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Research Article

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# Optimisation of Transport Capacity of a Railway Siding Through Construction-Reconstruction Measures

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**Abstract:** Railway sidings in the Slovak Republic, despite their reduction, still do not lose their importance. In railway transport, a significant part of the realised performances is represented by transport on railway sidings and there is therefore a need to continuously develop and adapt the siding operation to the requirements of the transport market. The reason for the decrease of their number is nowadays mainly the financial demands on the construction of the new siding and its operation. In view of this fact, there are sidings in several companies in the Slovak Republic where the transport performances do not decrease and the performances realised on their railway siding are considered as dominant and economically advantageous. The aim of this paper is based on the analysis of the current state of the siding operation in the selected company in order to solve the problem with insufficient capacity of the siding due to the increase in the volume of processed materials. The problem with the capacity of the analysed siding will be solved through construction-reconstruction measures - namely by construction of a new handling track. This option is a solution to the problem of an insufficient capacity of the siding, which affects the current transport performances and costs of railway wagons staying at stations, too. The proposed measures to support the increase of a siding capacity will be economically evaluated and the pay-back period of these solutions will be assessed.

**Keywords:** railway siding, capacity, costs, return, reconstruction

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## 1 Introduction

The analysis of a siding operation implies that in the territory of the Slovak Republic there decrease performances realised on sidings as well as the number of sidings transport performances are realised on. Nowadays the reason is mainly the financial demands on the construction of a new siding, but also high fees charged by siding operators to subjects, *i.e.* users of sidings, willing to use the siding for transport purposes [1]. In spite of this fact in big enterprises in the Slovak Republic there exist sidings whose transport performances do not decrease, and the enterprise considers railway transport realised on its siding to be dominant and economically profitable. The research of this project will be aimed at railway sidings when performances realised by railway transport are more profitable for the enterprise.

The aim of this paper is to propose such measures which will be in accordance with requirements put on an increased capacity of railway sidings for specific operators, and at the same these measures will serve for the support of railway transport in terms of an ecologically more favourable mode of transport. The problem with capacity of railway sidings there in Slovakia can be solved using several measures, *e.g.*: construction of a new handling track, change of a line class on an existing handling track, purchase of new mechanisms for a sufficient handling on a siding, support for siding operation, change of technology for shipments processing, or engagement of new employees to support the siding operation.

A quality transport infrastructure is a condition of the economy development and it belongs to basic criteria of making decisions regarding a new investment realisation. More favourable economic conditions of business making, flexibility and ability to respond to requirements of a modern economy have caused that road transport has been achieving a decisive market share, and its increase leads to congestions on main road lines and a negative impact on the environment and health of the population in towns [1]. From the point of view of making the transport green it is important to introduce renewable sources of energy within transport, to develop their utilisation, and to focus on the support and development of non-motorised and ecological modes of transport. Railway transport is safe and green. Greening will be playing a bigger and bigger role in the EU. This, however, means not only the support for production of biofuels or utilisation of hybrid engines, but also the support for an overall greening of individual modes of transport [2, 3].

## 2 Data and Methods

A scientific method will be used to solve the problem mentioned in the introduction of the article. The methodology is divided into several parts and its main objective is to achieve the support for railway transport as the most ecologically favourable mode of transport, and the support to increase the transport capacity of the analysed siding. The proposed methodology is in compliance with requirements of the siding operator, or user, with siding capabilities as well as with the applicable legislation. To accomplish the scientific method individual steps will be applied. The first part of the methodology describes a problem being investigated which relates to actual requirements within siding operation management in the Slovak Republic and to an inevitable support for its development. In the following analytical part of the methodology the following is worked out: the infrastructure characteristics of the observed siding, the identification of the siding capacity problem, the analysis of performances, the analysis of operations, the technical base, the analysis of operation processes of the siding, etc. The collected information, complexity and depth of surveyed indicators were the basis for creating a research plan which exactly identified individual phases, methods and procedures [4]. Based on the performed analysis it is possible to propose some optimisation measures. In the next to the last part of the methodology a specific measure to increase the transport capacity of the siding is worked out. The final part of the methodology is complemented with a calculation of the economic profitability of rationalisation measures in order to support the siding operation, and it is also complemented with a recalculation of return of investment period. The methodology represents a sequence of steps to ensure the support for a smooth siding operation with an increased volume of processed stocks on the observed siding, and to ensure the support for railway transport as a more profitable mode of transport. To protect personal data and sensitive data of subjects who the transport capacity is optimised in this paper for, some operating names will be used, mainly in the following cases:

- *a manufacturing plant the optimisation solution is being proposed for: Plant A,*
- *a railway siding as a site of measures realisation: Siding A,*
- *a railway station the siding runs into (a connecting station of Siding A): RS A,*
- *other: individual names of processed stocks will be operationally called as a commodity A to Z, specific products will be operationally called as a product A to Z, and a project of Plant A (a project which aims to increase the production of specific products) will be operationally called as a project A,*
- *a stock which affects the siding capacity after the project realisation: commodity C (realised measures).*

## 3 The Analysis of a Current State of the Siding Operation on Siding A

The operation on Siding A represents a set of transport-shipping activities which provide a shunting on this siding at the agreed time. The Siding A operation also includes performances related to shunting of wagons on tracks of the siding in accordance with the requirements and with the approval of the siding operator, or user, out of the scope of siding operation.

A big advantage of Plant A is the existence of its own railway siding whose construction project was prepared in 1979. Thanks to this siding it is possible to deliver stocks to the enterprise also by means of railway transport. Currently Plant A is planning to realise a planned project xy and as part of this project it is anticipated that the transport volume will be increased via railway transport in 24%. The position of the siding is of a strategic importance also because of its area [5].

The permission to operate a railway for Siding A is issued per Art. 36 Act No. 164/1996 Coll. National Council of the Slovak Republic on Railways and on amendment of the Act No. 455/1991 Coll. on Trade Licensing by National Rail Office under the licence number 0004/1997/p. On the basis of this permission Plant A may operate the railway (siding). The licence to provide services of railway transport was issued by the Transport Authority for Siding A with effect from October 5, 2017 sine die.

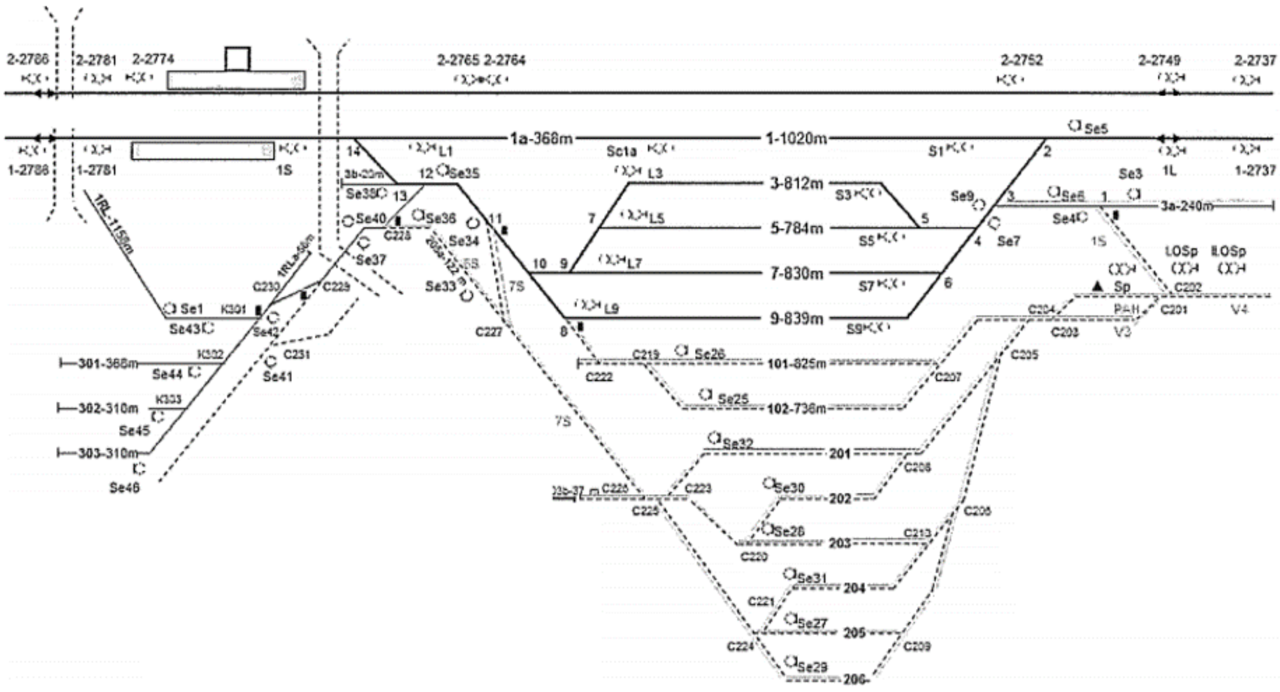



**Figure 1:** Scheme of a Rail Yard of RS A and Railway Siding A Source: [5]

## 3.1 The Characteristics of Plant A

Plant A belongs to the biggest manufacturers in Slovakia. Plant A features a production capacity of 100,000 t of commodity A for sale, 560,000 t of commodity B, and 66,000 t of commodity C. After constructing a new regenerative boiler an energetic self-sufficiency of Plant A reached 100%, where more than 94% of production originates from renewable sources. There are certificated stocks used in the production. Plant A directly employs 1,200 employees and other 6,000 people within a supply chain in the entire Slovakia. Plant A has also been credited a quality award for the best employer, safety, effectiveness, environment and management of the supply chain.

In the course of one year Plant A produces more than 620,000 t of sales production, producing 8 millions pieces of the product every hour, and exporting 32,000 trucks per year. The biggest purchaser is considered to be the central and eastern Europe, which amounts up to 50% of the sale; then there follows the western Europe (43%) and the remaining 7% are created by the rest of the world [5].

## 3.2 The Characteristics of Siding A

The railway siding is operated and owned by Plant A and transport services on the siding are provided by the carrier Železničná spoločnosť Cargo Slovakia, a. s. ("ZSSK Cargo") which entered into a contract with the siding operator (Plant A). Maintenance and repairs of telecommunication, notification and security systems are provided by the company Železnice Slovenskej republiky ("ŽSR"). Plant A is an owner of the railway siding, an operator of Siding A and in some cases it is also an operator of the transport on railway siding A (unless it is ZSSK Cargo). The operation on the siding is continuous, *i.e.* 24 hours.

Track gauge on Siding A is 1,435 mm with a total construction track length of 22.895 km. A minimum radius on the siding is 150 m, maximum gradient of the siding is 50%, and maximum load on the axle is 20 t. Maximum permissible speed in a rail yard within the station (which the siding is linked to) is 30 km/h for a single locomotive and towed wagons, and 15 km/h for pushed wagons. In a rail yard within the plant the maximum speed is 15 km/h for a single locomotive and towed wagons, and 10 km/h for pushed wagons. Admissible weight on axle (in tons) is 20 t [5].

Siding A is linked to the railway infrastructure from two railway stations ("RS"), namely RS A and RS B. Siding A comprises two sections:

- a rail yard in RS A,
- a rail yard in Plant A.

These two sections are joined with an interchange track which serves for moving the wagons between rail yards. This track crosses the access road to the enterprise and the river Váh with a flyover steel bridge [5].

Figure 1 represents the rail yard of Siding A with a dashed line, and it is divided into a northern and southern branch. There in RS A the tracks (a solid line) are used for a delivery of wagons between Plant A and the carrier ZSSK Cargo, then for weighing, sorting, collecting and repairing of wagons.

## 3.3 Identification of a Problem with the Capacity of Siding A

Currently Plant A is planning to realise a long-term planned project A. This project has been the biggest investment of Plant A recently. The aim of project A is to extend the production of product A in premises of Plant A with the production of a new product. Maximum production will add up to 300,000 t of the product per year. The main purpose is to extend the production of the product A and to bring a recycled product to the market. There will also be a contribution in the form of an economic stabilisation and growth of the enterprise, impacting the region itself.

The investment, called Project A is evaluated with the amount of 310 millions EUR, under the condition of getting a financial support from the government. The investment will include a purchase of a new production machine, a construction of new warehouses/buildings as well as new urban areas for road vehicles and logistics of trains. Its name (not published in the article) implies that project A means an ecologic and economic plus, a plus for the employment, development and stability. Thanks to this project there will new job positions emerge; 105 direct positions, and the others should be indirect ones. The production will be ecologic and the impact on the environment will be reduced thanks to the best technologies available [5].

The realisation of Project A makes ground to anticipate an increase in delivered stocks by railway transport in approx. 24%, thus it will be necessary to increase the transport capacity of the siding, which is also the aim of this paper.

## 3.4 A Technical Base of Siding A

In the rail yard of the plant there are mechanisation means and pump facilities which speed up the loading and unloading of railway wagons.

#### A Stabile Base

In the rail yard of RS A there is a track weighing machine TRAPPER DRS with the length of 18.5 m and load of capacity of 120 t. It has got the Certificate of rail weight validity. Loading, unloading and handling ramps, which are 1,100 mm high above the upper surface of the rail, 1,725 mm away from the centre line of a track, are placed on Siding A. Furthermore, Siding A is equipped with lighting masts, operation buildings, such as the building of a switch tower in RS A and the building of engine sheds ("locomotives") there in Plant A.

**Table 1:** Mechanisation Means and Pump Facilities on Siding A

| Track | Utilisation |
|---|---|
| 2, 2a, 3, 4 | Pumping of commodity A |
| 5a | Pumping of commodity B |
| 16a | A travelling crane with the loading capacity of 5 t,<br>a channel for locomotives repairs |
| 18 | Unloading of commodity C with mobile unloaders |
| 10d, 22a | Unloading with fork lift trucks |
| 22a | Unloading with mobile machines |

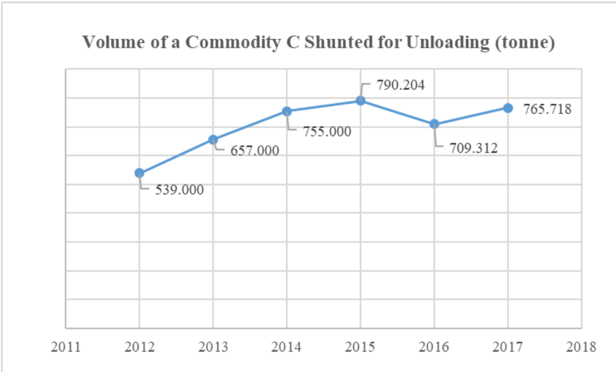
Source: [5]

#### A Mobile Base

On Siding A there are 4 locomotives, series 740, type T448.0903, T448.0952, T448.0617 and T448.0737, and one track machine MUV 69 used. They are owned by Plant A. They mainly serve for shunting the wagons in the rail yard of RS A and Plant A, but they also serve for handling processes between the rail yard and the plant.

## 3.5 The Analysis of Siding A Performances

There are multiple kinds of commodities delivered to Plant A by railway transport, which are important for the




**Graph 1:** The Volume of a Commodity C Shunted for Unloading on Siding A Source: [5]

production of several products. A finished product is delivered to a customer by railway transport which is provided by the carrier ZSSK Cargo. The commodity C features the biggest share of the delivered stock via railway transport, since it is a raw material in the production. Therefore the analysis of performances and the proposed measures will mainly be focused on the delivered commodity C (the object of measures), whose volume will be increased after the project A; the volume of other materials will be the same as nowadays, their increase is not anticipated. Graph 1 represents the volume of commodity C, which has been delivered onto Siding A since 2012.

After the realisation of project A, which will be focused on the production of product A, the increase of commodity C transport is anticipated when compared to 2017; the assumption is expressed as follows:

- year 2017: 765.718 t,
- A project by: 950.000 t.

The volume of commodity C transport will be increased in 184,282 t after the termination of project A; after a recalculation to a percentage it means an increase in 24%.

## 3.6 The Analysis of Operation Processes of Siding A

Operation processes comprise transport and shipping processes on Siding A, where both the siding and connection operations include transport and shipping operations. The performed analysis has brought the following findings: the average number of shunted railway wagons onto Siding A during its 24-hour operation is as follows: 90 wagons with commodity C (the object of measures), 10 wagons with commodity A, 5 wagons with paper and 10 wagons with commodity B.

### Transport Part of a Connection Operation

The connection operation within the operation of Siding A is performed by the carrier ZSSK Cargo using a shunting crew in regular times of operation given in a valid train traffic diagram. The agreed times are as follows: 3:00, 8:00, 14:00 and 21:00. The handover of wagons between the carrier ZSSK Cargo and an employee of Plant A takes places on Siding A in the rail yard of RS A on tracks No. 101, 102 and 201. Shunting stand-bys in the circumference of the siding are controlled by a traffic controller in RS A [5].

The admissible shunting on the siding is a roundabout shunting. The siding operation is governed by Regulations of railway operation ŽSR Z1. An employee who shunts the cars is responsible for preventing a self-motion of cars on factory sidings. After the operation is finished and the shunting crew leaves the handover site the responsibility for shunted cars is transferred to a siding operator. Cars being shunted may be uncoupled only after securing the cars against their self-motion via tightening a necessary number of parking brakes and blocking the cars with stop blocks.

## 3.7 The Evaluation of the Analytical Part

After implementing the measures introduced in project A, Plant A will encounter a problem with shunting the wagons onto the siding due to an insufficient capacity of Siding A. The Siding A capacity problem is actual even without the implementation of measures from project A. Plant A solves this situation through shunting the wagons in neighbouring villages which results in high costs on placing the wagons onto sites different from Siding A. To fulfil the measures in project A, which will increase the volume of commodity C transport by railway transport in 24%, it will be required to propose some operation-investment measures which will solve the considered problem.

# 4 A Proposal of Measures to Increase the Transport Capacity of Siding A

Part of a construction-reconstruction measure is to build a new handling track in the rail yard of Siding A. For the sake of proposing this solution it was necessary to analyse spatial possibilities of building a new track on Siding A, or a spatial capacity of Siding A for construction works.

The proposal of the construction solution comprises building a new track in the rail yard of Siding A near the warehouse of commodity C which would branch off the track 14b. This measure will make it possible to put more wagons onto the siding; it will also ensure a faster shunting of wagons from Plant A into RS A and a subsequent handover of wagons to a carrier.

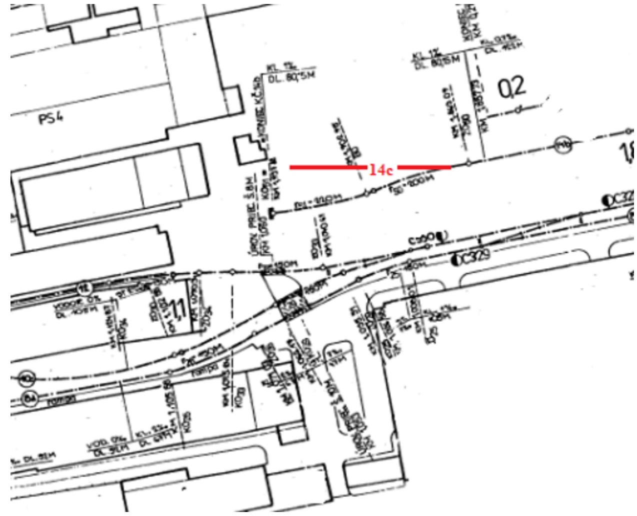



**Figure 2:** A Schematic Representation of a New Track on Siding A
Source: [5]

### Building a New Handling Track on Siding A

The warehouse of commodity C is an area where the commodity C is unloaded from wagons, or road vehicles directly onto the ground. It is an external area. Building a new track would ensure a faster unloading of the commodity C in the plant.

The effective length of the proposed new track is proposed as follows: (Černá, 2018):

$$L_e = (2 * l_{sd}) + l_{loc} + l_{tr} \quad (1)$$

where:
$L_e$ – effective length of the track [m],
$L_{sd}$ – safety distance [m],
$L_{loc}$ – length of the shunting locomotive [m],
$L_{tr}$ – length of the train [m].

Calculation: $L_e = (2 \times 5) + 13.6 + 503.68 = 527.28\ m$

The safety distance is determined with a standard per 5 m, the length over buffers of the shunting locomotive, series 740, is 13.6 m, and the length of the train was given as 503.68 m. The length of the train includes wagons with the commodity C only, since there in the warehouse it is this commodity which is unloaded either directly into the usage or onto the ground. The calculations considered wagons, series Eas and Snps; their number and length as well as the volume of the shunted commodity C after its increase within project A were decisive to determine the length of the train.

Figure 2 represents a scheme of the rail yard on Siding A with a new track being marked. As part of sensitive data protection the scheme is modified by authors of the paper.

The new track is labelled as 14c. Using this measure the commodity C could be unloaded in two sites at the same time: on the track No. 14b and on the new track No. 14c. This would ensure a faster unloading of wagons and after shunting empty unloaded wagons onto Siding A the process of handover of wagons to the carrier would be faster. There would also emerge a space on the siding for shunting more wagons intended for unloading. Through the implementation of this measure the empty wagons would not stay on the siding for a useless long time and they would not take the area needed for shunting of other wagons [6].

# 5 A Technical-Economic Evaluation of the Measure

The following part of the paper will comprise the evaluation of a construction-reconstruction measure mentioned in the chapter 3 of this article. It is the assessment of the current technical state of Siding A, evaluation of costs on investment, and identification of benefits of this measure. From the economic point of view the following aspects will be evaluated: investment costs of the measure, operation costs at its implementation, saving of costs at the implementation of the measure, and subsequently the effectiveness of the investment will be expressed. The starting point is a comparison of a starting variant, which is the current state, with a state which will result from the proposed measure. To calculate the effectiveness and pay-back period the Net present value method (NPV) will be used [6, 7].

## 5.1 Net Present Value Method

NPV is a cash flow method (CF); it expresses a total real gain of an investment per a period of its anticipated utilisation or evaluation. It represents a difference between a present value of anticipated revenues and costs of investment [8, 9].

A basic formula to calculate NPV is as follows on Figure 2 [8]:

$$NPV = SHCF - IC = \sum_{t=1}^{n} CF * \frac{1}{(1+k)^t} - IC \qquad (2)$$

where:
NPV – a net present value of an investment and operation CF per the period of evaluation,
SHCF – a net present value of CF,
IC – one-off investment costs,
k – a discount rate,
n – a period of evaluation,
CF – an anticipated value of an operation CF in the year t,
t – a year of evaluation [8].

A discount rate determines a required rate of return on investment for an anticipated development of a capital market, inflation and risk rate of the investment. The amount of the discount rate depends on the investment type, co-financing way, and the period of the investment evaluation. There in this paper 5% will be used as the discount rate for the measure.

The Internal rate of return (IRR) method consists of a comparison of a real internal rate of return on investment with the required rate of return. If an investment does not meet the rate of the return criterion, it will be rejected. More effective is that investment which has a higher IRR. A year when NPV equals 0 is the year of return on investment and achievement of the required rate of return using the discount rate.

## 5.2 A Technical Assessment of Building a Handling Track on Siding A

A substructure of a track is built with a construction work of a terrestrial body terrain. The terrestrial body must ensure a stability of the superstructure even under unfavourable weather conditions. The first layer of the substructure is a 30 cm layer of sand with a fraction of 32 - 63 mm on which a geotextile is laid. On the geotextile there is a 3 cm protective layer of gravel with a fraction of 0 - 63 mm, and then there is a geogrid. There on the geogrid a 10 cm layer of gravel and another geogrid is laid; on it there is the last 20 cm layer of gravel present. These layers are required due to permeability as well as anti-freezing against the weather conditions [10, 11].

The superstructure which forms an own guide and carrier route of railway vehicles comprises rails, track fastenings, sleepers, and a rail bed. To build new tracks there will be rails with the shape S 49 and the weight 49 kg/m on concrete sleepers SB 8P used. There will be S 49 1:9-190 switches used which will be adjusted centrally [12, 13].

## 5.3 An Economic Assessment of Building a Handling Track on Siding A

The calculation of costs of a construction measure is worked out on the basis of obtained data from a company (it will not be labelled in the paper) which would perform the prospective implementation of the measure [14, 15]. The company provided its own rates for a needed material and labour, required for building a new track on Siding A.

The effective length of the newly built track will be 527.28 m, and the building length of the new track will be 577.28 m, which is decisive in cost calculation. In the following Table 2 there are investment costs of the needed material evaluated.

Total costs needed for the material in building a new track are **287,915.28 €**. In the following Table 3 there are operation costs of a new track on Siding A evaluated.

Total annual operation costs per a track in the plant are 323.88 €. Saving of costs after building the new track in the rail yard comprises costs of a stay of wagons held only in the rail yard of Plant A. All of these are wagons which are shunted on tracks in Plant A. Mostly these are wagons for transport of the finished product, wagons with the commodity A, commodity B and wagons with the commodity C. We are speaking about the stay of wagons for up to 24 hours with 3,982 wagons held per year. Fees for a wagon stay are evaluated on the basis of available tariff conditions of the carrier ZSSK Cargo, a. s. Costs of a wagons stay:

- A fee for a stay: 15 €/wagon,
- Total costs: 59,730 €.

Total investment costs of building a new track in the plant are 287,915.28 €. Total annual operation costs for a track in the plant are 323.88 € and the saving of annual costs for a wagon stay is 59,730 €. Table 4 represents cash flows of investment in case of building a track on Siding A.

**Table 2:** Investment Costs in Building a Track on Siding A

| Item | Unit | Unit price in euros | Total price in euros |
|---|---|---|---|
| Rails (shape S49), division of concrete sleepers, body of ballast UIC | m | 297.1 | 171,509.88 |
| Switch J49 - 1-9 - 300 | ks | 84,428.7 | 84,428.7 |
| Base layers from broken stones | m | 34.37 | 19,841.11 |
| Horizontal relocation of excavation along paved road | $m^3$ | 3.96 | 1,600.22 |
| Adjustment of the subgrade in cuttings with compaction | $m^2$ | 0.55 | 635.01 |
| Base layers for the newly installed track track with leveling og the top by broken stones | $m^3$ | 24.5 | 9,900.35 |
| Total | - | - | **287,915.28** |

Source: [5, 8]

**Table 3:** Operation Costs

| Item and fee number | Required amount | Times per year | Rate in euros | Total price in euros |
|---|---|---|---|---|
| Cleaning and lubrication of switches 1/01 | 1 unit | 1 | 173.91 | 173.91 |
| Cleaning of the switch from snow, ice, deposits and stands 1/06 | 1 unit | 1 | 52.83 | 52.83 |
| Patrolling the siding 2/01 | 5.7728 m | 1 | 0.59 | 3.41 |
| Measure the geometric position of the siding tracks 2/02 | 5.7728 m | 1 | 2.67 | 15.41 |
| Inspection and measurement of switches 2/04 | 1 unit | 12 | 5.07 | 60.84 |
| Commissional inspection of one switch unit 3/01 | 1 unit | 4 | 4.37 | 17.48 |
| Total | - | - | - | **323.88** |

Source: [5, 8]

A positive NPV occurs in 2026, which means that investments will return to the enterprise in that year. Building of a new track on Siding A is an optimal solution of the situation due to the positive NPV, which means that the investment will be returned to the enterprise. Plant A will save costs of wagons stays and fees for using stabling sidings which currently must be paid due to an insufficient capacity.

# 6 Discussion and Interpretation of Results of the Construction-Reconstruction Measure

### The Analysis of Sensitivity

The analysis of sensitivity enables to identify critical variables of an investment. Using the analysis of sensitivity we can find out how a selected input value impacts the change of an observed resultant value. According to this finding it is possible to determine which factors are significant in this investment decision. Critical variables say that a change in 1% leads to a change of NPV. As part of the analysis of sensitivity in the paper there will be a risk of decreased benefits in 20% evaluated. Thus we will observe changes of a present value NPV with a changed value NPV after decreasing the benefits in 20% in the last year of the investment life. Afterwards a percentage of change will be calculated; if the value changes in more than 1%, the change is considered critical [16].

In the following part we will analyse the sensitivity of a construction-reconstruction measure of building a new track according to prices mentioned in the previous chapter of the paper. The risk of decreasing benefits and its impact on changing the NPV during building a new track according to prices in the 25th year of investment is as follows:

- Current NPV: 492,774.03
- Change of NPV: 335,784.91

**Table 4:** Cash Flows of Investment

| Year | investment costs | Operating costs | Cost savings | SHCF (€) | NPV (€) |
|---|---|---|---|---|---|
| 2019 | – 287,915.28 | −323.88 | 0 | −287,915.28 | −287,915.28 |
| 2020 | 0 | −323.88 | 59,730 | 53,883.10 | −234,032.18 |
| 2021 | 0 | −323.88 | 59,730 | 51,317.24 | −182,714.94 |
| 2022 | 0 | −323.88 | 59,730 | 48,873.56 | −133,841.38 |
| 2023 | 0 | −323.88 | 59,730 | 46,546.25 | −87,295.13 |
| 2024 | 0 | −323.88 | 59,730 | 44,329.76 | −42,965.36 |
| 2025 | 0 | −323.88 | 59,730 | 42,218.82 | −746.54 |
| 2026 | 0 | −323.88 | 59,730 | 40,208.82 | 39,461.86 |
| 2027 | 0 | −323.88 | 59,730 | 38,293.72 | 77,755.57 |
| 2028 | 0 | −323.88 | 59,730 | 36,470.20 | 114,225.78 |
| 2029 | 0 | −323.88 | 59,730 | 34,733.53 | 148,959.31 |
| 2030 | 0 | −323.88 | 59,730 | 33,079.55 | 182,038.86 |
| 2031 | 0 | −323.88 | 59,730 | 31,504.33 | 213,543.19 |
| 2032 | 0 | −323.88 | 59,730 | 30,004.13 | 243,547.32 |
| 2033 | 0 | −323.88 | 59,730 | 28,575.36 | 272,122.68 |
| 2034 | 0 | −323.88 | 59,730 | 27,214.63 | 299,337.31 |
| 2035 | 0 | −323.88 | 59,730 | 25,918.69 | 325,256.00 |
| 2036 | 0 | −323.88 | 59,730 | 24,687.47 | 349,940.47 |
| 2037 | 0 | −323.88 | 59,730 | 23,509.02 | 373,449.49 |
| 2038 | 0 | −323.88 | 59,730 | 22,389.54 | 395,839.03 |
| 2039 | 0 | −323.88 | 59,730 | 21,323.37 | 417,162.41 |
| 2040 | 0 | −323.88 | 59,730 | 20,307.97 | 437,470.38 |
| 2041 | 0 | −323.88 | 59,730 | 19,340.93 | 456,811.31 |
| 2042 | 0 | −323.88 | 59,730 | 18,419.93 | 475,231.24 |
| 2043 | 0 | −323.88 | 59,730 | 17,542.79 | 492,774.03 |

Source: [5, 8]

– Share: 0.68

The change of decreasing benefits during building a new track is not a critical variable since its value is under 1%.

## 7 Conclusion

A basic identified problem of railway transport and its decreasing performances in freight transport lie in the absence of a unifying vision of railway transport development, and a lack of coordination between subjects operating in the railway sector in Slovakia, and individual modes of transport. There are mainly the following measures which would support the development of railway freight transport: creation and full application of state transport policy principles which will support railway freight transport and disburden the overladen road network, *e.g.* harmonisation of business conditions, internalisation of external costs, support for ecologic modes of transport, state subsidy of railway sidings, support for intermodal transport, applications of neighbouring countries' standards in granting licences to operate railway freight transport, full toll fees for the road network for road motor vehicles with a commercial utilisation, expansion of a check system of adhering to duties of road carriers, and the state's support for removing environmental burdens found in the railway space.

The aim of the paper was to use the analysis of the current state of the siding operation on an observed siding to propose such a measure which will ensure an increase of transport capacity and at the same time which will support an ecologically more suitable mode of transport so that transport performances increased in 24% (by a planned project) will not be realised by road transport. In case of the measure of building a new track the investment costs of Plant A will be returned after a certain period (2026) due to the saving of costs of wagons stays on tracks other than tracks of Siding A. Through the increase of a transport capacity of the siding we have achieved a possibility to handle a bigger number of wagons.

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## References

[1] Gašparík J, Cempírek V. (2019). Railway Infrastructure Capacity in the Open Access Condition: Case Studies on SŽDC and ŽSR Networks. IntechOpen, DOI: https://doi.org/10.5772/intechopen.88929. Available from: https://www.intechopen.com/online-first/railway-infrastructure-capacity-in-the-open-access-condition-case-studies-on-s-dc-and-sr-networks

[2] Kampf R, Stopka O, Kubasaková I, Zitrický V. (2016). Macroeconomic Evaluation of Projects Regarding the Traffic Constructions and Equipment. Procedia Engineering, Vol. 161, 2016, pp: 1538-1544. World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium, WMCAUS 2016; Prague; Czech Republic; 13 June 2016 through 17 June 2016; Code 132600. https://doi.org/10.1016/j.proeng.2016.08.623.

[3] Gašparík J, Gáborová V, Ľupták V. (2016). Process portal for railway cargo operator with CRM support, Transport Means - Proceedings of the International Conference. ISSN: 1822-296X.

[4] Mašek J, Kendra M, Čamaj J. (2016). Model of the transport capacity of the train and railway track based on used types of wagons. Transport means 2016: proceedings of the 20th international scientific conference. Kaunas University of Technology.

[5] Bárošová B. (2019). Increase of transport capacity on siding. Diploma thesis. EDIS - University of Žilina, Žilina, Slovak republic.

[6] Gašparík, J., Abramović, B., Zitrický, V. (2018). Research on dependences of railway infrastructure capacity. Tehnicki Vjesnik-Technical Gazette. Volume: 25 Issue: 4 Pages: 1190-1195. DOI: https://doi.org/10.17559/TV-20160917192247.

[7] Kampf, R., Hladká, M. Bartuška, L. (2018). Optimization of Production Logistics. Advances in Science and Technology-Research Journal. Volume: 12 Issue: 4 Pages: 151-156. https://doi.org/10.12913/22998624/100351.

[8] Nedeliaková E, Harmanová D. (2015). Economics of rail transport. University of Žilina. Bratislava – DOLIS. ISBN 978-80-8181-003-9.

[9] Kampf R, Lorincova S, Hitka M, Stopka O. Generational Differences in the Perception of Corporate Culture in European Transport Enterprises. Sustainability. 2017;9(9):1561.

[10] Stopka O, Chovancová M, Ližbetin J, Klapita V. Proposal for optimization of the inventory level using the appropriate method for its procurement. Nase More (Dubr). 2016;63(3):195–9.

[11] Dedík, M., Gašparík, J., Záhumenská Z., Ľupták, V., Hřebíček, Z. (2018). Proposal of the measures to increase the competitiveness of rail freight transport in the EU. Naše More = Our Sea: Znanstveni časopis za more i pomorstvo : International Journal of Maritime Science & Technology. https://doi.org/10.17818/NM/2018/4SI.7.

[12] Gašparík J., Abramović B., Halás M. (2015). New graphical approach to railway infrastructure capacity analysis, Promet - Traffic - Traffico„ 27(4), 283-290. DOI: https://doi.org/10.7307/ptt.v27i4.1701.

[13] Stopka O, Kampf R. Determining the most suitable layout of space for the loading units' handling in the maritime port. Transport. 2018;33(1):280–90.

[14] Chovancova M, Klapita V. (2016). Draft Model for Optimization of the Intermodal Transport Chains by Applying the Network Analysis. In: 20th International Scientific Conference on Transport Means - Proceedings of the International Conference, pp. 112-116, Juodkrante, LITHUANIA, OCT 05-07.

[15] Ližbetin J, Ponický J, Zitrický V. The throughput capacity of rail freight corridors on the particular railways network. Nase More (Dubr). 2016;63(3):161–9.

[16] Abramovic B., Zitricky V., Mesko P. (2017). Draft Methodology to Specify the Railway Sections Capacity. LOGI – Scientific Journal on Transport and Logistics, 8(1), pp. 1-10. https://doi.org/10.1515/logi-2017-0001.