XXI INTERNATIONAL SCIENTIFIC-EXPERT CONFERENCE ON RAILWAYS
RAILCON '24
October 10-11, 2024; Niš, Serbia

Original scientific paper DOI: 10.5937/Railcon24131M

DESIGNING THE WEAR AND TEAR COMPONENT IN THE STRUCTURE OF TRACK ACCESS CHARGES

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Abstract *– This paper aims to provide and analyse the structure of Track Access Charges (TAC) for small railways, with a focus on the wear and tear component and its elements. A review and analysis of the wear and tear component in the TAC models for selected small railways have been conducted. The impact of wear and tear component in freight train charges, as well as the ratio between wear and tear charges and infrastructure capacity charges within the total TAC, has been thoroughly analyzed. The paper provides a discussion on the selection, representation, and evaluation of the impact of specific elements on the wear and tear of rails in TAC determination models. The research contributes to understanding the complex interactions between elements within the TAC structure, based on the experiences of railway infrastructure managers to date. The results of this research indicate that infrastructure managers of small railways have not developed a clear understanding of the factors influencing the wear and tear costs of infrastructure, leading to heterogeneity in the structure and level of Track Access Charges (TAC).*

Keywords – railway network, wear and tear, train weight, infrastructure manager.

1. INTRODUCTION

Regulation 2015/909/EU from 2015 is currently the latest document published by the EU concerning the rules for designing Track Access Charges (TAC). This legal act effectively defines the limitations in the scope of direct costs incurred as a result of operating the train service [4]. The term "structure of TAC" refers to the components of the TAC and their elements used for calculation of the charges level, along with their interrelationships, i.e., connectivity [1]. The charges components and their elements (variables, coefficients, weights) should reflect the allocation of infrastructure costs according to track categories, traffic types (passenger or freight), market segments, as well as according to vehicle categories and defined services [2]. By selecting elements in the TAC structure, evaluating them, and establishing relationships between these elements, the infrastructure manager encourages specific operator behaviors, as well as the rationalization of certain costs incurred by the operators.

In overview of papers focused on TAC modeling, few papers provide a critical review of the structure of TAC components or explain the reasons for introducing specific elements. There is a particular lack of research dedicated to small railways networks, as well as their specificities that are crucial for designing TAC. Small countries with their small railways networks often face challenges such as resource constraints or limited opportunities to achieve market competition within a small railway network. The aim of this paper is research the structure of TAC for small railways, with a particular focus on the wear and tear component and its elements. Based on the criteria such as network length under European conditions (up to 4,000 km, as adopted in this research) and the intensity of its use, a cluster of twelve small European railways has been defined. The cluster includes the railways of Montenegro, Luxembourg, North Macedonia, Slovenia, Greece, Portugal, Lithuania, Latvia, Croatia, Serbia, Slovakia, and Bulgaria.

A review of the wear and tear component and its elements for this selected cluster of small railways has been done, the relative share of the wear and tear component in the TAC structure for freight trains of different weights has been analyzed. The research contributes to understanding the complex interactions

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between elements within the TAC structure, thereby providing relevant guidelines for creating a charge model for small railways that would be suitable for their needs and constraints.

2. ELEMENTS OF THE WEAR AND TEAR COMPONENT IN THE TAC STRUCTURE

According to the legislative framework, the TAC structure, in addition to being based on the direct costs incurred as a result of operating the train service, must also be transparent, clear, and standardized for all railway operators. The general formula for calculating infrastructure charges for the minimum access package (MAP) can be represented as the sum of the following components [1]:

$$C = C_{ad} + C_{op} + C_{wt} + C_{oh}$$

where:

- C_{ad} - the charge component that represents the costs of requests for railway infrastructure capacity,
- C_{op} - the charge component that reflects the use of the railway infrastructure operational costs,
- C_{wt} - the charge component that reflects the costs of infrastructure wear and tear, and
- C_{oh} - the charge component that reflects the costs of maintaining electrical supply equipment for traction current (if the route is electrified).

The TAC calculation formula, as presented, provides insight into the method of cost calculation by the place of origin and allows railway operators to calculate the effect of cost rationalization by optimizing their expenses. The focus of this research is the wear and tear component (C_{wt}), its elements, recognizability, and relative share in the charges for freight trains within the defined cluster of small railways.

Depending on how it is structured and presented to railway operators, charges are classified into four categories: simple, simple +, multiplicative, and additive [7,8]. This classification considers the number of components, the number of elements, the measurement units used, and their relationships. It has also been established that the structure of charges may or may not be based on market economic principles of supply and demand, which primarily depends on the size of the market and the competitiveness of the railway within it [3]. The structure of charges varies from country to country, and this has so far been justified by the specificities of the particular railway or the different objectives that need to be achieved. However, the significant heterogeneity of TAC models suggests that the allocation of costs, as well as their management by infrastructure managers (within the TAC structure), is highly questionable.

By analyzing Network Statements [6] published on the websites of the selected cluster of infrastructure managers, Table 1 provides an overview of the type of TAC calculation formulas an d the elements in the wear and tear component. The railway infrastructure managers of Montenegro (MNE), Luxembourg (LU), North Macedonia (MK), Slovenia (SI), Portugal (PT), and Croatia (HR) impose charges for the MAP based solely on train kilometers, while in Latvia (LV), Greece (GR), Serbia (RS), Slovakia (SK) and Bulgaria (BG) charges are imposed based on both train kilometers and gross tonne kilometers. Within the analyzed group of countries, Lithuania (LT) is an exception, where the infrastructure manager imposes charges solely based on gross tonne kilometers. The wear and tear component is generally clearly distinguished in the simple and additive types of formulas, as seen in RS, LT, LV, GR, SK, and BG. In Luxembourg (LU), the formula is also additive, but the wear and tear and capacity components are incorporated into a multiplicative term within the additive formula. In Portugal (PT), the charge is calculated as the product of two elements: the route length and the unit price per train kilometer, which varies depending on the line, type of traction, timetable, and market segment. In such a designed formula, the wear and tear component is not distinguishable.

Tab. 1. Overview of TAC Calculation Formula Types and Elements in Wear and Tear Component

Country	Type of TAC calculation formula	TAC calculation		Elements of wear and tear component		
		train km	gross tonne km	Weight (train)	Weight coefficient	Speed
Montenegro (MNE)	multiplicative	✓			✓	
Luxembourg (LU)	additive	✓			✓	
North Macedonia (MK)	multiplicative	✓			✓	✓
Slovenia (SI)	multiplicative	✓			✓	✓
Lithuania (LT)	additive		✓	✓		
Latvia (LV)	additive	✓	✓	✓		
Greece (GR)	additive	✓	✓	✓		
Portugal (PT)	simple	✓				
Croatia (HR)	multiplicative	✓			✓	
Serbia (RS)	simple +	✓	✓	✓		
Slovakia (SK)	additive	✓	✓	✓		
Bulgaria (BG)	additive	✓	✓	✓		

In Table 1, the influential elements of the wear and tear component (gross train weight, infrastructure wear and tear coefficient as a function of gross train weight, and speed) are also identified and highlighted. In some countries, wear and tear coefficients, which vary depending on the gross train weight or train type, are used to calculate wear and tear charges (MNE, LU, MK, SI, and HR), while in other countries, the actual gross train weight is used (LT, LV, GR, RS, SK, and BG). When the wear and tear component is determined directly based on the gross train weight, the train's weight is multiplied by the unit charge per gross tonne kilometer. When the wear and tear component is a function of the wear and tear coefficient, infrastructure managers combine the impact of capacity usage and wear and tear in a multiplicative formula, where the measurement unit for capacity (train kilometers) is combined with the wear and tear coefficient. The wear and tear coefficient is presented in intervals (ranging from) with a more or less developed scale of train weight intervals or depending on the type of freight trains. It is important to note that determining the wear and tear coefficient is extremely complex and requires more precise cost allocation and monitoring over a longer period [5].

3. THE SHARE OF THE WEAR AND TEAR COMPONENT IN THE TAC STRUCTURE

The length of the reference route, on which the impact of train weight on the wear and tear component was examined, was determined based on the average value of the mean transport distance for one ton of freight on the selected small railways, amounting to 220 km [9]. This is an average value, considering all cluster participants equally, even though they do not achieve the same transport volumes. For a relevant analysis, it was further assumed that the entire route is electrified and located within the national territory, and that the reference route is on an international main line (first category line) that is not declared congested. It was also assumed that the freight train operates as a regular train with a regular path request and a maximum train speed of 80 km/h.

It is important to note that in the multiplicative TAC structure categories where the wear and tear coefficient is an element, it is not possible to accurately estimate the exact ratio between the track wear and tear component and the capacity component in the route charges. Therefore, different calculation mechanisms were applied to ensure approximate accuracy and consistency in analyzing the ratio between these two components. Bearing in mind the defined assumptions, figure 1 presents a comparative view of the share of the wear and tear component in the overal TAC structure for two categories of freight train weights: 960 t and 2,000 t. The adopted value of the characteristic freight train weight of 960 tonnes is taken from previous research [7,8] as the defined minimum train weight that ensures the competitiveness of freight transport by rail.

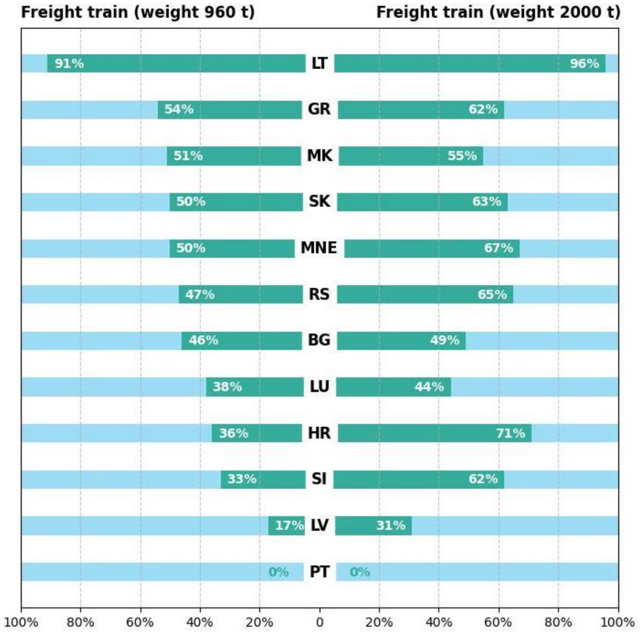

Fig. 1. Comparison of the wear and tear component contribution in the TAC structure for a freight train with weights of 960 t and 2000 t

For a characteristic freight train of 960 tonnes, the share of the wear and tear component in the TAC structure of the analyzed cluster of small railways varies significantly, ranging from 54% in Greece (GR) to 17% in Latvia (LV). This broad range highlights the different approaches to designing TAC structures and/or varying priorities in infrastructure management among these countries. Lithuania (LT) and Portugal (PT) are excluded from this analysis because their specific TAC structures prevent direct comparison with countries that redistribute charges between the wear and tear and capacity components.

In the following countries: GR, MK, SK, MNE, RS, and BG, the share of the wear and tear component is consistent at 46%-67% for both freight train weight categories, despite differences in the measurement units used for calculating charges and the TAC structure categories. In these countries, the share of the wear and tear component within the TAC structure remains relatively consistent, indicating shortcomings in the allocation of wear and tear costs and in the TAC methodology. In contrast, in SI and HR, a significant increase in the share of the wear and tear component is observed, rising from 33%-36% for 960-ton trains to 62%-71% for 2000-ton trains. This suggests that these countries place a different value on the impact of increased train weight when calculating infrastructure wear and tear charges, recognizing it as a factor that incurs additional infrastructure maintenance costs. Diagram 2 provides a clear view of the relative share of the wear and tear component and its significance within the TAC structure for the range of gross train weights from 600 to 2000 tonnes on the adopted reference route of 220 km.

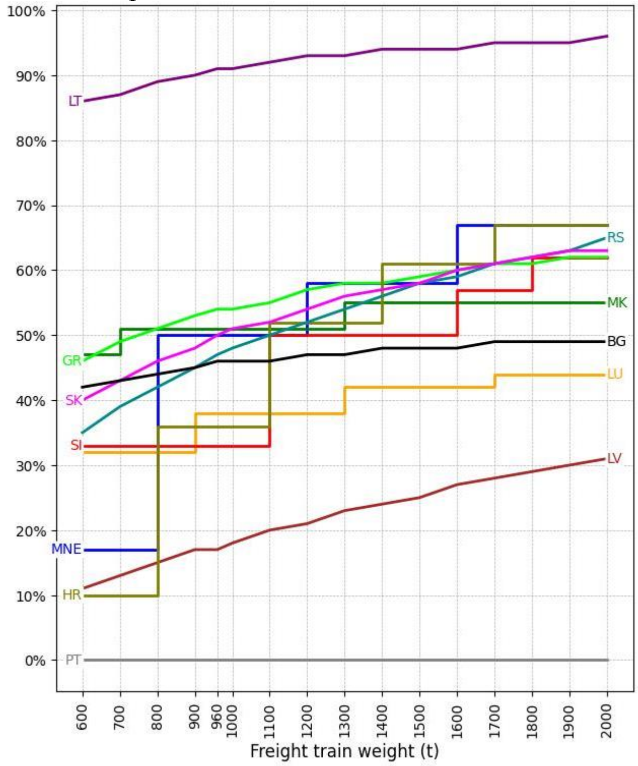

Fig. 2. Contribution of the wear and tear component to TAC

Growth trends vary significantly across countries. In some cases, the increase is gradual and continuous, while in others, there are stepped (discontinuous) changes due to the use of a wear and tear coefficient based on gross train weight as an element of the TAC structure. The stepped lines observed in MNE, LU, MK, SI, and HR indicate that charges are calculated based on defined gross train weight classes. The fewer the number of classes, or the wider the range of these classes, the more significant the increase in the relative share of the wear and tear component when moving from one train weight class to another.

4. CONCLUSION

Infrastructure managers do not publish the theoretical basis or conceptual framework of the adopted TAC model, which complicates the understanding of its structure and the measurability of the impact of individual factors. Nevertheless, gross train weight remains a key element in the TAC structure for determining the level of charges. However, the significant heterogeneity in the evaluation of the impact of gross train weight on the wear and tear component and its share within the TAC structure, as identified in this study, indicates that the allocation of infrastructure wear and tear costs by infrastructure managers is still at a low level. It is evident that infrastructure managers of small railways have not yet developed a clear understanding and assessment of the factors influencing infrastructure maintenance costs. The calculation models lack transparency, making it difficult to clearly and precisely determine the impact of different train weights on infrastructure maintenance costs and on the overall TAC structure. This research highlights significant differences in TAC structures for small railways, which sends a negative message to operators. Specifically, the varying assessments within the designed TAC calculation formula confuse and disorient operators, as they struggle to navigate and identify ways to reduce their TAC costs in their operations. This research is limited to small railways, and comprehensive conclusions require further analysis of TAC models for other European countries. A deeper understanding of these causes, factors, and relationships represents the direction of future research, which would contribute to the harmonization and improvement of the charging system within the Single European Railway Area.

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