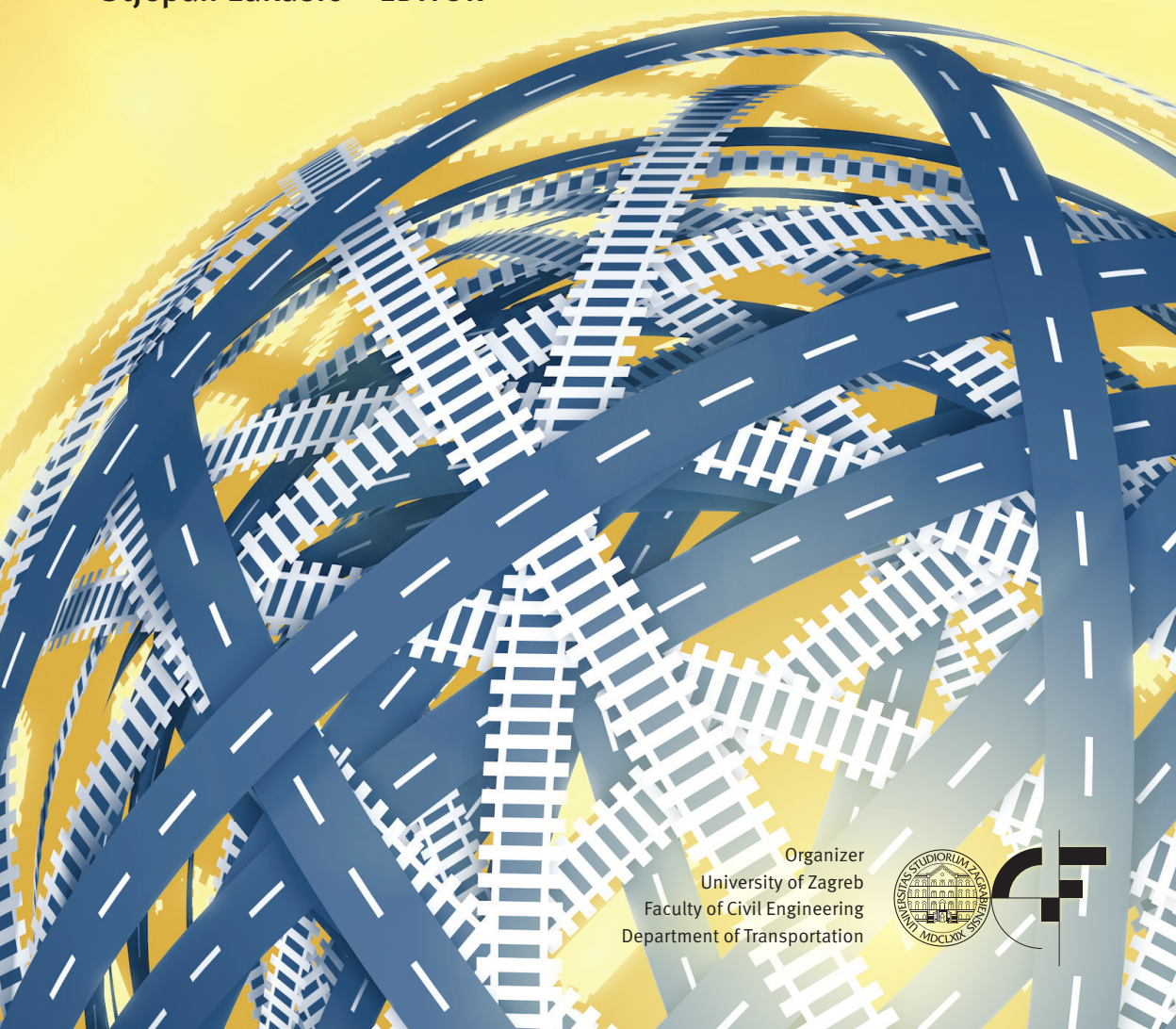
CETRA 2016

4th International Conference on Road and Rail Infrastructure
23-25 May 2016, Šibenik, Croatia

# Road and Rail Infrastructure IV

Stjepan Lakušić – EDITOR



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# OPERATIONAL PLAN FOR CONSTRUCTION OF RAILWAY LINE BELGRADE – NIŠ ON SECTION STALAĆ – ĐUNIS

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## Abstract

The Serbian Railways network consists of state, regional and local rail lines which form part of the Pan-European corridors – lines of international importance connecting Serbia with neighbouring countries. Priority of developing Serbian Railway Network are pointed to integration of the most important international main railways through Serbia and the Pan-European network providing interoperability railway with high performance standards and increasing service quality on other railways on the network (higher speeds, greater bearing capacity, greater transport capacity, greater security, electrification, etc.). In the Spatial Plan of the Republic of Serbia, the first strategic priority is development of Corridor X; an important part of this corridor is the section Stalać – Đunis on the railway line Belgrade – Nis, which is the subject of this title. Operational Plan during construction contains descriptions of main works on the construction this section as first input for the Final Beneficiary in decision-making process for the next steps. Organization of construction for of this phase of the project documentation – Preliminary Design for the aim has to make a proposal of necessary time for separately building in accordance with the schedule of the total time that was developed during the design. Complexity of the route with a large number of structures 5 tunnels and 5 bridges, more overpasses/underpasses, inaccessibility approach, the reconstruction of two stations with accompanying railway infrastructure were a major challenge for the preparation of the organization plan for construction works

*Keywords: Railway constructing, civil works, systems, operational plan*

## 1 Introduction

Having in mind that the focus of the National Programme of the Republic of Serbia focused on the completion, modernization and sustainable development of the Serbian Railways and inland waterways transport system within the Pan-European Corridors X and VII to the required capacity levels and quality standards relevant to the TEN-T network, financial assistance for realisation of the National Programmes has been provided through the Instrument for Pre-Accession Assistance (IPA) by the Government of Serbia.
In the Spatial Plan of the Republic of Serbia, the first strategic priority is development of Corridor X. An important part of this corridor is the section Stalać – Đunis on the railway line Belgrade – Niš. The existing Stalać – Đunis section on the railway line Belgrade – Niš is 18.7 km long and is a priority for reconstruction and modernisation, because this is only single-track section on the railway line between Belgrade and Niš. This section currently follows the narrowed and winding valley of the Južna Morava River through an area with numerous unstable spots, landslides, and landfalls of riverbanks.
The main issue on the section Stalać – Đunis is the lack of reliability (and potential) delays caused by the single track section. The backlog of maintenance (ordinary and periodic) has

produced a constant trend of deterioration of the rail network. In order to alleviate this trend and keep the rail infrastructure operating, speed restrictions (permanent and temporary) are imposed. The design speed is no longer achieved. In general, main lines are designed for a maximum speed of 120 km/h. However, the present permissible train speeds are far below the design speeds on most lines and line sections.
The main objective of the Serbian railway transport system within the Pan-European Corridor X railway is to achieve a much higher quality in order to meet the actual needs of a modern transportation market. Only if this is achieved will the number of transported passengers and the amount of freight transport return to levels significantly greater than the current ones.
The Preliminary Design on the section Stalac – Djunis includes the provision of Preliminary Design with Feasibility Study, Environmental Impact Assessment and Expropriation Plan for:

- Reconstruction of the existing track and construction of a second track (subject to existing topography meeting track design requirements for 160 km/h);
- Overhead contact line (catenary),
- Signalling-safety and telecommunications installations;
- Construction and reconstruction of structures: tunnels, bridges and viaducts;
- Railway stations and stops; and
- Removal of level crossings.

## 2 Overview the scope of work in the project

### 2.1 Alignment

Currently there are six official points on the section of Stalać to Đunis: Stalać station at km 176 + 311, the Stevanac passing loop at km 181 + 880, Braljina station at km 186 + 487, Cerovo Razanj halt at km 190 + 300, the Staro Trubarevo passing loop at km 192 + 216 and Đunis station at km 194 + 940. The new railway line will keep only the stations at Stalać and Đunis. The existing geometry and the curve radius could not satisfy the requirement for the design speed of 160 km/h (min R = 1500 m).
For this reason a completely new alignment is designed, with min R = 1500 m, max longitudinal grade 12.5‰ and, due to a heavy terrain conditions, 5 new tunnels along the new railway alignment. The newly designed alignment has cca 17.7 km of reconstructed or completely new railway. Between the station of Stalać and Đunis the existing distance is 18.7 km and the new distance is 16 km.
On the designed railway line from Stalać to Đunis, there are 5 tunnels, two underpasses, 7 bridges (1 over the river South Morava), 1 viaduct, and several culverts. The total length of railway line in the tunnel is 6.9 km which is about 40% of the reconstructed line.
The Figure 1 shows the existing alignment – grey colour and the new alignment – red colour on the section Stalać-Đunis.
Stalać station is an intermediate station on the railway line and currently has 8 tracks and one safety track. The station has an industrial track that, along with the reconstruction of a certain length, will be kept. At the station, currently, there are two platforms and a pedestrian underpass to access the platforms. The station is also a terminus for the railway branch line Stalać-Kraljevo and, as such, will retain this function after reconstruction. The designed layout has also eight tracks, with three platforms and one pedestrian underpass to access the passenger platforms in order to avoid crossing the tracks at grade. Platforms are 400 m in length (two) and one with length of 220 m. Switches on main passing tracks and overtaking tracks are designed with R300 and on the other tracks R200 switches are designed. Rails on the main passing tracks and overtaking tracks are type 60E1, and the other tracks have rail type 49E1, mounted on reinforced concrete sleepers with elastic fastenings, both on tracks and switches.

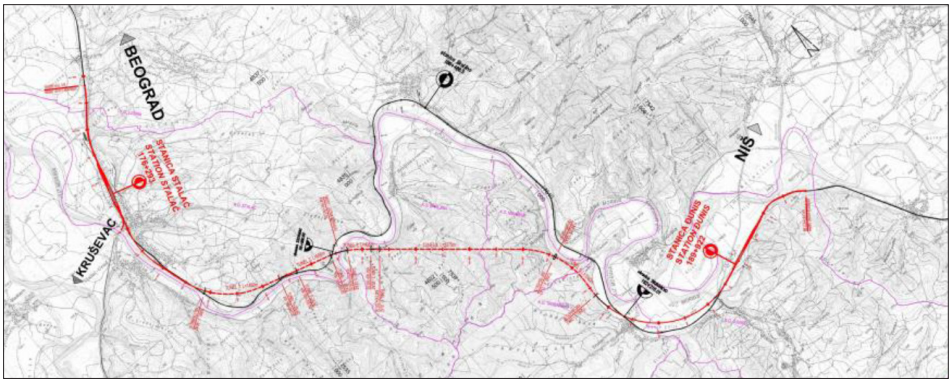


**Figure 1** Overview map – existing and new alignment on the section Stalać-Đunis

Đunis station currently represents the changeover from a single-track to a double track railway. Currently the station consists of 5 tracks and 2 low platforms. Reconstruction provides a layout plan with 5 tracks as well. The designed layout is slightly translated towards Niš, because of the complex layout geometry in front of the station (S curve with transition curves). Also, two new platforms, placed between the main passing tracks and the overtaking tracks with a height of 55 cm from the top of the rail, are designed at the station. The length of the platforms is 220 m. The useful length of the tracks is 753 m (direction towards Niš) and 667 m (direction towards Stalać). At the entrance/exit of the station "A-V" track connections are designed with switches R500. Switches on the main passing tracks are designed with R300, and on the other tracks with R200. The type of rails on the main passing and overtaking tracks is 60E1, and on the other tracks 49 E1, they are placed on reinforced concrete sleepers with elastic rail fastening, for tracks and switches.

## 2.2 Structures

After station Stalać railway line is founded on the embankment and follows the bed of the river South Morava. The track on the open line is with rails type 60E1 on reinforced concrete sleepers with elastic rail fastenings.
All crossings with roads are designed separate grade – underpasses. According to that abolition of the existing level crossing after station Stalać is planned. Due to unfavourable terrain conditions, deviation of the local road that leads to the state road IIb 23 is designed with a new underpass at km 177+594 and connection to the main street in Stalać. In order to approach the emergency vehicles and possible evacuation from the tunnel 1 (1.45 km tunnel length) on the left side of the railway road is designed width of 3.5 m with the turn out for emergency vehicles. On the right side of the railway road width 3.5 m is designed as access to the evacuation plateu from the tunnel. At place of the tunnel 4 entrance (L = 3275 m) approaches are designed, and at the exit from the tunnel 5 there are also approaches designed, which will serve as the access for emergency vehicle in case of possible accidents.
Designed railway is, from km 178+895 (tunnel 1 entrance) up to the exit from the last tunnel 5, km 186+670, mostly in tunnels or on structures (bridges, viaducts, galleries). After the exit from the tunnel 5, the railway is on viaduct with a length of 300 m, from where it is designed on a high embankment all away to the entrance to the station Đunis.
In front of the station Đunis, near the bridge over the Ribarska river, existing railway line intersects with the state road IIa order, with separate grade underpass. After testing several solutions that would include a new underpass, designers came to the conclusion that, due to the proximity of the riverbed and flood level, the optimal variant would be overpass along with the state road deviation.

**Table 1** The list of structures

| STRUCTURE | CHAINAGE | NOTE |
|---|---|---|
| beginning of the section which is subject of design | 174+200.00 | |
| existing overpass of state road | 175+409.66 | Existing |
| culvert | 174+478.13 | 2,0 x 2,00 |
| culvert | 174+970.47 | 6,0 x 3,00 |
| culvert | 175+269.54 | 2.0 x 2,00 |
| pedestrian underpass | 176+324.51 | Stalać station |
| bridge | 176+620.68 | over stream |
| retaining wall – beginning | 177+079.33 | **retaining wall on the left side of the track** |
| retaining wall – end | 177+190 | |
| underpass | 177+593.80 | span 10 m |
| culvert | 177+377.22 | 2,0 x 2,00 |
| culvert | 177+465.30 | 2,0 x 2,00 |
| culvert | 177+785.33 | 2,0 x 2,00 |
| culvert | 177+988.90 | 2,0 x 2,00 |
| culvert | 178+339.77 | 2,0 x 2,00 |
| culvert | 178+512.98 | 3,0 x 2,50 |
| culvert | 178+719.78 | 2,0 x 2,50 |
| TUNNEL 1 – ENTRANCE | 178+895 | **TUNNEL 1, L=1450 m** |
| TUNNEL 1 – EXIT | 180+345 | |
| bridge | **180+435.65** | **L= 90m** |
| bridge | | |
| culvert | 180+687.56 | 2,0 x 2,50 |
| TUNNEL 2 – ENTRANCE | 180+700 | **TUNNEL 2, L=690 m** |
| TUNNEL 2 – EXIT | 181+390 | |
| bridge River Južna Morava, | 181+554.80 | L=298m |
| TUNNEL 3- ENTRANCE | 181+725 | **TUNNEL 3, L=435 m** |
| TUNNEL 3 – EXIT | 182+160 | |
| bridge over stream Gorčilovac | 182+200.18 | L=34m |
| TUNNEL 4 – ENTRANCE | 182+325 | **TUNNEL 4, L=3275 m** |
| TUNNEL 4 – EXIT | 185+600 | |
| gallery | 185+615 | |
| TUNNEL 5 – ENTRANCE | 185+630 | **TUNNEL 5, L=1040 m** |
| TUNNEL 5 – EXIT | 186+670 | |
| viaduct | 186+850.38 | L=290m |
| Culvert Livadski stream | 187+113.10 | 3,0 x 2,50 |
| bridge Trubarevački stream | 187+520.46 | L=15,0m |
| Bridge Zmijarnik stream | 187+657.65 | Zmijarnik stream, L=10 m |
| underpass | 188+342.27 | L=10m |
| Overpass state road IIA order | 189+098.40 | state road |
| bridge river Ribarska | 189+190.47 | L=50 m |
| culvert | 189+330 | pipe |
| footbridge | 190+076.10 | Đunis station |
| culvert | 190+562.22 | pipe |
| culvert | 191+446.95 | pipe |
| **end of the section which is subject of design** | **191+937.96** | |

## 2.3 Roads

In order to maximize the safety of rail and road traffic relocation of existing roads is planned. All railway crossings with road traffic are designed to be grade separated. After examining the boundaries of cadastral municipalities along the respective section of the railway line, it has been found that the above mentioned intersections and deviations are within the cadastral municipalities that belong to the municipality Ćićevac, except for the crossing at km 188 + 342.27 (existing chainge), which belongs to the municipality of Krusevac.

## 2.4 OCL/Substation

The configuration of the station tracks is changed in Stalać station so that all the catenary wire has to be dismantled, while in Đunis station two existing portals are kept and all other equipment of catenary wire has to be dismantled.Except for the first 2 km after Stalać, the new alignment of two-track rail from Stalać to Đunis is completely separate from the existing alignment of one-track rail with geometry that allows maximum speed to 160 km/h with minimal radius 1500 m and cant of 110 mm. This open part of rail is 11,588 km long, with 5 tunnels that are 6,890 km long – tunnel 4 isthe longest tunnel, 3,275 km long. Part of the catenary wire on the open track from km 174+170 till existing insulated overlap at Stalać station is dismantled. The same occurs for the catenary wire of open track from the insulated switch at Đunis station till km 191+938. Thus, the scope of the Design is new catenary wire with construction for maximum rail speed to 160 km/h between Stalać and Đunis stations .The technical solutions of the catenary wire are standard solutions for speeds to 160 km/h, which is used on rails of Serbian Railway company according to General Design of catenary wire and Equipment specification catalogue CW. On the open part of the rail line, standard catenary wire is used with maximum spans of 70 m, maximum length of tensile sections 1600 m with the fixed point approximately in the middle of the span section. The system height is 1400 mm with mutual straining of the contact wire and the support cable above with an automatic straining device with ratio 1/4. In tunnels although a standard solution of catenary wire is used, reduced values are applied because of the limited space, so maximum distance of the span is 50 m and the system height is reduced to 1000 mm. The contact wire and support cable are strained separately on the tunnel wall, and the fixed point is derived as a fixed point at the portals.
Substation Đunis – The overhead contact line (OCL) between Sectioning Switchgear with Neutral Section (SSNS) Grejač and SSNS Sikirica is supplied by the Substation (SS) at Đunis. These switchgears (SWG) are remote controlled by remote control centre (RCC) Niš. SS Đunis is connected to 110kV grid through two 110kV overhead lines (OHL). Each OHL is with three phases. 110kV SWG is outdoor air isolated type (AIS). 25kV SWG is AIS indoor type. In the substation building the following equipment is located: 25kV SWG and equipment for control, protection, metering and auxiliary supply. The new traffic line No.5 in Đunis station is located in the area of the Đunis SS. This is the reason that the existing building in Đunis SS should be dismantled and a new one should be built. The ocation of the new building is on the right side of the existing SS Đunis SS, as is shown on the Layout dwg.

## 2.5 Signalling and safety installations and devices

As an overlay of the conventional signalling/interlocking system, an ETCS Level 1 system with infill function shall be installed to increase the capacity and reduce headways on the section. This will comprise of fixed and switchable eurobalises and euroloops on the station tracks with platforms (for wrong way train running, e.g. in case of down train on the up line block section with the same block length for both ways). In the neighbouring stations with relay interlocking devices Siemens SpDrS-64 (Cicevac, Korman), appropriate interfaces shall be installed to retain the function of distributed relay automatic line block. On sections Cicevac-Stalać and

Đunis-Korman all existing level crossing interlocking devices shall be modified concerning activation sections, according to the new regulations in force. During the construction phase, a temporary interlocking shall be installed in stations to enable signalled traffic operation (without the possibility of automatically setting the point machines), by using the relocated existing signalling cables for connection of field elements. Existing level crossing interlocking devices on section Stalać-Đunis (one), as well as level crossing interlocking devices on adjacent sections Cicevac-Stalać (two) and Đunis-Korman (six), will remain in automatic operation mode until the interlocking devices in Stalać and Đunis stations are switched-off. After that, during the remaining construction period, railway traffic over these level crossings will be conducted according to the procedure defined in Traffic Rulebook /Rulebook 2/- the train must slow down and stop in front of each level crossing, with audible warning to the road drivers.

### 2.6 Telecommunication installations and devices

Along the new alignment, the following telecommunication systems shall be installed:
- Lineside railway copper cable
- Lineside railway optical cables (2 redundant cables, one on each side of the alignment)
- Cable ducts
- SDH-based transmission system (STM-16 rate)
- Railway dispatching system
- Local telephone network in stations
- GSM-R network with temporary centre (OMC) in Stalać station, base stations along the alignment located about 7 km each and repeating base stations on entry/exit of the tunnels together with radiating cable inside
- Analogue 460MHz band radio-system, for trains not equipped with GSM-R in this phase
- Station telecommunicatiom systems (structural IP network, passenger information system, announcement (sounding) system, video surveillance system, fire detection system, master clock system)
- Telecommunication systems in tunnels

Protection and relocation of the affected existing telecommunication installations is predicted according to the conditions issued by telecommunication authorities in charge: "Telekom Serbia", "Emisiona Tehnika" and "Ratel",as well as other involved vendors of the telecommunication services (cable operators SBB and VIP). In the received technical conditions, a corridor of the existing telecommunication lines is shown, and in cases that there are interferences with installations along the new track alignment, corresponding technical measures for mounting of new installations are prescribed together with protective measures for performing works in the vicinity of existing installations (for example manual trench excavation, minimum horizontal and vertical distances from existing installations etc).

## 3 Operational plan during construction

Operational Plan during construction contains:
- Organization of railway traffic during construction
- Organization of Construction works

Proposal of organization of traffic during the construction works and estimation of total duration of construction of new double track railway section Stalać – Đunis it will be first input for the Final Beneficiary in decision-making process for the next steps.
Study on Organization of construction for this phase of the project documentation – Preliminary Design will give an overview of the time required for construction in accordance with the time schedule that the Consultant developed during the design.

In the next phase of preparation of project documentation, which will provide a greater level of details and proposals of construction technology based on previous inputs, the Beneficiary will have a comprehensive view on the subject of construction works methodology for the selection of the Contractor.

### 3.1 Organization of railway traffic during construction – as note

The intersections between the existing railway line and the newly designed one are primarily at the railway stations Stalać and Đunis, but at 4 spots on the open line (at km 177+325, km 178+642, km 181+421 and km 187+290).
To determine the principles of the organization of railway traffic during construction, a traffic plan will be used on the basis of the Timetable 2014/15. The analysis includes the existing volume of traffic and the existing capacity in the stations, and the phases of the works that will provide a minimum of disruption to railway traffic. Times in the timetable, which can be used for construction works, are limited by planned train-paths of international passenger trains. Rail closures should be introduced taking into account the international passenger trains as well as future international freight trains, as much as possible. Buses can be used as replacements for domestic passenger traffic, in periods of railway traffic closure. Domestic freight traffic should to be planned in the free intervals (at night, for example).
Serbian Railways will determine and make a final decision on the way of the organization of railway transport during the works, and the documentation from this project aims to present the potential issues and help in future decision-making. Detailed conditions and timelines with the costs will be determined in the future design phases.
Civil and structural engineering construction works are the most time consuming. All other works relating to the installation of signalling & interlocking devices, telecommunication devices, as well as electrical works on the catenary, will be defined by phases, the same ones as for the construction works, and must be fitted into the planned duration of each construction phase. Before the start of construction work, it is necessary to protect telecommunication cables along the railway line in order to avoid damages. Some of the existing cables will be used in the inception phase of construction until all of the existing interlocking and telecommunication devices will be dismantled. In the event of cable disruption, the Traffic Rule Book determines the procedures, according to a potential hazardous situation. Railway traffic will be performed in interstation distance mode, according to applicable regulations. Handling of switches will be performed manually in the stations. It is necessary to plan for an increased number of staff, which is particularly related to the required number of switchmen. During the works, it is necessary to determine speed limits as follows:

- On interstation distance mode, where works are performed – it is necessary to reduce the speed of trains to 50 km/h,
- In sub-sections adjacent to the zone of the works, it is necessary to limit the speed to 20 km/h,
- Speed Reductions will have an adverse effect on the line capacity, but not significantly, because the existing speed on this section is 85 km/h or 65 km/h, and during the works it will be reduced to 50 km/h, except in sub-sections adjacent to work sites, where it will be 20 km/h. The decrease of the line capacity will be caused by the regulation of traffic in the interstation distance mode.

In the stations, the purpose of the station tracks will be changed, in relation to the station Rulebook. In accordance with the provisions of the Traffic Regulations, it is necessary to plan the works in advance to allow time to make a temporary timetable and deliver it in a timely manner to interested staff (station staff, staff on the open line and driving personal). Driving personnel have to be informed about all changes in the timetable. Notification of personnel is performed at terminus or dispatching stations, according to current regulations.

During the works, for the needs of transport of the material and disposal of the old material, works trains should be planned, whose routing must be provided in the Guidance on the Organization and performing of traffic services during the works that need to be prepared by Serbian Railways.

**Organization of Construction works**

New double-track railway line section between Stalać and Đunis is designed in it's greatest part on structures and in tunnels (to adhere to the requirements of the Terms of Reference and the terrain topography). Length time for construction work depends on the time for the construction on tunnels and structures. Works on the superstructure will follow dynamic of construction works on the tunnels and structures. Total time duration on the one group of construction work consists of individual time for:

- Preparatory works
- Main works
- Finishing works

The construction of the following sections will be done without interference to the traffic on the existing railway line:

- km 175+450 – km 175+535,
- km 177+000 – km 177+200,
- km 177+300 – km 178+550,
- km 178+700 – km 187+200,
- km 187+400 – km 189+350,

The proposed PHASES of construction works are shown below:

**PHASE 1** – For the purpose of the start of work on the bridge at km 181+556, suspension of traffic is necessary for the alteration of the entrance to Stevanac passing loop. Rail closures can be planned for 8 hours for construction works and alterations to the overhead contact line.

**PHASE 2** – During Phase of Stalać station reconstruction, tracks 5, 6, 7 and 8 are reconstructed first. Traffic is carried out over tracks 1, 2, 3 and 4. During Phase 1 in Đunis station, tracks 4. and 5. are under construction with a temporary connection to the existing track No. 4 at the station entrance, as well as a temporary connection of new track 4 to the existing right track on station exit. Traffic is carried out tracks 1, 2 and 3.

**PHASE 3** – During Phase of Stalać station reconstruction, tracks 1, 2, 3 and 4 are reconstructed.Traffic is carried out over tracks 5, 6, 7 and 8. During Phase 2 in Đunis station, tracks 1, 2 and 3 are under construction, as well as part of the new railway alignment from km 190+900 up to km 191+200. Traffic is carried out on tracks 4 and 5.

**PHASE 4** – Connection of the main tracks from Stalać station entrance to the existing railway tracks.Connection of the main tracks from Stalać station exit to the tracks on the new railway alignment.Temporary connection of a new left track with the existing railway track at km 177+235.For the purpose of the construction works closure of railway traffic is required. After completing the works railway traffic is carried out on the new alignment up to km 177+235, and then along the existing track. Connection of the new main tracks in Đunis station with the new designed part of double track alignment at the entrance and exit, together with the connection to the existing alignment towards Niš.Temporary connection of the new left track on the existing railway line at km 187+300.For the purpose of construction total closure of traffic is required. After the completion of the intervention traffic is carried on the new left track and on the existing single-track railway line (km 177+235 to 187+300).

**PHASE 5** – Connection of a new alignment at km 177+235, km 178+643 and km 187+290. During the construction works traffic is carried out on the new left track and on the existing track (km 177+235-187+300).

**PHASE 6** – Abolition of temporary track connections.Traffic is carried out on the right track of a new alignment.

End of the construction works. Removal of exisiting tracks and the construction of access roads along the old railway alignment. Establishing of a regular traffic timetable.

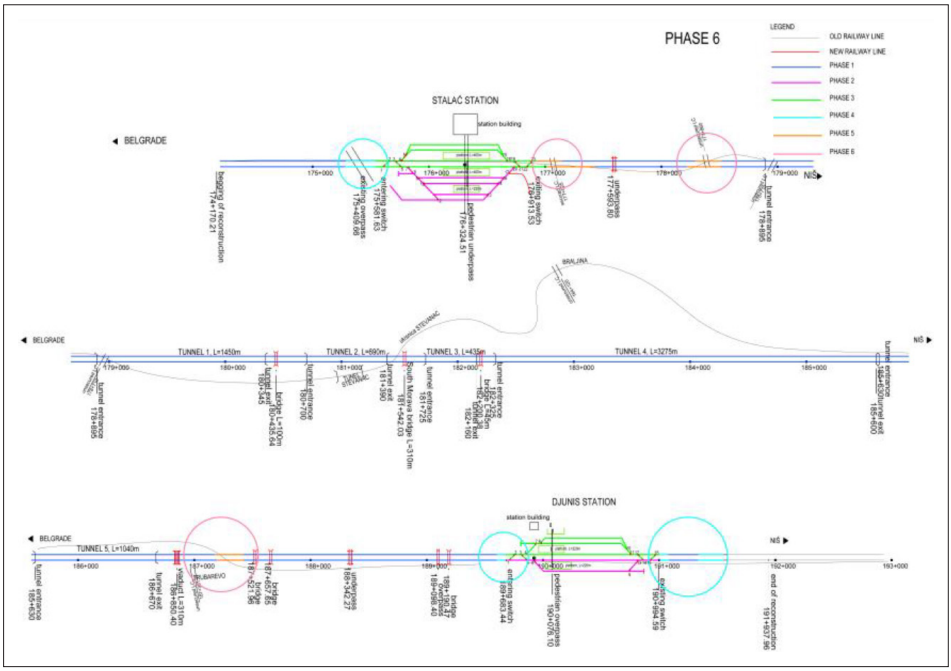


**Figure 2** Six phases during the construction works

## 4 Conclusion

The complexity and the multidisciplinary phases of the project and its preparation for the construction represent a challenge for the selected Constructor. Developing of operational plan and consultant's vision of constructuion works are one of the proposal which gives aproximately time and estimate cost for construction. The fulfillment of the three basic objectives: dates, quality and price, when deciding about selection of contractors, largely depend on the technology and organization of construction which will be offered.
Having that in mind, the proposal and consideration of construction feasibility represent good input data in preparing this project to become a real world railway line facility.

## References


[1] The European Agreement on Main International RailwaynLines (AGS), European Agreement on Important International Combined Transport Lines and Related Installations (AGTC), the South East European Co-operation Process (SEECP) and the Europen Technical Specification for Interoperability (TSI)

[2] Law on Railways ("Official Gazette of RS", No 45/2013)

[3] Law on Safety and interoperability of railways ("Official Gazette of RS", No.104 / 2013)

[4] Rulebook on the Designing, Reconstruction and Construction of certain elements of the Railway Infrastructure of some main Railway lines ("Off. Gazette of RS", No.100 / 2012)

[5] Law on Planning and Construction; Official Gazette of Serbia

[6] Other technical regulations and standards for preparation of the project documentaton for Reconstruction and Modernization of the Existing Railway Track and Construction of a Second Track on the Line Beograd–Niš, Section Stalać – Đunis