IMPLEMENTATION OF THE NEW INTELIGENT INFRASTRUCTURE WITH SIGNALSAFETY AND TELECOMMUNICATION SYSTEMS IN THE RAILWAY CORRIDORS

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Abstract: *At the beginning of 20th century most of the continental transport was carried out by railway. But railway in spite of its golden era did not evolve on the whole, but partially. Each country was developing its own railway system which was usually not compatible to other systems. There were several reasons for that but they are not the main issue today, anymore. What is important is that we recognize the existing opportunities and we are now trying to carry them out better, faster and more successfully. Thus we must completely change our way of thinking, working and mutual cooperation between individuals in railway systems. Unification of equipment, work technology and services can be seen as steps or measures which ensure conditions for a railway to be on a par with other systems on the open transport market, such as road, sea or air traffic.*

Railway interoperability can otherwise be called a railway globalization. Technically speaking this means preparing railway infrastructure and superstructure for uninterruptible and borderless railway traffic. Unified supervision and traffic management systems of railway traffic will enable equal track side and train side equipment everywhere they will be installed. This will not only indicate standardization of equipment, systems, mutual communication, unified maintenance and maintenance of railway systems, but those system also will thoroughly change the realization of domestic and international railway traffic management.

Supervision and traffic management of railway systems will become more like traffic management of air traffic, more like corridor traffic. Exchange of experiences and planning of projects execution is very important as large railway infrastructure projects will appear and they will require longer periods of realization. After years of joint development and efforts for unified European system supervision and traffic management ERTMS/ETCS there is still a challenge remaining, whether we will succeed to implement it on time and on the whole European railway network.

Key words: *TEN-T corridors, railway intelligent infrastructure, transition model, technical uniformity, standardization intelligent system for rail traffic managing and supervision, ERTMS/ETCS, railway interoperability, signal safety and telecommunication devices, education process.*

1. DEFINITION OF THE PROBLEM AND GOAL

Intelligent railway infrastructure (IRI) is one of the basic part of railway infrastructure. We are talking about mechanical, electronic and digital devices and systems, which through their way of operation, management and maintenance importantly influence on the selected technology and organization of railway transport.

Telecommunication devices, interlocking systems, electro-energetic devices and information technologies are a part of this field.

The goal of this article is to analyze possibilities of unified intelligent railway infrastructure utilization on the railway corridor D of TEN-T European network.

2. CORRIDORS

Railway corridor D of European TEN-T network is set on the route Valencia-Lyon-Torino-Trst-Ljubljana-Hodoš-Budapest. It was selected as one of six priority corridors within European TEN-T railway network. It is important especially because of the access from European inland to the Adriatic and Mediterranean ports. As a formal approach to activities on this corridor the signing of intention letter [1] is considered which binds all joined countries to mount unified intelligent railway infrastructure, named ERTMS/ETCS along the whole track of corridor D.[2]

3. JUSTIFICATION CRITERIA

Corridor D is the only corridor besides corridor F which links west and east Europe in a wide area within TEN-T network. [3]

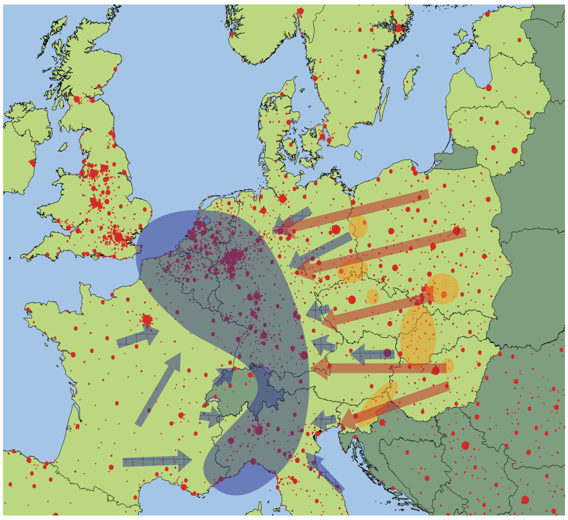

Image 1: Transit requirements after 2006

All other priority corridors are set on the relation north-south. **Image 1** show that the number of potential railway services users climbed to for almost 75 million. Consequently the railway network enlarged and traveling times prolonged. The competitive role of railway on the free market changed.[4] Therefore it is necessary to install unified telecommunication systems[5], supervision and management systems [6] and interlocking security systems[7].

4. TECHNICAL SOLUTIONS

We can conclude that technical interoperability of IRI is the key factor for railway transport services quality improvement. On the whole length of corridor D one can expect various approaches to the implementation of IRI. Key factors such as local railway industry interests, the amount of transferred cargo and passengers, logistics nodes, transit growth predictions and the amount necessarily modified IRI systems, will influence on the dynamics of mounting unified ERTMS/ETCS systems. But they all share one common denominator. Regardless to the possible influences we must set goals which

[1] MOU - memorandum of understanding, signed in decembre 2006 by secretaries of transport of all countries except Hungary.

[2] ERTMS / ETCS is a system of unified european railway traffic management system.

[3] Corridor F is the corridor on the northern Europe and connects Duisburg-Berlin-Warsaw.

[4] With enlargement of railway network the railway infrastructure »aged« and the number of ITS used by EU countries for traffic management increased.

[5] Unified telecommunication systems will enable the same ways of communication between train and centre on the technical level.

[6] Management and supervision systems ensure unified control, tracking and train traffic decision protocol.

[7] There are more than 25 various interlocking systems in Europe. Unification of these systems simplifies and speeds up border transition.

have to be the same in all countries throughout the corridor:

- Reduction and eventual removal of waiting time on borders,
- Increase of traveling speeds and track efficiencies
- Reduction of braking times
- Reduction of delays.

In the field of telecommunication unification we must ensure unified frequency range, which will only be indented for railway users. Besides that we must also implement unified services which will be available in all countries throughout the corridor. Standardized equipment and GSM-R systems enable unified data and voice communication between train and traffic management center (CVP). GSM-R system is a mobile communication system, derived from public digital radio system GSM and adopted for the needs of railway sector. Special frequency ranges are used for GSM-R. 876-880MHz and 921-925 (transmit).
An important factor for choosing GSM-R is the fact, that there can be a shortage of free communication channels. We can expect that especially on larger railway nodes and shunting stations, where there will be an increased requirement for simultaneous communications. We must be aware of the fact, that the needs for free frequency channels increase even more in the case of usage of GSM-R to transfer interlocking data. The answer to those challenges is the standardization and usage of data transfer, such as GPRS. [8] GPRS with its internet protocol platform enables a completely different approach to data communication between train and traffic management center. Information is encrypted into the telegrams, data packets with IP addressing. Basic principle of their transmission is similar to classic IP traffic, but with several additional security measures which are required by technology of railway traffic management. Data transport media types are optical or wireless. Because of different data type the consumption of frequency space is smaller or more information can be transmitted within one time frame. GSM-R and GPRS systems are in the test phase and they represent an important intermediate step to the use of satellite information system Galileo. Start of Galileo is expected in 2012. The system itself may bring a significant change at ensuring data transmission between train and its supervision. Key elements of its utilization in railway segment are applications, which will simplify, unify and make supervision procedures of supervision and management of railway traffic more cost-effective.

We can see that various approaches to the possible solutions by unified railway traffic management and supervision are in progress. The goal however is well known: Unification of IRI equipment. Currently countries in D corridor have various systems Ebicab+Asfa,[9] ETCS 1/2, [10] KVB, [11] Bacc,[12] PZB [13].

These systems are not mutually compatible. Therefore they will have to be replaced with unified interlocking system, which will not only present unified technical but technological ground as well.

Two important areas will be described. First is model of parallel operation in Slovenia and the second is education model which is extremely important for implementation of ERTMS/ETCS model in a real life.

5. MODEL OF PARALLEL OPERATION

The consequence of finding that an existing section of railway network should be selected as a test location brings us to the model of parallelism of railway supervision and management systems. In operative sense of railway traffic management this imposes a special challenge. Traffic management is an executive activity which doesn't allow doubts or duality of operation execution. Duality is only possible at the level of railway track condition data collection in the sense of checking whether information is identical or not. From here forward only one information must be forwarded to the supervision personnel.

Parallelism of operation is necessary and bothering fact of the railway traffic management process. Therefore we must foresee possible scenarios which in practice could occur and at the same time we enable as short parallel systems operation as possible. All activities in technical and technological fields must be followed by activities on administrative levels when preparing and coordinating railway legislation.

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[8] GPRS system is already a standardized type of data transfer for public purposes. Some additional safety measures should be acepted for GPRS railway implementation.

[9] Ebicab and Asfa : Spain,
[10] ETCS 1/2 : Spain, France,
[11] KVB : France,
[12] BACC : Italy,
[13] PZB : Slovenia.

Transition from existing signal-safety system and train protection system to the unified ERTMS/ETCS in the whole is too demanding for Slovenian conditions and it is also financially unacceptable and operatively unrealizable in one step. Therefore gradual transitions or timely divided investment cycles on the separate fields (signal-safety, telecommunication and traffic management) are more suitable. [14]

Image 2 shows timely and gradual transition from one to another system. This model will enable upgrading system of supervision and management of railway traffic during regular operation with possible interruptions at their minimum.

lays in existing relay and electronic signal safety system and their adaptations to ERTMS/ETCS 2 within parallel operation and adaptation of necessary legislation within satisfactory time limits.

A proposed system which will unify supervision and management of railway traffic is named ERTMS/ETCS[16].

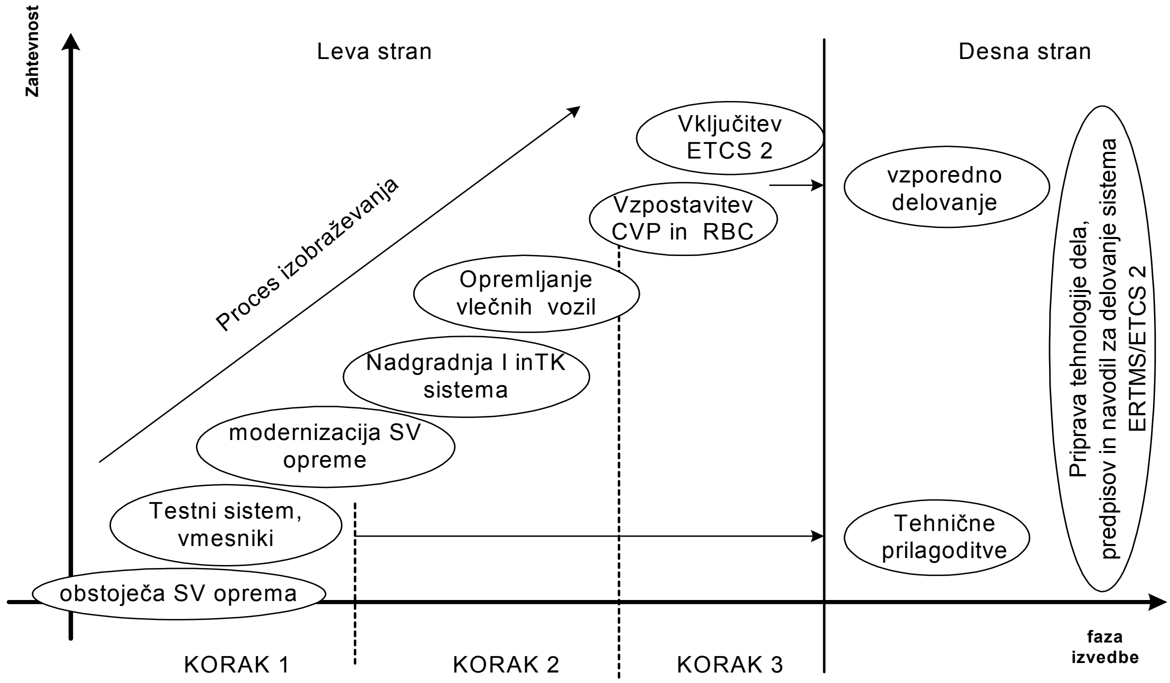

Image 2: Model of transitions

On the left of the **Image 2** standard procedures of ERTMS/ETCS system level 2 are presented and their necessary steps or elements are regulated with UNISIG classification.[15]

Key elements of national specific solutions of traffic management and supervision systems are in the right side of **Image 2**. Specialty of these elements

We must explain several facts here. First problem is that the system ERTMS/ETCS as a technology isn't standardized yet. There are no such standards like for example at GSM field which would prevent manufacturers to deviate from recommendations. Regardless to the series of »evolution« solutions, from level 1, 2, Regional, up to STM, neither separate components nor the system itself isn't precisely defined. On the market there are versions 1.0.0, 2.2.0 and 2.3.0. Each represents an upgrade

[14] More: cf. MANTEL, S. J., MEREDITH, R. J., SHAFER, M.S., and dr.: Project management in practice, John Wiley & Sons, New York, 2001.

[15] More: cf. http://www.aeif.org/ccm/doclist.asp (november 2005).

[16] ERTMS / ETCS : European Rail Traffic Management System / European Train Control System

of the previous version, unfortunately mostly within hardware. So the idea is that the next version of ETCS, so called version 3.0.0 will ensure necessary unified IRI on which upgrades are made only on the vehicle side through software upgrades. Such model would be safe, economically efficient and simple and it would also ensure interoperability of railway traffic.

6. CORRIDOR CENTRE OF RAILWAY TRAFFIC MANAGEMENT

Length of the D corridor is almost 2500 km. From technical and technological aspect it means a unified traffic management and supervision throughout the whole corridor. Local traffic management makes the supervision harder rather than easier. So the whole supervision and overview of the traffic on the line of corridor D can only be ensured from centers of traffic management and supervision. It makes sense to talk about corridor centers of traffic management regarding the length of the track. Three or four of them are expected.

In such centre we would supervise, coordinate and manage transit traffic on corridor D. Because of operative part of national railway traffic management a good national and transit coordination would be very necessary.

So the idea to organize national railway infrastructure managers into similar formations is also very logical. With forming of traffic management center the management of railway traffic gets a new dimension of supervision. Traffic management center is an executive as well as key factor with which railway infrastructure cooperates at the management of traffic on public railway infrastructure. It combines functions which were separated until now it executes working processes transparently and simplified together with transporters coordinates, prepares and executes necessary activities for traffic management from one point and it has all available resources and services for separate fields at disposal. And by that it entirely fulfils regulated directives of railway traffic management and supervision. Because of these facts different professional resources are needed in comparison to current resources structure. Direct and indirect benefits of central traffic management can be dealt with on several fields such as traffic, technical, economical, security and energetic:

- Interoperability of railway traffic: increase of railway transport competition,
- More lines because of greater railway system capabilities,
- Less cargo redirection to the roads,
- Lower operation costs,
- Higher passenger and cargo safety,
- Higher safety of level-crossing participants,
- International comparability.

7. EDUCATION OF PERSONNEL

When defining model of transition from one to another system of railway traffic management and supervision on Slovenian railways one must, in compliance to **image 3**, execute process of continuous education mostly of new techniques and technologies throughout the process of transition.

To implement such a complex system which introduction of new kind of railway traffic management and supervision ERTMS/ETCS most certainly is, one must carry out a demanding education process. Educated personnel will get to know the new system during its regular operation. The educated personnel are system managers (traffic personnel), maintenance personnel (signal-safety personnel, telecommunication personnel, information technology personnel and traffic), system developers and administration management. The process of education must be executed from the beginning to the end of the whole process. Theoretical and practical part must be executed separately due to work process. It is also important that education of all maintenance personnel is also executed because of so far unsuccessful transfer of knowledge from educated personnel to the others. As execution of such education will be logistically demanding, it makes sense to introduce simulators (software and hardware). That way we significantly shorten and improve education processes.

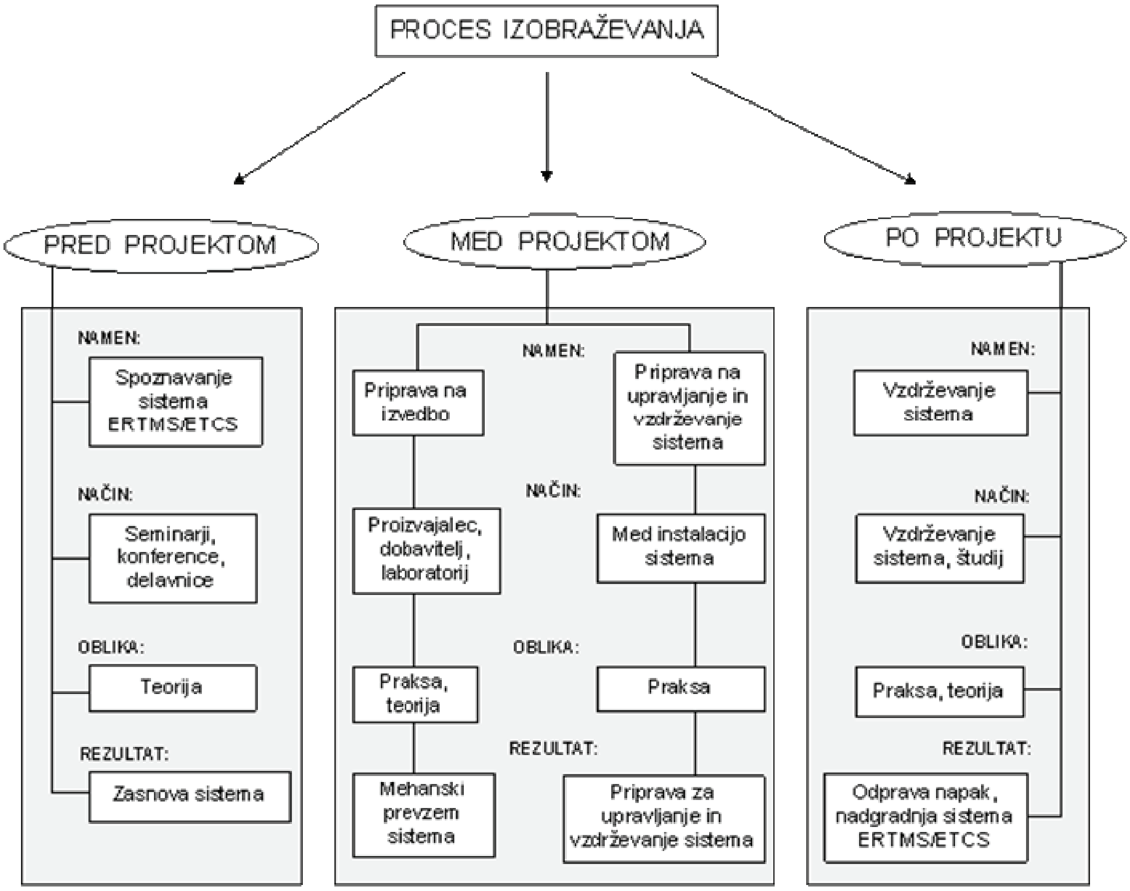

Image 3: Education model

8. FURTHER STEPS

When we are talking about investments of such scale we cannot talk about a single project.

Investment cycle must be carried out as well as long-term development shape of railway infrastructure which will proceed in several levels in the period of 10 to 15 years. Before that it is reasonable to establish a team which will actually prepare groundings for intelligent railway infrastructure implementation.

Parallel to that it is necessary to build an education system which will provide necessary resources not available on the market due to their specifics.

9. CONCLUSION

In this article we discussed the importance and role of intelligent infrastructure systems on railway field of corridor D TEN-T network. We set starting points and basics from which we defined the problem and presented solutions. It is a fact that existing IRI and train management technology must be adapted, adjusted and unified with European standards. That way we will ensure effective, safe and clear model of railway management and supervision in Slovenia. So it is considered beneficiary to establish a strategic development of railway infrastructure and superstructure parallel with service development, which railway transport can offer on the market.

LITERATURE

[1] EC: Strategy and implementation plan for the ERTMS migration, Corridor D study, Ljubljana, 2005,

[2] Boštjan Hernavs: Implementacija novega inteligentnega sistema nadzora in vodenja vlakov na slovenskem železniškem TEN-T omrežju, Fakulteta za gradbeništvo, Maribor, 2006, Mag. delo,

[3] Lyoyola de Palacio: Prednostni projekt št. 6, Bruselj, 2006,

[4] Boštjan Hernavs, Andrej Godec: Influence of intelligent systems of railway traffic management on railway infrastructure interoperability, EZS, ISEP 2006, Ljubljana 2006,

[5] Georg Theeg, Techniche Universitat Dresden, Sergej Vlasenko, Omsk State Transport University: Railway Signalling & Interlocking, DW Media Group, Hamburg 2009

[6] Peter Winter, et all: ERTMS, DW Media Group, Hamburg 2009

[7] Boštjan Hernavs: Technical and technological view of introduction and compatibility of supervision, control and management of railway traffic ETCS in dependence to infrastructural technological factors and equipment of rolling stock, EZS, ISEP 2010, Ljubljana 2010,

[8] Kerbeck M., Zuverlässige adaptive Informationssysteme, Technische Universität Kaiserslautern, Januar 2006

[9] Boštjan Hernavs: Implementation of intelligent infrastructure systems IIS on railway sector – D corridor, EZS, ISEP 2007, Ljubljana 2007.

[10] Direktiva 2001/16/ES evropskega parlamenta in sveta, z dne 19. marca 2001: Interoperabilnost vseevropskega železniškega sistema za konvencionalne hitrosti

[11] DIREKTIVA SVETA 96/48/ES z dne 23. julija 1996. Interoperabilnost vseevropskega železniškega sistema za visoke hitrosti.

[12] Slovenske železnice: Final report for MATTILD, Slovenske železnice, d.o.o., Služba za elektrotehnično dejavnost, Ljubljana, Februar 2008

[13] Boštjan Hernavs: Implementation of new technical solution of signal safety and telecommunication systems in to the second railway line between Divača and Koper, EZS, ISEP Ljubljana, 2011