



## KPIs FOR EVALUATING THE NEW TECHNOLOGIES EFFICIENCY: THE CASE OF ZRS A.D. DOBOJ

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**Abstract** – European freight railway operators, aiming to remain competitive in the Single European Railway Area, cannot enhance their competitiveness relative to road transport or meet user demands without investing in new technologies. The efficiency brought by these new technologies is a current and relevant topic (state of the art), but it must be verifiable and measurable. This is particularly important for railway operators on small networks, such as Republika Srpska Railways JSC. (Serbian: *Zeljeznice Republike Srpske A.D. - ZRS*), which have limited resources for investment. Therefore, it is crucial to identify and implement new technologies that will yield the greatest effect, thereby improving the competitiveness of the operators in the open market. The primary goal of this paper is to quantify the effects of introducing specific new technologies on the competitiveness of ZRS. The competitiveness of freight rail services is evaluated from the perspective of users (end users, freight forwarders, and logistics companies). By developing a set of KPIs for ZRS as a freight railway operator, it is possible to measure the direct impact of new technologies and technical solutions on the competitiveness of ZRS's rail services, thereby addressing identified weaknesses.

**Keywords** – freight railway operator, performance indicators, efficiency, new technologies, competitiveness.

### 1. INTRODUCTION

The introduction of new technologies, digitization, and automation creates conditions for providing more efficient, reliable, and higher-quality transport services [1]. European railway operators, if they want to remain competitive in the Single European Railway Area, cannot enhance their competitiveness without investing in new technologies. The efficiency brought by new technologies is a current and relevant topic (state of the art), but to invest in new technologies, it is necessary to answer the question of which new technologies to implement. The selected solutions must be verifiable and measurable.

The comprehensive goals of European policy for establishing an internal railway market and strengthen the competitiveness and attractiveness of railway operators, while maintaining the position of the European railway industry, will inevitably result in the emergence of innovative approaches and the application of new technologies in business models, services, and products throughout the entire rail transport chain [2]. This would undoubtedly necessitate a significant rise in research and innovation efforts in freight

transport operations.

The role of railways in global transport could and must be increased, primarily in the area related to leveraging the advantages of digital technologies to ensure that rail services are well integrated into a range of mobility options available to transport service users. Therefore, it is important to understand the new technologies that will produce the greatest effects, i.e., improve competitiveness in the freight railway market. This is particularly important for small operators like Republika Srpska Railways (ZRS), which have limited resources for investment, to take advantage of certain grants from various EU funds and prepare and improve its operator's business for market competitiveness.

Over the following decade, three main areas have been designated as the primary areas for railway and transport industry enhancements: vehicles, signaling, and after-sales services. Each of the three components can be analyzed independently from the viewpoints of companies (operators and infrastructure managers) and service users.

Bearing in mind above mention the question that the future national ZRS freight railway operator face on is :which new technologies, as researched through literature and

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supported by EU funds, could be applied and utilized to improve competitiveness? An answer to the abovementioned question is provided by the establishment of a set of key performance indicators (KPIs) to evaluate the contribution of new technologies to increasing competitiveness.

This paper first identifies certain weaknesses of ZRS freight railway services compared to competitors from the perspective of users (end users, freight forwarders, and logistics companies). New technologies used by freight operators, which ZRS could implement to increase its competitiveness and eliminate identified weaknesses in railway services are presented. A set of key performance indicators (KPIs) is defined for evaluation of the impact of new technologies on improving ZRS's competitiveness.

## 2. WEAKNESSES OF RAILWAY SERVICES AT ZRS A.D. DOBOJ

ZRS A.D. Doboj is a joint-stock company that is currently in the process of restructuring and has not yet experienced market liberalization. Therefore, the quality of service has remained consistent, and there is no competition in freight transport on ZRS infrastructure. Nevertheless, road carriers are ZRS's primary competitors in the global market, and the quality of service that freight forwarders and customers anticipate in terms of digitization and door-to-door service delivery is becoming more rigorous.

From the perspective of freight forwarders and transport service users, the following are the weaknesses of ZRS freight railway services that require development in order to increase the operator's competitiveness:

**Transport service costs** – As transport costs include all expenses incurred during the provision of transport services (electricity or diesel fuel costs, labor costs, maintenance costs, auxiliary service costs, etc.), it is necessary to do everything possible to rationalize these costs to ultimately achieve competitive transport prices in the market.

**Transport time** – The transport time in rail traffic depends on many factors (line speed, border crossing delays, marshalling yard delays, initial and final operations delays, wagon turnaround time, etc.). The goal is to achieve the shortest possible transport time, thereby increasing the competitiveness of the railway operator.

**Availability of information on transport and goods** – This includes the availability of information on train movement, wagon status, infrastructure load, tracking of goods being transported, transport disruptions, travel time delays, transport reliability, the percentage of realized paths, etc. For users, it is crucial to have timely information on the status of trains, wagons, or containers during transport (to enable timely response and create competitive advantages over other freight transport competitors).

## 3. NEW TECHNOLOGIES FOR FREIGHT TRANSPORT ON RAILWAYS

A variety of contemporary technologies are implemented in the global railway freight transport industry to enhance the competitiveness of operators.

The new technologies elaborated further in this paper are presented in the context of contributing to overcoming the identified weaknesses in ZRS transport services.

### 3.1. New technology for eliminating weaknesses - Transport service costs

A wide range of wagon types run on railways, the technical state of which is largely determined by the railway administrations where they are included in the fleet and the method of maintenance. ZRS and Eastern European railways are distinguished by relatively old wagons and inadequate maintenance, reducing rail freight movement to a period of limited effectiveness. . By including an obsolete maintenance workshops and a technical delay in comparison to advanced railways, a comprehensive understanding of the factors that greatly impact the costs of transport services is gradually achieved.

Cavuto et al. (2016) note that most wagon defects can be detected under dynamic conditions [4]. That is, it is necessary to monitor the condition of individual parts and assemblies of wagons even during operation. The development of electronics, sensors, and computer technology enables the introduction of onboard diagnostics in wagons and trains.

The continuous monitoring of railway wagons and the efficiency of maintenance and propulsion energy consumption are substantially enhanced by modern diagnostic systems [5]. Recorded measurement data are stored and systematized, and decisions are made to implement specific activities that are designed to reduce maintenance costs and enhance vehicle efficiency, thereby rationalizing overall transport costs.

### 3.2. New technology for eliminating weaknesses - Transport time

Radio Frequency Identification (RFID) technology is a type of automatic identification system that is employed in transport systems to generate, consolidate, and accelerate information processing, as well as to increase accuracy and automate data processing [6].

Tracking the dispatch of trains and goods within the railway system is essential for optimizing operational efficiency. Positioning and identifying trains with high precision in any environment is made possible by RFID technology. RFID equipment is employed to identify an ID tag affixed to a train or wagon in order to determine the precise moment at which the train passed a specific location in the context of the train location. On a railway sleeper, the reader is situated between the rails or along the track [7]. The track is typically

equipped with a system that has the reader positioned along the side to identify each passenger coach or freight wagon that passes by [8]. Through the installation of tags on trains and wagons, as well as their readers in stations and on the track, the digitization and transmission of information regarding the status of the wagons and trains on the track are facilitated digitally and directly into the system.

The operator can optimize the transport process and time by facilitating the monitoring of wagons or products being transported through the availability of real-time information regarding the movement of trains and wagons on the track network.

### 3.3. New technology for eliminating weaknesses - Availability of information on transport and goods, as well as transport time

The utilization of electronic consignment notes, which are derived from Electronic Data Interchange (EDI) technology, is becoming more prevalent in international freight transport. This results in increased operator competitiveness in the transport market, speedier data transfer, data processing efficiency, and data accuracy, in addition to time savings. The exchange of standard business documents in a predefined format between the computer applications of business counterparties via computer networks is a component of EDI [9].

The electronic consignment note is implemented in railways through the utilization of software designed for electronic consignment notes, as well as the connection to European information systems and services such as "Orpheus," which facilitates the transfer of electronic consignment notes between countries that are structured in accordance with a widely accepted and widely implemented html standard. Information regarding products transported by rail to the ZRS network or other countries is immediately accessible to ZRS and, subsequently, to users through the utilization of these digital systems.

Finally, the gradual harmonization of technical, administrative, and regulatory rules is essential if railway transport is to achieve competitiveness and increase its share in the transport market.

### 4. KPIs FOR EVALUATION THE EFFECTIVENESS OF NEW TECHNOLOGIES ON COMPETITIVENESS

To quantify the impact of the abovementioned new technologies and technical solutions on ZRS and simultaneously contribute to achievement of the primary objective such as enhancing the competitiveness of railway operators in the market, it is imperative to establish key performance indicators (KPIs). From the perspective of service users, three characteristics of transport services are key for pursuit

the overarching objective of enhancing competitiveness. Consequently, KPIs are organized in accordance with these characteristics.

The defined individual KPIs, which allow for measuring the impact of selected new technologies on overcoming the weaknesses of freight transport services and consequently on improving competitiveness, are presented in Table 1.

Tab. 1. KPIs for assessing new technologies and improving the competitiveness of freight transport services

KPI	Description	Unit
<b>TRANSPORT SERVICE COSTS</b>		
Specific transport costs	Transport costs for the customer in euros per train kilometer and unit	EUR/km/unit
Operational costs	Operational costs include energy consumption, traction costs, maintenance, and repair costs	EUR
Productive use	Represents the annual km of a wagon or locomotive. The higher the effective km, the lower the impact of investment costs	km
Administrative costs	Personnel costs, forms, licenses, permits, etc.	EUR
Level of staff expertise and training costs	Specific skills are required for the implementation of new technologies – training costs	EUR
<b>TRANSPORT TIME</b>		
Delivery time	Time elapsed from the moment the transport order is placed to the arrival and receipt of goods (includes loading/unloading times, waiting times, train configuration times, etc.)	h
Loading/unloading	Average and maximum time necessary to load/unload a wagons or trains in the terminal or an end point	h
Idle time	Average and maximum idle time (or exceeded idle time): - waiting at the terminal; - waiting for departure; - waiting for transshipment at the port; - waiting for equipment (engine), etc.	h
Train configuration time	Average and maximum time necessary to get wagons coupled to form a train	h
<b>AVAILABILITY OF INFORMATION ON TRANSPORT AND GOODS</b>		
Visibility	Infrastructure visibility: - Volume of network information; Visibility of service: - % of freight for which information in transit is available; - % of km for which information in transit is available; - Number or % of partners who provide data. Tracking and tracing: - Availability of precise tracking; - Availability of tracing; Disruption visibility: - Availability of information in case of disturbances; - Idle time between arising an event and getting inform;	%
Reliability	% of transport meeting the scheduled and promised time	%
Technical reliability	- Delays on the railway network, locomotive, wagons; - Train path availability (% of successfully vs. rejections); - Time deviation of the demanded train path (demanded vs. assigned ).	%, h

Operational costs, for example, are one of the numerous indicators that demonstrate the freight transport operator's capacity to address the identified weaknesses from the perspective of transport service users, thereby improving its overall competitiveness. The significance of economically advantageous, timely, and swift delivery of goods to users is undeniable. As a result, any new technology that reduces the overall costs of vehicle maintenance also reduces the total transport costs, thereby enhancing the operator's competitiveness.

## 5. INSTEAD OF A CONCLUSION

Modern freight transport operators require technological advancements in all aspects of their operations in order to endure and enhance their operations. In light of the restricted resources and capabilities available for investment, it is imperative to exercise caution when selecting innovations. It is essential to evaluate which new technology is most effective in reducing the weaknesses of transport services, particularly from the perspective of transport service users, and, in the end, contributing the most to the overarching objective of enhancing the operator's competitiveness, given the current wide range of modern and new technologies being implemented in the railway sector.

The main focus of research on transport service weaknesses and the analysis of new technologies for operators is not to establish key performance indicators (KPIs) for the purpose of enhancing operational processes, but rather to evaluate the direct impact of new technologies and technical solutions on their efficiency and competitiveness.

Particularly for small railway operators with restricted innovation capabilities, the establishment of critical key performance indicators (KPIs) is of utmost importance. By using key performance indicators (KPIs), it will be possible to evaluate the results of the implementation of new technology more efficiently and make decision-making faster.

This paper has identified the weaknesses of transport services that are essential for the overall

objective of competitiveness, as well as the key performance indicators (KPIs) with a total of 12, which evaluate the impact of new technology on the competitiveness of ZRS. The quantification of key performance indicators (KPIs) for the final set of new technologies and a more comprehensive analysis of transport service weaknesses are potential future research directions for small freight railway operators.

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