

Design of new effective train traffic diagram for a railway line

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Abstract. The paper presents the result of a case study analyzing the current state of rail transport in Slovakia, namely the current state on the line Humenné – Medzilaborce in the east part of Slovakia and also the current train traffic diagram. On the base of the realized analysis, it was determined the problematic parts of this line, as the insufficient occupation of the transportation line by passengers. This is caused by a lower number of inhabitants of the researched area and also the geographical position of some villages in this area. The aim of this study was therefore to find a solution that would increase interest in the use of rail transport in this region.

1 Introduction

Rail transport, as well as passenger transport and freight transport, has a very important status in the national economy of each country. It is a type of land rail transport along an artificial traffic road which serves to move of material or passengers from the point A to the point B, by the help of rail vehicles. The technical base of rail transport is created by means of transport, i.e. rail driving vehicle for the realization of transport, traffic roads, i.e. railway track and equipment of the rail transport (for example building for transport control, dispatching building, stations, etc [1]. There is about 3624 km of railway line in Slovakia, from this number 3593 km are operated, and electrified are 1576 km. Every year, new proposals are being made for electrification of further kilometers of existing lines, but this innovation is costly and therefore these plans are not always going to be implemented. Electrification also brings additional costs related to the innovation of wagon stocks that must be adapted to this change [2,3]. Table 1 presents the current state of the railway network in Slovakia.

Table 1. Railway network in Slovakia [2]

Length of railways	total: 3624 km	Narrow gauge railway: 50 km
	Operated: 3593 km	Wide-gauge railway: 98 km
	Single-track: 2576 km	Standard gauge: 3444 km
	Double-track: 1016 km	Electrified: 1576 km
Turn-out tracks	Number: 8425	
Bridges	Number: 2317	Length: 52 km
Tunnels	Number: 75	Length: 43 km
Railway crossings	Number: 2205	

2 Train traffic diagram (TTD)

Train traffic diagram (TTD) presents an understanding among all parts of railway transport and organization of train transport. It is a set of measures and tools related to rail transport. TTD is implemented in total railway network, on the base of international railway agreements and conventions. TTD should ensure the speed, safety, and economy of people and goods transport, the required amount of transport and the optimal use of wagon stocks. It should harmonize the activities of stations with adjacent track sections, full use of staff working time and also ensure the highest productivity of work and the lowest costs. Although train movement is often uneven, in the TTD it is presented simplified as a uniform movement between two units. [4-6] It would be unnecessarily complicated to illustrate the actual precise movement of the train and therefore the principles of calculations and graphical depictions of train movements related to the front of the train were adopted. It is possible to classify TTD by indicators, such as the mutual ratio of trains speed in the TTD, number of tracks, ratio of train number for one and reverse direction, an organization of rides for subsequent trains, duration of occupancy of interstation sections, time of operation, level of occupancy and use of track capacity, orderliness. [7] TTDs are classified by the mutual ratio of trains speed as parallel – this type belongs to the simplest type of TTD because all trains have the same driving time in the determined section due to the same weight, length, speed and specific capacity of trains; normal/commercial/out of parallel – train in the same direction are not parallel because they have different driving time, length and transport weight. TTDs are classified by the number of tracks as single-line (bi-directional) – trains in both directions run on one track alternately. Contrary trains can encounter only by

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crossing in stations or shunts. The quality of TTD can be affected by the suitable layout of the junctions; double-line (one-way) – for trains in the same direction more frequent is the right-hand track [8]. Trains in the opposite direction are not dependent.; multi-track – presented by three-line pairs and the outer tracks are used for driving of trains in the same direction and the middle track serves for trains in both directions and it is marked as null. There are four-track sections in Slovakia, which include two-track divisions for two tracks for slower trains and two tracks are for faster trains. The ratio of train number for one and reverse directions includes these types of TTDs: the pair – the number of trains is the same in each direction; unpaired – the number of trains is different in each direction. Duration of occupancy of interstation sections include these types of TTDs: identical – duration of occupancy is the same in all interstation sections created by the pair of trains; non-identical – the value of periods for single-track, i.e. times of occupancy and meantime for double-tracks are different. Time of operation presents these types of TTDs basic (for the total time during one year, or in some cases also half-year traffic diagram for summer and winter TTD) and temporary – in the cases for exclusion in tracks, for example, crisis traffic diagram and alternative traffic diagram. By the level of occupancy and use of track capacity TTDs are presented by these types: low manned – the track capacity remains unused; medium manned – are used by normative capacity; high manned – excessive use of capacity. By orderliness, it is possible to classify TTD into non-systematic – because TTD presents a daily repeating model, non-systematic TTD does not exist but it has internal time relations; systematic – characterized by fixed time sequence for driving time in both directions, repeating of rides in the upcoming hours, the same driving time for both directions, among the nodes, the driving time is half or all multiple of the interval. By the periodicity, it is possible to classify TTD into interval – departures of trains are in the interval 1-60 min in the same minute, tact – tracks of trains are in the distance presented by multiple of hours [9]. The base for TTD design is created by these parameters [10,11]:

1. The extent of train traffic – derivation of the number of trains, determination of properties and cycle of train sets,
2. Quantitative indicators – data about technical character,
3. Qualitative indicators – a type of speed in the train traffic, other qualitative indicators,
4. Time norms of the TTD – driving time, movement of trains, operational intervals, meantime, electric meantime, arrival meantime, the final value of meantime.

3 The current state of the line Humenné – Medzilaborce

The line Humenné – Medzilaborce (Fig. 1) with the distance 43 km has 18 stations. The crossing of the trains is possible in the stations Humenné, Udavské, Koškovce,

Radvaň/Laborec, and Medzilaborce. From the station, Humenné 12 trains are daily dispatched to Medzilaborce. From the station, Medzilaborce has dispatched 11 trains to Humenné. The railway station Humenné is situated on the single-track 191 Michal'any – Medzilaborce – Lupkôv (Figure 1).

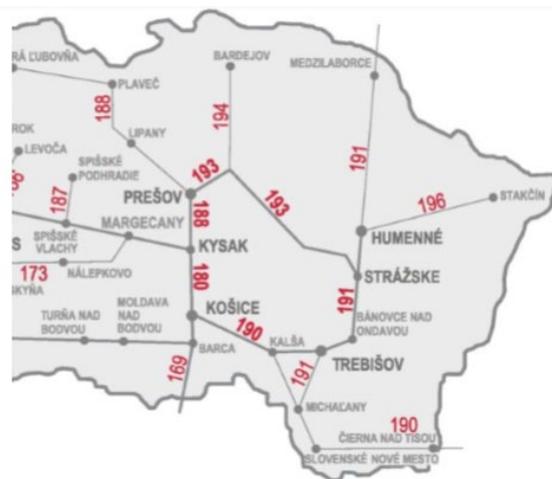


Figure 1. The track 191 presented on the map of Slovak railway network [2]

The track Humenné-Medzilaborce belongs to the least economical route in the Slovakian region. Modernization of track which would bring an increase of operating speed at 160 km/h would allow more efficient and flexible planning of TTD. But due to the geography of this regions, this speed is impossible. Therefore the case study analyses a model that could increase its economy. [12]

4 Modification of TTD and extension of the actual TTD

The aim of the analysis is to add new trains to the current TTD, in addition to the routes from the station Humenné to Košice, Prešov, and Michal'any. The track Humenné-Medzilaborce is considered as closed. By analysis of the current state of TTD on the line Humenné-Medzilaborce, it was found free spaces for completion of the TTD about new trains. The study met driving times and by determination of the times of departure, the study regarded crossing in the stations Medzilaborce, Radvaň/Laborec, and Udavské. The study also regarded roads, i.e. if we wanted to add a train, from the station Medzilaborce, the study had to lead out trains by previous or another possible transportation line. [13,14] Figures 1, 2 and 3 present the cycle of driving trail vehicles by the current TTD with new trains by the case study. These are marked as Os 89yy, Os 89xx, Os 89xy and Os 89yx. The Os 89yy has a departure in the time 7:51 from the station Medzilaborce and arrival in the time 8:31 from the station Humenné. Os 89xx has a departure in the time 5:48 from the station Medzilaborce and arrival in the time 7:03 from the station Humenné. Os 89xy has a departure in the time 14:14 from the

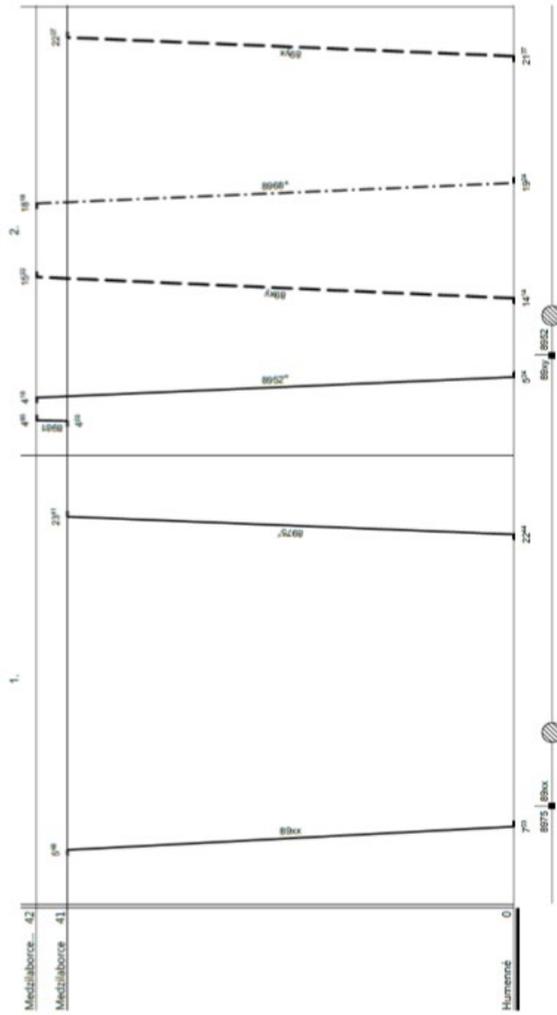


Figure 4 Design of modification of the current cycle of driving trail vehicles by the TTD3 on the line Humenné-Medzilaborce

TTD also brings the turns to need of engine crew and train crew. The turns need of engine crew and train crew is based on the cycles of driving trail vehicles related to the turns of the crew with an emphasis placed on some rules, for example, the maximal duration of the turn, pauses among turns, etc. [15] Turns of engine-drivers and head guards have a different maximal duration of the turns. Fig. 5 presents the design of new turn group for engine drivers. Figures 6, 7, 8 and 9 present design of new turn group for head guards.

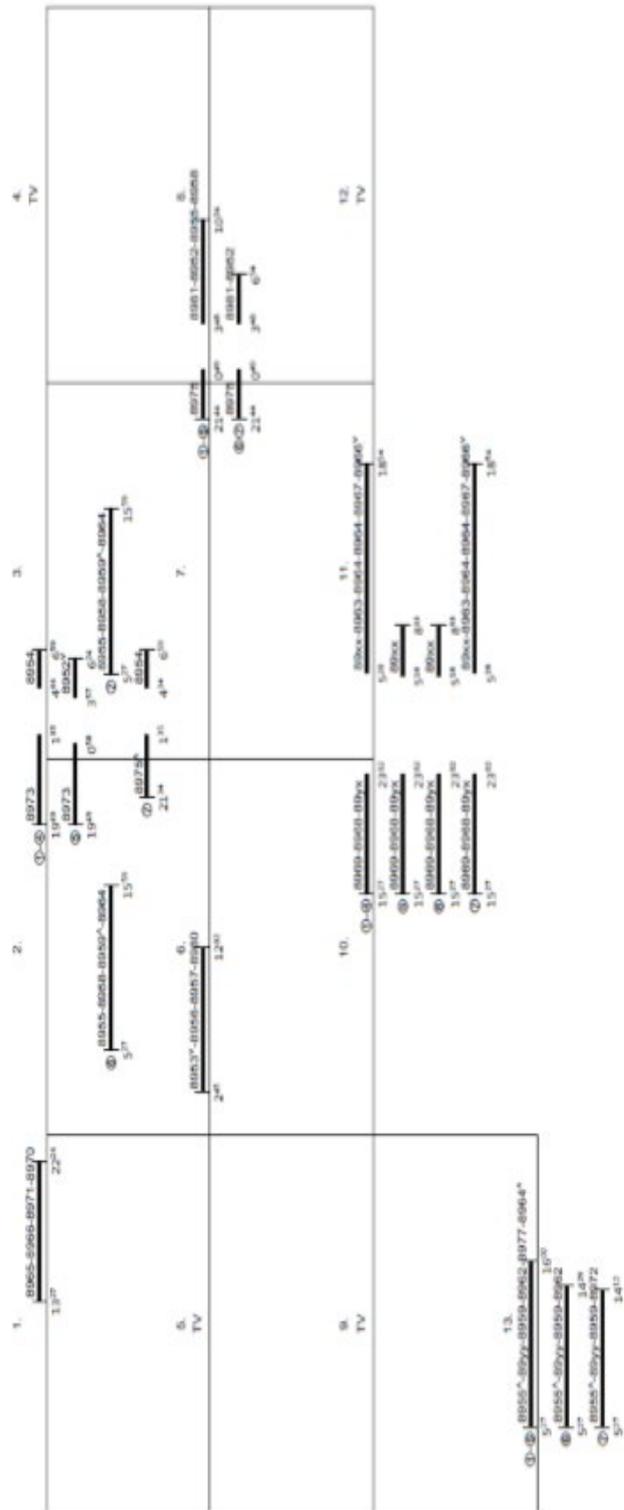


Figure 5 Design of turns group for the engine crew

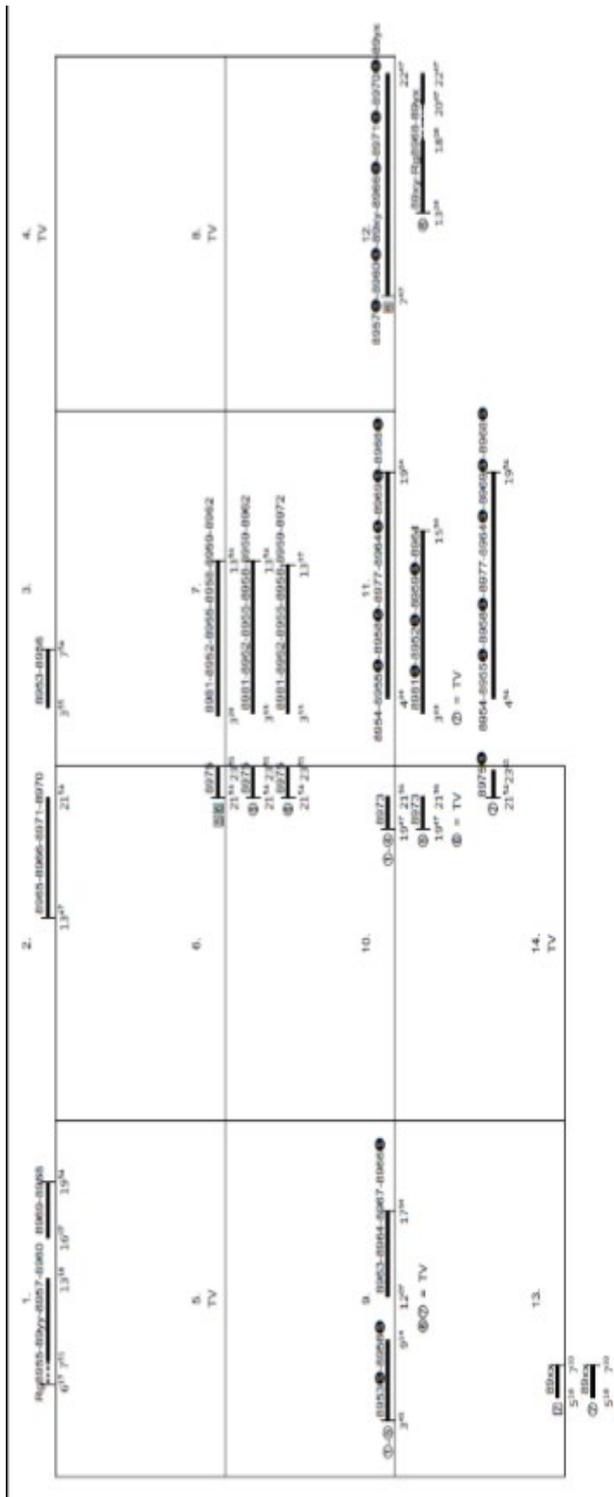


Figure 6 Design of turn group for the train crew

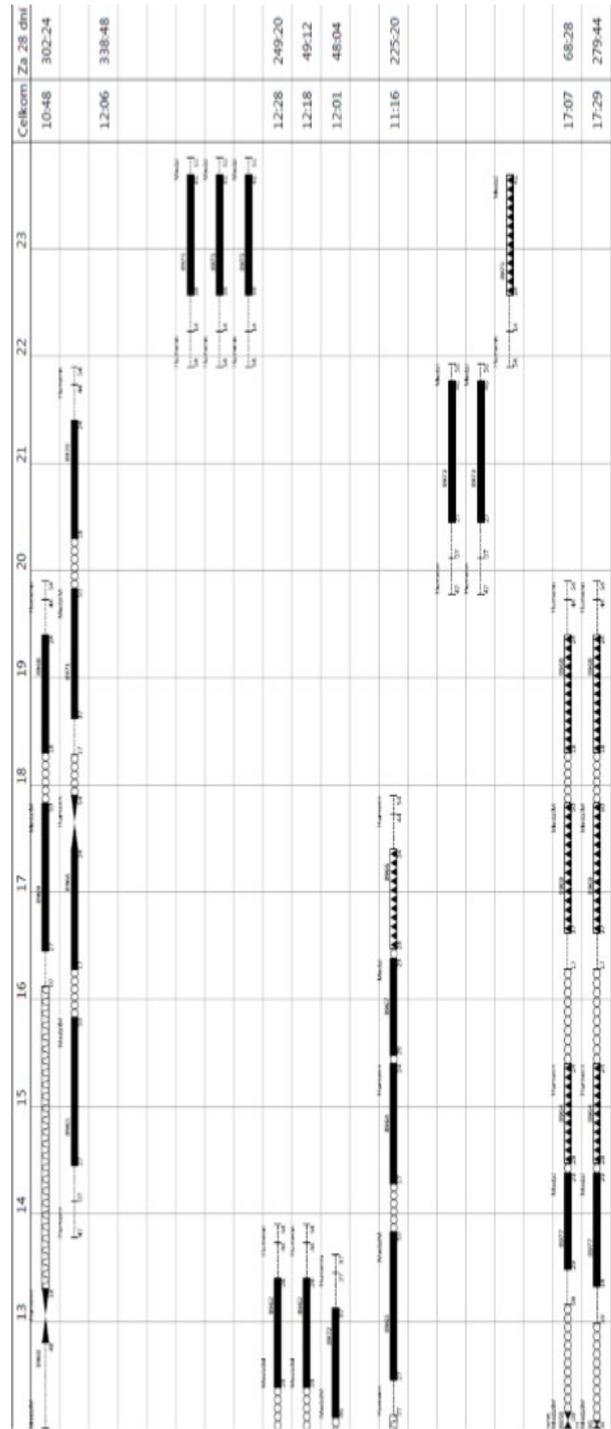


Figure 7 Design of turns group for the train crew 2 (starting point Humenné)

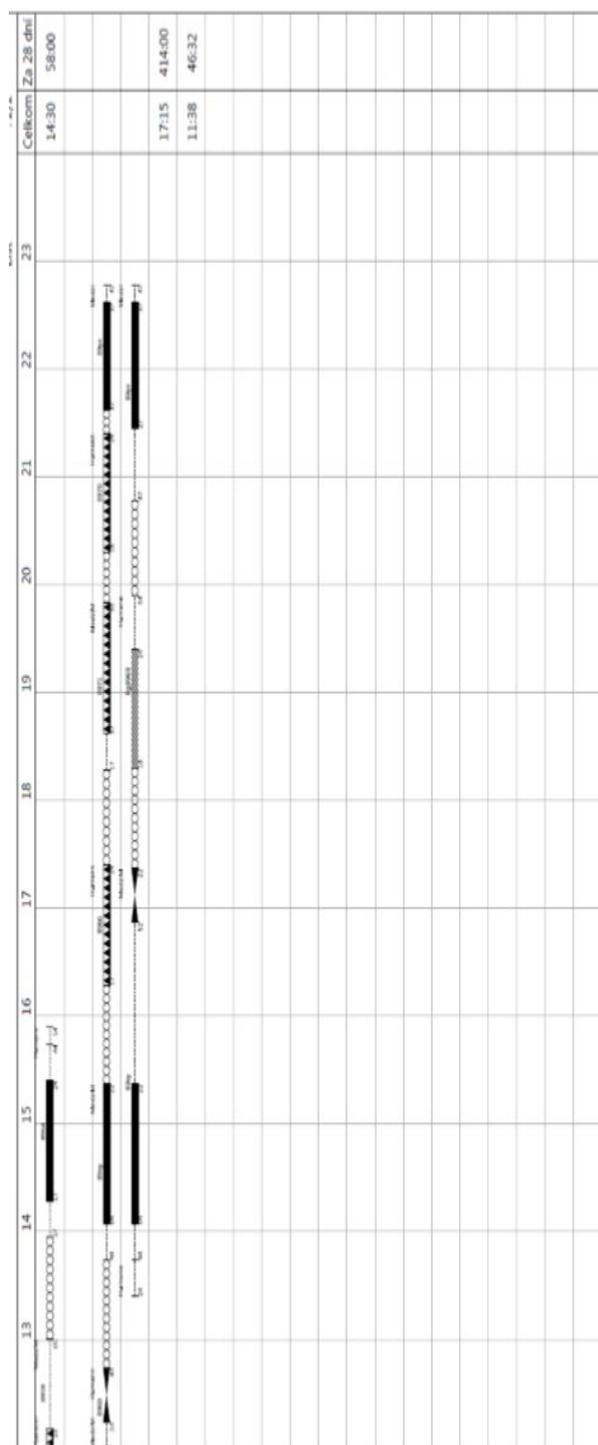


Figure 8 Design of turns group for the engine drivers (starting point Humenné)

Conclusion

Insufficient occupancy of connections outside the traffic peak causes a high cost of rail traffic and at the same time low return of invested funds. The aim of this study was to find free spaces in the current TTD for new connections and this can increase the interest of public and use of rail transport. Another possible solution is also the modernization of railway infrastructure from single-track to a double-track and increases the service

speed to 160 km/h. This modernization needs significant expenses for realization. Similar designs could be applied to other, less attractive routes and lines. Investments to the modernization of railway infrastructure in Slovakia can bring desired effect in long-term aspect because benefits of rail transport in terms of safety, ecology, and economics are increasingly desirable for the public, especially in comparison with road transport. Increasing interest in rail transport and integrated transport system can in part eliminate the negative impact of road transport on the public.

VEGA 1/0063/16, VEGA 1/403/18, KEGA 018TUKE-4/2016.

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