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INTEROPERABILITY OF RAILWAY TRANSPORT – IRICoN 2016

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FOREWORD

The papers of the Scientific Student Conference Interoperability of Rail Transport – IRICoN 2016 are concerning new results coming from the project Interoperability of Railway Infrastructure Competence Network (IRICoN) which was coordinated by Technical University in Brno in collaboration with the Technological platform „Interoperability of Railway Infrastructure" and was closed in 2015. The project was supported by the operational programme of the Ministry of Education, Youth and Sports - Education for Competitiveness under the priority axis - Tertiary Education, Research and Development. The aim of the project was to improve the quality of human resources for research and development and improve training of target groups, consist of students and young professionals in the field of interoperability of railway infrastructure. Necessity of the project was supported by the research interests of students and academic staff of technical universities and research institutes.

The project enables to involve young experts in advisory groups for members of the governing organs of the European network interoperability, which was established for the preparation and implementation of the interoperability of the European rail system.

The project has set up expert groups called the Mirror Groups, which reflect the activities of the trans-European rail networks in the areas of: (i) Infrastructure, (ii) Management and Safety, (iii) International Railway Research Board, (iv) Energy, (v) System Solutions and (vi) Research.

Preparing members of the target groups took the form of: (i) traineeships for young researchers at foreign universities or at European institutes aimed in railway interoperability (ii) organizing workshops and training sessions with the participation of domestic and foreign experts, (iii) participation in international conferences on railway transport, (iv) fellowships at leading foreign railway sites, (v) workshops aimed at exchanging the latest information about news in railway transport and (vi) additional training focused on project management in the field of railway research. Besides the aforementioned activities there was created portfolio of complementary activities for the target groups aimed at transfer of technology and improving knowledge in the field of control and legislation in the field of research and development and for evaluation of scientific results.

The aim of our conference is to exchange knowledge and connections of scientific and technical potential of universities, research and design institutes together with professional potential of construction and manufacturing companies to promote innovation in rail services in accordance with the requirements of Technical Specifications for Interoperability trans-European rail system in subsystems of infrastructure, energy and management and safety. An important aim of the conference is also to contribute to higher education and professional qualifications of future graduates master and doctoral studies, which will enable them to participate on the management, coordination and other activities in the area of interoperability of the European rail system.

Otto Plášek
Project Manager IRICoN

CONTENTS

Problems of EN 50 128:2011 Railway Standard

Tomáš Brandejský, Faculty of Transportation Sciences, Czech Technical University in Prague

Since the origin, the group of CENELEC's railway stands [1], [2] and [3] was declared as standard of all safety related railway applications including not only interlocking systems, but rolling stock and related communication too.

The standard EN50126 defines its applicability to "*the specification and demonstration of RAMS for all railway applications and at all levels of such an application, as appropriate, from complete railway systems to major systems and to individual and combined sub-systems and components within these major systems, including those containing software*".

The standard EN50128 defines its application domain as: *"This European Standard specifies procedures and technical requirements for the development of programmable electronic systems for use in railway control and protection applications. It is aimed at use in any area where there are safety implications. These may range from the very critical, such as safety signalling to the non-critical, such as management information systems. These systems may be implemented using dedicated microprocessors, programmable logic controllers, multiprocessor distributed systems, larger scale central processor systems or other architectures*".

And the standard EN50129 defines its scope as electronic systems related to safety in application to railway interlocking systems.

It means that at least standards EN50126 and EN50128 must be reasoned in any railway system related to safety. On the beginning of application of these standards safety assessors required application of these standards especially in the domain of interlocking systems and the rest was frequently omitted. After the year 2011, when the second generation of these standards has come into the operation the situation changed and the conformity with these standards is required also by assessors of rolling stock and other railway systems. It brings some problems described below due to different requirements on system functions in situation, when the system malfunction is detected.

The CENELEC's standard EN 50128 "*Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems*" was defined as part of three standards group [1, 2 and 3] applying standard IEC 61508 "*Functional safety of electrical/electronic/programmable electronic safety-related systems*" into the specific area of railway systems. The main difference is in different safety assessment scheme, where not only developer, validator and assessor are reasoned but also railway safety authority as next independent body.

2.1 The last version of the standard is less transparent than original one. The change of the standard structure was asked by CENELEC due to unification of all CENELEC standard structure. Whilst the original standard was divided into 17 chapters and 2 annexes, the 2011 version is organised into 9 chapters and 4 annexes (2 are new). This change causes not only that there are no separate chapters e.g. for software validation and assessment, but software assurance chapter describing testing, verification, validation and assessment is before chapter 7 describing development process! Furthermore, the chapter 7 is named "Generic software development" now not looking that the term "generic software" in computer science doscon mean "common sense software", as this term is used in the standard, but "a class of software that can be used for a number of different purposes without requiring modification", as it is defined e.g. in [4,5].

Similarly in the chapter v 3.1.4 of original EN50128 introduces the term "component" which is defined extremely vague (and in the EN50128:2011 even it is not defined), but especially in the area on object oriented programming the meaning of this term if defined precisely and totally different. Because the standard EN50128 is used especially by programmers, such drifting of frequent term sense might cause many misunderstandings. Because EN50128:2011 allows to understand term component also as object, module or even function, the meaning of e.g. chapter 7.5 might be understand totally different by particular people in particular situations.

There is not explicitly declared applicability of the standard to railway vehicles and especially differences in requirements to behaviours of vehicle control systems in the case of malfunction, which is opposite to required behaviours of interlocking control systems in the analogical situation. Typically, in the case of control system error vehicle must keep moving but interlocking system can signalize stop to all tracks and perform e.g. restart of the control system.
There is not solved defence against targeted attack (terrorism). Defence of mission critical systems against targeted attacks e.g. requires ability of the system to isolate attacked parts and thus to reconfigure system. It is a big problem, because dynamic reconfiguration is listed in table A.3 as technique 14 and it is not recommended non respecting fact that this technique is frequently adopted e.g. in military, cosmic or avionics systems.
The standard does not solve design of programmable HW, where on interface of SW/HW occur many specific problems which solution is not defined in the actual standard. Many of these problems were discussed in [6], like specific problems of design, timing and application structure.
The standard EN50128 contains extensive appendix B "Key software roles and responsibilities" on ten pages and small appendix C "Documents control summary", which only recapitulate textual part of the standard and do not bring any additional information.
Chapter 8 "Development of application data or algorithms: systems configured by application data or algorithms" should explain better requirements of systems with different level of configurability. It is hard to compare simple system which is configured by one dimensional table of parameters and system where safety-related functions are described in configuration language, which is interpreted in real time and where part on safety checks is dedicated to development tools.
The standard defines five different SIL levels but de facto it specifies only three different cases: SIL0, SIL1 and 2; and SIL 3 and 4. In addition, requirements to SIL 1 and
2 systems are inappropriate strict as well as there are requirements to documentation complexity of SIL0 systems, especially in comparison to COTS systems of the equal SIL level. But in fact, it would be just opposite – e.g. it is need to do precise testing developed by other company, which design process is not well described, where the documentation is missing, than in the case of well documented one.
Ten year cycle of CENELEC standard upgrade is difficult especially to rolling stock manufacturers. Locomotives, carriages and other vehicles have extremely long life-cycle taking any tens of years. There is long design phase including real research, own assessment phase some times takes about ten years and also operation is reasoned in horizon of thirty years or more.
The above presented paper summarises problems on the today railway standard EN50128:2011, which were observed in certification body of Czech technical university in Prague – COV FD ČVUT v Praze during certifications of many railway systems serving especially in Czech Republic.

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On Efficient Operational Concept of Future High-speed Railway in the Czech Republic

Michal Drábek, Faculty of Transportation Sciences, CTU in Prague

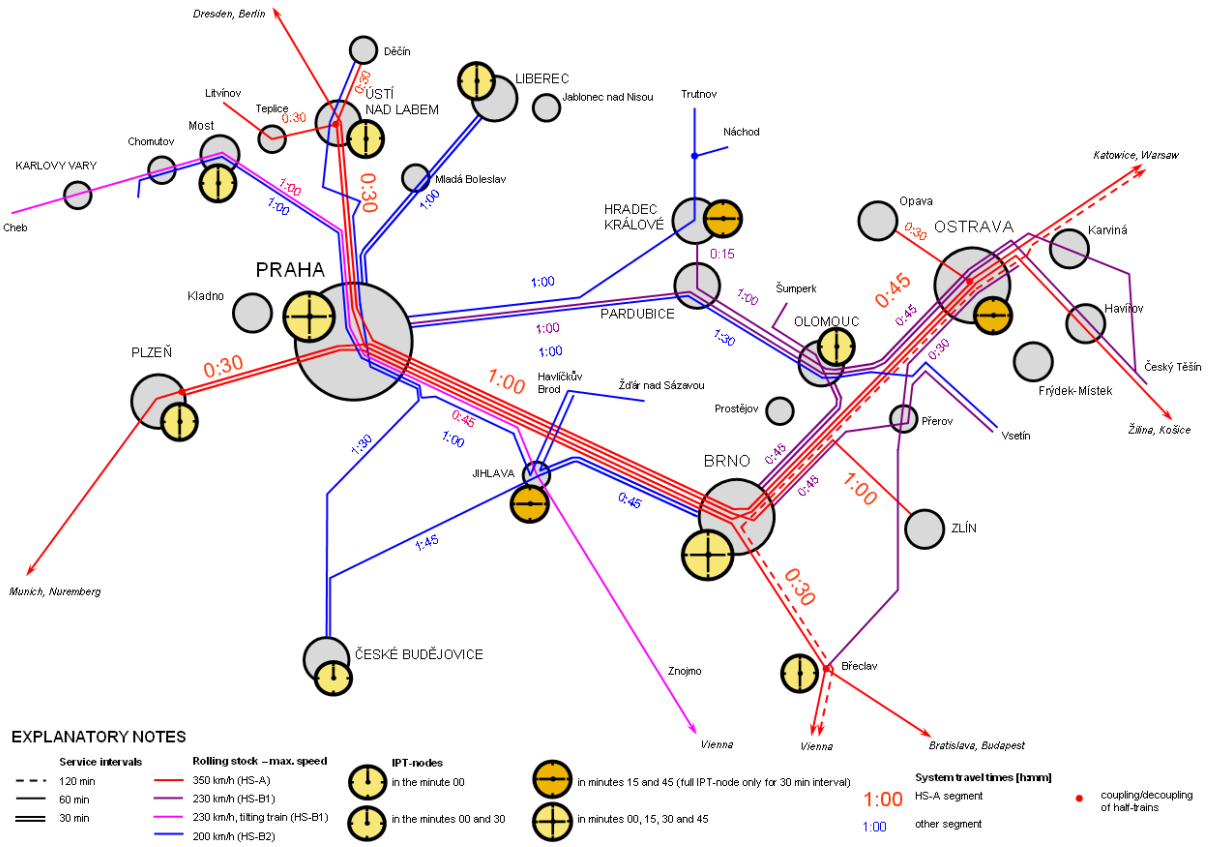
The aim of this paper is to elaborate a layout of the first operational concept of Rapid Services with 1 hour system travel time between Praha and Brno. Two basic methods are used – Integrated Periodic Timetable (periodic rendezvous of all services in IPT-nodes) and Operational Concept Economy Approach, as defined below by the author.

In this paper, three recent high-speed railway concepts for the future so-called Rapid Services network of the Czech Republic are followed-up. The first one is an operational traffic planning study by Kalčík, Janoš et al. on behalf of Czech Ministry of Transport from 2010. The second one is the high-speed railway promoting book High Speed Rail Even in the Czech Republic **by Šlegr et al. from 2012, with likely the most detailed concept of Rapid Services network. The third one is a paper on progress of the official spatial-technical studies for some future Czech high-speed lines by Šulc from 2014.** The importance of achievement of 1 hour travel time between the largest agglomerations is briefly presented.

The presented methodological approach, although soft and manager-oriented, comprises some firm principles: segmentation of high-speed train offer, so that more expensive rolling stock is not wasted by operation on long conventional line sections, consideration of system travel times for efficient rolling stock circuit, restriction of need for links from high-speed to conventional lines, and utilization of high-speed lines as a “rail highway”. This approach is intended to be particularized iteratively, with every application. So, in this paper, first version of Operational Concept Economy Approach is introduced.

The key idea is that passengers should be offered such travel times and service intervals (headways) and such number of direct services, which are adequate to their potential demand, but as much synergistic effect as possible should be strived to be achieved for every proposed construction (new or modernized one). Such approach goes towards economic efficiency, which is crucial indicator for political decision necessary for building, let alone EU co-funding of the construction. Experience shows that in many Czech feasibility studies, achievement of sufficient economic efficiency was the most complicated part of the study.

Results (displayed in the figure below) show that an efficient operational concept can be designed *not at the expense of runtimes between the largest cities*. Development of transport systems are always subject to political decision, and so the realized alternative is very likely to be a compromise. Neverthless, such compromise should be outlined with respect to principles to economic design, as mentioned in this paper.



Keywords: high-speed railway, high-speed line, Rapid Services, Integrated Periodic Timetable

On Operation of 740 m Long Freight Trains on Czech TEN-T Railway Network

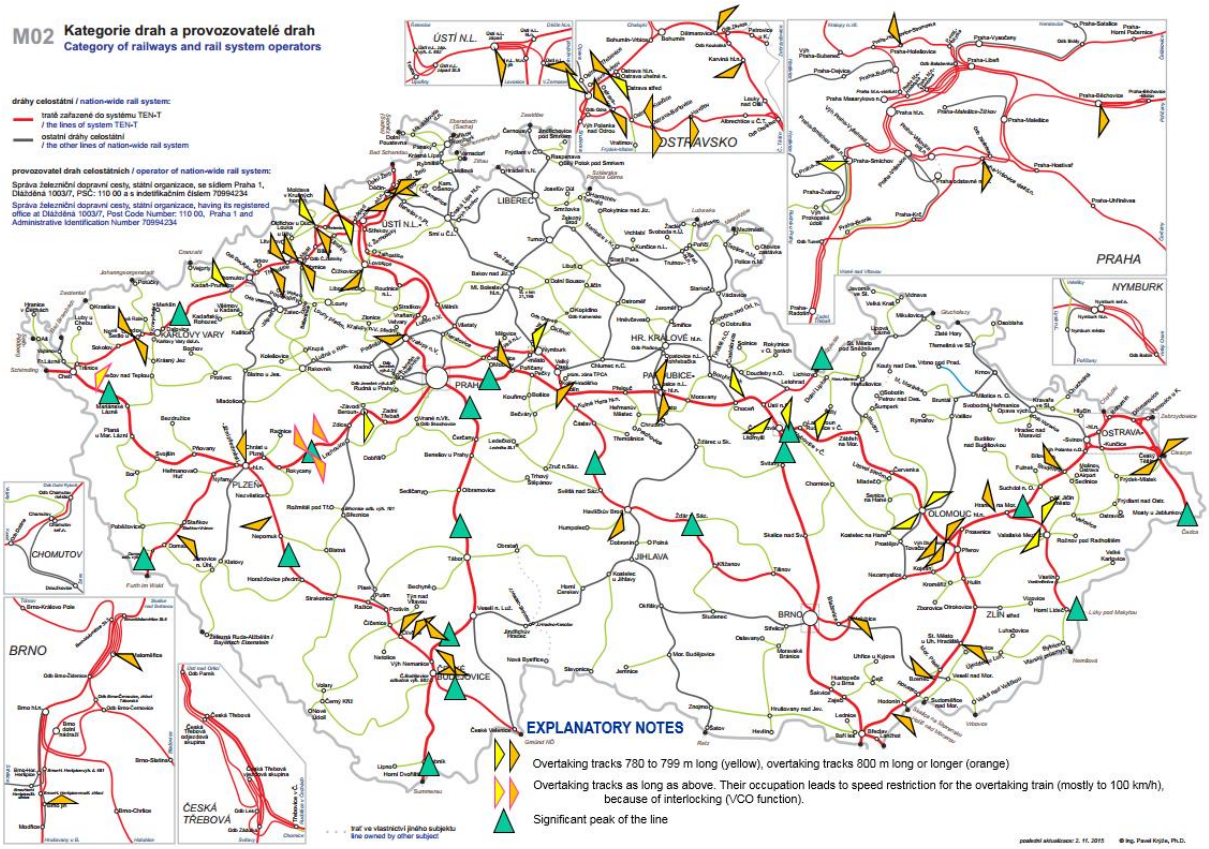
Michal Drábek, Vít Janoš, Zdeněk Michl, Faculty of Transportation Sciences, CTU in Prague

Regulation (EU) No 1315/2013 defines actual scope of core and comprehensive TEN-T network, including both networks for railway freight transport. For the core network, possibility to operate 740 m long freight trains is required. The aim of this paper is to analyse availability of appropriate overtaking tracks for 740 m long freight trains. Due to ETCS braking curves and odometry, such trains, after ETCS implementation, will require 780-800 m long overtaking tracks. For practical reasons (e.g. bypass lines), whole Czech railway TEN-T network is analysed. The overtaking track, whose occupation means influence on scheduled traffic or threat to boarding passengers, are excluded. The data was collected from station schemes from **Collection of Official Requisites for 2015/16 Timetable, issued by SŽDC, Czech state Infrastructure Manager.**

Results are displayed in the figure below. Most of appropriate tracks are over 800 m long, but their density in the network and in particular directions varies considerably. For freight traffic, gradient of the line is important, so there are marked significant peaks for particular lines as well.

Czech TEN-T lines are further segmented on the basis of number of track and their traffic character. Then, specific issues on overtaking or crossing of 740 m long freight trains are discussed.

As a conclusion, for long-term development of Czech TEN-T lines, *targeted investment is recommended not only for passenger railway, but also for freight railway*. An attractive capacity offer for railway undertakings, which can stimulate freight traffic on European Rail freight corridors, can be represented by network-bound periodic freight train paths with suitable long overtaking tracks outside bottlenecks. After the overtaking by passenger trains, a freight train should run without stop through large node station or a bottleneck area. Before the sections with high gradients, coupling of additional locomotives should be connected with the overtaking process. Next suitable overtaking tracks should be available behind every significant peak of the line.



Keywords: European freight corridor, long freight train, overtaking track, freight train path, peak

Design Parameters of Buffer Stops

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INTRODUCTION

Buffer stop is a device at the end of dead-end track or closed track with a purpose of stopping the rolling stock. In Czech Republic, it is allowed to use three types of buffer stops (according to national regulation ČD Ž9). All three types are fixed (rigid) construction, yet there are numerous designs of buffer stops used abroad. We can divide buffer stops in categories depending on the principles of absorbing the kinetic energy, thus stopping a rolling stock of certain mass with a certain collision speed. As basic categories, we can name fixed buffer stops, hydraulic buffer stops and friction buffer stops. Every type has its pros and cons and suitable place to be installed (depending on circumstances).

KINETIC ENERGY

Kinetic energy of moving rolling stock can be calculated as sum of the kinetic energy of transitional motion and kinetic energy of rotating parts of the rolling stock. Formula (1) shows the calculation of kinetic energy after modification, where the coefficient of rotating parts ρ is included.

$$E_{kin,c} = \frac{1}{2} m(1+\rho)v^2 \qquad (1)$$

Design of buffer stop, as a device (structure) that has to work properly and must ensure high level of safety and reliability, needs do involve a safety coefficient in calculations. Therefore, the buffer stop's kinetic energy absorbing capacity has to be determined as follows:

$$R \geq E_{kin,c} k \qquad (2)$$

COLLISION SPEED

The collision speed is defined as the maximum permissible speed in which trains may travel when colliding with buffer stop. There are various approaches, how to determine collision speed. German standard DS 800 01 uses the collision speed based on train type: passengers trains: 15 km.h^{-1}; freight trains: 10 km.h^{-1}.

Many others foreign railway infrastructure managers are designing buffer stops using same speeds for calculations.

Chyba! Nenalezen zdroj odkazů. displays braking distances (using operating brakes and emergency brake) and speeds of trains at the end of dead end track (distance between the start of braking and buffer stop is 100 m).

Table 1: Deceleration of trains

Speed [km.h^{-1}]	Braking distance [m]			Speed at the end of dead-end track [km.h^{-1}]		
	Os	R, Ex, IC	Emergency braking	Os	R, Ex, IC	Emergency braking
50	192,90	214,33	40,19	9,64	10,14	- [1]
60	277,78	308,64	57,87	13,33	13,70	- [1]
70	378,09	420,10	78,77	16,68	16,97	- [1]
80	493,83	548,70	102,88	19,85	20,10	13,39
90	625,00	694,44	130,21	22,91	23,13	43,35
100	771,60	857,34	160,75	25,92	26,11	61,48

Input parameters:
- Os deceleration – 0,50 m.s^{-2} (2x unit 451/452);
- R, Ex, IC deceleration: 0,45 m.s^{-2} (locomotive 363 + 8 coaches type Y);
- emergency brake deceleration: 2,40 m.s^{-2}.

[1] train stops before the buffer stop

FIXED BUFFER STOPS

We can divide fixed buffer stops into two groups, with mechanical bumpers and with hydraulic bumpers (hydraulic buffer stops). Construction of fixed buffer stop consists of a block or frame fixed rigidly to the rails or the ground with bumpers attached in front. One of advantages is that fixed buffer stop can be placed at the end of the dead-end track, thus it does not reduce the usable length of the track. However for fixed buffer stops with mechanical bumpers cons prevail, such as low resistance and manner of deceleration (fixed buffer stops used in Czech Republic are built for 0,7 – 1,6 km.h^{-1} collision speed and train mass up to 90 t).

Hydraulic buffer stops absorb kinetic energy in gradual manner (depends on the type of the hydraulic bumpers) and in general has higher resistances than those with mechanical bumpers.

FRICTION BUFFER STOPS

Friction buffer stop is the most effective way of stopping moving rolling stock. The way of absorbing the kinetic energy is the most efficient and safe. Friction buffer stop generally consists of rigid steel frame with buffers, connected to rails using arresting devices (friction jaws). In case of collision, kinetic energy is transformed into heat by means of friction. Therefore, energy absorbing capacity of friction buffer stop depends on the number of friction jaws, friction coefficient resp. braking force of jaws and length of braking.

Three types of friction buffer stops can be named: friction buffer stops (without additional brakes), friction buffer stops with additional brakes, friction buffer stops with hydraulic bumpers (with/without additional brakes).

BRAKING FORCE

Braking force is the determining factor of friction buffer stop. As mentioned above, buffer stop must absorb high amount of kinetic energy. Calculation of breaking force in case of friction buffer stops depends on numbers of arresting devices, braking force of each arresting device and maximum braking distance.

$$R = n_b F_b L_W \tag{3}$$

Braking force of friction buffer stop with additional brakes comes from formula (3). Formula is modified considering braking force of additional brakes while braking distance of each additional arresting device is included separately.

$$R = \sum_{i=1}^{n_Z} 2F_{bi} L_{Wi} \tag{4}$$

CONCLUSION

Many aspects have to be taken in account while designing buffer stop. One has to consider its location – ending of dead-end track in railway station, ending safety track from sidings, service track or running track. Every scenario brings different requirements such as type of train, collision speed, impact mass etc.

Fixed buffer stops with mechanical bumpers are more than useless for higher collision speeds considering its manner of deceleration and its resistances. However, using fixed buffer stops is justified e.g. in shunting yards, where rolling stocks are moving in low speeds and no passengers are on board.

As the most effective ending of dead-end track is usage of friction buffer stop. Resistances are much higher than fixed buffer stops and the deceleration of train goes in gradual manner and no harm to the rolling stock or buffer stop itself is done if the design was precise.

Infrastructure Parameters Affecting Capacity of Railways in TEN-T

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Abstract. The article presents possible solutions of the issue of the lost capacity on a double-track line. It is shown a solution where an inserted train on the double-track line use the lost capacity of the opposite line track using active overtaking. The feasibility of such a solution is discussed and the length of sections suitable for active overtaking is calculated.

Keywords: Capacity, UIC 406, speed ratio.

1. Introduction

The capacity of the railway infrastructure can be considered as a usable time space for the train paths. Capacity is thus influenced not only by the parameters of the infrastructure, but also by the character of the traffic – by the designed train paths and their heterogeneity. With increasing degree of heterogeneity the capacity consumption increases too and the number of possible train paths in a defined time windows declines. This phenomenon is also called "capacity balance"[1]

General effect associated with the modernization of the Trans-European conventional rail network (typically the modernization of the transit railway corridors in the Czech Republic in the original routes to a maximum speed of 160 km/h) is the rising heterogeneity of the traffic on some routes in the network. This problem occurs also in the Czech Republic.

2. Heterogeneity and its measuring

Heterogeneity can be measured in different ways. One way is to compare running speeds of individual train (or train paths). For this purpose Krueger [2] proposed and used so called Speed Ratio (SR). The Speed Ratio is the ratio of the fastest train speed to the slowest train speed:

$$SR = \frac{\max(v_1, v_2, ..., v_n)}{\min(v_1, v_2, ..., v_n)} \tag{1}$$

So the SR on the typical line section on some transit railway corridor in the Czech Republic can reached value of 3 (the speed of the fastest train about 140 km/h and the speed of the slowest train about 45-50 km/h).

3. Active overtaking

On double-track lines, where high degree of heterogeneity is because of the mixed traffic and high requirements for the number of the train paths, so called lost capacity arises. Lost capacity is unusable time space between train paths with different train speeds, where any additional train path cannot be inserted. Lost capacity can be used for active overtaking, which can be defined as an overtaking of slower train by faster train, when the slower train does not have to stop [4].

There are generally two cases possible:

1) The slower train crosses over to the other line track and runs against the right direction, the faster train runs in the right direction.
2) The faster train crosses over to the other line track and runs against the right direction, the slower train runs in the right direction.

4. Case study: the first transit railway corridor between Prague and Děčín

The part of the first transit railway corridor between Prague and Děčín links the Prague Metropolitan Area [3] with the Ústí Metropolitan Area and with the north part of Germany. The most typical

situation for the active overtaking is an interaction of a fast freight train (maximum train speed about 100 km/h) and a regional passenger train (journey speed about 50 km/h).

The active overtaking of the first type can be used in the line sections:

- Hněvice – Hněvice seř.n.
- Roudnice nad Labem – Hrobce
- Lovosice jih – Lovosice
- Prackovice nad Labem – Ústí nad Labem jih – Ústí nad Labem hl.n.

Sections Hněvice – Hněvice seř.n. and Lovosice jih – Lovosice can be excluded immediately, because the result time savings will be negative. In both cases the regional passenger train is stopping only once in the line section and in both cases the speed limit over crossovers in the stations which bounds the line section is lower than the speed limit on passing sidings in these stations.

Sections Roudnice nad Labem – Hrobce and Prackovice nad Labem – Ústí nad Labem jih – Ústí nad Labem hl.n. show always positive time savings. In both cases the regional passenger train is stopping twice in the line section. In these cases, the parallel run is generally about 2 minutes more effective then overtaking of the slower train in the station. It is very important that the overtaking train is guided precisely to the desired time position. The accuracy of this guidance may have a significant effect on the resulting time savings.

The required length of the line section for the active overtaking depends especially on the speeds of the faster and slower train and on the sum of operating intervals in the bounding stations of the line section. The higher the SR is, the shorter the line section need to be. If the speed of the slower train is 50 km/h, the speed of the faster train is 80 km/h and the sum of operating intervals is 5 minutes, then the length of the line section has to be approximately 11,1 km. If the speed of the faster train is 100 km/h, the line section has to be approximately 8,3 km

5. Conclusions

The Verification of heterogeneity in relation to the partial use of the lost capacity by active overtaking of differently fast trains showed clearly that in the case of the interaction of regional passenger trains and freight trains there are solutions which can be divided into two situations.

With regard to the actual length of the line sections for active overtaking and with regard to demand for the train paths it is necessary to mention that on Trans-European conventional rail network this solution will be usually marginal. In the Czech Republic the construction of quadruple-track line sections remains as a permanent challenge in cases where a high degree of heterogeneity connected with high demand for train paths occurs. Only such a solution leading to the segregation of various types of traffic allows homogenization of the train paths and effective elimination of the lost capacity.

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Traffic Management System in Terms of Data Exchange

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Abstract

Prediction of train running and IT support of conflict resolution decision for an efficient use of the existing railway infrastructure is needed. To meet these requirements standardized interfaces between infrastructure managers and railway undertakings and infrastructure description are indispensable.

Keywords: technical specification for interoperability, infrastructure description, traffic planning, dispatching, train controlling, telematics applications, railML, RailTopoModel

1. Introduction

With the increasing demand for freight and passenger transport railway subjects aims on increasing the capacity by a reduction of delays and improved traffic fluidity. To meet these requirements modern traffic management systems are implemented. They are based on a prediction of train running and automatic conflict resolution. The paper describes data exchange with focus on the operational management.

2. Architecture of management process

Railway management process can be divided into three basic layers: traffic planning, dispatching and train controlling.

Traffic planning can be characterized as conceptual planning, strategic network development, service planning and infrastructure planning in long term, timetabling in short term. Timetabling is a process of path requests and allocation by railway undertakings and infrastructure managers. Traffic planning shall define rules, like priorities of the train and competence between railway undertakings and infrastructure managers.

The aim of dispatching is at close approximation to scheduled state, from which railway system has been deflected by external influences. IT support is necessary in dispatcher decision processes. Quality and timeliness of information is necessary condition the dispatcher could correctly decide the intervention, which leads to fulfillment of the planned timetable. Infrastructure manager dispatcher is responsible for changing train sequences to minimalize deviations from the timetable. Railway undertaking dispatcher is responsible for skipping a commercial stop, breaking a connection, providing rolling stock and staff.

Train controlling is process train route setting, shunting route managing and setting, infrastructure elements controlling to ensure railway safety. Routine processes can be performed by automatic train route setting system.

Automatic train control system, which is designed to eliminate human error, can be supplemented by automatic train operation system or driver advisory system. A train movement is adjusted to achieve defined points of infrastructure in defined time slot and therefore to reduce energy consumption and increase the capacity at a time.

3. Standardized Interfaces

Technical parameters of infrastructure elements, like line layout, track parameters, switches and crossings, platforms etc. are defined by 1299/2014/EU TSI “Infrastructure”. With exception of the requirements for infrastructure register, infrastructure description, methodology of representation or the storage of infrastructure data are not defined.

Infrastructure register is defined by 2014/880/EU. Railway network shall be subdivided into sections of line and operation points. Section of line means the part of line between adjacent operational points. Operational point means any location for train service operations, where train services may begin and end or change route and where passenger or freight services may be provided.

The structural subsystems specific requirements that interoperable railway lines and rolling stock must meet and many of these requirements must be stored in the infrastructure registers and the register of rolling stock. Comparing those registers should make it clear which lines accept which rail vehicles.

Telematics applications for passenger and freight services subsystem equipment are defined by 2006/62/ES TSI TAF and 2011/454/ES TSI TAP.

The specifications relating to telematics applications define architecture of information system and interfaces among subjects: infrastructure manager, railway undertaking and customer. Processes and data exchanges to allocating of train path and monitoring train movement are defined.

Interface between telematics applications and subsystem “Control-command and signaling” is not specified, although interlocking equipment need data on the parameters of the trains. Interface between telematics applications and subsystem “Infrastructure” is given with the train path data definition and via the infrastructure restriction notice database. Interface between telematics applications and subsystem “Rolling stocks” is only given via the rolling stock reference database

The procedures enabling a coherent operation of various structural subsystems during both normal and degraded operation are defined by 2015/995/EU TSI Operational and traffic management. From the viewpoint of the data exchange, relevant is requirement of Route Book and Timetables. The development of the Route Book is the responsibility of RU and should be prepared in the language of the railway undertaking. However, the format of the Route Book is not specified. Each train must be identified by a train running number. The train running number is given by the infrastructure manager when allocating a train path. The train running number format is defined in Commission Decision 2012/88/EU.

Interfaces among different railway IT applications weren´t specified. The railML.org initiative was founded in 2002 in order to create an interface to enable heterogeneous railway applications to communicate with each other. The result has been the development of the Railway Markup Language - railML- which delivers a universally applicable data exchange format.

The railML specification contains subschemas for four main areas: infrastructure, timetable, rolling stock and interlocking. RailML can be seen as a direct use case of the RailTopoModel.

The RailTopoModel is a logical object model to standardize the representation of railway infrastructure-related data. On the other side, RailTopoModel will become International Railway Standard (IRS) in spring 2016, compiled by UIC, the largest railway organization worldwide.

4. Conclusion

Technical specification for interoperability defines technical requirements of infrastructure, energy and rolling stocks parameters and control-command and signaling system to enable interoperable vehicle driving on interoperable infrastructure. Necessary data exchange relating to path allocation and operation and management processes relating to ensure safety are defined in function subsystems. However, data exchange relating to dispatching is not standardized. Infrastructure description, specified in infrastructure register, is not sufficient for prediction of train running. Data exchange relating to train parameters, like traction characteristics, and timetable requirements is not specified. Infrastructure managers and railway undertakings interface ensuring dynamic data exchange relating to breaking a connection is not defined in technical specification for interoperability.

RailML seems to become effective tool for data exchange supporting prediction of train running and conflict resolution decision among others.

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Assets of Model Metro Station and Their Criticality

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Abstract

The paper deals with identification of protected assets in model metro station, which is part of critical infrastructure in Praha; and with identification of their criticality. Metro station is used by a lot of people and it involves many expensive components and devices that formed system of systems. It contains a lot of devices and fittings that are very vulnerable to damages from disasters of many kinds. From the protection reasons on the concept of integral safety of complex technological facilities in the practice it is necessary to identify the protected assets and to establish their criticalities taking into account all relevant sources of hazards. The first step of ensuring the metro station safety is the identification of basic metro assets that are important for safe metro operation and for human (employee and passengers) security and environment safety; and the other is the determination of criticalities of considered assets. These facts are input data for further processes important for safe metro operation under the different conditions.

Key words: safety; security; metro station; assets; disasters; criticality

Introduction

A metro is very important means of transportation in cities. Therefore, to its safety it is pursued special attention, and it is part of critical infrastructure, to which it is now concentrated special attention because especially at critical situation its status predetermines the capability of human society to ensure human survival [1]. Metro is composed from fix and movable parts; the fix ones are structure element, stations and tunnels with many fittings; the movable ones are trains [2]. The paper takes into account the metro stations.

Each metro station is equipped by many technical devices and fittings that ensure metro operation and comfort space for passengers. From safety reasons it also involves support elements for safety operation of station; they are for instance construction design, operation devices and systems, control systems, protection systems, electronic devices like lifts, escalators, air conditioning, trains and systems for train control, communication systems, staff etc. Mentioned elements including the humans and personnel staff of station are in interaction each other and they create complex system prone to harm [2]. Moreover, the system is mostly part of whole transportation infrastructure - connections with track and next stations, material, energetic and informatics flows, and number of served persons.

It is reality that devices and fittings that are very vulnerable to damages from disasters of many kinds [3]. From the protection reasons in the practice it is necessary to identify the protected assets and to establish their criticalities taking into account all relevant disasters, i.e. the sources of hazards, and to consider possible risks. This procedure is a common part of formation of safety management systems in all systems, i.e. also in railway domain. The first step is the identification of basic metro assets that are important for safe metro operation and for human (employee and passengers) security; and the other is the determination of criticalities of these assets.

Criticality of assets in model metro station

The most critical assets are identified: humans; flows (information, energy, controls orders); air-conditioning; some machinery fittings; communication equipment; and other. On the basis of the data referred to such cases according to [4, 5] it is necessary to perform in all cases where the criticality rate is 3 the following:

- the analysis of the ability / competence of operator of metro to handle with emergency situations in the station and in the infrastructure,

- the inventory of available resources for quick and proper response to the emergency situation in a metro station in the subway,
- the assessment of current vulnerability of items of metro stations and the entire metro subway,
- the specification of the coordination of activities to support the continuity of subway stations and underground infrastructure,
- the division of responsibilities for actions to promote the continuity of the subway stations and underground infrastructure,
- the setting up the organisational instructions and features to support the renovation of subway stations and underground infrastructure,
- the establishment of criteria for the selection of main features of elements of subway stations and underground infrastructure,
- the determination of support processes that support the main features of subway infrastructure,
- identification of key personnel, to ensure the continuity of the subway stations and underground infrastructure,
- prioritizing the main functions on the basis of the criticality of time, sequence of key recovery processes and personnel capacity.

Conclusion

From the protection reasons on the concept of integral safety of complex technological facilities in the practice it is necessary to identify the protected assets and to establish their criticalities taking into account all sources of hazards. The results of performed research show that metro stations have a certain level of safety (according to **[**4] it holds that ***level (rate) of safety = 1 – criticality rate***). However, it is necessary to carry out the measures referred to in the previous chapter, because there are items for which in the occurrence of large (i.e. beyond design extreme) disasters there are get to significant impacts of disasters, which have the ability to disrupt seriously the metro station and the entire infrastructure. It means that present standards and legislative do not provide sufficient range for integral safety, including the safety of important assets and systems that predispose sufficient human security and human society development.

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SELECTED ASPECTS OF ETCS-L3 DEPLOYMENT

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1. Introduction

Control and command systems on the railways have undergone a relatively long development. On the one hand, the development is driven by increasing demands on safety, reliability, smoothness and fuel economy, on the other hand, the development was mainly limited by technical capabilities of the time in the past. The development possibilities of electronics and especially microprocessor technology and computing power have allowed in recent years to increasingly address the question of optimizing the control process quality and minimizing the necessity of the human factor's intervention, which in earlier times was not possible to such an extent.

The aim of this paper is to point out possible problems in the implementation and deployment of ETCS L3 on the conventional railway network and suggest possible solutions to these problems with the specification of advantages and disadvantages of the various options.

2. Requirements

For the full implementation of intelligent transport systems on railways (hereinafter ITS-R) and for the purposes of this article, we consider the target state to be a state in which the following conditions are met:

1. there is a bidirectional data connection to the train (between mobile and stationary parts),
2. the integrity check of the train using technical means on the vehicle is ensured,
3. all locomotives are equipped with an on-board unit (OBU) ETCS.

2.1. Substantiation of the requirements

Requirements specified in the previous section are based primarily on the overall concept of ITS-R. The need for a data connection to the train is given mainly by the necessity of the existence of such a data transfer connection between the stationary and mobile parts of the ETCS L3 system. However, the data connection can also be used with other subsystems in the ITS-R concept, such as the transmission of data for the ATO system, transmission of diagnostic data, etc. Second and third requirement are necessary condition for the ETCS L3 system's using, where the existence of detection devices already disregarded and there isn't possible mixed traffic (such as with L2).

Only the connection and fulfillment of all three requirements above at the same time gives us the opportunity to fully start taking advantage of ETCS L3 – primarily minimize the infrastructure elements.

3. Definition of problem areas

3.1. The accuracy of the odometer

A key part of the function of determining train location in the ETCS system is an odometer and Doppler radar. Since this is a safety-relevant function, it is necessary to consider a possible error in the given position in a safer direction. According to the specification [1], the required accuracy is expressed by the formula according to the traveled distance *s*:

$$s_{diff} = 5 + 0.05 \text{ x } s \; [m] \tag{1}$$

The position is specified (error is null) always after reading a balise group and the error refers to the distance traveled from that point. For the operation of the ETCS system in its current form it is therefore necessary to count with this error in determining the usable length of each track - e.g. for track length of 600 m it is necessary to consider an error of up to 35 m.

3.2. Train handling

The method for determining train location and sections occupancy in the stretch of ETCS L3 makes it necessary to address potential problems arising from the train handling, such as splitting, joining and shunting of train cars. The simplest situation occurs when joining and separating sets of coherent units, where with regard to the assumed equipment of all driving vehicles it will be possible to locate both parts and detect their integrity after division. However, this does not apply to the movement of parts of the train set and keeping a part of the train on the station track or to the train splitting into multiple parts. In such a situation, the vacancy of the concerned part of the infrastructure cannot be safely determined only with the use of the ETCS L3 system's technical means.

4. Suggested solution

4.1. The accuracy of the odometer

To increase the usable length of the transport rails, it may be necessary to increase the accuracy of the positioning system. With current specifications, this problem can be solved by placing one or more locators inside the balises of a long track section. This will split it into several smaller sections, where the odometer's inaccuracy is proportionately smaller.

Another possibility is the gradual tightening of the requirement for maximum permissible error in the ETCS odometer (now 5m + 5%). Similar devices used in the CBTC systems achieved accuracy of about 1% according to [3] already (using e.g. a Doppler radar with multiple antennas).

4.2. Train handling

The problem with train division, shutting down of train cars, and shifts can be solved in principle several ways, which will be discussed in the following text. The advantages and disadvantages of various options and a comment on the possible applicability are also mentioned.

4.2.1. Confirmation of occupancy by human operators

The occupancy of selected parts of the infrastructure can be confirmed with the participation of the human factor. This principle is used according to [4], e.g. in ERTMS Regional in Sweden. After confirming the section's occupancy with the human factor, the ride through the stretch is possible only in the Staff Responsible mode with speed restrictions. After the first train passes, the stretch is already considered vacant from the point of view of previous manipulation, and the ride of the following trains is no longer restricted.

The disadvantages of this solution are obvious – the need for participation of the human factor, the risk of failure is limited by limiting the speed for the next train. This thereby decreases the throughput performance parameter. However, this solution may be suitable for regional routes with limited speed and sporadic shifts.

4.2.2. Partial equipment with detection resources

In case of frequent handling, using conventional detection devices (track circuits, axle counters) at this point is offered as a solution to the question of detecting the occupancy of the infrastructure's section. The disadvantage regarding the involvement of the human factor on detecting the occupancy of the section is thus eliminated, the disadvantage being the need to install detection devices, albeit to a very limited extent.

5. Evaluation, conclusion

The article pointed out several questions that will be necessary to address within the preparation of the possible pilot deployment of ETCS L3. The solution's suitability in some

cases depends on the local situation and the kind of the track on which the system will be deployed; all possible situations cannot generally always be covered.

In the near future it is also possible to expect verification of the related technologies that could help contribute as another alternative to solving open points (e.g. use of satellite positioning systems instead of fixed balises, use of modern communication technology instead of GSM-R, etc.) in the event of a positive outcome.

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Modernization of Railway Stations Česká Lípa and Karlovy Vary with the Expected Co-Financing from European Funds from Opd2

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ABSTRACT.

The article describes the planned modernization of railway stations in Česká Lípa and Karlovy Vary, their scope and financing. The emphasis is laid on the expected co-financing of these projects from European structural and investment funds planned for the years 2016-2020. It is case of the operational program Transport - OPD2. The study compares the two projects from many aspects, in particular from the economic and structural-urban planning points of view.

On 12 May, 2015 The European Commission approved **Operační program Doprava pro období 2014–2020** - the newly designated as OPD2. In the past, the Transport Operational Program designed for the years 2007 – 2013 was used the Czech Republic. This OPD2 program will provide the Czech Republic with the possibility to draw from the EU funds the amount of almost EUR 4.7 billion, in particular for the development of road and rail infrastructure.

General allocation of OPD2 5 524 434 631 EUR,
including the European share 695 769 435 EUR

Programming Document OPD2 (2014CZ16M1OP001) contains detailed information about co-financing projects in various areas of transportation. We will within this article deal with the issue of rail transport. Here, there are some important and interesting facts contained in this document relating to the modernization of rail and multimodal transport:

Currently approximately 9,500 km of railway tracks are operated in the Czech Republic, which makes it - considering the total area of the Czech Republic - one of the densest rail networks in the world. The big problem of the railway network in the Czech Republic is its low technical level (insufficient track speed and frequent speed drops, low capacity, lack of interoperability, insufficient parameters for freight transportation, particularly the length of tracks in stations and terminals for multimodal transport), poor condition and lack of amenities of transport terminals, railway stations and stops and the related low comfort for passengers, resulting in low competitiveness in comparison with the road transport in most important directions and aspects.

Co-financing of the rail transport within OPD2 is possible under the Priority Axis 1, where inter alia, the following objectives are determined:

- Point 1.1 Improving the infrastructure for increased competitiveness and greater use of rail transport

For this priority axis is the support of the EU is set in the amount of **EUR 2,395,964,680**. The share of overall EU support in the Operational Program is 51.02% - it is clear from Table 2 (Overview of investment strategy of the Operational Program) of the program document OPD2.

This article has compared two different projects on modernization of railway stations. The two projects vary greatly in terms of their scope of works and, of course, in terms of the related budgets. The planned modernization of the railway station of Česká Lípa is much broader and includes, for example reconstruction of two bridges, construction of 19 railway crossings and 32 switches on the 33 km long track.

Žel.st. Česká Lípa	1 006,4
Žel.st. Karlovy Vary	75,8

TABLE 1: Construction costs of projects (CZK million excluding VAT)

Both construction projects have the same investors, designers and construction contractors and both have been designed to be co-financed from European structural and investment funds - Operational Program Transport - OPD2. This is a very important parameter of the project, because it would be very difficult to finance the projects of this size without the EU support.

KEYWORDS: modernization, railway station, OPD2, construction costs.

Railway Infrastructure Capacity Management for Ad-Hoc Trains on the SŽDC Network

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Abstract

The paper describes basic principles of ad-hoc routes assignment. Each carrier has its own interface called information system KADR with SŽDC for capacity requests management. The paper describes all steps which must be done before train departure.

Key words
Information system, carrier, ad-hoc train, railway infrastructure capacity

1. Introduction

For last couple of years is growing volume of request from railway operators to infrastructure manager (SŽDC) for so called ad-hoc trains [1]. These trains are operated out of the regular construction of the timetable. To make this agenda easier, there was developed an information system called ISOŘ KADR. The effects of the implementation of this system were in much faster and streamline assignment of the ad-hoc routes. Faster is as well the distribution of the time table to all supporting information systems. Among the most important systems which are linked with KADR belong ISOŘ (Information system for operative control), ComposT (Train composition) and Aport (Preparedness and composition of the train). Via KADR are constructed deflecting routes by traffic incidents and by traffic situation which requires that the train is going on different than basic route. The SŽDC has also competency to set the request instead of the carrier and assign the route and the capacity in one step. Information system KADR has two main parts. There is a web part and a desktop part. The access rights for both parts of the system are restricted by roles in the system.

2. Web part of the application

The web part of KADR is available anywhere on public internet at the website of the infrastructure manager (http://provoz.szdc.cz/KADR). This part is used mainly by carriers pro submitting of their new requests for assignment of the capacity, for activation and deactivation of trains, for statistics and so on.

The basic screen has some bookmarks with groups of functions:

- Requests/DJŘ (day time table) – on this bookmark are all routes of the carrier (including routes from the year time table). Each row is one train and carrier can see their basic information and the application status. At the end of each row are icons for work with each request.
- Activation – this bookmark is for changing of the train status. The carrier can activate the train (train will be really operated), deactivate the train (carrier doesn't use the capacity that day or period), put together some routes and submit a request for re-activation of the detached train.
- Train preparation – carrier can set the analysis of the train and preparation of the train for the departure. Both information are absolutely necessary for train operation.
- Restrictions – link for DOMIN (Database of infrastructure restrictions) application.
- Carriers, numbered lists, archive and statistics.

Probably the most important feature of the web part of KADR is for the carrier submitting of the application. The carrier must fill in step-by-step the following information – Schedule, Route, Train data, Extending data. After completing the entire information carrier is allowed to forward the application to the interfaces of the infrastructure manager.

Next possibility for submit of the request is via data communication, when carrier has its own software which is compatible with KADR. The data interface is in the format of TSI TAF. This requires bidirectional communication between KADR and carrier's information system. This interface shall be in defined format TSI TAF with annexes.

The web part of the application is for the infrastructure manager very similar to the carrier's web part. The infrastructure manager doesn't use this part very often, because most of his usually used functions are in the desktop part.

3. Desktop part of the application

The desktop part of KADR is available only for infrastructure manager. The installation is executed through the web part. The work with the desktop part is possible only from the SŽDC intranet. The infrastructure manager is setting up the time table of ad-hoc trains in this part of the application. Here can be also authorized the carrier's request for the ad-hoc trains or prepare the aids of the time table like dispatch or tabular time table.

4. Conclusions

The information system KADR becomes during its existence one of the most important planning tool for basic operation of the railway transport. Without its existence isn't nowadays possible ride of any train, because KADR secures activation and deactivation of trains and information system ISOŘ on request of KADR establish the route into all other information systems. The SŽDC offers to all carriers the web part of KADR for free. Each carrier pays only charges and fees for capacity assignment and using of railway infrastructure according to the Czech law [3].

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Current Challenges for Research Activities in the Field of Railway Infrastructure

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Introduction

The increasing importance of railway systems, arising from both national and European strategic documents, leads to increasing demands on its infrastructure. Transport development in the European territory is defined in the strategy summarized in the "White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system", which was released by the European Commission in 2011. This strategy defines the "Roadmap to a Single European Transport Area" with the aim of creating a competitive and efficient transport system. It is evident that an efficient transport systems are crucial for the competiveness of European enterprises in the global economy. This fact is supported by an argument that transport and freight storage costs are 10-15 % of the final products costs. Every European household gives approximately 13.2 % of its budget on transport-related products and services. Annual congestion costs in Europe are approximately 1 % of gross domestic product.

Current role of rail transport

Rail passenger transport in Europe now plays an important role in long-distance transport (from 300 km) through especially high-speed trains. The definition of high-speed services is not easy and involves a wide range factors which determine operator access to the passenger rail transport. Nevertheless, it is usually considered the rail traffic at speeds higher than 230 km/h. The suburban transport in big cities or regional centres is another important area of the positive benefits of passenger rail transport. The inclusion of railway transport into integrated transport systems reflects this trend. Rail freight transport currently plays an important role in the field of long distance, especially the transcontinental transport. The effectiveness of the railways in this regard improves the use of combined systems. However, it must be noted that the increase in the medium-range transport (mainly domestic) will always run into tough competition with road transport.

Research activities in the field of railway infrastructure

Research, development and innovation will be focused on construction of high-speed lines, increasing speeds on existing rail lines, increasing reliability and durability of tracks with mixed railway traffic in the context of increasing service load and capacity. The current issue of interoperability of the railway infrastructure is taken into particular consideration.

Rail infrastructure is in the state that corresponds a history of its construction, maintenance, renovation and modernization. Rail infrastructure must be considered as a very complex system, which consists of components that are of different technical, technological advancement and age. Railway track consists both from earthworks such as embankments or cuts and from advanced railway superstructure both ballasted and ballastless, characterized by the controlled vertical stiffness of substructure and with resilient rail fastening. Most of tracks are of different age and technological advancement due to the gradual replacement of the structural elements except completely renewed or modernized tracks.

The main research activities aimed in the development of rail infrastructure, both railway and urban lines are focused on requirements of speed increase, higher service and axle load, safety and security, ride comfort while meeting economic needs, environmental requirements, i.e. reduction of noise, suppression of vibrations spreading, especially in urban areas, also reducing

costs of maintenance and repair works, reducing energy consumption and consumption of raw materials. Calls for research projects both national and European correspond to the above specified requirements.

The focus of the research activity in the Czech Republic is the preparation of technological solutions for the design and construction of high-speed railways. An important part of the process is development of decision-making strategies for choosing the most appropriate design solutions for high speed lines (eg. ballasted vs. ballastless track). Research activities are focused on the preparation of new structural and technological solutions to meet the requirements of the railway superstructure and substructure of high-speed lines, especially on the structural design of switches and crossings. The attention must be paid to the particular design of the high speed structures as well as to encourage the readiness of domestic suppliers in railway industry and track work contractors.

A significant part of the research work is aimed at the technology procedures and management of construction activities and maintenance work. Next subject of research works in this field is the development of advanced technological processes, rules of guarantee service and preventive maintenance strategy. Innovative and advanced technological procedures for maintenance and reconstruction of tracks, logistics issues, management and strategy of maintenance are developed.

Outcomes of research activities lead to the development of such infrastructure design, which also contributes to the reduction of negative impacts on the track vicinity, while solutions are being sought especially economically efficient from a lifecycle. cost perspective.

In all fields of research activities is considered the issue of interoperability of the railway infrastructure. The project “Interoperability of Railway Infrastructure Competence Network (IRICoN)” helps to connect national activities to European network for interoperability which includes institutions, agencies, organizations and expert groups cooperating on coordination and executive activities in this area. The network provides possibilities to cooperate within the European organizations such as UIC, RISC (Railway Interoperability and Safety Committee), ERA (European Railway Agency), CER (The Community of European Railway and Infrastructure Companies), ERRAC (The European Rail Research Advisory Council), NB-RAIL, etc.

Conclusions

Railway infrastructure administration put emphasize on research and development and implementation of research results into practice. It is considered as the fundamental way to increase the competitiveness of rail transport in the process of developing a sustainable and efficient transport.

With respect to the current support of science and research projects at national and European level, with regard to available facilities of newly built research centres, excellent research teams, it can be assumed that research activities will achieve the objectives which were defined in the White Paper and further specified in the particular requirements of railway companies, contractors and manufacturers in the railway industry.

Criticality of Transportation Infrastructure in the Czech Republic

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Abstract: The paper deals with transportation infrastructure criticality because this quantity determines the State capability to overcome the critical conditions and to ensure the inhabitants survival. The criticality rates for individual types of transportation infrastructure and for the entire transportation infrastructure are determined by data from experts from the areas: transportation; transportation management in the territory; supply chains; public administration; and the Integrated Rescue System. The experts assessed 14 factors, which have been often used in the developed world countries, from the view of human security and development. The result values and their interpretations were determined by using the Multiatribute Utility Theory.

Key words: transportation infrastructure; system of systems; interdependences; criticality; interoperability; serviceability; human survival; State stability

Description of research and its results

Transportation infrastructure belongs to the basic systems that make up the critical infrastructure in the European Union, in developed countries and also in the Czech Republic. We understand the system of transportation in accordance with the current knowledge as a system of systems, i.e. the set of several overlapping systems. The most important property in such type of system is the interoperability of partial systems that depends on interdependences [1]. The interdependences are the cause of different emergent phenomena and cascade failures that cause that the transportation infrastructure does not fulfil its function, i.e. the serviceability of territory at normal, abnormal and critical conditions if it is threatened the human survival and State stability. Therefore, it is necessary to manage the transportation infrastructure by the way so infrastructure criticality is acceptable [1].

According to the detailed discussion given in [1, 2] ***the criticality of item means that item has simultaneously great importance and great vulnerability***. It means that we work with conflict criteria at the solution of problem. Therefore, we use the strategy defined by the Keeny and Raiffa [3] by the mathematical statement "the higher, the worse, i.e. the higher criticality in our case" and a multicriterial approach and information from experts [4]. In accordance with the procedures that are used in the USA, Australia, Canada etc. there were used the 14 factors that are important to the criticality of transportation infrastructure. With the facts in the documentation of the Czech Republic transportation system [5] and with the data from 5 experts from the areas: transportation; transportation management in the territory; supply chains; public administration; and the Integrated Rescue System, there were obtained verbal assessments of the factors mentioned above. Since the main human objective is the human safety and the human development [6], for which the safe transportation infrastructure is vital, the criticality of the transportation infrastructure is understood from the perspective targeted on the human survival. The criticality rates determined are in Table 1.

Table 1 shows that the greatest criticality has rail transport, which is followed by air transport, road transport and water transport. According to the chosen concept, the chosen scale and evaluation provided by the experts the criticality rates of both, the rail transport and the air transport are very high, the criticality rate of road traffic is high and the criticality rate of water transport is medium, and the criticality rate of whole transport system is high.

From Table 1 it is clear that to the size of criticality rate mostly contributes the vulnerability to attacks, little capability of protection (the protection of long linear networks in the territory is

always a big problem), the importance for ensuring the functions of the army and the police, a big impact of transport failure on the economy of region (State), and the big importance for ensuring the emergency and rescue functions in the territory. The above facts show that it is urgent to pay increased attention to safety issues of transportation systems. It needs to be processed as a separate concept of transportation system safety, so the concept of critical infrastructure safety, as it shows the work [7].

Table 1. Rates of criticality of the transportation infrastructure in the Czech Republic.

Factor	**Rail transport**	**Road transport**	**Air transport**	**Water transport**	**Entire transport**
1	5	4	5	2	16
2	5	4	5	3	17
3	4	3	4	3	14
4	4	3	3	2	12
5	4	3	5	2	14
6	3	2	4	3	12
7	5	5	4	1	15
8	3	3	2	2	10
9	5	5	5	2	17
10	3	2	3	1	9
11	3	2	3	1	9
12	5	4	4	4	17
13	4	4	4	2	14
14	3	2	3	2	10
All factors	56	46	54	30	186

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The priority of international freight expresses in the overlapping section of RFC 7 and RFC 9 Kolín - Česká Třebová

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1. Introduction

One of the aims of European transport policy is to redirect capacity of road freight traffic to other modes of transport, where rail transport is an interesting and environmentally friendly alternative, especially in terms of speed, availability and amount of transported cargo. On the other hand, by customers is required delivery time is guaranteed by carriers, what is unfortunately not always possible, especially due to high utilization of European rail infrastructure. The solution could be one of operational measures, concretely changing priorities of a particular type of train, e.g. train category Fex (freight express).

2. Aims

The aim of this article is to find the optimal priority of international freight expresses to satisfy the customers required delivery times due to optimization of railway traffic control.

3. Materials and methods

This paper deals with the model study of common section of RFC 7 and RFC 9 Kolín - Česká Třebová. To satisfy the end users of rail freight and ensure its full competitiveness, it is necessary to trace freight trains in the fixed periodic routes. To increase the transport speed and reduce the overall delivery time is also desirable international freight train paths were carried out accurately under deadline cargo - for this purpose it may be necessary to change the current train priority so that international freight expresses (Fex) weren´t in their paths delayed by stop passenger trains. This measure in addition to increasing the speed of transport and reducing the overall delivery time also contributes to reducing the overall energy efficiency of rail freight, which will no longer need to waste power electricity due to start heavy freight trains.

In overlapping section of RFC 7 and RFC 9 Kolín - Česká Třebová there are a total amount of 14 railway stations, in which it is possible overtaking trains (double track line). Interstation sections are divided by an automatic block into track sections; all crossing safety devices are equipped with gates. For simulation was used simulation tool SimuT, developed by Pavel Krýže, PhD. from CRIA. It was created the daily timetable, which included the amount of 384 trains, concretely 160 express trains, 34 speed-up passenger trains, 46 stop passenger trains and 144 Fex trains. The passenger transport trains were concentrated especially from 6 am to 23 pm. All trains were conducted in periodic timetable.

Within the simulation program was established the average delay increment (ADI). The average delay increment was calculated by dividing the difference between total output and total input delay and the total number of trains. This indicator was calculated as an ongoing basis for each simulation run, so the total for the entire graph (all simulation runs). The indicator was also calculated for different types of transport, i.e. for long-distance passenger transport, regional passenger transport and freight transport. In order to achieve measurable results of transiting Fex within RFC in the deadline cargo mode, the freight transport segment was narrowed to only those trains, for which it was created recurring schedule, counting 3 pairs of trains every hour (the period 20 min) on the prescribed speed of 100 km/h (total amount of 144 trains). In the real operation the other freight trains shouldn’t delay the trains of Fex category.

Three variants were created, reflecting the priority of Fex. The first variant corresponded more or less simultaneous the operation in the Czech Republic, when international freight trains of the Fex category were delayed by all passenger trains including stop passenger trains. In the second variant there was set priority of trains, corresponding to the Transport prescription D1 of CRIA, when the Fex trains overtook stop passenger trains. And in last, the third variant, received international freight trains of the Fex category the second highest priority, not just for passenger trains category Ex (Expresses).

As part of the simulation was set for all simulation runs random entry delay based on the exponential probability distribution. There were solved conflicts of station tracks, freight trains were allowed to ride before their schedule time (in the case of free capacity). For each variant was made a total of 365 runs of simulation (for a daily timetable).

4. Results

The total average delay increment is getting lower with the increasing priority of Fex trains. In the growing amount of Fex trains, which are operated on RFC, it seems quite logical to overtake some passenger transport trains by Fex trains to balance the railway transport. For CRIA is this model convenient because of higher fee payed for using of the railway infrastructure (which is generated by Fex trains). And especially the high priority of Fex trains fulfil at most the terms of deadline cargo mode, which is preferred by customers. The results are illustrated on Figure 1.

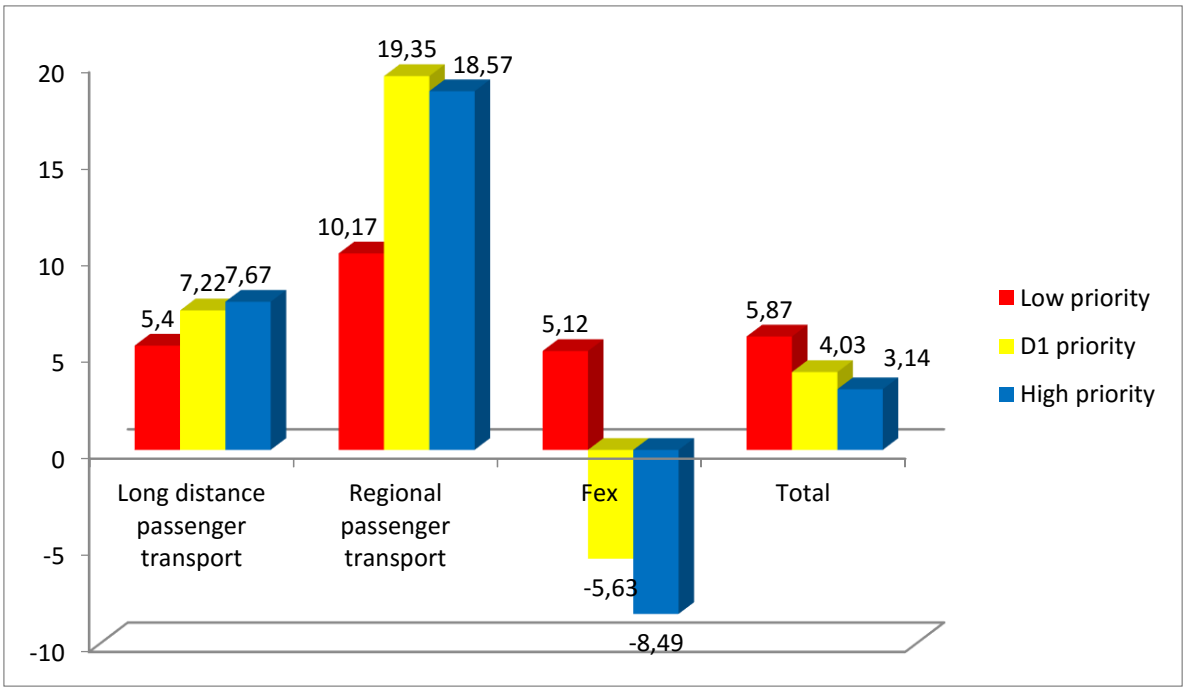

Figure 1: Average delay increment for different variants of Fex train priority

In the context of implementation of TSI-TAF in the overlapping section, it means operation of ETCS Level 2 with full-functional GSM-R, it is offered the extension to ETCS Level 3 or the implementation of automatic train paths on ETCS Level 2. Both variants enable to improve the railway traffic control technology and to reduce the amount of human interventions to do the railway traffic safer and well-timed.

5. Conclusion

To guarantee the train path stability for freight trains it has to be increased priority of freight trains (expresses). In the overlapping section of RFC 7 and RFC 9 Kolín - Česká Třebová there could be generated free capacity due to expresses consolidation (passenger transport), too.

Monitoring of Track Sections with Long-Pitch Corrugation

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1. INTRODUCTION

The focus of this paper lies on monitoring of the track sections with rail corrugations caused by wheel sliding. Short waves on the running surface of the rail head on low rail are typical for this defect. Long-pitch corrugation is a significant cause of vibration and noise pollution in the railway infrastructure. Therefore it is very important to understand the formation and development of this imperfection of the rails.

2. SELECTION OF LOCATIONS AND MEASUREMENT

Appropriate sections for the monitoring of long-pitch corrugation, where typical signs of this defect occur, were chosen in association with the Railway Infrastructure Administration of the Czech Republic.
The monitored sections are chosen by the presume of the influence on formation and development of long-pitch corrugation, by the track alignment, by the permanent way design and by the substructure design.
All of the sections are monitored and documented using the following methods:

- visual inspection and photo documentation,
- measurement of track geometry by the trolley Krab,
- measurement of wavy deformations of the rail head by the device Salamander,
- monitoring of the speed of trains and train compositions.

During the measurements, the influence of the difference between the tracks allowed speed and actual speed of the vehicles proved to be imperative. That is the reason for closer observation of the traffic with respect to the measured speed of trains. In some cases the track allowed speed, or sometimes cogitated as a designed speed, differs significantly from the actual speed of the vehicles.

Generally, the difference between the allowed and actual speed produces a cant excess or cant deficiency. Analogically, these values grow parallelly to the difference, so when the difference increases, the values increase accordingly. Therefore, a weighted average of all speed measurements in a set section was calculated, when the mass of each train was taken into consideration.

3. OUTPUTS

The first set of data was evaluated by two different means:

- In order to monitor the development speed of long-pitch corrugations,
- In order to be able to differentiate between the factors influencing the development of waves.

First of the monitored track locations consists of a double track with consecuting reverse compound curves.
The results of the train speed measurements were the differing speeds of trains in both tracks and both curves. After the calculation of the weighted averages, the data revealed the presence of cant excess in both tracks and both curves.

The train speed in the curve A in the track No. 1 is affected by braking/accelerating station. Some freight trains stopped at the station head in such a way that the end of the train was standing in the curve (*E* = 2 mm).
For the curve A (first curve) on track No. 2 the weighted average equals *E* = 27 mm. When comparing with the track No. 1 the wavy deformations reach the amplitudes twice as high.
On the contrary the cant excess markedly dominates in the curve B (second curve) in comparison to the curve A. The weighted average the curve B equals *E* = 57 mm.
The track No. 1 of the curve B is passed with almost all trains with a cant excess (*E* = 72 mm) since they have to reduce the speed according to a change of allowed speed between the curves. The designed cant in the curve B of 142 mm corresponds to the recommended cant for speed 75 kph. The allowable speed in this curve is on the other hand only 70 kph and realistically achievable speed is just 55 kph. Surprisingly, the wavy deformation of microgeometry is less developed in this section in comparison to other measured sections.
One of the possible explanations of this phenomenon may be the usage of the under sleeper pads, which were installed in this curve and only in the track No. 1
Despite of the fact that the above mentioned data indicated that higher values of cant excess have the most adverse effect on microgeometry, the slowest development of the long-pitch corrugation occurred in the curve B in track No. 1.
The second monitored location is the opposite to the first location in the means of the unequal cant excess. In this location the cant deficiency plays the main role.
During the year 2015 the rails have been replaced and the development of the long-pitch corrugation thus could be observed and measured since the time zero i. e. from the perfect condition. The measuring location consists of two curves.
Considering the common structure and geometrical parameters of the track and the railway superstructure they do not exhibit significant differences. Initial analyses of the data show significant differences in development of the long-pitch corrugation in the curves with small radii. The curve B embodies the weighted cant deficiency *I* = 67 mm. The curve A shows the weighted cant deficiency *I* = 47 mm.

4. CONCLUSIONS

The adverse effect of the speed occurs in two forms:

- the higher the value of the speed, the more significant the development of the defect,
- the higher the value of the cant inequity occurs, the more significant the defect is.

At the current state of the research it might be said that the higher the speed or the bigger the difference between the actual speed of the vehicle and the designed track speed, the faster and greater the development of the defects.
The composition of the railway superstructure and setting of the appropriate speeds of trains and also appropriate cant values seem to be promising factors to reduce the development of the long-pitch corrugation. Whether these parameters alone would be sufficient the following research will show.

Deployment of ERTMS in Czech Republic

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ABSTRACT.

The article describes current situation and expected deployment of international standard for automatic rail vehicle protection in Czech Republic for period 2014 – 2020. Article introduces expected status in 2020 and subsequent implementation of commitments until 2026. It also introduces expected result of gradual implementation for tracks and vehicles and displays brief deployment overview of European Rail Traffic Management System in European Union countries for each level of European Train Control System.

ERTMS is automatic train protection which represents basic part of interoperability in European rail system. The term is abbreviation of "European Rail Traffic Management System" and it was defined to synchronize nationals systems to the one common compatible system.

Urgency of the unification and cooperation between European countries caused an increase in freight which had negative impact for environment and ecology. The implementation of interoperability and automatic train protection across European countries allows competition to air and car freight. Implementation of the standard is business initiative that transforms the operation of the tracks, enhance safety, capacity, performance and reliability. It also have impact on reduce of cost of operation and maintenance.

The system allows one compatible system for cross-border traffic what reduce cost for implementation several regional stand-alone systems. The synchronization of automatic train protection increase competitiveness of the European rail sector.

It is divided into two basic components, ETCS "European Train Control System" and GSM-R "Global System for Mobile Communication for Railway". Both systems can be configured to operate in levels 0 - 3 to enable ETCS equipped vehicles to operate in not ETCS equipped system where the safe movement of the vehicle is controlled by the default national control system.

Unification of Europe requires to all transport systems operates without restrictions and time losses, especially when crossing borders. The Deployment started in most of European Union countries.

The participation on deployment of the ERTMS standard started in Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.

By 2020 the GSM-R will cover major sections of the Rail Freight Corridors in the Czech Republic. The system will be further deployed progressively on all 3700 km of national routes in order to create comprehensive operational tracks.

ETCS deployment priority by 2020 is Rail Freight Corridor 7, partially corridors 8, 9, 5 and the track Přerov – Česká Třebová.

By 2020, it is necessary to ensure the development of the ETCS about 1350 kilometers of tracks and 890 vehicles, i.e. for additional six years, around 250 km of tracks and 150 vehicles every year, but this is conditional on the timely implementation of the modernization infrastructure.

This requires the necessary financial resources for the trackside and on-board ERTMS and creating motivational factors and efficient financial support equipping vehicles with on-board equipment of GSM-R and ETCS.

KEYWORDS: ERTMS, ETCS, GSM-R, Interoperability