25.	Velký Osek – Hradec Králové - Choceň	100	40	after 2020	after 2023		4) 12)
26.	Cheb – Karlovy Vary - Chomutov	120	50	after 2020	after 2023		4)
27.	Ústí nad Labem – Chomutov, Ústí nad Labem – Úpořiny – Bílina	110	50	after 2020	after 2023		4)
28.	Protivín – Písek – Písek town, Putim – Ražice	30	10	after 2023	after 2023		6)
29.	Boskovice connecting track	5	4	after 2020	after 2023		7)
30.	Blažovice – Veselí nad Moravou	70	40	after 2020	after 2023		8) 12)
31.	Šakvice – Hustopeče u Brna	7	4	2019	2020 - 2021		9)
32.	Židlochovice – Hrušovany u Brna	3	2	2019	2020 - 2021		10)
33.	Ostřešany connecting track	10	4	after 2020	after 2023		11)
34.	Olomouc – Uničov	30	10	2018	2023		15)
35.	Uničov – Šumperk – Zábřeh na Moravě	40	10	after 2020	after 2023		15)
36.	Brno junction	40	10	before 2020	2023		16)
37.	Otrokovice – Zlín – Vizovice	30	10	2019	after 2023		17)
	Total length:	**2,995**	**1,654**				

1) A possible prolongation the derogation granted by Commission Decision No 2010/691/EU until 31 December 2018 is now being negotiated with relevant EU bodies.

2) Necessary coordination with the project "Reconstruction of railway station, 2nd structure".

3) Depends on the completion of the Ejpovice tunnel.

4) The stated ETCS structures will be realized depending on the progress of upgrading of a given line section.

5) The construction in line section Praha-Ruzyně – Praha-V. Havel Airport is being prepared for exclusive operation under supervision of ETCS after the start of operation without trackside multiple-aspect signals.

6) Based on the approved feasibility study – depends on the progress of optimization structures.

7) Depends on the progress of construction of "Boskovice connecting track".

8) Based on the approved feasibility study. 6) Depends on the progress of individual structures of the reconstructed line section Blažovice – Veselí n. M.

9) The intention of the construction project "Upgrading and electrification of the line Šakvice – Hustopeče u Brna" was approved.

10) The intention of the construction project "Upgrading and electrification of the line Hrušovany u Brna – Židlochovice" was approved.

11) Depends on the progress of construction of "Ostřešany connecting track".

12) The approved feasibility study requires that the national Class B system LS will not be constructed in parallel with ETCS.

13) Section Praha – Kralupy nad Vltavou until 2023.

14) Section Cheb – Cheb state border Czech Rep./Germany

15) Depends on the progress of realization of the structure "Electrification and upgrading of the line Uničov (inclusive) – Olomouc".

16) Shall be coordinated with the reconstruction of signalling equipment in Brno main station.

17) Depends on the progress of realization of the construction "Upgrading and electrification of the line Otrokovice – Vizovice".

18) The construction in line section Plzeň – Stod is being prepared for exclusive operation under supervision of ETCS after the operation without trackside multiple-aspect signals will be started.

*) Approximate values

**) The latest deadline for equipment of the line with ERTMS established by Commission Implementing Regulation (EU) 2017/6 for core network corridors.

***) Approximate values

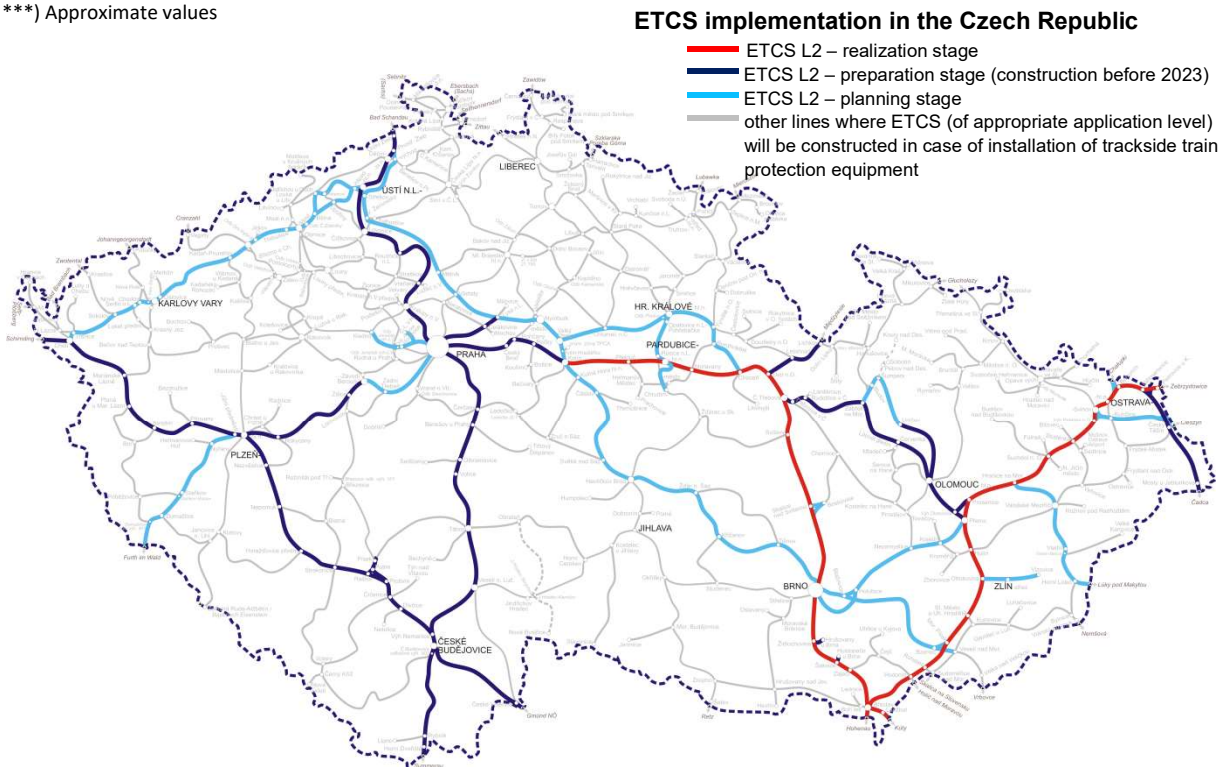

Figure 7: The planned stages of ETCS implementation from 2017 onwards

From 2018 onwards, the infrastructure manager SŽDC will each year, by 31 December at the latest, submit to the Ministry of Transport an updated schedule of preparation and realization of projects that are shown in the table with the note "after 2023".

3.3.6 Strategy of transition from the national ATP system LS to ETCS

In the Czech Republic, the following facts and principles were taken into account when developing the strategy of transition from the national Class B train protection system (system LS), or from lines unfitted with trackside train protection, to the Class A system (European Train Control System, ETCS).

- Benefits of ETCS:
  - **significant increase of functionality and safety of railway transport compared to the Class B system LS** (importantly, ETCS substantially reduces the risk of overriding a signal at stop or exceeding current, permanent or temporary speed limit),
  - minimum of accidents due to driver's failure (overlooked or ignored signal),
  - lower dependency of safe train movement on human factor both on trackside and on-board level,
  - faster movement of trains thanks to more precise speed profiles,

- an opportunity to use speed profiles for vehicles with permitted cant deficiency where speed indication signals cannot be used in order to reduce the effect of speed drops on traction power consumption and to achieve shorter running times,
- traction power savings due to fluent running of trains which results from early information on the profile of a line,
- after the completion of ETCS in neighbouring countries, higher productivity of vehicles with the opportunity to use them for operation on long international served lines,
- simpler operation of vehicles in foreign countries (no other national Class B systems need to be installed),
- ETCS is one of the preconditions of operating trains at speeds exceeding 160 km/h which will be used on newly upgraded lines, particularly on the lines of Rapid Service connections.

➢ Mandatory application of ETCS has the following advantages:

- significantly improved safety resulting from the fact that vehicles unfitted with on-board ETCS will not gain access to lines equipped with trackside ETCS,
- higher capacity of overloaded lines thanks to shorter intervals between trains (achieved by setting shorter block sections) – this benefit is however not fully reaped until all vehicles are mandatorily fitted with on-board ETCS (an unfitted vehicle would delay not only itself, but also other vehicles),
- removal of a train route under restrictions (by means of holding the train being overtaken by not granting it ETCS movement authorization),
- an opportunity to remove some trackside signals (elimination of undesirable concurrence of two methods of communication with driver; reduction of operating costs),
- the ground for high-quality operative traffic control (controller system has information about actual position and speed of all trains),
- the ground for implementation of advanced forms of automated train driving (ATD) – driving system has information about all trains and can influence their movement according to traffic control requirements.

➢ On-board ETCS improves not only the safety of vehicles, or trains, but also the whole system. However, this potential is not fully realized until all vehicles are mandatorily fitted (an unfitted vehicle would endanger not only itself, but also other vehicles).

➢ Widespread implementation of ETCS improves the safety also by introducing train protection system into larger part of railway network than the national Class B system LS.

➢ The following data should be taken into account when considering economic aspects of ETCS implementation:

- specific costs of trackside ETCS are approximately CZK 4.5 million per km[12],
- specific costs of trackside GSM-R are approximately CZK 3 million per km (GSM-R is a precondition of ETCS L2 application),
- depreciation period of trackside of radio communication systems and interlocking systems is 20 years (see Implementing guidelines for evaluation of investments in railway infrastructure, published in the Journal of the Ministry of Transport No 11/2013),

[12] This is only an estimate based on experience with previously realized projects. Actual costs can be estimated with the help of tools defined by Act No 134/2016 Coll. on Public Procurement, as amended (e.g. market consultation).

- costs of on-board ETCS are approximately CZK 10 million in case it is installed to **new vehicles** which are manufactured in such a way to be technically fitted for ETCS installation,
- costs of on-board ETCS are approximately CZK 14 million in case it is installed to **vehicles which are not manufactured in such a way to be technically fitted for ETCS or in other more complicated cases** (problems with placement of on-board components in a vehicle, cabling installation etc.),
- the specific amount of on-board ETCS per 1 km of ETCS-fitted line depends on traffic intensity, but the mean value is approximately 0.6/km (this is true for uninterrupted served lines hundreds of kilometres long; in the beginning this proportion is higher due to the fact that the system is used only in a part of train journey – this value decreases with increasing length of trackside installation, see also experience with GSM-R),
- the present state of technology make it possible to equip integrated traction units with only one set of on-board ETCS (as opposed to the practice used in case of the national Class B system LS or in case of the pilot project),
- specific costs of on-board ETCS are approximately CZK 6 to 8.4 million per km, taking account of the above costs of equipment and specific amount of on-board equipment 0.6 per km.

- The requirement to equip all new vehicles with on-board ETCS is defined in TSI CCS, points 7.4.2 and 7.4.3 of its Annex. Decree No 173/1995 Coll. of the Ministry of Transport, issuing the railway transportation rules, as amended, requires that driving rail vehicles and driving trailers – that are intended exclusively for national service and are newly approved to be put into operation after 1 January 2017 – are fitted with functional compatible on-board ETCS, if they are to be operated on lines equipped with approved trackside ETCS, irrespective of the length of the fitted section. **From 1 January 2020, this obligation will apply also to mobile railway infrastructure construction and maintenance equipment, except for vehicles that may be independently operated in stations or in line sections on blocked (closed) tracks only.**
- According to the TSI CCS, the state (i.e. the Ministry of Transport of the Czech Republic) may decide that vehicles without functional on-board ETCS are denied access to ETCS-fitted lines.
- Based on the TSI CCS, the NIP ERTMS approved in 2014 and the ERTMS European Deployment Plan, strategy of transition from the national Class B system LS to ETCS system suggests combining investments in fitted lines and in equipment of vehicles – trackside equipment thus prepares the ground for the operation of fitted vehicles. Operation of ETCS in the migration period is ensured by using dual trackside equipment which allows concurrent operation of ETCS-fitted vehicles and vehicles equipped with the national LS system only.
- **In order to ensure railway transport safety and secure cost-effectiveness of investments, on-board ETCS should be installed in vehicles at least at the same time as the lines are being equipped with trackside ETCS. Thus it will be possible to start exclusive (100 %) operation under supervision of ETCS immediately after trackside ETCS installations in sufficiently long integrated line sections are completed.** The growth of quantity of ETCS-vehicles will occur due to both new vehicles and previously operated vehicles.

Considering these fact the following principles of migration to ETCS were adopted:

- **The period of migration to the ETCS system is defined as a time interval between putting ETCS into operation and introducing operation of all trains exclusively under supervision of ETCS, irrespective of train speed. No train led by a vehicle unfitted with compatible on-board ETCS can enter a given line section after the end of migration period.**

- **Migration period should be kept as short as possible in order to maintain safety and avoid other negative operational effects. Migration period for a given line (line section) shall not be longer than 5 years. The date of the end of migration period is determined by the Ministry of Transport.**
- **The date of putting ETCS into routine operation (which is not the same thing as the exclusive operation of all vehicles under supervision of ETCS on a given line) will be announced at least 6 months before the infrastructure manager starts the routine operation (conditions of using the ETCS system will be announced in the same way).**
- **Once the migration period is over, trackside part of the national train protection system LS must be completely put out of operation in order to fully use benefits of ETCS in terms of improved safety and efficiency of rail traffic management.**
- **Fitting of vehicles with on-board ETCS will be supported by the state (in accordance with the Transport Policy of the Czech Republic for 2014 – 2020) by combining two basic tools:**
  - **systematic funding of purchase and installation of on-board ETCS granted to railway undertakings (registered in the Czech Republic) and primarily covered from EU funds – basic measure;**
  - **granting a discount on the charge for the use of railway infrastructure to the amount stated in "The Network Statement on nationwide and regional rail networks" (as per Directive No 2012/34/EU of the EP and of the Council) – complementary measure.**
- **The first sections with exclusive operation of trains under supervision of ETCS from 1 January 2025 will be:**
  1. **Děčín – Praha – Česká Třebová – Brno – Břeclav;**
  2. **Břeclav – Bohumín;**
  3. **Česká Třebová – Přerov.**
- This method will be gradually used also on other lines being equipped with ERTMS. Benefits of this strategy are as follows:
  - Fulfilment of conditions for financing railway upgrading constructions from EU funds
  - Significant improvement of railway transport safety (minimization of accidents due to driver's failure) in the shortest possible time.
  - Minimization of damages due to accidents in the shortest possible time.
  - Increase of capacity (by means of shorter block sections and arrangement of station and track signalling equipment) on the most overloaded railway lines in the shortest possible time.
  - Shorter period of mental strain for drivers who have to simultaneously follow information obtained from ETCS and trackside multiple-aspect signals that are necessary for train driving.
  - Faster train transport due to better fluency of running and higher maximum authorized speeds that will not be signalled by single-aspect signals any more.
  - Energy savings due to fluent running of trains.
  - Achievement of interoperability to convert transit transport from roads to railway by mandatory equipment of vehicles with only one type of train protection (ETCS).

- Achievement of interoperability to convert transit transport from roads to railway by preparing the ground for future replacement of track circuits on lines of European corridors by more durable vehicle detection devices.
- Prevention of economic losses due to depreciation of unused trackside ETCS (depreciation of necessary investments in stationary ETCS is during the life-cycle of trackside ERTMS several-fold higher than investment in the purchase of on-board ETCS).
- Development of a continuous system that can be gradually applied to the whole economically active railway network in the Czech Republic.
- After the end of migration period, **trains led by vehicles unfitted with functional on-board ETCS of an appropriate level and version, including trains of foreign undertakings, will not be granted access to ETCS-fitted lines.** Once the migration period is over, trackside part of the national train protection LS can be completely put out of operation so that the benefits of ETCS in terms of improved safety and efficiency of rail traffic management could be reaped – all this is in accordance with Regulation (EU) No 1315/2013 of the EP and of the Council, Commission Implementing Regulation (EU) 2017/6, Directive (EU) 2016/797 of the EP and of the Council, Directive (EU) 2016/798 of the EP and of the Council and Commission Regulation (EU) 2016/919.

➢ **During construction of new or upgraded lines (that will not be equipped with the national LS train protection system any more) only ETCS-fitted sections will be put into operation. On these sections only ETCS-fitted vehicles will be operated. The following sections are being prepared for exclusive operation of ETCS-fitted vehicles:**

- **Railway connection Prague – Václav Havel Airport (the operation in the section Praha-Veleslavín – Praha-V. Havel Airport will be launched without trackside multiple-aspect signals);**
- **Plzeň – Domažlice – state boder Czech Rep./Germany (the operation in the new section Plzeň – Stod will be started without trackside multiple-aspect signals).**

➢ **Other new or upgraded lines will be prepared for exclusive operation of ETCS-fitted vehicles within the system of the so-called Rapid Service connections (e.g. the line section Brno – Přerov).**

➢ **After the operation of ETCS system will be started in these sections, the infrastructure manager will allow using allocated infrastructure capacity only by traction units, driving trailers or special powered vehicles for which keys were issued and activated – these keys are used to log in to RBC(s) under conditions established in "The Network Statement on nationwide and regional rail networks" issued by the infrastructure manager.**

3.3.7 Overview of potential factors which might have impact on the implementation progress

➢ In order to identify, minimize or eliminate possible risks, the pilot ETCS project Level 2 was launched in the Czech Republic. All the findings and experience obtained were evaluated and used for further ETCS system implementation in the Czech Republic. The benefits of ETCS implementation will be best used if the system will be operated in sufficiently long integrated line sections.

➢ The critical factor is funding of development of both trackside and on-board ETCS. In order to fulfil the NIP ERTMS, approximately 170 km of lines and 135 vehicles should be fitted with ETCS each year. This requires a continuous financial flow amounting to approximately CZK 765 million per year (not counting construction of GSM-R and adaptation of infrastructural signalling equipment), plus approximately CZK 1.62 billion per year (providing that one half of

ETCS will be installed in new vehicles and one half in older vehicles that were not manufactured to be technically fitted for ETCS). This equals to approximately CZK 2.385 billion per year between 2017 and 2023 and also from 2023 onwards. At the same time, actual progress of installing on-board equipment in vehicles of railway undertakings should be taken into account.

- Another important thing is testing of vehicles fitted with on-board ETCS in relation to respective trackside ETCS.
- The delays in the selection of the contractor within the public commercial tender caused by protests of the unsuccessful applicants represent further factor with negative impact on the time schedule of ETCS implementation.
- Delays of infrastructure upgrading constructions, within which the basic conditions for subsequent line construction of ETCS system are prepared (new signalling equipment, laying optical fibre cables, power supply etc.), may also have a negative influence on the ETCS implementation schedule.

For risk assessment purpose the SWOT analysis of ETCS implementation was elaborated (see Appendix 1). The analysis shows that if strengths and opportunities are to be optimized and weaknesses and threats reduced, investments in vehicles and infrastructure should be coordinated in such a manner as to keep migration period as well as the period of ETCS implementation as short as possible so that the benefits of ETCS are reaped soon.

It is obvious that we have to focus on **continuous development of staff qualification in the area of ERTMS** across all professions (i.e. design, operational and managerial staff).

We have to also address many highly professional tasks, both on the part of railway infrastructure (ETCS implementation in railway junctions, terminal stations, shortened block sections etc.) and vehicles (braking curves, rapid change of control station, change of train configuration). In this sense, we should communicate with representatives of railways in neighbouring states that solve similar problems.

3.3.8 ETCS implementation – Summary

All investment projects of railway infrastructure should be prepared in a way as to allow the application of train protection equipment of Class A (ETCS) which remains an exclusive train protection system for the Czech Republic. Implementation of ETCS in the Czech Republic shall significantly improve railway transport safety compared to the existing Class B system LS. Between 2017 and 2023, ETCS should be implemented at least on 1,200 km of lines and 950 vehicles, which is 170 km of lines and 135 per year for the period of seven years. Indeed, this is challenging but achievable objective. Priority should be given mainly to overloaded transit railway corridor I and then to transit railway corridor II and the connecting line Přerov – Česká Třebová (part of transit railway corridor III). We have also meet our liabilities to the EU by implementing ETCS in the section Strančice – České Budějovice (part of transit railway corridor IV) and fitting other lines as per Commission Implementing Regulation (EU) 2017/6.

In the next step, our efforts will concentrate above all on ETCS implementation on main by-pass routes of transit railway corridors. Achievement of this depends on realization of other investment projects in the area of infrastructure upgrading, above all upgrading of junctions that is realized gradually and should be therefore coordinated with construction of ETCS.

New structures must be designed in such a way as they allow for introduction of ETCS and avoid undesirable drop of infrastructure capacity, which might undermine goals and economic effectiveness of upgrading projects.

An important step in the Czech Republic is the definition of migration period during which railway undertakings can plan, prepare and implement the process of fitting their vehicles with on-board ETCS equipment. Fulfilment of this intention strongly depends on the financial support from the state and EU funds. Concurrent equipment of tracks and vehicles proved successful during implementation of GSM-R and should be used also in case of ETCS. Migration period for ETCS system shall not be longer than 5 years.

This approach will allow us, in a reasonable timeframe, to accomplish complete transition from the national LS train protection system to the uniform European train protection system ETCS and to derive all benefits of this step in the area of interoperability, especially in terms of improved safety and effectiveness of rail traffic management in the Czech Republic.

Keeping in mind that only successful implementation of exclusive operation of vehicles under supervision of ETCS will ensure the improvement of rail transport safety and that parallel operation of Class B system dually with Class A system is strongly undesirable from the safety, technical, transport, technological and economic perspective, it is imperative that any investment or non-investment projects concerning the Czech railway infrastructure must not lead to implementation of Class B systems and systems incompatible with on-board ETCS-fitted vehicles (this applies to the first installation of trackside train protection). In sections where the Class B system LS was operated before the start of an investment or non-investment project the Class B system LS may be refurbished only under special conditions as per paragraph 3.3.3 of this document. Nevertheless, Class B systems must not be extended to other stations and line sections. Trackside Class B system LS must be put out of operation right after exclusive operation under supervision of ETCS is introduced.

Full operation of trackside multiple-aspect signals on ETCS L2-fitted must be ended no later than at the moment of introduction of exclusive operation of vehicles under supervision of ETCS. Trackside ETCS must be always implemented in view of the requirements of transport technology for ensuring required railway infrastructure capacity – temporary placement of trackside multiple-aspect signals must not compromise this fact.

Implementation of ERTMS will undoubtedly result in overall and substantial technological development of the railway.

4 Conclusion

The approach of the railway organizations in the Czech Republic to the ERTMS system implementation is active and it is fully supported by the state administration authorities.

An accelerated realization of the ERTMS project in the Czech Republic will contribute especially to:

- improvement of an economically important position of the railway in transit transport,
- significant improvement of railway transport safety as compared to the existing national Class B system,
- minimization of the number of railway accidents and their direct results (damages) and indirect consequences (transport irregularities, cancelled trains, route diversions, delays),
- higher capacity of railway infrastructure thanks to considerate designing and allowing for parameters of ETCS (the potential for conversion of transport form roads to railway),
- energy savings due to fluent running of trains,
- inputs necessary for safe driving of a vehicle are available right in the driver's cab, which eliminates driver's dependence on trackside signals, particularly in bad weather,
- higher speed of trains (also in connection with line upgrading),
- higher level of railway transport operational processes efficiency,
- achievement of interoperability in accordance with the transport policy of the EU and Czech Republic, fulfilment of European law,
- respecting the EU goals, which is a precondition of financing of railway structures,
- opportunity to use GSM-R for other applications, improving services for customers
- the ground for the achievement of interoperability in the area of detection systems.

The proposed time schedule is conditioned by:

- early realization of upgrading and optimization constructions that allow introduction of ERTMS,
- provision of necessary funding of trackside and on-board GSM-R and ETCS,
- introducing motivators and effective financial support of fitting vehicles with on-board GSM-R and ETCS,
- effective internal and external information campaign initiated by railway transport sector and, above all, by infrastructure manager to continuously improve expertise,
- active approach of educational institutions – education of graduate students in terms of designing, construction and utilization of ERTMS,
- systematic development of qualification of staff across all professions (project organization, SŽDC, railway undertakings, industry, state administration),
- cooperation (exchange of experience) with representatives of foreign railways implementing ERTMS and entities that collaborate with them.

Appendix 1: SWOT analysis concerning the ETCS system implementation

Strengths	Weaknesses
• significantly improved safety as compared to the status quo • higher usable capacity of railway infrastructure • higher speed of train running • energy savings due to fluent running of trains • equal transport conditions for all transportation systems – operation without restrictions and delays • enhancement of the traffic management in the railway corridor • more effective use of the corridor capacity • no changeovers of traction units on state borders; operation of electric units across multiple countries • shorter running times, improved safety and reliability of railway transport • project realization in existing technological buildings and on existing lines • environment-friendly system (lower energy consumption, minimum number of accidents) • positive effect on landscape character (an opportunity to reduce the number of signals and cablings in future) • project supported by the EU and rail sector	• possible change of the investment costs amount after signing contracts for realization • ETCS L2 has to be preceded by GSM-R, signalling equipment has to be often upgraded – risk of delayed implementation • varying periods of implementation of the system in follow-up sections • long period of migration from the existing national signalling systems to ETCS • potential benefit might be postponed by the current lack of vehicles that are able to use the system • wasting of investments in trackside ETCS when on-board ETCS equipment of vehicles is delayed • certain benefits are not achieved until 100 % of vehicles are fitted with on-board ETCS (exclusive operation)
Opportunities	**Threats**
• railway freight transport can get competitive advantage over road transport • potential reduction of existing road traffic due to its partial transfer to railway freight corridors • general development of the railway transport • customer services enhancement • new quality offer for railway undertakings; higher attractiveness of corridors • technological development • generation replacement of signalling equipment • the ground for development of higher levels of Automatic Train Driving (ATD) • the ground for development of higher levels of Automatic Train Operation (ATO)	• economic and legal issues connected with contracts granting • possible technical problems with the feasibility of new products • problems with installation and testing the system in practice which lead to line blockages • lack of financial resources for the system implementation in a reasonable timeframe • inappropriate habits of drivers operating concurrently two systems during migration period, • vehicles must be equipped with two on-board devices (or STM modules) during gradual construction of trackside ETCS

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