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The Position of Railway Sidings in the Slovak Republic

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Abstract: The COVID-19 pandemic disrupted businesses and economies worldwide, including Slovakia, and interrupted supply chains, causing a decline in rail freight volumes, particularly in the second quarter of 2020, though the impact in Slovakia was less severe than in other EU countries [1]. Combined with a recession in the metallurgical sector, the pandemic contributed to historically low rail freight performance [2], forcing many companies to limit or suspend production, which reduced transport demand before partial recovery. This paper analyses the current state of railway sidings in the Slovak Republic, focusing on their role in freight transport, operational trends, and usage [3]. It applies an analytical approach supported by statistical data and computational tools to assess siding capacity, efficiency, and potential environmental benefits of modal shift from road to rail. The study also reviews public funding mechanisms supporting siding development. Results highlight declining interest in siding operations, the influence of industrial production changes, and opportunities for targeted investment. Findings provide a strategic basis for sustainable freight planning and infrastructure development [4].

Keywords: Railway sidings, freight transport, rail infrastructure, Slovak Republic, transport capacity modelling

1. Introduction

A railway siding is a track section intended to meet the operational requirements of a particular enterprise or organization. It branches off from a mainline — either a national or regional railway — or from another siding. Typically, it forms a link between a railway station and an industrial facility, often extending into the internal premises of the facility itself [5]. The total length of such a siding can differ significantly, ranging from several dozen meters up to hundreds of kilometres, especially in the case of expansive industrial operations. Just like standard railway infrastructure, a siding must be managed by a track owner and can involve one or more transport operators. Historically, the siding's owner was also responsible for both infrastructure management and transport services. Over time, however, as the complexity and technical requirements increased, many owners have opted to delegate the operation and management of sidings to external specialized service providers [5].

The gradual annual decrease in the number of permits granted by the Transport Authority reflects a declining overall interest in the operation of railway sidings. Based on the most recent registry of valid permits, there are approximately 350 officially registered sidings in Slovakia. However, it is not easy to determine how many of these are currently operated by private entities. Based on the preceding analysis, it can be concluded that the main reasons for the reduced use of railway sidings include the cost advantage of road transport, the high expenses associated with the operation and maintenance of sidings, as well as changes in the structure and volume of supply in industrial production. The declining interest in siding operations is also reflected in the statistics of permits issued by the Transport Authority of the Slovak Republic, which have shown a consistent year-on-year decrease in recent years. The exact number of permits issued for siding operations between 1997 and 2024 is illustrated in Figure 1.

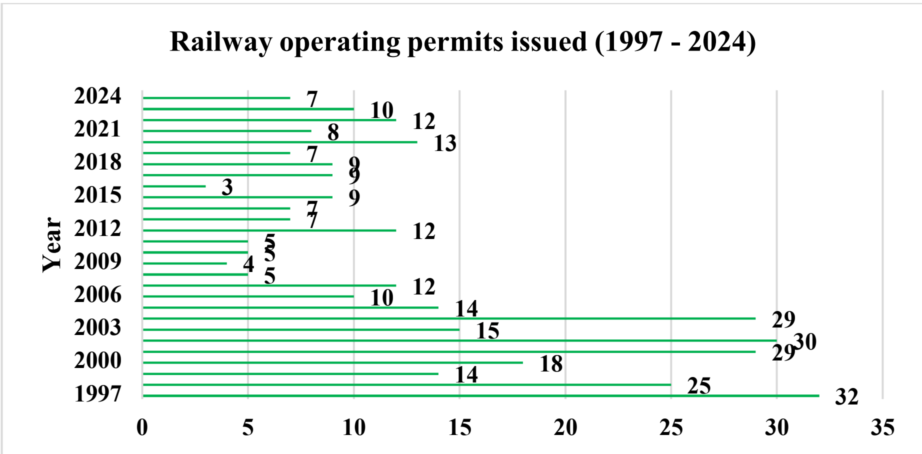

Fig. 1 Evolution of Siding Operation Permits. Source: [6]

The figure illustrates that the number of permits issued over the years has not followed a uniform trend. In the long term, a downward trajectory in license issuance can be observed. A notable increase occurred in 2004, largely because of Slovakia's accession to the European Union. Another rise was recorded in 2007, coinciding with the implementation of the Second Railway Package and the ongoing liberalization of the railway sector. In contrast, the year 2011 saw a decline, which can be attributed to the impact of the economic crisis.

2. Literature Review

The operation of a railway siding in Slovakia is permitted only to entities holding a valid license issued by the competent regulatory authority. In addition to technical requirements, operators must sign a contract with the siding owner (if they are not the owner themselves) and employ professionally qualified staff who meet medical and competence standards for railway operations [7]. Applicants must provide a detailed technical description of the siding, including track length, gradients, curve radii, axle load limits, electrification, and signaling equipment, and must demonstrate financial capacity to operate for at least 12 months [8].

The development of active sidings in Slovakia reflects broader economic and political changes. Over the past 25 years, the number of sidings contributing to rail freight performance has steadily declined due to the transition from a centrally planned economy to a market-based system and the growing competitiveness of road transport [8,9]. The COVID-19 pandemic further reduced freight volumes and disrupted supply chains between 2020 and 2022 [1,2]. Nevertheless, data show a moderate recovery in 2022 (Table 1), suggesting a remaining potential for sidings in regional logistics [9].

Table 1 Freight volume (in tons) between 2020 and 2022. Source: [9]

Freight volume (in tons)							
		2020		2021		2022	
		Domestic	Exported/ Imported volume	Domestic	Exported/ Imported volume	Domestic	Exported/ Imported volume
Incoming	The railway sidings	2,814,803	6,241,714	2,610,416	5,987,233	2,749,105	7,115,175
Outgoing	The railway sidings	3,481,689	11,799,556	3,067,795	10,061,222	3,349,815	13,033,588

Table 1 presents the overall volume of goods, in tons, handled on railway sidings—both loaded and unloaded—during the period from 2020 to 2022. In 2022, there was a noticeable rise in freight activity on sidings, reflected in the increased amount of loaded and unloaded cargo in both domestic and international transport compared to the previous year.

Similar trends are visible across Europe: Abramović et al. [1] analyze the role of EU railway freight corridors, and Flašík [10] proposes measures to strengthen sidings within single wagonload systems. Li et al. [15] presents an optimization model for hybrid siding networks, demonstrating increasing interest in capacity planning. Studies by Kendra et al. [21] and Zitrický et al. [3] emphasize the environmental benefits of shifting freight from road to rail in line with the European Green Deal.

Despite these international studies and EU policy frameworks, a detailed assessment of the regional distribution and utilization of sidings in Slovakia remains missing. This paper addresses this gap by evaluating the current state of sidings, modeling freight capacity, and assessing opportunities for modernization and integration into logistics chains.

3. Data and Methods

This section outlines the outcomes of a transport modeling study conducted for the Žilina self-governing region, focusing on how accessible urban centers are to both main and secondary railway networks used for freight transport. A key emphasis is placed on isochrone-based accessibility to railway sidings, which represents a critical condition for promoting the use of rail freight.

In order to strengthen strategic planning in freight transport, it is advisable to pinpoint major industrial zones that demonstrate significant transport demand yet lack sufficient access to the railway network. Such locations represent promising candidates for focused investment in railway siding infrastructure. Moreover, integrating accessibility evaluations into regional policymaking and transport investment schemes would facilitate the selection of projects that contribute to environmentally sustainable mobility objectives.

Effective management and development of railway sidings require not only technical and organizational measures but also analytical and quantitative tools that enable objective evaluation of their performance, capacity, and potential. While empirical decision-making is often used in practice, there is room for a more systematic approach based on computational models and performance indicators [10-12].

This chapter provides an overview of theoretical calculations that can serve as a guideline for professionals, investors, and transport planners in the analysis and planning of siding infrastructure. The presented models and formulas can help estimate siding capacity, utilization rates, indicative investment costs, or simulate transport benefits under various development scenarios.

The input parameters used in the capacity calculation model (number of train movements N, number of wagons per train W, and average load per wagon L) were derived from real operational data collected for the Žilina Self-Governing Region. These data correspond to the existing siding infrastructure and freight-handling locations listed in Table 3. The values were obtained from publicly available infrastructure records and verified operational information provided by ŽSR and ZSSK Cargo for the period 2020–2023. Average observed values were used where multiple records were available.

By basing the model on real siding characteristics, the calculations reflect actual operational conditions and can be replicated for other regions using comparable datasets.

Although these calculations are not yet widely applied in siding-related decision-making in Slovakia, their implementation could significantly improve transparency and efficiency in assessing the return on both public and private investments in railway infrastructure.

A: Siding Capacity Calculation

This formula provides a baseline estimate of how much freight a siding can theoretically handle in each time period. It is useful for comparing the current capacity with forecasted demand or for identifying bottlenecks in infrastructure:

$$C = N \times W \times L, \quad \text{[tons; wagons]} \tag{1}$$

where: C is siding capacity (total transport capacity in tons or number of wagons) [tons; wagons]; N is number of train movements per day [movements/day]; W is number of wagons per train [wagons]; L is load capacity per wagon [tons].

This calculation provides an estimate of the theoretical transport capacity of a siding under standard operating conditions

B: Siding Utilization Index

This indicator shows how effectively a siding's capacity is being used. A low percentage indicates underutilization and may signal economic inefficiency or unused potential:

$$U = \frac{T_{actual}}{\mathrm{T}_{maximum}} \times 100\%, \ [\%] \tag{2}$$

where: U is utilization rate of the siding [%]; $Tactual$ is actual annual transport volume [tons]; $T_{maximum}$ is theoretical capacity of the siding [tons].

C: Estimation of Investment Costs

This simple model is used to estimate the financial resources required to build or modernize a siding. It helps in drafting budgets, cost-benefit analyses, and investment proposals:

$$I = L \times \ C_u, \ \ [€] \tag{3}$$

where: I is estimated investment cost [€]; L is length of the siding [km]; C_u is unit cost of construction or reconstruction per km.

D: CO_2 Emission Savings Estimate (Modal Shift)

This formula quantifies the environmental benefit of moving freight from road to rail. It can be used in sustainability assessments or environmental impact reports to demonstrate alignment with climate goals:

$$S = D \ \times Q \ \times (E_{road} \ + \ E_{rail}), \ \ [\text{kg or tons}] \tag{4}$$

where: S is CO_2 savings [kg or tons]; D is transport distance [km]; Q is quantity of goods transported [tons]; E_{road}, E_{rail} is emission factors for road and rail transport [e.g. g CO_2/tkm].

The implementation of these computational models and indicators in the evaluation of railway sidings represents a significant step toward systematic and objective planning. They help establish a methodological framework that enables transparent and comparable assessment of investment returns in siding infrastructure. At the same time, they allow for the quantification of the benefits of rail-based solutions compared to road transport — particularly in terms of capacity, economic efficiency, and environmental impact. These analytical approaches thus provide a solid foundation for strategic decision-making, transport policy development, and the preparation of projects seeking funding from public calls and European funds.

5. Results

Currently, the number of privately operated railway sidings is steadily declining. Each year, several licenses authorizing the operation of these sidings are removed from the registry of valid permits. This downward trend is largely attributable to the increasingly challenging economic and regulatory environment faced by siding operators. A significant number of companies that once managed these facilities have either ceased operations or entered liquidation, which has contributed to a notable slowdown in the construction of new sidings. Operating a siding involves substantial financial obligations, particularly in meeting the requirements stipulated by current railway legislation and safety regulations. These obligations may include technical maintenance, personnel qualifications, and compliance with administrative procedures, all of which can discourage potential investors or operators from maintaining or developing siding infrastructure.

Table 3 Assessment of the potential of railway sidings. Source: [13]

Train Line		**Station**	**Total Rail Sidings**	**Public Freight Track**
Connection	Line number			
Važec - Žilina	105	Kráľová Lehota	3	yes
		Liptovský Hrádok	1	yes
		Liptovský Mikuláš	2	yes
		Liptovská Teplá	2	yes
		Lisková	2	
		Ružomberok	5	yes
		Ľubochňa	1	yes
		Kraľovany	0	yes
	106A	Turany	1	yes
		Vrútky nakl. St.	4	
		Vrútky	3	yes
		Varín	2	yes
		Žilina Teplička nad Váhom	1	
		Žilina	3	yes
Žilina - Predmier	106A	Žilina zr.st.	1	
		Dolný Hričov	3	yes
		Bytča	2	yes
Žilina - Čadca – Skalité	106D	Kysucké Nové Mesto	3	yes
		Krásno nad Kysucou	1	yes
		Čadca	0	yes
	114B	Skalité	0	yes

The following chapter offers an overview of existing sidings and designated freight handling points within the Žilina self-governing region. This overview serves as a foundation for assessing the region's rail freight potential. Railway infrastructure in the Žilina region is typically used for both passenger and freight services, requiring careful consideration when assessing its accessibility for freight operators. From a logistical perspective, freight customers can access the national railway network either through private sidings (including intermodal freight terminals) or via public freight loading and unloading tracks located within railway stations. Both options represent important elements of the regional transport system and can significantly influence the competitiveness of rail over road transport.

Table 3 indicates that the region has a relatively extensive railway infrastructure, providing a solid foundation for the development of intermodal and regional freight transport. However, this potential remains partly underutilized due to the uneven distribution of railway sidings and the limited number of public loading points in certain sections.

The highest number of rail sidings is found on the Važec – Žilina line (line numbers 105 and 106A). The stations with the greatest number of sidings are Ružomberok (5 sidings), Vrútky Freight Station (4 sidings) and Kráľová Lehota and Kysucké Nové Mesto (3 sidings each).

Some stations (e.g. Kraľovany, Čadca, Skalité) have no sidings, but they do provide a public loading track. Most stations offer public access to loading facilities, which increases the usability of rail transport even for smaller customers without their own siding. Sidings without a public loading track can be found, for example, in Lisková, Vrútky Freight Station, Žilina – Teplička nad Váhom, and Žilina Marshalling Yard.

The railway infrastructure is relatively evenly distributed across the region, particularly along the main lines leading to and from Žilina. Good accessibility to rail sidings and loading facilities creates strong potential for the use of rail transport in regional logistics and industry.

Some stations located in industrial areas have a low number or complete absence of rail sidings — for example, Čadca or Skalité — which may limit their logistics potential. From a strategic planning perspective, attention should be focused on the following:

- modernization of existing sidings,
- utilization of stations with public loading tracks for smaller freight operators,
- reactivation of sidings at stations currently lacking active connections.

Despite Žilina region's strong railway network with many sidings and public loading points, parts of the area lack adequate rail links to industry. Focused investments, planning, and policy support could strengthen rail's role in regional freight transport [13].

Figure 2 shows that most populated areas in Žilina region can access stations with sidings within 30 minutes. These stations generally meet loading requirements for smaller clients, supporting future rail freight growth, though modernization will be needed [13].

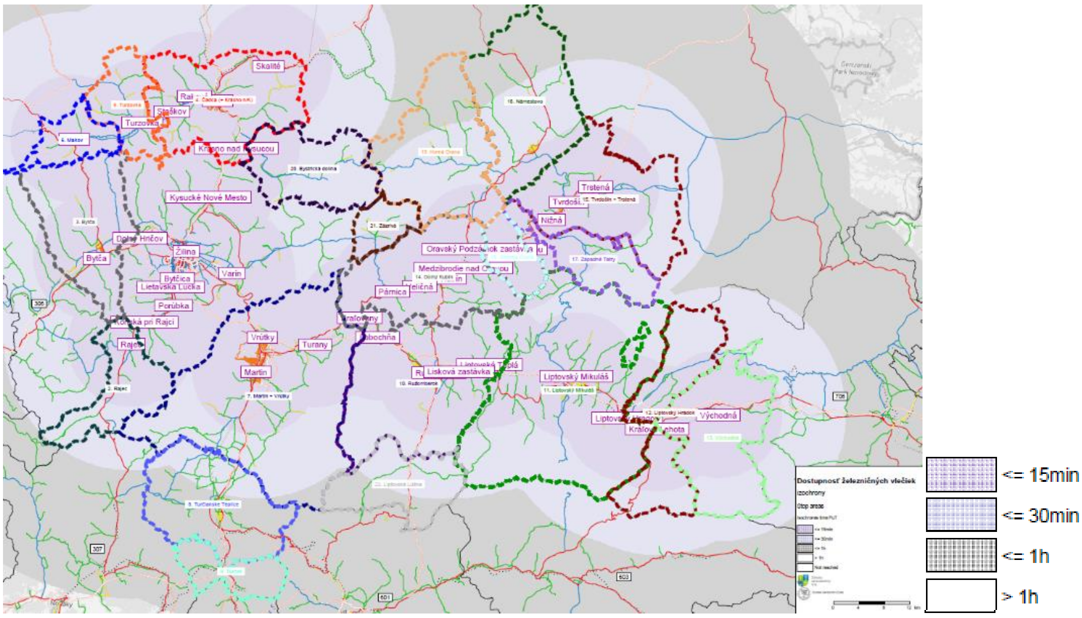

Fig. 2 Isochrone accessibility of railway stations with sidings in the Žilina region. Source: [13]

4. Discussion

The development of railway sidings is closely tied to the objectives of the European Green Deal, which emphasizes the need to reduce greenhouse gas emissions. As part of this strategy, transport-related emissions must be reduced by 90% by 2050, with rail and intermodal freight transport playing a vital role in achieving this target. Better integration of rail infrastructure with industrial zones and logistics centers is essential to promote more sustainable and efficient freight transport, ultimately contributing to a more environmentally friendly and resilient transport system [13].

Under Slovakia's Recovery and Resilience Plan, specific funding calls have been launched to support combined transport projects, including infrastructure related to railway sidings. This makes siding development a key tool in fulfilling national transport policy objectives while also promoting long-term economic sustainability in the sector.

Financing Mechanism for Railway Sidings

The development of sidings is funded through state aid provided by the Ministry of Transport of the Slovak Republic. Grants are awarded based on public calls, where applicants must meet eligibility criteria and demonstrate the economic viability of their projects. Eligible costs covered by the aid include:

- Construction of new sidings,
- Modernization of existing sidings,
- Purchase of technological equipment and handling devices,
- Environmental measures aimed at reducing noise and emissions.

Applicants are required to submit project documentation, a financial sustainability analysis, and proof of ownership or lease of the infrastructure. Once the application is approved, a grant agreement is signed that defines the terms of funding, monitoring obligations, and the requirement to maintain the investment for at least five years. The maximum aid intensity is capped at 49% of eligible costs. The support is provided in the form of a non-repayable grant, subject to strict compliance conditions. Eligible costs include railway substructure and superstructure, handling areas and equipment, signalling technologies, and environmental measures. In contrast, operational costs, taxes, and routine maintenance are not eligible [13].

The findings of this study have several practical implications for both the infrastructure manager (ŽSR) and railway freight operators, particularly ZSSK Cargo. For ŽSR, the results highlight the need to prioritise the modernisation of sidings located in areas with strong regional industrial activity but exhibiting technical or capacity limitations. This applies especially to sidings on lines 105 and 106A, where the analysis indicates a discrepancy between potential demand and the current level of infrastructure provision.

For freight operators, especially ZSSK Cargo, the findings suggest opportunities to improve the organisation and planning of wagon movements by optimising shunting processes and concentrating cargo handling in stations with better operational facilities. A more strategic integration of active sidings into existing freight routes could reduce shunting times, streamline operations, and increase overall economic efficiency.

Overall, the results provide a useful basis for investment prioritisation, capacity management, and operational optimisation within the rail freight sector.

Control and Monitoring

The Ministry of Transport carries out regular audits of how funds are used. Beneficiaries are required to submit annual progress reports and comply with the sustainability conditions of the investment. In cases of non-compliance, part or all the granted funds may be reclaimed. This funding mechanism ensures the efficient use of public resources, strengthens the competitiveness of rail freight, and contributes to the sustainable development of Slovakia’s transport infrastructure [13].

The opening of the EU freight market introduced strong competition, yet it has largely affected only the high-yield block train operations. However, former national carriers in many countries still maintain the service of individual wagon consignments. The individual wagon consignment segment transports one-third of the freight but employs two-thirds of the workforce.

The basic logistical principle of individual wagon consignments is the so-called hub and spoke model. In this model, nodes, or "hubs," are designated to which individual consignments and groups of wagons from a certain radius are collected. In the case of ZSSK CARGO, these are sorting stations. At these stations, wagons from shunting trains are sorted and maneuverer so that mixed trains are formed based on their destination from individual consignments and groups of wagons (now referred to as through freight trains). These then travel across the country to another hub. There, they are sorted again into shunting trains for their "last mile," and on the return journey, they bring new consignments for sorting [14].

The entire system functions better the higher the utilization of the trains. Essentially, it is a system like multimodal terminals, with the distinction that consignments are not transferred to trucks for the last kilometers but remain on the tracks throughout the process. One of the key conditions for the functioning of this system is railway sidings. These tracks leading directly to businesses allow goods to be loaded and unloaded only once. If it is necessary to load the goods onto a truck and transfer them onto the general loading and unloading track at the station to the train, costs increase. Railway sidings play a key role in the logistics of individual wagon consignments (IWC). These are special tracks that lead from the main railway line to industrial, commercial, or storage facilities. The significance of railway sidings for IWC can be summarized in several main points.

Direct access to manufacturing and storage facilities: Railway sidings allow direct access for wagons to industrial plants, warehouses, and logistics centres. This eliminates the need for further transfer of goods from the wagon to another mode of transport, thereby reducing costs and the risk of damage to the goods.

Efficient loading and unloading: Sidings enable efficient loading and unloading of goods directly at the destination. This improves the time efficiency of transportation, which is especially important for time-sensitive shipments.

Flexibility for smaller shipments: For businesses that do not produce sufficient volumes of goods to fill an entire train, sidings are an ideal solution. They allow the transport of smaller quantities of goods in individual wagons, providing flexibility and adaptability to customer needs [15].

Reduction of road transport: Using railway sidings for IWC reduces the burden on road infrastructure, which positively impacts traffic congestion and the environment. Fewer freight trucks on the roads means lower emissions and less wear and tear on roads [16].

Improved safety: Direct access to rail transport reduces the need for handling goods on the roads, which lowers the risk of accidents and increases overall transportation safety.

Competitive advantage: Companies with their own sidings can offer more reliable and faster delivery of goods to their customers, which can be a significant competitive advantage in the market.

Integration into multimodal transport: Railway sidings are a key element of multimodal transport, where goods can be transported using a combination of rail, road, and maritime transport. This integration allows for the optimization of the entire logistics chain [17-19].

Support for regional development: The presence of sidings can support regional economic development by providing better access to rail transport for local businesses, which can attract new investments and job creation.

9. Conclusion

The Slovak transport system has long undervalued the role of rail freight, resulting in a shift toward road transport. To reverse this trend, consistent investment and the development of strategic infrastructure—such as railway sidings—are essential. Sidings provide direct connections to industrial and logistics zones, improving the competitiveness of rail, reducing road congestion, and supporting environmental goals. Aligned with the European Green Deal, which calls for a 90% reduction in transport emissions by 2050, railway sidings can facilitate a shift toward more sustainable freight movement. They also support regional development by improving access for businesses and stimulating local economies [20-22].

However, many sidings remain outdated and underutilized. Upgrading and integrating them into multimodal systems is crucial for ensuring efficient, low-emission freight transport and building a more balanced and resilient transport network.

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