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Assumptions used to develop the strategy of the interoperability implementation for the railway network managed by PKP Polish Railway Lines SA

Abstract: The article presents the assumptions, determinants, and evaluation criteria adopted in the interoperability implementation strategy as well as the reasons for creating this strategy with regard to the issue of constraints and the dynamics of changes in the scope of rail infrastructure investments.

Keywords: Strategy; Interoperability; Implementation of the TSI; Railway infrastructure

Introduction

Opening of the transport market and transport services in the European Union (EU) through the abolition of boundaries between membership countries has boosted demand for international services and reduced absorptivity of transport services [10], [23]. Positive changes were observed in the road and air transport, while the existing restrictions in the system of rail transport do not confirm such changes on the railways [19]. Demands for freight between industrial areas and regions of freight distribution as well as for passenger transport between agglomerations and cities of the EU confirm the existence of untapped potential for the railway transport in the area of EU [10], [23].

From the point of view of large multinational corporations, the key is to secure sources of supply through the diversification and dispersion of supply bases and subcontractors. As it was shown in paper [15], the process of cooperation between companies is carried out in factories distant several thousand kilometres. This situation results from the concept of management and strategy of companies involving the use of components from different suppliers, so that the production process proceeds without any interruption and eliminates the risks resulting from one of the subcontractors, strikes, failure in delivery of components and so on.

Significant factors limiting the possibilities of creating an open market for services and railway transport are technical differences in the railway systems, control systems, traction power supply, the rules of railway traffic etc., as well as discrepancies in the legal - administrative field concerning the authorization of vehicles and railway infrastructure to exploitation [13], [11].

The idea of "integrating" railway networks and achievement of compatibility between the systems of railway transport appeared in the 90s of the twentieth century, along with the desire to unify technical, operational and legal standards. This concerned in particular to international investments related to the construction of the high-speed railway in EU.

In the next years, the EU directives widened the scope of interoperability to the area of conventional lines, located on the trans-European transport network TEN-T (Trans European Network), while in 2014, on the basis of regulations and decisions of the European Commission (EC), Technical Specifications for Interoperability (TSI) included the application the entire railway network in the EU, and also the infrastructure of tracks with 1520 mm spacing [4], [5], [6], [7], [8], [3].

The key regulations for security and interoperability, and principles for functioning and admission of the railway superstructure and infrastructure into exploitation within the EU Member States, have been defined in the directive number:

- 2012/34/EC on the creation of a uniform European railway area,

- 2004/49/EU (with further changes) on the safety of railway traffic,
- 2008/57/EC (with further changes) on the interoperability of the rail system.

Obligations imposed on EU Member States to implement interoperability on railway lines in the case of: construction, upgrading or renewal of a structural subsystem[1] are limited by technical or financial capacities of infrastructure managers [11]. Such aspects were described in the directive 2008/57/EC in the article on exemptions from the application of the TSI as well as in each TSI, in the section on implementation of the given specification.

EU Member States are also responsible for the development of national plans to implement the requirements of interoperability, taking into account the positive economic effect of investments and the coherence of the railway network.

In terms of investment project management, it is essential to determine technical, operational and financial limitations for the individual infrastructure investments and the time needed to adjust individual railway lines to the requirements of interoperability, taking into account the scale of the changes, as well as the consistency of the rail network [1], [11].

Issues concerning the implementation of interoperability

The size of the railway network managed by PKP Polish Railway Lines SA constitutes more than 18 thousand km, of which about 6.5 thousand lines are included in the TEN-T network. Adopting the right strategy allocation of funds to adapt the railways to the requirements of interoperability is important from the point of view of the functioning and the infrastructural investments by PKP Polish Railway Lines SA, as well as the real possibilities of absorption of funds and disposal of resources and means for the implementation of investment plans [1].

Assuming the approximate value of the cost index for the adaptation to the requirements of interoperability of structural subsystems "infrastructure", "energy" and "control", for 1 km of lines, amounting to about 2 million PLN[2], the entire railway network in Poland may require funding of about 36 billion PLN. Such value constitutes a significant amount in the state budget, even taking into account the large timing of the planned investments.

Deadlines for implementation of the requirements of interoperability have been indicated, among others, in the regulation EC no 1315/2013 [24] on European Union guidelines for the development of trans-European transport network and the EC regulation No. 1316/2013 [20] establishing a financing instrument called. "Connecting Europe" (CEF).

The core network of railway lines covered by the TEN-T should be adjusted to the interoperability till 31 December 2030, whereas the deadline for the full interoperability adaptation of the railway lines covered by the comprehensive network TEN-T was set to the 31 of December 2050 [24].

For projects submitted for co-financing from CEF sources, a prerequisite for obtaining such funding is the implementation of agreement with the requirements of interoperability in the planned changes in the structural sub-systems [20], resulting from TSI.

In order to achieve the interoperability for "Control" subsystem, the construction of supervisory system ERTMS (European Rail Traffic Management System) is required. The time frame for the implementation of such a system has been indicated in the EC decision No. 2012/88/EC (TSI CCS) [2]. In this decision, together with the "linear" implementation of the ERTMS system, the necessity

[1] Subsystem - part of the railway system with structural or functional character, for which separate essential requirements were set in the case of the interoperability of the railway system [11]

[2] Estimates based on an analysis [1] and revised based on the experience of other infrastructure managers EU countries in the scope of adaptation of existing railway lines to interoperability. Precise estimation of costs will be possible on the basis of the experience gained from the implementation of interoperability, at least several railway lines in Poland, taking into account the status and level of technical modernization of infrastructure.

of building a system of corridors for connections to the main European ports, marshalling yards, freight terminals and freight transport areas was indicated.

The EC decision No. 2012/88/EC indicates also the mandatory of implementation of ETCS projects funded by the EU, in the case of modernization or construction of train protection equipment (section 7.3.2.4 of this decision). The above requirement has been extended to the whole network managed by PKP Polish Railway Lines SA in connection with the decision of European Commission No. 2015/14/EU [3] changing the decision No 2012/88/EU.

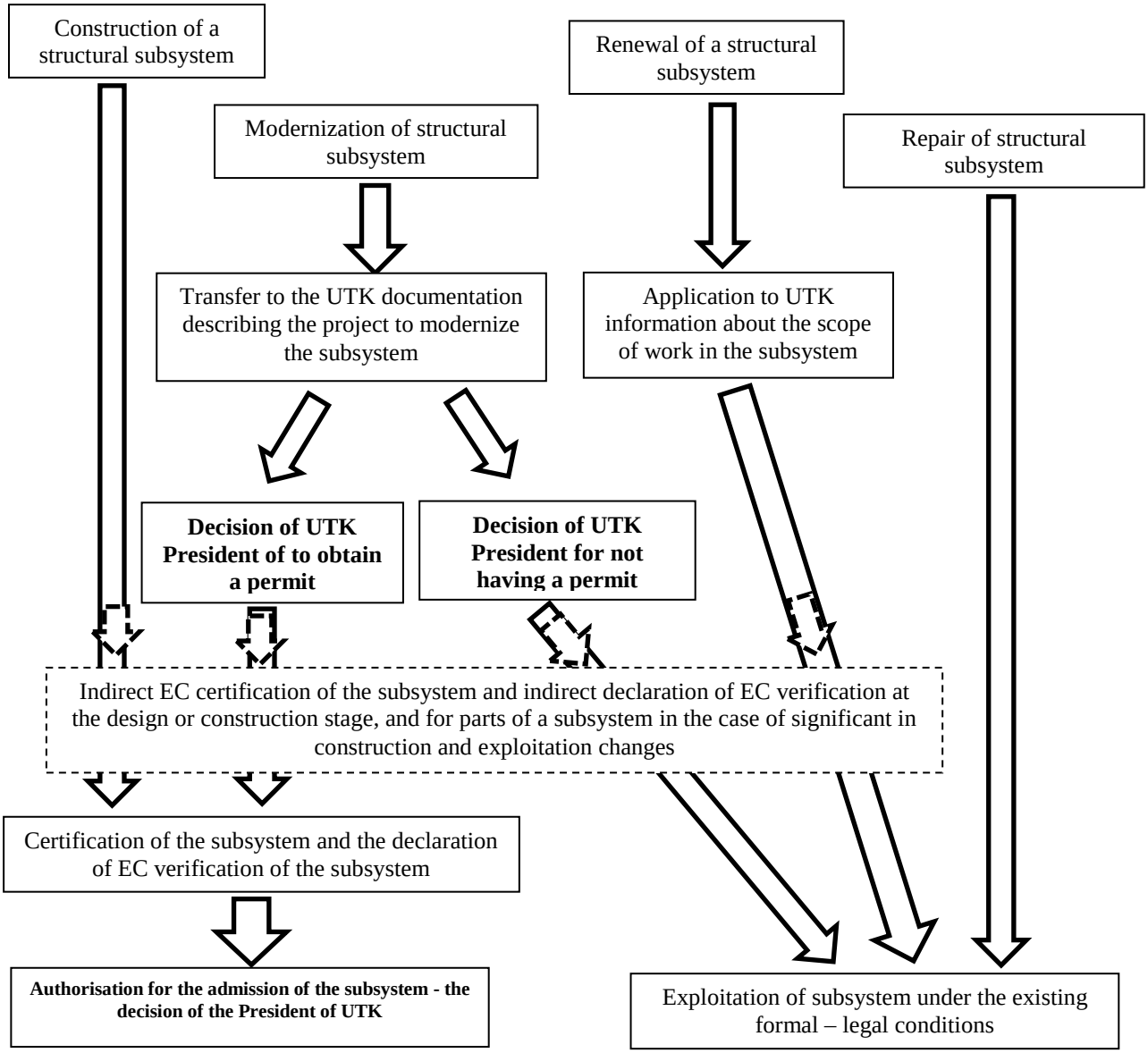
Another issue concerning the implementation of interoperability issues is qualifying changes in the structural subsystems. In the framework of an investment, the project is often divided into separate parts, contracts and tasks, which can cause ambiguity in the interpretation, whether the implemented changes affect parts of the subsystem or the whole structural subsystem implemented in various stages of investment. An example could be the modernization of the railway line in the field of engineering objects without changing the subgrade and track structure, modernization of traction network without changes to the power supply system and so on.

A certificate under EC verification may be issued for the whole subsystem or part of it - within the range defined and possible under the relevant TSI. However, in the opposite case, an intermediate certification for the EC structural subsystem can only be issued.

It is important from the point of view of the planned investment that the change in performance of the subsystem is a key element determining the extent of the modifications of technical or operational qualification, as a modernization of the subsystem, for which the President of UTK decides whether it is required to obtain an authorization for the structural subsystem into exploitation.

Determining the scope of changes in the structural subsystem is the responsibility of the infrastructure manager on the basis of, among others, prepared project documentation. In the case of upgrading subsystem, the infrastructure manager or a contractor are obliged to submit to the UTK a request containing technical documentation describing the project in order to issue the above decision [17].

In case of renewal of a structural subsystem, it is only required to send information about the scope of work, which does not imply a decision of the President of the UTK, while for the subsystem or repair work in the structural subsystem, is not obliged to apply to the President of UTK. Diagram of the possible scenarios is shown in Fig. 1.



1. Formal-legal requirements resulting from the scope of changes in the structural subsystem. The dashed line indicates alternative solutions. Source: based on [17] with modifications.

Taking into account the above aspects, it is important to consider how the scope of the planned infrastructure changes may imply formal-legal requirements and requirements for carrying out the certification process.

Implementing Interoperability

Directive about interoperability 2008/57/EC indicates the possibility of partial implementation of the interoperability at the assumption that the target subsystems specified in the TSI can be introduced gradually within a reasonable time, and each TSI should indicate the strategy for implementing the strategy of migration subsystems from the existing state to a state of full compliance with the TSI requirements [4][5][6][7][8][3].

Member States are required to develop a national plan for implementation of the TSI, given the consistency of the entire EU railway system [11]. This plan includes all the projects under construction, modernization and renewal of structural subsystems. This obligation results basically

from the Article 20 (Directive 2008/57/EC) with regard to the rules for admission of structural subsystems into service after renewal or upgrading.

In each TSI, the Chapter 7, indicates also the framework for the application of the TSI and the migration criteria, conditioned by the scope of the changes in the structural subsystem, to which the TSI data refer. The use of TSI to existing lines (with the exception of special cases), includes the following items:

a) in the case where the Article 20, paragraph 2 of directive 2008/57/EC can be applied;
b) when the Article 20, paragraph 2 of directive 2008/57/EC cannot be applied, it is recommended to obtain the agreement with the TSI. When it is not possible to achieve the agreement, the contracting entity should inform the Member State of the reason for this state of affairs;
c) if a Member State imposes the requirement to obtain a new authorization to exploitation, the contracting entity determines the practical measures and different phases of the project needed to ensure the required usable levels. These project phases may include transition periods for placing equipment into service with reduced levels of utility;
d) the existing subsystem may allow traffic compatible with TSI with simultaneous meeting the essential requirements of directive 2008/57/EC. The procedure to be used to demonstrate the level of compliance with the basic parameters of the TSI must be in accordance with Commission Recommendation 2011/622/EU.

The Plan of the interoperability implementation on the railway network depends mainly on the obtaining answers to the following questions:

1. Taking into account the consistency of the railway network and the availability of financial resources, is it possible to determine the priorities for the implementation of interoperability for individual railway lines?
2. To what extent, individual railway lines should be subject to adaptation to the requirements of interoperability (e.g. whether to build costly system ERTMS?), taking into account the type of train traffic or railway usage?

International obligations concerning the TEN-T and international freight corridors suggest that railways should be given priority in the implementation of interoperability [10][23][22].

Individual TSI for structural subsystems provide transition periods and a timeframe for full implementation of the TSI, e.g. the year 2021 is set for Infrastructure and energy [4][6].

In the case of railway lines located outside the corridors of the TEN-T, there is no clear legal and technical interpretation about the time and scope of the implementation of interoperability. It is therefore necessary to identify such factors which allow the prioritization of the different railway lines, taking into consideration the adjustment of the interoperability requirements for the entire railway network.

Such factors are closely connected with international conditions as well as strategic plans concerning the investment processes carried out by PKP Polish Railway Lines SA, namely:

1) the expected demand for interoperable trains on the railway line,
2) co-financing the modernization of the railway line from EU funds,
3) the economic effect resulting from the difference between the income resulting from the size of the number of interoperable trains in passenger and freight traffic, and costs resulting from the modernization and adaptation of the railway line to the requirements of interoperability.
4) other plans, e.g. National ERTMS Plan of Implementation [24].

So formulated determinants were the basis for the adoption of guidelines for the implementation of interoperability strategy, which based on the list of railway lines, will allow for the indication of the priority of implementation of the requirements for interoperability in individual railway lines.

Prerequisite for derogation from the TSI

According to directive 2008/57/EC and the Railway Transport Act about the implementation of interoperability in the area of infrastructure, obtaining derogation from the requirements of the TSI is possible in the following cases [17]:

1) publication of new TSI during the design or construction of a new subsystem or upgrading or renewal of an existing subsystem, or its parts - which are at an advanced stage of development or subject to contractual obligations;
2) projects concerning the renewal or upgrading of an existing subsystem, when the loading, track spacing, distance between track axes or power system are not compatible with the TSI of this subsystem;
3) projects concerning the renewal, extension or upgrading of an existing subsystem, when the use of TSI would undermine the economic viability of the project or the consistency of the railway network on the Polish territory;
4) the need to quickly restore the consistency of the railway network as a result of a serious accident or natural disaster, when the full or partial application of the TSI is not possible because of the economic or technical reasons.

In the case of the planned infrastructure investments, one of the most important conditions is to obtain a positive effect of the economic changes, as indicated in the Section 3.

Determining the benefits that may result from the implementation of interoperability reduced by costs resulting from the modernization of the structural subsystems allows for evaluation of the project and possible withdrawal from the implementation of the TSI.

In this context, questions arise about the economic impact, when the analysis of transport offer indicates that on the railway line there is no interest and demand for the movement of interoperable trains.

In certain cases (e.g. in local or regional movement), railway carriers may be against to incur significant costs to upgrade or purchase interoperable trains. Therefore, adjustment of the railway line to the interoperability requirements may affect the unnecessary increase in the cost of the project, thus contradicting the meaning of realized investment plan.

Therefore, it is appropriate to indicate such restrictions, which may affect the assessment of the railway line in terms of its adapting to the requirements of interoperability [12][14] e.g.:

1. Obtaining suitable transportation offer for interoperable trains.

The limitation resulting from the minimum number of interoperable trains forming the transport offer, attractive from the point of view of time travel on the given railway line and the frequency of running. Taking into account that the interoperable train, sense of interoperability [17], should move in a safe and uninterrupted way. Moreover, stopping the train should be considered only for making trade transactions, thereby, the minimum as possible travel time should be obtain, for a given speed of movement.

Obtaining the appropriate frequency of interoperable trains should take into account the ability to secure routes for interoperable train at different times of the day. If we consider the fact that interoperable train moves at a distance greater than local trains and thereby travel time between the start and end station can take more than a few hours, even distribution of intervals of train paths in the age will increase the attractiveness of this service.

The above-mentioned advantages apply basically to the carrier, which will have the motivation to invest in the interoperable stock and to use the offer of available routes on the given railway line.

2. Justification effect of the financial or economic modernization of the line.

The decision to upgrade the railway line and adapt it to the requirements of interoperability can be considered from the financial or economic point of view. For the railway line outside the corridors of international e.g. beyond the trans-European transport network TEN-T, where the most common upgrade is carried out on the basis of own resources of the infrastructure manager, it is necessary to consider the financial terms of the investment, the commercial purpose of the lines and the demand for the number of trains on the railway line [15].

By contrast, the railway line in the so-called international corridors, the effect of economic changes is mainly analysed, including also social costs and benefits as well as the economic profits in the scale of the region and country [15].

The economic effect can be determined on the basis of analysis and comparison of the number of interoperable trains expected on the line, retraining existing trains to interoperable ones, start-up of freight and passenger transport etc. The resulting benefits to increase the influence of the available routes and reduce operating costs must be related to the funding necessary for the modernization of structural sub-systems, in particular the implementation of the "expensive" ERTMS system should be taken into account.

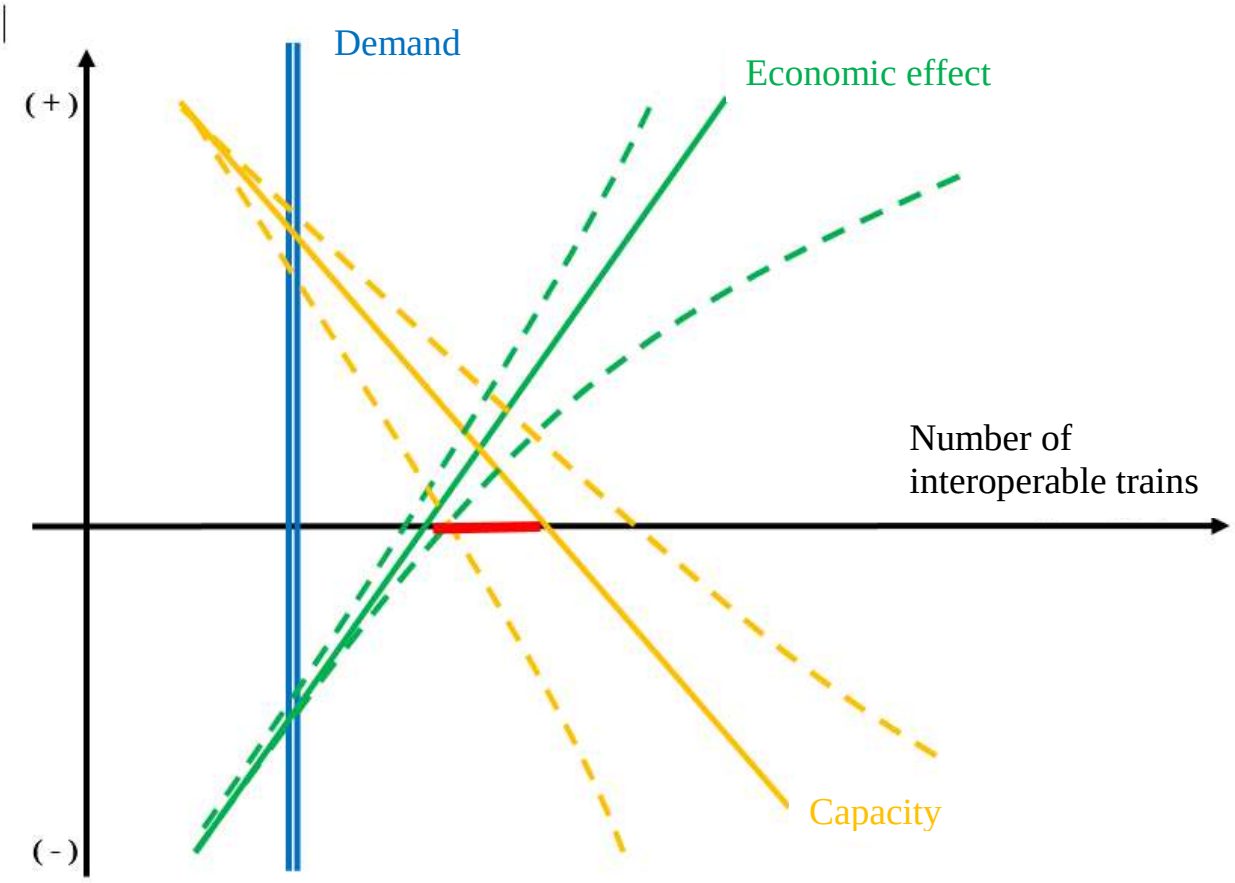
3. Ensuring adequate capacity of railway line.

One of the limitations to put the interoperable traffic on a given railway line could be its technical condition and throughput capacity. The capacity of the railway line - defined as the maximum number of trains moving on the line in a safe manner and not disturbed - may imply the need for costly and significant changes in the infrastructure [1][18].

Analysis of the requirements for investment expenditure should take into account relevant mobility - transport aspects, obtaining the minimum time of changing trains, the application of dilatation times for the suppression of the original disruptions and providing an adequate flow of traffic on the given railway line [23].

Therefore, economic viability of projects will be the difference between the benefits of the minimum number of interoperable trains running on the line, and the minimum cost necessary to implement the requirements of interoperability and enable the traffic of interoperable trains.

Fig. 2 shows a schematic representation of the impact of these restrictions on the assessment of the railway line in terms of implementing the requirements of interoperability.



2. Limitations affecting the decision on the derogation of application of the TSI or implementation of interoperability on a specific railway line.

Red colour indicates the area of feasible solutions for specific number of additional interoperable trains on the railway. The non-linearity of curves for "economic effect " and "capacity" appears in the scenarios of liquidation of the existing train routes for interoperable trains. *Source: own work*

Assumptions of strategy for implementation of interoperability

Based on the analysis of issues and legislation related to interoperability, one can make the following assumptions about the implementation strategy of interoperability:

1) Changes in the railway system cannot create new or deepen existing obstacles and constraints in implementing the interoperability of the railway network of PKP Polish Railway Lines SA (Paragraph 21 of the preamble to directive 2008/57/EC) [11].
2) The strategy will allow the orderly and chronological implementation of the interoperability requirements of the TSI, based on objective criteria.
3) The strategy will allow for proper programming the range of changes in the railway infrastructure.
4) Progressing towards the full implementation of the requirements for the interoperability of the railway network must take into account the financial capacity of the infrastructure manager.

In order to implement the interoperability on the railway network, the following priorities are proposed:

- Priority FULL IMPLEMENTATION - any investment includes the implementation of interoperability according to the TSI for all structural subsystems;
- Priority MIGRATION - the process of collecting indirect EC certificates of verification for structural subsystems for upgrade or renewal of these subsystems or parts thereof;
- Priority DEROGATION - application for derogation from TSI on the basis of art. 25f of the regulation on railway transport, and the implementation of the essential requirements for interoperability involving the implementation of interoperability based on the so-called the list of the President of UTK.

The proposed priority "Full implementation" means that for a given section of railway line should be implemented all the interoperability requirements specified for the scope of the projected work of modified structural subsystems. The planned scope of work should basically take into account the need to adapt the railway line for the international movement of interoperable trains.

The proposed priority "Migration" means that for a given section of railway line should be applied to the requirements of interoperability with the possibility of obtaining a possible derogation from the TSI requirements because of the technical, economic, geographical, urban or environmental reasons. The planned scope of work is focused on the need to adapt the railway line for running the national and international trains as well as a local traffic.

The proposed priority "Derogation" means that for a given section of railway line, there is no reason to extend the scope of the planned changes in order to intensify the implementation of the requirements of the TSI. The planned scope of work should be basically focused on the need for streamlining and improving operating conditions for regional and local transport. Within the scope of planned works should be considered the existing TSI used in the range of certified interoperability constituents. For structural subsystems and, within available financial resources, the indirect certification of EC verification for the subsystem elements modified for changes to the design parameters or supplies should be implemented.

Assessment of a railway line in terms of network interoperable lines and priority of their adaptation to the requirements of interoperability should be determined on the basis of:

- the number of trains in national and international traffic (passengers and freight)
- distribution of railway lines, where there is international or only domestic traffic,
- belonging to the railway network TEN-T,
- co-financing of the project work on the given railway line from EU funds: Operational Programme Infrastructure and Environment [OPI] financial instrument "Connecting Europe Facility" [CEF]), the Operational Programme Eastern Poland etc.
- affiliation of railway lines to freight corridor (Baltic Sea - Adriatic Sea and the North Sea - Baltic Sea) [22],
- ERTMS buildings (existing or planned).

Criteria for evaluation of sections of railway lines to determine their priorities:

- characteristics of international and national traffic being a potential interoperable traffic, with differentiation into passenger and freight traffic:
  - daily cyclicality,
  - continuing of motion in the range of at least 5 consecutive years,
  - the volume of traffic in relation to the maximum amount of traffic on the line with a maximum intensity of traffic.
- Qualifications of the railway line belonging to the network line TEN-T
  - a network of baseline,
  - a network of complex lines.
- Qualifications of the railway line belonging to the dedicated freight corridor:

- the main route,
- the route roadshow.

➢ Funding from OPI or RPO
- in the period 2007 - 2013,
- in the period 2014 – 2020.

➢ Qualified to CEF funding sources

➢ Planned implementation of the system ERTMS
- till 2015,
- till 2023,
- till 2030,
- till 2050.

For a formal record, there is proposed the numbering the railways by the index nl, a set of railway lines *nl*, For a formal record, there is proposed the numbering the railways by the index nl, a set of railway lines: $\boldsymbol{NL} = \{ nl: nl = 1,\ldots, NL\}$, where *NL* is the number of "railways". Each railway line consists of segments determined by movement checkpoints with certain technical, operational and traffic-transport conditions (according to the list of railway lines - "OBLIKO"). The set of such segments can be presented in the form of: $\boldsymbol{NOL} = \{nol: nol = 1,\ldots, NOL\}$, where *NOL* is the number of "sections of railway lines", while *NOL*(*nl*) is the number of sections on the given railway line with the number *nl*.

If sections on the lines are different, then the sections of the railway line *nl* create the set ***NOL***(*nl*). The sets ***NOL***(*nl*) are pairwise disjoint and their sum creates the entire rail network.

$$\forall nl, nl' \in \boldsymbol{NL}, \quad nl \neq nl' \qquad \boldsymbol{NOL}(nl) \cap \boldsymbol{NOL}(nl') = \varnothing \tag{1}$$

$$\bigcup_{nl \in \boldsymbol{NL}} \boldsymbol{NOL}(nl) = \boldsymbol{NOL} \tag{2}$$

where: ***NOL*** **–** the set of all sections of the railway network.

Each segment has been assessed according to the above-mentioned criteria and their weights. Set of criteria can be written as: $\boldsymbol{K}(nol) = \{k_i(nol): k_i(nol) = k_1(nol), k_2(nol), \ldots, k_n(nol); nol \in \boldsymbol{NOL}\}$, where *n* is the number of the applied evaluation criteria, and the collection of individual weights for each criterion can be expressed as: $\boldsymbol{W} = \{w_i: w_i = w_1, w_2, \ldots, w_n\}$, where individual weights w_i are common to all evaluated sections of the railway line in the set ***NOL***.

Scores given for a particular section of the railway line is the sum of the products of the value of each criterion and its weight, which can be summarized as follows:

$$\mathrm{p}(nol) = \sum_{i=1}^{n} (k_i(nol) * w_i) \tag{3}$$

If we assume that a set of line segments consists of three subsets corresponding to the above priorities: "Full implementation of interoperability" ($\boldsymbol{Z_{implementation}}$), „Migration in the implementation of interoperability" ($\boldsymbol{Z_{migration}}$), „Derogation from the implementation of interoperability" ($\boldsymbol{Z_{derogation}}$), then classification of individual sections of railway lines to subsets can be realized on the basis of the conditions:

$$\mathrm{p}(nol^*) < 4 \Rightarrow nol^* \in \boldsymbol{Z_{derogation}} \tag{4}$$

$$4 \leq \mathrm{p}(nol^*) < 10 \Rightarrow nol^* \in \boldsymbol{Z_{migration}} \tag{5}$$

$$\mathrm{p}(nol^*) \geq 10 \Rightarrow nol^* \in \boldsymbol{Z_{implementation}} \tag{6}$$

where: $Z_{implementation}, Z_{migration}, Z_{derogation} \subset NOL$, whereas the values of the criteria, their weights and qualification conditions can be determined based on the Delphi method[3].

Dynamics of changes in the process

The formulated above assumptions reflect a static picture of the network, but does not include certain dynamic changes taking place in the investment process. Since the decision to start investing in the modernization of railway infrastructure there are many aspects at the stage of study regulations as well as during the implementation of projects of technical and physical execution of the works, which may affect the predetermined scope of the project, also in the area of implementation of the requirements of interoperability.

Analysis of the demand for railway transport, taking into account social expectations and carriers, assessment of the necessary technical, operational and mobility - transport changes, estimating costs and time needed for investments set at the studied stage may change during the subsequent steps of investments.

The reasons for such changes may be different, e.g. unfavourable administrative decisions, not identified technical collisions or technical state of engineering objects, increasing the area or extent of ongoing work etc. Such changes may affect other qualification works in terms of the obligation to implement interoperability, the scope of certification and the obligation to obtain authorizations for structural subsystems into exploitation.

If the scope of work will be classified as a renewal, modernization or construction of a structural subsystem, this implies a need to carry out the assessment of conformity of changes with the requirements of the TSI, which is confirmed by an EC verification certificate issued for the structural subsystem by the approved office. The full certification is mandatory for obtaining the decision by UTK President about the authorization for exploitation of a structural subsystem.

Given the above it can be concluded that these factors should be taken into account in the implementation of interoperability on the network.

The aim carried out by the infrastructure manager related to upgrading or renewal of the railway line and a planned scope of work in subsystems, including changes in its performance imply the need to implement interoperability and to carry out the certification process of EC. Although there is the possibility of a derogation from the application of the TSI (in accordance with Art. 25f of the Act on railway transport) - in the case of hedge funds on EC certification and achievement of positive economic effect - the derogation does not have to be completed due to the benefits of the implementation of interoperability and efforts to improve the coherence of the national railway network with other railway networks in the EU.

Considering the above issues, one can suggest in the strategy to implement an inclusion of interoperability assessment issued by EC verification certificates on individual sections of railway lines. Rating completeness of EC verification certificates allows determining the degree of implementation of the requirements of interoperability on the line section, and can also affect the certification process of adjacent sections to achieve interoperability across the whole railway line.

An approach based on raising the score for sections of the railway line as a result of accumulation of EC certificates has one important advantage, namely, shows us the areas of railway infrastructure for the implementation of interoperability, in which costs have been already incurred because of the aim to technical compatibility in terms of interoperability.

[3] https://en.wikipedia.org/wiki/Delphi_method

Summary
The evaluation of the railway network managed by PKP Polish Railway Lines SA allows for an objective and rational approach to adapt it to the requirements of interoperability. The assumptions for the implementation strategy for interoperability will allow the formation of action and programming investments in the pursuit to interoperability of the railway network, taking into account the limitations, timeframe and financial possibilities of PKP Polish Railway Lines SA. The implementation strategy for interoperability should be periodically (at least once a year) updated due to the EC verification certificates issued for structural subsystems and emerging obligations under the European law.

Source materials

[1] CNTK, work nr 4127/12, „Bieżąca analiza prac AEIF i ERA w ramach Zespołu ds. Interoperacyjności. Raport zbiorczy z prac Zespołu ds. Interoperacyjności", Warszawa, January 2006.
[2] EU Commission, decision no 2012/88/EU from 25 January 2012, „on the technical specification for interoperability relating to the subsystems "control" trans-European railway system", Dz. U. L 51 z 23.2.2012.
[3] EU Commission, decision no 2015/14 from 5 January 2015, amending Decision 2012/88/EU on the technical specification for interoperability relating to the subsystems "control" trans-European railway system.
[4] EU Commission, regulation no 1299/2014 from 18 November 2014, concerning the technical specifications for interoperability relating to the 'infrastructure' railway system in the EU;
[5] EU Commission, regulation no 1300/2014 from 18 November 2014, on the technical specifications for interoperability relating to the availability of the rail system of the Union for disabled persons and persons with reduced mobility;
[6] EU Commission, regulation no 1301/2014 from 18 November 2014, on the technical specification for interoperability relating to the 'energy' of the railway system in the Union;
[7] EU Commission, regulation no 1302/2014 from 18 November 2014, on the technical specification for interoperability relating to the subsystem "rolling stock-locomotives and passenger rolling stock 'of the railway system in the EU;
[8] EU Commission, regulation no 1303/2014 from 18 November 2014, on the technical specification for interoperability relating to 'safety in railway tunnels "railway system in the EU;
[9] EU Commission, regulation no 1305/2014 from 11 December 2014, concerning the technical specification for interoperability relating to the subsystem telematics applications for freight included in the railway system in the EU and repealing regulation (EC) No 62/2006;
[10] EU Commission, White Book; COM (2011) 144, Brussels, 2011.
[11] European Parliament and Council Directive 2008/57/EC of 17 June 2008, "on the interoperability of the Community railway system (with further changes)"; Dz. U. L 191 from 18.7.2008.
[12] Jacyna M., Szkopiński J., art.: „A holistic approach to analysis the interoperability the railway system", WIT Press Conference - COMPRAIL 2014.
[13] Jacyna M., Szkopiński J., art.: „Interoperacyjność systemu transportu kolejowego - warunki integracji", konferencja „Pojazdy szynowe" Wrocław 2014.
[14] Jacyna M., Szkopiński J., art.: „Wdrożenie wymagań interoperacyjności na sieci kolejowej - zmiana systemu transportu kolejowego", VII Międzynarodowa Konferencja Naukowo – Techniczna „Systemy Logistyczne – Teoria i Praktyka", Lidzbark Warmiński 2014, Logistyka 4/2014.
[15] Jaspers: „Niebieska Księga. Sektor kolejowy. Infrastruktura kolejowa" September 2015.
[16] Mindur M., „Transport w erze globalizacji gospodarki", PIB Warszawa – Radom 2010.

[17] MIR Ustawa o transporcie kolejowym z dnia 28 marca 2003. (z późn. zm.).
[18] PKP PLK S.A., CNTK, „Standardy Techniczne. Szczegółowe warunki techniczne dla modernizacji lub budowy linii kolejowych do prędkości Vmax ≥ 200 km/h (dla taboru konwencjonalnego)/250 km/h (dla taboru z wychylnym pudłem), Warszawa 2009.
[19] Praca pod redakcją Marianny Jacyny, System Logistyczny Polski. Uwarunkowania techniczno-technologiczne komodalności transportu, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2012.
[20] Regulation of the European Parliament and of the Council (EU) No 1315/2013 of 11 December 2013 on Union guidelines for the development of trans-European transport network.
[21] Regulation of the European Parliament and of the Council (EU) No 1316/2013 of 11 December 2013 establishing the "Connecting Europe".
[22] The European Parliament and Council regulation No 913/2010 of 22 September 2010, "concerning a European railway network for competitive freight"; Dz. U. L 276 from 20.10.2010.
[23] The European Parliament and Council Regulation on Union guidelines for the development of trans-European transport network, COM (2011) 650, Bruksela 2011.
[24] Uchwała Zarządu PKP PLK S.A., nr 826/2014, „Projekt aktualizacji 'Narodowego Planu Wdrażania ERTMS', Warszawa, 21 października 2014.
[25] Ustawa Ministra Transportu, Budownictwa i Gospodarki Morskiej z dnia 10 września 1998. (z późn. zm.), „w sprawie warunków technicznych, jakim powinny odpowiadać budowle kolejowe i ich usytuowanie", Dz. U. nr 151, poz. 987.