



**CETRA** 2018

5<sup>th</sup> International Conference on Road and Rail Infrastructure  
17–19 May 2018, Zadar, Croatia

## Road and Rail Infrastructure V

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**CETRA<sup>2018</sup>**

**5<sup>th</sup> International Conference on Road and Rail Infrastructure**

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TITLE

Road and Rail Infrastructure V, Proceedings of the Conference CETRA 2018

EDITED BY

Stjepan Lakušić

ISSN

1848-9850

ISBN

978-953-8168-25-3

DOI

10.5592/CO/CETRA.2018

PUBLISHED BY

Department of Transportation

Faculty of Civil Engineering

University of Zagreb

Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE

minimum d.o.o.

Marko Uremović · Matej Korlaet

PRINTED IN ZAGREB, CROATIA BY

“Tiskara Zelina”, May 2018

COPIES

500

Zagreb, May 2018.

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Proceedings of the  
5<sup>th</sup> International Conference on Road and Rail Infrastructures – CETRA 2018  
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# Road and Rail Infrastructure V

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## RAIL TRAFFIC TECHNOLOGY DURING THE CONSTRUCTION OF LJUBLJANA PASSENGER CENTER

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### Abstract

The paper presents the transformation of the Ljubljana railway station as required for the construction of the Ljubljana Passenger Center. In this context, it discusses certain issues, including the construction of middle supports, the reorganisation of railway tracks, as well as the track devices, catenary, signalling and telecommunications devices etc. The article defines the specific construction phases for which the corresponding railway traffic organisation and obstructions to the railway traffic are summarised. Multiple organisational measures have been foreseen for both the passenger as well as freight traffic. The objective of the organisational measures during construction of Ljubljana Passenger Center is to reorganise the railway traffic at the Ljubljana railway station in order to achieve a better utilisation of the existing infrastructure and decrease the number of conflicting situations related to the train and shunting routes. Due to the challenges which the organisation of traffic and the potentially insufficient capacity of the passenger station for both the passenger and freight trains pose for the construction, the traffic was simulated with a modern rail traffic simulation software, which supports on-the-fly calculations of traffic-related effects, including the station track occupancy, based on the suggested infrastructure measures (the RailSys programme).

*Keywords: Ljubljana Passenger Center, construction, railway traffic, RailSys*

### 1 Introduction

The Ljubljana railway station is an important rail hub, since it operates as the end, start and shunting station for the main and regional railway lines (Fig. 1, [1]). The existing rail infrastructure (Fig. 2) currently supports concurrent transit through the Ljubljana station by means of four separate tracks at the East (“A”) end of the station (both tracks of the main Zidani Most – Ljubljana line, as well as the lines No. 12 and 13) and by means of four lines on the West (“B”) end of the station (both tracks of the main Ljubljana – Sežana line, the Ljubljana – Jesenice line and the Ljubljana – Kamnik line). On the South end, the railway station also has the capacity to support the Ljubljana – Novo Mesto transit on one track concurrently with the above-mentioned East-West transit [2]. The greatest problems regarding the freight traffic appear to be on the Koper – Jesenice line, as there are no direct connections and currently all trains on the line have to change their direction at the Ljubljana railway station.

The Ljubljana railway station, which was built approximately 170 years ago, has been upgraded and enlarged multiple times, but it has never been completely rebuilt. Considering its current function, the station is overloaded and operates almost on the edge of its capacity [3]. Any increase in activity without an appropriate upgrade would be very risky.

A new facility, i.e. the Ljubljana Passenger Center, is planned at the Ljubljana railway station. The facility will be extending across railway tracks along the entire station area (in the North-South direction), which will pose considerable problems to the construction and traffic

management. The work will be carried out in several phases (Fig. 3), presented in chapter 2, with individual tracks completely closed to transit, which will be redirected to the remaining open tracks. Considering how large the part of the building above the tracks will be (more than 100 m) and the fact that the site will have to be bridged, it has been decided that permanent and temporary structures middle supports will be built in the area around the tracks. Having to take into account and adapt to the middle supports makes the planning and construction even more difficult and will obstruct the rail transit during the construction. The permanent middle supports are planned on the island platform No. 3 (between the tracks No. 8 and 10) (Fig. 3); they represent a dividing line separating the station into the North part and South part for the purpose of closing them in order to construct the Ljubljana Passenger Center above the tracks.



Figure 1 The Ljubljana railway station marked on the Slovene railway network chart [1]

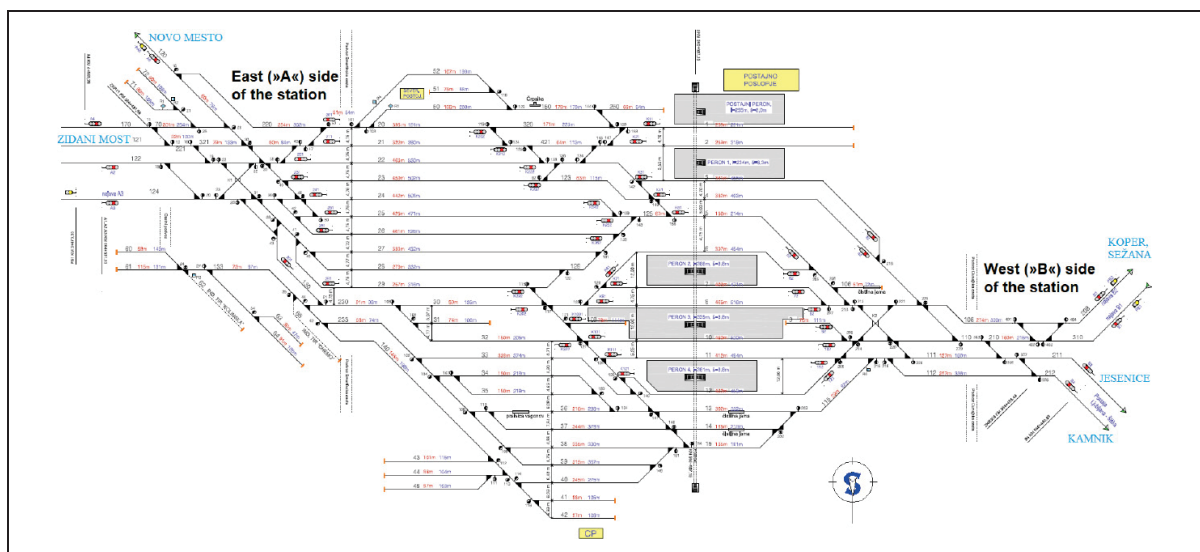


Figure 2 Ljubljana railway station chart [2]

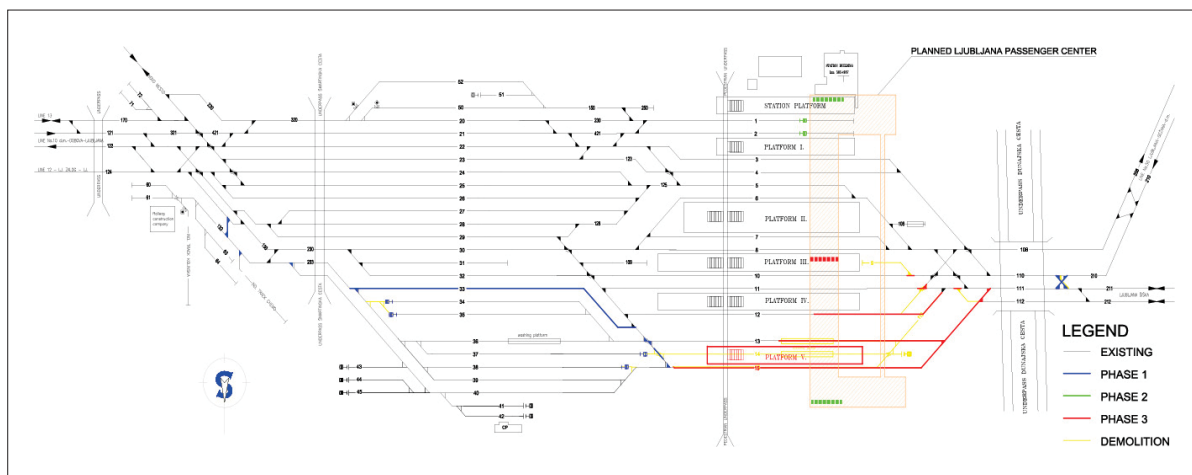


Figure 3 Ljubljana railway station chart with displayed phases of construction [4]

## 2 Organisational and technical measures

The construction work and the planned closure of tracks will necessitate certain organisational measures. Multiple organisational measures have been foreseen for both the passenger as well as freight traffic, in order to achieve a better utilisation of the existing infrastructure and decrease the number of conflicting situations related to the train and shunting routes during works. The speed at the station, which is currently limited to 40 km/h, will be decreased to 30 km/h for all trains passing the construction site.

### 2.1 Initial measures

During the construction at the Ljubljana railway station, it is important to ensure that the rail transit is as smooth and safe as possible. Along with technological processes, it is necessary to consider the movement of passenger trains, cars etc. Movements performed by a shunter require it to be driven on multiple station tracks, which may obstruct the flow of regular train traffic at the station. For this reason, any extra operations (operations relating to train operators, servicing and other operations, such as the stabling of passenger cars, trains and locomotives, as well as train locomotive and car inspections), which may obstruct the operation of the station, will be relocated to other, more suitable locations in a timely manner. By relocating these operations, some tracks at the Ljubljana railway station will be freed. This will further unburden the station and allow better traffic management at the facility. At the same time the number of shunting moves will be decreased, which will in turn improve the station's throughput. All these operations will have to be relocated before the construction of the Ljubljana Passenger Center starts.

### 2.2 Measures in passenger traffic

The passenger traffic will be obstructed during all implementation phases. Due to closures, delays are expected. To prevent delays and any related foreseeable problems, a new timetable for passenger trains will have to be created, which will adequately reorganise the traffic by taking into account the construction work and any obstructions this work will cause. The adapted timetable must not significantly alter the current arrival and departure times; it may, however, change the tracks for passenger train arrivals and departures. Here, the goal is to avoid the need to organise alternative bus transports for passengers during the construction and expected traffic closures at the Ljubljana railway station.

### 2.3 Measures in freight traffic

According to our estimates, during the construction of the Ljubljana railway station and the planned closures, all existing freight trains will be able to pass through. However, the transit will have to be reorganised. All freight trains that would, according to the valid timetable, be put on waiting, moved or involved in any shunting moves at the Ljubljana railway station, will have to undergo operations at other suitable freight stations.

Most of the problems are already caused by freight trains operating on the Koper – Jesenice line, since they have to change the direction at Ljubljana. Since there is no direct connection between the two lines, a train stopping at the Ljubljana railway station freight area has to change its direction there, which means the locomotive has to be moved. The train can leave the Ljubljana railway station only after a prescribed procedure and a brake test have been performed. This shunting operation involves multiple tracks, which significantly affects the available capacity at the already overloaded Ljubljana railway station. To avoid problems with trains changing direction at the Ljubljana railway station, multiple organisational measures are possible to increase the capacity of the station. We would like to specifically point out three of them.

One possibility foresees the adding of extra locomotive (at the back of the freight train) at the Ljubljana Vižmarje railway station (from Jesenice), so that freight trains at the Ljubljana railway station may rapidly change direction and continue towards Koper, with the locomotive which drove the train from Jesenice to Ljubljana uncoupled at the Borovnica railway station. The same applies for the opposite direction (from Koper), except that the locomotive at the back of the freight train would be coupled at the Borovnica railway station, while at the Ljubljana Vižmarje station the locomotive which drove the train from Koper to Ljubljana would be uncoupled.

Another possibility foresees the extra locomotive that would be waiting at the Ljubljana railway station to be coupled to a freight train, where the locomotive which drove the train to Ljubljana would be uncoupled to wait at the station for the next train. This way a train could quickly change its direction and continue towards Koper or Jesenice.

The third possibility foresees trains operating on the Koper – Jesenice line to travel to the Ljubljana Moste or Ljubljana Zalog railway station, where they would change their direction or perform shunting manoeuvres.

These measures may be applied separately or simultaneously and may be combined as required. The suitable number and combination of these measures will be decided with regard to conditions emerging during the construction. It must be noted that some proposed organisational measures depend on the availability of the workforce and the rolling stock.

## 3 Phase implementation timeline and traffic management during individual phases

The described implementation phases represent the planned process. The accompanying work on the railway substructure, platforms, piles etc., which does not represent an obstruction to the rail traffic, will be performed along with the work carried out on tracks. The traffic management solutions were checked with the RailSys modern rail traffic simulation software, which simulates the operation of rail traffic based on the information about the infrastructure, timetable, rolling stock and delays [5]. The software utilises a synchronous simulation model and provides a microscopic as well as a macroscopic simulation model based on the already developed timetable. RailSys has been used primarily to test and evaluate the operation and traffic organisation optimisation for main construction phases.



### 3.1 Main implementation phases

During the main implementation phases, that will take place after work on the Center has been finished, work will be carried out with individual tracks completely closed to transit, which will be redirected to the remaining open tracks. Certain work has to be completed before any work on the Center is started.

Some tracks or parts of the station will have to be shut down, mostly because the work platform will have to be prepared, piles and support pillars built, the building constructed etc. When defining the phases, the goal was to minimise obstructions to traffic and decrease both traffic on single-track sections and the duration of phases requiring implementation of single-track traffic. The main implementation phases for the construction work on the Ljubljana railway station tracks and track devices and the organisation of the rail traffic during that time are described below.

#### 3.1.1 Phase 0: preliminary work

Preliminary work includes: setting up temporary objects, preparing machines, supplying material, restoring staking, constructing access paths, adapting signalling and telecommunications devices, adapting the existing control panel, carrying out preliminary work on catenaries, constructing foundations and setting up new catenary masts etc. This is also the final phase still allowed for the relocation of all additional operations. At this phase, it is important to prepare the construction site and necessary material, as well as carry out work so as not obstruct the rail traffic at the railway station and to contribute to a faster execution of work during the subsequent phases (e.g. the foundations and catenary masts will be constructed at this phase, whereas the contact wires will require the tracks to be closed during the following phases). During phase 0, the rail traffic will take place on the existing tracks in accordance with the existing timetable. At this phase, all existing main tracks, track devices, catenary, and signalling and telecommunications devices will be in operation (except for the short, temporary closures).

#### 3.1.2 Phase 1

In this phase, a new junction at the side “A” of the station will be constructed, the track No. 33 will be electrified and connected to the signalling and telecommunications device, and the side “A” of the station will see some worn-out switches replaced. On the side “B” of the station, a double junction will be constructed (Fig. 3). The measures implemented at the first phase will make the traffic management and the construction of the Ljubljana Passenger Center easier owing to the connection of an additional track at each side of the station and the inclusion of track No. 33 to the signalling and telecommunications device (the control panel). Along with the work carried out at this phase, work will also be done on the signalling and telecommunications devices (moving and securing cable lines) at the side “B” of the station, because of the work planned for the subsequent phases. Other than the already mentioned, decreased speed and the short, temporary obstructions of the neighbouring tracks, no major obstructions to traffic are expected.

#### 3.1.3 Phase 2

This phase will comprise of the construction of piles for permanent supports of the Ljubljana Passenger Center (Fig. 3). Since most piles foreseen for this phase will not be constructed in the area of the tracks, the construction is not expected to present major obstacles for the rail transit.

#### 3.1.4 Phase 3

Most of the work on tracks and track devices falls under this phase. At this phase, a partial closure of tracks No. 10 – 12 (entry from the side “A” of the station will be possible) and a complete closure of tracks No. 13 – 15 is planned. This phase will include the construction of

piles and permanent supports on the island platform No. 3 (between tracks No. 8 and 10), a new island platform No. 5 and a new track No. 15. New connections are planned between the above-mentioned tracks on the side “B” of the station (Fig. 3). Along with the work carried out on the tracks and at the Center, the catenary and the signalling and telecommunications lines and devices will be moved on the above-mentioned tracks. In this phase, the part of the building above the tracks will be built, i.e. from the middle supports on the platform No. 3 to the new bus station in the North. This work will require a partial or complete closure of transit in the Northern part of the station. Trains arriving to/departing from side “B” of the station (from/to the direction of Kamnik, Jesenice and Sežana) will be able to access tracks No. 3 – 8; all six of them enable passage and four of them have platforms (tracks No. 3, 6 – 8). To and from the side “A” of the station (to and from Moste, Zalog, Zidani Most – through lines No. L10, D10, 11, 12 and 13), it will be possible to access the tracks No. 1 – 12, six of which enable passage (tracks 3 – 8) and nine of them have platforms (tracks No. 1 – 3, 6 – 8, 10 – 12). The tracks No. 1 and 2 may only be used by diesel motor units. Trains arriving from/departing towards the direction of Novo Mesto may access the station on tracks No. 1 – 5, three of which enable passage (tracks No. 3 – 5) and three of them have platforms. All platforms will be used, except for platforms No. 3 and 4, which cannot be utilised completely. In the phase 3, freight trains will pass through the station on tracks No. 4 and 5, as before, except that they will not stop here nor perform any shunting manoeuvres.

### 3.1.5 Phase 4

At phase 4, the construction of the Center will continue at the South part of the facility, from the middle supports at the platform No. 3 to the station building at the South. Due to the planned construction technology, the tracks No. 1 – 8 will be either closed or accessible only from the side “A” of the station.

As far as the traffic organisation and management is concerned, this will be the most demanding phase. At this phase, trains arriving from/departing towards the side “B” of the station (from/towards Kamnik, Jesenice and Sežana) will be able to access the tracks No. 10 – 13 and 15; all five tracks enable passage and have platforms. Trains travelling to and from side “A” of the station (to/from Moste, Zalog, Zidani Most – through the lines No. L10, D10, 11, 15 and 13), will be able to access all tracks (tracks No. 1 – 8, 10 – 13 and 15), except that only five of them will enable passage (tracks No. 10 – 13 and 15) and eleven of them will have platforms (tracks No. 1 – 3, 6 – 8, 10 – 13 and 15). The tracks No. 1 and 2 may only be used by diesel motor units. The tracks No. 4 and 5 may be used for shunting and other manoeuvres, or they may be used for stabling or as spare tracks. Trains arriving from/departing towards Novo Mesto may access the station on tracks No. 1 – 5, three of which have platforms (tracks No. 1 – 3) and none of them enable passage. The platforms No. 4 and 5 can be utilised entirely, while the station platforms No. 1, 2 and 3 can be used only partially. During the phase 4, freight trains will pass through the passenger station through the outmost traversable tracks No. 10 and 15. After the end of the phase, all temporary supports and the temporary platform at tracks No. 1 and 2 will be removed (relocation of buffer stops to previous/current position). At these tracks, the catenary will be restored and the signalling and telecommunications lines and devices will be either replaced or upgraded.

## 4 Conclusion

Due to the closures and consequently lower throughput capacity of the Ljubljana railway station during the entire time of phase 3 and 4 Ljubljana Passenger Center construction, the traffic obstructions and consequent delays can be expected. Passenger trains arriving from/departing towards Kamnik, Jesenice and Sežana will arrive to/depart from different tracks (change in organisation), which may in turn affect which tracks are used by arriving/departing trains from/in direction of Zidani Most and Novo Mesto.

As far as the management and organisation of rail traffic are concerned, the phases 0, 1 and 2 will not represent major problems, whereas the phases 3 and 4 will be very challenging. Nonetheless, we have estimated that all current passenger and freight trains can be operated with a proper organisation of rail traffic during the entire time of phases 3 and 4.

At phases 3 and 4, as many passenger trains arriving from/departing towards Zidani Most as possible will be rerouted to tracks featuring partial closures, which will relieve space on other tracks, which will feature no closures. These tracks will be utilised for the passing and stopping of passenger trains that arrive from/depart to Kamnik, Jesenice and Sežana.

It has to be pointed out that the signalling and telecommunications devices at the station allow two passenger trains to stand at the same platform at the same time. This means that, at one side of the platform (e.g. the side “A”) trains arriving from/departing towards one direction (e.g. Zidani Most) can stand, and on the other side of the platform (e.g. side “B” of the platform) trains arriving from/departing towards opposite direction (e.g. Kamnik, Jesenice or Sežana) can be positioned. Such organisation further contributes ensures that, during the construction, it is indeed be possible for all passenger trains to operate.

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