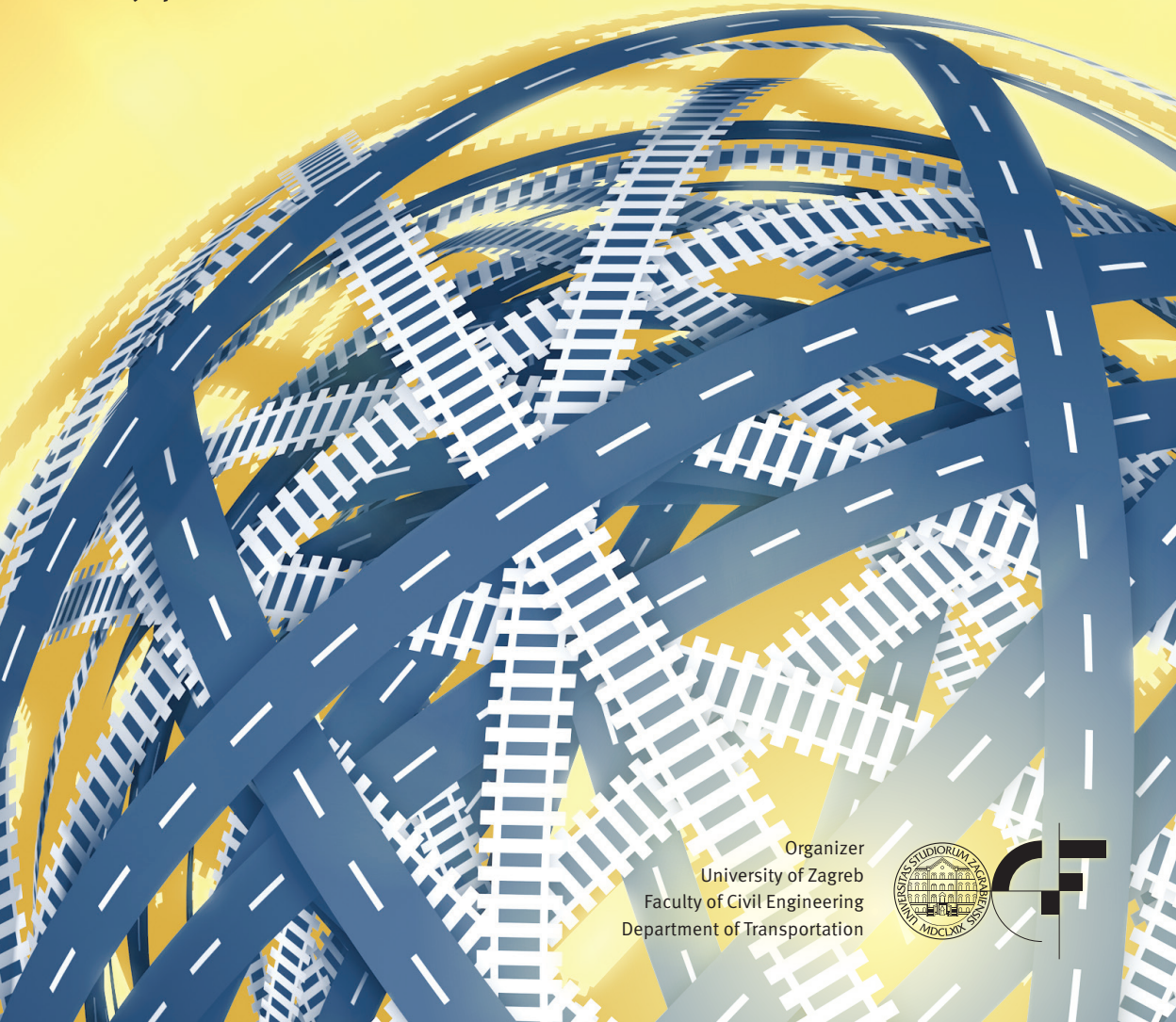


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23-25 May 2016, Šibenik, Croatia

## Road and Rail Infrastructure IV

Stjepan Lakušić – EDITOR



Organizer  
University of Zagreb  
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# Road and Rail Infrastructure IV

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## FUNCTIONAL CONNECTING OF THE RAILWAY BYPASS AROUND NIŠ AND THE RAILWAY JUNCTION NIŠ

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### Abstract

This paper presents functional connecting of the railway bypass around Niš and the railway junction Niš. Railway infrastructure in the city of Niš consists of two main railway lines Belgrade – Niš – Preševo – state border (E-85 and E-70) and Niš – Dimitrovgrad – state border (E-70) and one regional railway line (Niš) – Crveni Krst – Zaječar – Prahovo Pristanište. Within the junction, connections are made by railway lines which are the parts of main directions E-85 and E-70: Crveni Krst – Niš Marshalling, (Crveni Krst) – (Čele Kula), Trupale – Niš Marshalling – Medjurovo, Niš – (Niš Marshalling). The traffic issue is for the city of Niš on one hand – the limiting factor, and on the other hand – stimulating factor of development. Functionality of railway traffic in the city, in addition its' basic function, need to have a positive effect to meet the needs of citizens' mobility. Reduction of collision points "city – railways" should correspond to the strategy of the city development, previously planned and defined. In the city centre, a huge problem of level crossings exists. In the present situation, running of freight trains through the central zone of the city produces increased levels of pollution and noise, and increases risk of environmental pollution, due to the passing of dangerous goods through the town. Construction of the railway bypass is one of the phases of solving traffic problems in Nis, and by its construction following will be achieved:

- The separation of the railway line and roads in the city area, the separation of passenger and freight traffic in the urban area and the separation of transit from local traffic;
- Harmonization of transport infrastructure development with city's development and development of the airport "Constantine the Great" in Niš;
- Development of railway facilities without disruption of transit traffic on Corridor X by local works.

*Keywords: railway junction, traffic organization, functionality of the station, traffic flows, technological effects*

### 1 Introduction

For designing of the railway bypass, existing century-old railway corridors and railway land, previously planned corridors for the railway, and railway capacities on existing locations and their integration in a new technical – technological solution, all according to urban and spatial plans, were maximally used. Construction of the railway bypass is planned in the Alignment of the Corridor X. On the international railway network, Niš is the common connection point of two international traffic directions, actually main railway lines according to AGC Agreement. Main railway line E-85 is Budapest – Subotica – Belgrade – Niš – Skopje – Athens and main railway line E-70 is Paris – Turin – Sežana – Ljubljana – Zagreb – Belgrade – Niš – Sofia. It is

about the construction electrified, single-track railway bypass around Niš for the speed up to 160 km/h, in length of approximately 20 km.

Due to the equal participation of Serbian railway traffic on the single European market, it is necessary to harmonization of all elements of conventional railways in our country with the standards and regulations of the European Union. To facilitate the flow of goods and passengers it is necessary to establish mutual connection, harmonization of technical standards, the characteristics of the infrastructure and rolling stock, efficient connection between information and communication systems, the application of interoperability in national railway networks. Accession to membership of UIC and CER, and the decision of the state to initiate activities as planned accession to the EU, implies a clear defined obligations concerning the harmonization of national regulations and standards with those in force for the EU member states and member of railway organizations UIC and CER.

## 2 Overview of the existing railway framework

The starting point in the approach to solving the railway bypass is the retention of the entire existing circular ring of Niš railway junction. Referent model was defined on the existing railway network, without previous reconfiguration of railway junction. The referent model of junction includes common elements from existing railway junction and constructive elements for the construction of railway bypass, and it is shown on the Figure 1.

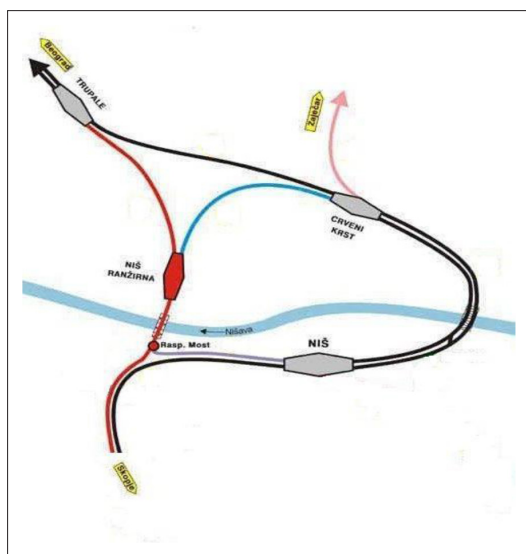


Figure 1 Referent model of the junction Niš.

## 3 Main technological requirements for the railway bypass and establishments

The railway bypass should be designed according to AGC, AGTC, European Technical specification for Interoperability TSI and SEECF Agreement in common rail-road Corridor X.

- Separation of freight and passenger trains on the approaches to the city, and relieve the central city zone of the freight traffic.
- Direct traffic of passenger trains on the main lines through the station Niš without changing the operational direction of the trains and head of trains, and no change of type of traction.

- Functional and rational solution of the railway bypass, the railway station on the bypass and connections between new bypass line and existing infrastructure capacities. Keeping the existing and planned connections between the industry and railways.
- Maximum speed on railway bypass is adapted to the terrain conditions and urbanized city area.
- Safe traffic of all types of trains which are operating with different speeds.
- Providing the Centralized Traffic Control (CTC), Automatic Train Control (ATC) and Automatic Train Protection (ATP); Installation of the ETCS Level 1 system as an overlay to the basic interlocking system.
- New open line sections will be equipped with electronic centralized single-track automatic line block system with axle counters for occupancy control of block sections.
- Installation of the GSM-R network, which would be at this stage used for the transmission of voice, with the possibility of later modification for signalling data transmission. Planning all telecommunication systems to guarantee interoperability and all links for interlocking systems.
- Traffic management could be provided by manned establishments and also by tele control centre at Niš. Foreseen capacities that will provide the inclusion of stations on the railway bypass into the tele control system.
- The stations shall be designed in compliance with European standards (AGC/TSI standards), with track connections which allowed reception and departure of trains of all station tracks; Usable length of relief tracks is 650- 750 m.
- Platforms and underpasses shall be designed in accordance to TSI PMR.
- Station buildings are designed to provide all necessary premises for traffic services, as well as premises for official staff and equipment.

#### 4 Identification of the functional characteristics of the railway bypass and the functional tasks of the establishments for the new junction configuration

The main existing junction stations Niš Marshalling, Niš and Crveni Krst retain their operational function for passenger railway traffic and for servicing of industrial tracks. Connections of the Junction Niš with the new railway bypass are realized at the station Niš Marshalling, Crveni Krst and Trupale. Connection of the railway bypass with existing, but reconstructed railway lines, will be performed at: new station Niš Sever, new station Pantelej, new junction point "Prosek".

- **Station Niš** is the main passenger station in the junction, and also a diverge station. It is opened to provide all services in international and domestic passenger traffic
- **Station Niš Marshalling** is the main shunting station in the junction, and also a diverge station for freight trains.
- **Station Crveni Krst:** The main technological task of the station Crveni Krst is regulation of railway traffic on main lines E-85 and E-70 and separation of railway line for urban transport.
- **Station Trupale:** The main technological task of the station Trupale is regulation of railway traffic and separation of passenger and freight traffic towards Skopje.
- **New station Niš Sever:** The station Niš Sever is the intermediate (transit) station, where three railway lines are branched and intersected. Vicinity of the airport and marshalling yard, and the further development of industrial zones of this area, place the station Niš Sever in a position to be established and transformed into a cargo transportation centre. Its neighbouring stations are Trupale, Niš Marshalling, Crveni Krst and Pantelej. The main technological task of the station Niš Sever is regulation of railway traffic on lines: Belgrade – Mladenovac – Niš – Preševo – state border (section Trupale – Crveni Krst) and Niš Marshalling – Crveni Krst, and on railway bypass (section Niš Marshalling – Pantelej). The entrance to station Niš Sever from one side is provided for two directions: Niš Marshalling and Trupale (for exi-

sting track and future second track of railway line Belgrade – Niš), and from the other side for three directions: Crveni Krst – Trupale, Crveni Krst – Niš Marshalling and from Pantelej (Dimitrovgrad). For passenger trains Niš Sever will be opened for suburban, local and urban passenger services for direction Niš – Belgrade. International passenger trains and domestic trains from Dimitrovgrad and Zaječar would not pass through this station.

- **New station Pantelej:** The station Pantelej is the intermediate station in terms of traffic, where two railway lines are separated and intersected. Its neighbouring stations are Niš Sever, Crveni Krst, Matejevac and Vrežina. The main technological task of the station Pantelej is regulation of railway traffic on lines: Niš – Dimitrovgrad – state border (section Crveni Krst – Vrežina) and (Niš) – Crveni Krst – Zaječar – Prahovo Pristanište (section Crveni Krst – Matejevac). The separation of direction for Dimitrovgrad and Zaječar will be performed at the station Pantelej. The entrance to station Pantelej from one side is provided for two directions: from Niš Sever and Crveni Krst for railway line (Niš) – Crveni Krst – Zaječar – Prahovo Pristanište, and from the other side for two directions: from Matejevac and Vrežina. For passenger trains Pantelej will be opened for suburban, local and urban passenger services. Station would not be open for work with goods (freight). Station Pantelej is passing station for international passenger trains and for all freight trains.
- **New station Vrežina:** The new station Vrežina on the bypass line will have primary the turnout function, due to increase of the railway bypass line capacity. Its neighbouring stations are Pantelej and Sićevo. The main technological task of the station Vrežina is regulation of the train traffic on main line Niš – Dimitrovgrad – state border. The entrance to station Vrežina from one side is provided direction Pantelej, and from the other side for direction Sićevo (Dimitrovgrad). For passenger trains Vrežina will be opened for suburban, local and urban passenger services. Would not be open for work with goods.
- **New establishment (junction point) Prosek:** In order to connect the new railway bypass and existing railway line Niš – Dimitrovgrad – state border, there is planned a construction of new establishment Junction Point “Prosek”. Control safety and handling of devices will be performed from the station Vrežina. Connection of railway bypass with the railway line Niš – Dimitrovgrad will be temporary performed by the junction “Prosek”, and it will be removed after the completion of the modernization of the railway line Niš – Dimitrovgrad.

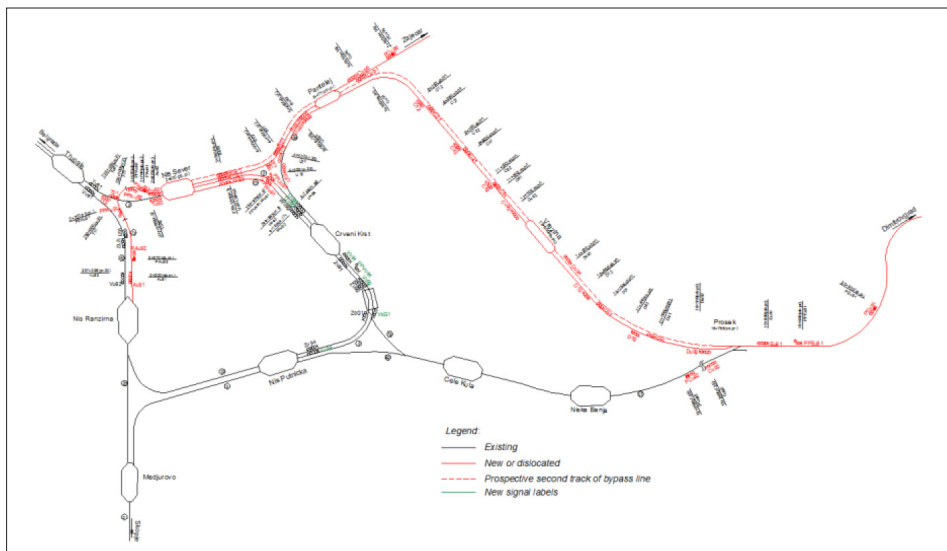


Figure 2 Proposed location and layout of the railway bypass line.



## 5 Assessment of traffic flows distribution for the new junction configuration

The construction and functioning of the railway bypass are directly related to the reconstruction and functionality of five existing railway lines in the junction.

Functional connection of railway bypass and the railway junction Niš will establish new traffic flows in the node. The greatest effects of bypass construction will be reflected in the transit freight traffic through the increased speed of the trains, reducing travelling time and shortening the time of execution of technological operations. Traffic organization in conditions of the newly built bypass and electrified railway line Niš – Dimitrovgrad will allow direct transit traffic through the node without changing the direction of movement and traction, reducing the number of shunting movements and reducing the number of technological operations that are performed on certain types of trains, thus reducing the harmful effects of pollution and noise, increasing road safety and eliminating number of level crossings in the city centre. New railway traffic organization, after bypass construction, is based on following:

- All predicted technological operations with passenger and freight trains, based on defined technological tasks of station, are performed with optimal usage of existing capacities at stations Niš, Niš Marshalling and Crveni Krst
- Shunting work is concentrated at the station Niš Marshalling, into which all connecting railway lines enter, and where all flows of wagons in the node are processed. Niš Marshalling is the terminus station for freight trains which are not transit the node.
- Station Niš is the main passenger terminal together with the bus station for the City of Niš, for remote and suburban passenger traffic. All categories of passenger trains have to stop at the station Niš
- All existing industrial tracks, which are the connection of railways and industry, are retained at the station Crveni Krst, where the servicing of these tracks is organized and performed.
- Establishments, railway lines and connections of tracks allow direct train traffic from Belgrade towards Sofia and Skopje without changing the head of train. For suburban traffic, the traffic of trains from all directions is allowed through the junction.

New organization of traffic flows through the junction, in conditions of the railway bypass built is shown on the Figure 3.

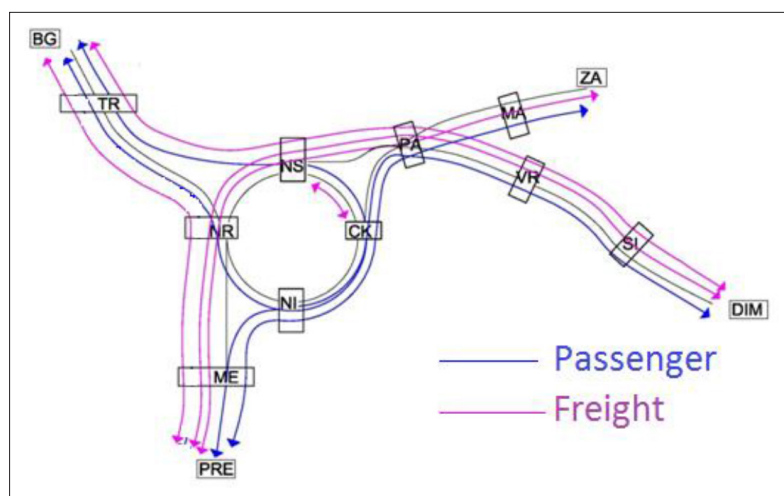


Figure 3 Passenger and freight flows in conditions of the railway bypass built.

All foreseen technological tasks will be performed with existing capacities at stations: Niš, Niš Marshalling, Crveni Krst, Trupale and Sićevo. Capacities of stations on the new railway bypass in the first phase of the railway bypass construction, were entered and checked in the simulation software package – Open Track.

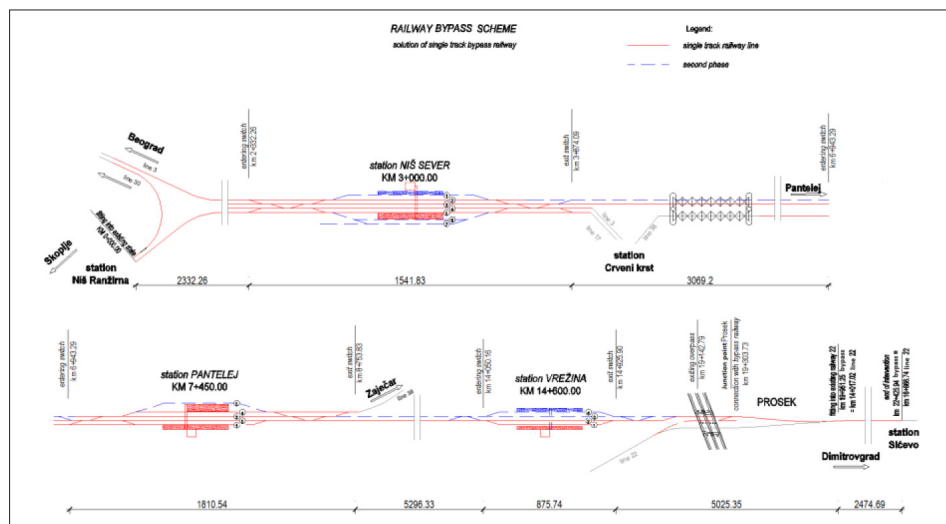


Figure 4 Display of capacities in new station on the railway bypass.

## 6 Technological effects of the railway bypass construction

### 6.1 Travelling time

Different categories of trains can operate:

- on the whole train path via the railway bypass,
- Through one of its parts in combination with other railway lines, depending on a given routing.

Over the whole railway bypass freight trains operate with  $V_{max}=70 - 100$  km/h. Travelling time for those trains is  $t_t^{f1}=19$  min in direction Niš Marshalling – Niš Sever – Pantelej – Vrežina – Sićevo, and  $t_t^{f2}=20$  min in the opposite direction. Dealing with freight trains in stations depends on the type of freight train and anticipated technological operations on them.

Passenger trains operate with  $V_{max}=70 - 160$  km/h via the section Pantelej – Sićevo. Travelling time for international trains is  $t_t^{ip}=9$  min in both directions, and for domestic trains  $t_t^{dp1}=11$  min in direction (Niš – Crveni Krst) – Pantelej – Vrežina – Sićevo and  $t_t^{dp2}=12$  min in the opposite direction.

### 6.2 Analysis of transport capacity

Two scenarios were considered for evaluation of transportation capacity of the railway bypass. In both scenarios observation of the capacity utilization was performed. Scenario 1 considers the situation on the basis of the Time table 2014/15. Scenario 2 considers presumed level of service in passenger traffic. Scenario 2 offers certain services in international and domestic passenger traffic, and after the determination of passenger routes, the railway bypass would be loaded with much more cargo traffic, in order to comprehend the restrictions in stations and on the open line. Following station capacities on the railway bypass are used in the analysis:

- Niš Sever – tracks No: 2, 3, 4 and 5,
- Pantelej – tracks No: 1, 2, 3 and 4,
- Vrežina – tracks No: 1 and 2.

### Scenario 1

Routing for all passenger and freight trains, that are planned in Time table 2014/15, was changed and routed the new ones, via the railway bypass. In simulation, departure time of trains from key stations in the junction Nis (Nis, Nis Marshalling and Crveni Krst) is retained, as well as transit time of trains through “border junction” station (Trupale, Medjurovo Matejevac and Sićevo). The obtained results are presented in graphs timetable.

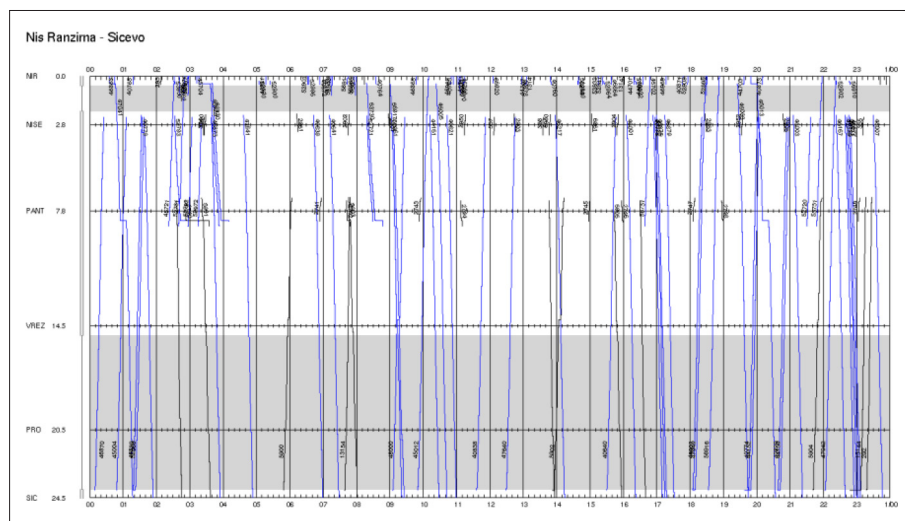


Figure 5 Time table for railway section Niš Marshalling – Sićevo: Scenario 1.

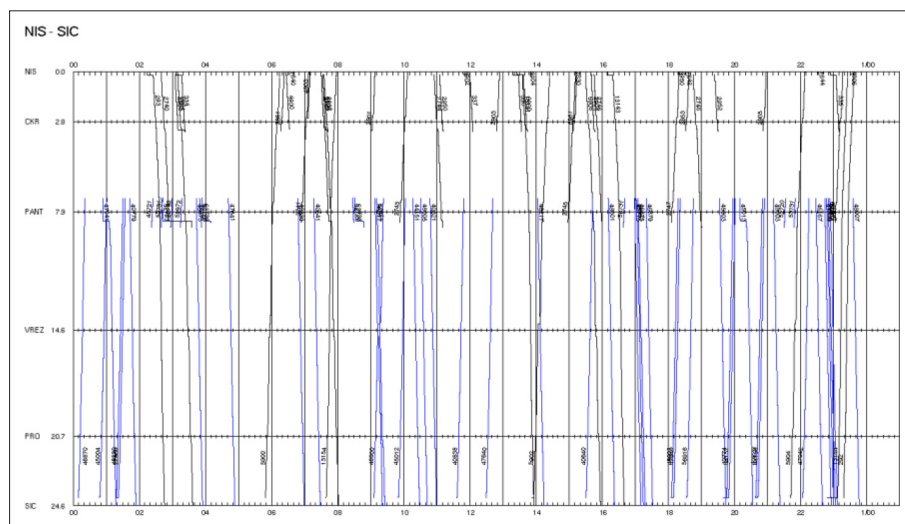


Figure 6 Time table for railway section Niš – Sićevo: Scenario 1.

## Scenario 2

The regime of passenger traffic proposed is based on the assumption of timetable with the same time gaps for departures of trains from stations Niš and arrivals at the station Niš, and on the following:

- The passenger traffic in period from 05:00 h to 23:00 h,
- For direction Belgrade – Dimitrovgrad: 6 pairs of trains, 1 pair every 3 hours, and for direction Belgrade – Preševo: 5 pairs of trains, 1 pair every 4 hours,
- Domestic passenger traffic, one pair of trains every hour in peak period and off-peak period one pair of trains every 2 hours in all directions (12 pairs of trains).

For directions Belgrade – Dimitrovgrad and Niš Marshalling – Dimitrovgrad, train paths for freight trains are planned at an interval of half an hour, and for direction Dimitrovgrad – Preševo at an interval of one hour.

In order to avoid disruptions in passenger traffic, individual train paths of freight trains have been “removed”, and the total number of freight train paths in the simulation model is 96. The obtained results are presented in graphs timetable.

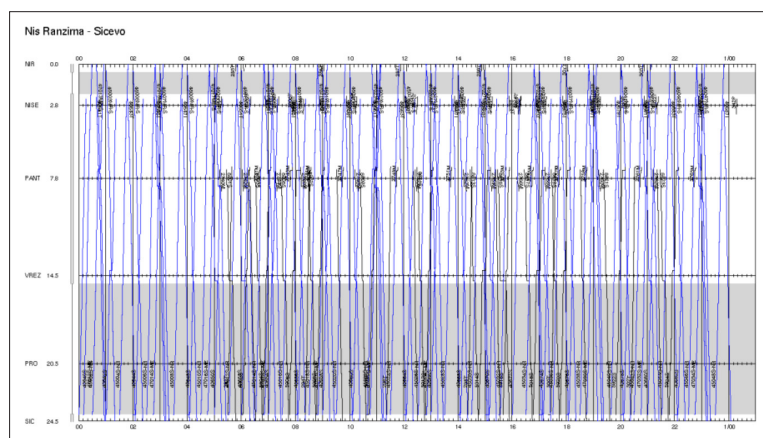


Figure 7 Time table for railway section Niš Marshalling – Sicevo: Scenario 2.

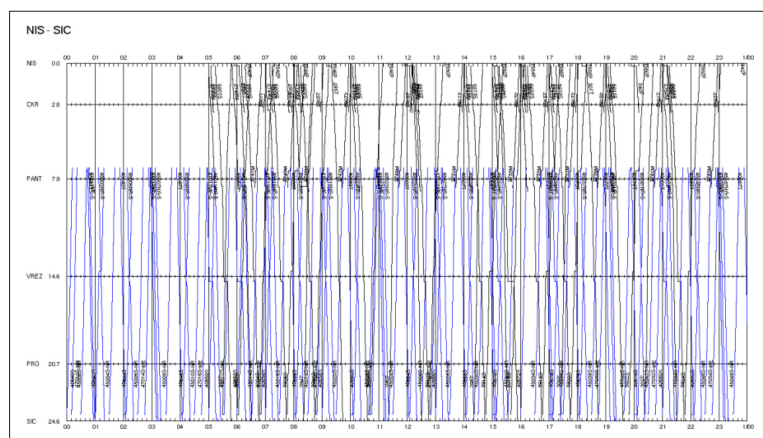


Figure 8 Time table for railway section Niš – Sicevo: Scenario 2.

### 6.3 Line capacity for the railway bypass

Theoretical line capacity was calculated on the basis of following conditions and parameters:

- Scenario 1 based on the Time table 2014/2015, Scenario 2 based on assumed volume of traffic and proposed passenger service,
- Train categories are: I – international passenger trains, II freight trains, III – local passenger trains,
- Number of influence of interstation distance is 5,
- Ruling section is Vrežina – Sićevo.

Results of the theoretical line capacity:

- Average headway of trains on the ruling section is 8,6 min.
- For period 24 h / 1440 min, 93 trains with capacity utilisation of 58,84%,
- For period 22 h / 1320 min, 86 trains with capacity utilisation 64,19%,
- Capacity utilisation in Scenario 2 is very high, close to 100%, and indicates the necessary changes in traffic organization.
- Realised traffic in Scenario 2 for 1440 min is 142 trains.

The observed scenarios are some of possible, and it can surely give a good representation of what can be expected when performing traffic over the railway bypass. For the real usage of the line capacity, for designers of the Timetable is essential to determine the additional time in order to ensure the quality of the Timetable execution. The theoretical calculation leaves the door for traffic on the railway bypass according to the scenarios that are considered, but does not apply to the whole railway line Niš-Dimitrovgrad, which has its own ruling section, which was not the subject of this project.

## 7 Conclusion and further recommendations

Proposed measures to further optimization of existing capacities and traffic organization after the construction of railway bypass are:

- Providing of at least one transit track at the station Nis Marshalling for international passenger trains running on direction Belgrade – Dimitrovgrad;
- Further development of the station Niš Sever in terms of freight station, which provides conditions for the relocation of the loading – unloading from the stations at the Niš junction
- Connection of industrial tracks at the station Crveni Krst with the station Niš Sever as the future freight station;
- On the section Niš – Sićevo of existing railway line Niš – Dimitrovgrad, after construction of bypass, conditions will be met for the elimination of 16 level crossings. The alignment from the station Niš to the station Čele Kula could be used in function of urban passenger traffic.

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