



## HIGH PERFORMANCE RAILWAY LINE FROM THE STATE BORDERLINE – ZAGREB – RIJEKA

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### Abstract

The area through which the new railway line passes, from the State borderline (Botovo) through Zagreb to Rijeka, is actually within the corridor of the existing railway line, in the sector from the State borderline to Dugo Selo and from Hrvatski Leskovac to Karlovac. From Karlovac onward, the railway passes through a completely new corridor, through Zvečaj, Josipdol, Velika Kapela, Novi Vinodol up to Rijeka (Krasica).

The route in the new corridor passes over an exceptionally rough relief, geologically complex area as well as protected parts of nature, representing an all encompassing challenge regarding planning and design. The idea of a new corridor exceeds the significance of only a new traffic route. It is an intervention into the complete urban and traffic development of central Croatian area, specifically the Karlovac and the Primorsko – Goranska Counties.

This project is very important for the overall Croatian economy, especially for the development of the Rijeka Port and its integration with the Ports of Kopar and Trieste into the European Railway network system. Since the new route is shorter for some 50 kilometers, it shall significantly contribute to the decrease of transportation costs in relation to the present situation. The paper gives an outline of how the Study and Design documentation was prepared for the subject new railway corridor, especially with regard to Sector III, from Zagreb to Rijeka, which is presently defined by a Contract. The paper deals with the problems occurring during design development of such a complex infrastructural project, primarily due to the lack of domestic legislation in this particular field.

*Keywords: railway, high performance railway line, Corridor VB, railway traffic, traffic forecast, environmental protection, Study, Feasibility, regulations.*

### 1 Introduction

The railway transport policy at the level of Croatia and the EU is based on the development documents adopted by Croatia, primarily on the Transport Development Strategy of Croatia and the Reconstruction and Modernization strategy of Croatian Railways from the year 2000, as well as the EU documents, the so-called White Book, “Rail plan”, and the Document on the Pan-European Corridors defined in Helsinki in 1998.

Further harmonization with the EU requirements calls for the need to prepare a draft of the new Act on Railways which would create the requirements for incorporation of Croatian railways into the EU railway market at an equal level.

Inclusion of Croatian Railways into the EU railway network can be done in two areas:

- normative area – through adoption of new legal and normative preconditions for Croatian inclusion into the EU, respecting the EU requirements, harmonization of the operation conditions on the EU railways (interoperability),
- Technical area – including infrastructure, transportation means and traffic organization.

The goals arising from the EU Directives, which impose themselves as priority requirements, are primarily relevant to the modernization and reconstruction of the railway infrastructure, division of the management of railway infrastructure from management of transport services, guarantee of free access to railway infrastructure, establishment of market based railway transport services and free access to railway infrastructure for all interested parties under the condition that they respect all legally imposed requirements.

## 2 Something of the corridor of the future planned railway line

THE railway line Botovo – Zagreb – Rijeka today represents the main railway route important in the connection of Central Croatia, the Gorski Kotar and the North Adriatic area, but also important for establishment of European regional integrations: Alps – Adriatic, The Mediterranean – Danube Region, Central European Initiative etc. This route is in the corridor  $V_B$  (Figure 1), connecting the largest and most important Croatian port, the Port of Rijeka with the Croatian inland, and through it with the Central European Countries which gravitate toward the Rijeka port. This Port is situated deep in the European continent, giving a natural, shortest and most efficient route for connection of the Central and North Europe with the Mediterranean and the near and far east countries through the Sues Canal.

The present railway line from Botovo on the Hungarian border, through Koprivnica, Križevci and Vrbovec to Dugo Selo. i.e. to the east entrance to Zagreb, is defined as flatland railway line with a safety strip, which largely enables reconstruction of the railway for higher speeds and capacities. The existing railway line from Hrvatski Leskovac, the station preceding the Zagreb Main terminal, i.e. the southwest entrance to Zagreb, to Karlovac is also a flatland line constructed for lower speeds and requiring reconstruction.



Figure 1 Position of the traffic corridor V in Europe

Single track railway line is in operation on the mountainous route from Karlovac to Rijeka, whose ascends and descends fall under the greatest tractive resistances in operation today. This is at the same time the first electric railway in Croatia and the only one with partial direct current feed system in Croatian railways. Its elements and capacity do not satisfy the requirements of passenger and cargo traffic for a long time now.

The planned corridor of the new railway line is a priority within the development strategy of Croatia, and it was decided that the complete railway line from the Hungarian state border to Rijeka will be a double track railway line, and that the line shall have the capacity between 28 to 32 million tons of cargo / year. The railway is designed for the speed of 160 (200) km/h,



as the technological designs giving answers to some of the above set goals, as well as guidelines for further preparation of required documents.

The study and design documentation in the past three years was prepared by a multi-disciplinary team of experts consisting of representatives from all fields of expertise from the Civil Engineering Institute, the ŽPD - Željezničko projektno društvo, the Brodarski Institute, Dalekovod, VPS-engineering, The Institute of transport and Communications, the Ekonomski Institut and several more companies specialized for individual areas of the design. The documentation was reviewed in cooperation with renowned international institutions in this field.

### 3 Traffic analyses

#### 3.1 Present railway traffic in corridor V<sub>B</sub>

The flow of cargo and passenger traffic on the routes of the Pan European corridor v<sub>B</sub> which pass through Croatian territory was studied in more detail in the Traffic Study as part of the design documentation, and was based on the statistical data received from the Croatian Railways Company. From these analyses (Tables 1 and 2), it can be seen that the traffic load is decreasing during the nineties of last century, with different causes for this decrease. The main reason was the War of Independence in Croatia and the separation former Yugoslav states, which resulted in the abandonment of the transport corridor toward the Port of Rijeka by transport companies now formally in other states. Political changes in the eastern parts of Europe, resulting with radical changes in the structure of their industries which used the railway corridor v<sub>B</sub> and the Rijeka Port (closing down of some steel works, heavy industry, large socialist industrial and other complexes), and sudden development of the ports in Trieste and Kopar, were further reasons for fall of traffic. After the end of war in 1996, the complete economy in Croatia is undergoing consolidation thus increasing the transiting traffic and the traffic in the port of Rijeka as well.

**Table 1** Global indicators of transport by the Croatian Railways in 1987, 1988 and 1989.

Indicators	1987	1988	1989
Overall passenger transport	45.668.600	45.316.000	43.655.000
Realized transport/km	3.899.795.700	3.833.289.000	3.664.629.000
Total transport of cargo	40.524.000	38.863.000	39.950.000
Realized net ton/km	7.698.433.400	7.211.328.000	7.419.341.000

**Table 2** Global indicators of transport by the Croatian Railways in 2004, 2005 and 2006.

Indicators	2004	2005	2006
Overall passenger transport	36.747.051	39.842.268	46.211.441
Realized transport/km	1.212.994.459	1.265.523.846	1.361.737.162
Total transport of cargo	13.707.109	15.830.310	16.956.917
Realized net ton/km	2.733.112.215	3.106.364.608	3.603.165.155

The number of transported passengers on the Croatian railway network in the year 2006 nears the number realized in the period of most intensive transport activities. However, it can be seen that this number consists of a large portion of passengers traveling on shorter distances (local, town or suburban passengers in the Zagreb area and other larger Croatian towns). There is also an increase in the cargo transport as well, and this was app. 50% of transport realized in the period at the end of the eighties of the last century. Large obstacles to the development of transiting traffic are a large number of border crossings as a result of the independence of several new states in the region.

There is also a marked decrease in the number of passengers since the road network has significantly increased its level of service, resulting in much shortened travel time to Rijeka. This travel time is app. two hours when traveling by road and double when traveling by railroad.

### 3.2 Cargo traffic forecast

The cargo traffic forecast was prepared on the basis of results of the Master Development Plan for the Port of Rijeka (prepared by RMG, October 2007, and supplemented in March 2008), the results of the traffic forecast study prepared by IPV company (December 2007), as well as additional studies of the conceptual design engineers. The cargo traffic was further segmented into three parts: traffic port of Rijeka (the basis was the Rijeka port Master Plan), transiting traffic on the railway transiting Rijeka railway junction (basis was the study prepared by IPV, statistics of Croatian Railways-Cargo) and the traffic of local users in the junction itself which are a part of the Rijeka port (basis was the study prepared by IPV, statistics of Croatian Railways-Cargo). The traffic forecast was made in three basic options (scenario I, II and III), and one additional scenario III-, which largely confirmed the possibility of operation of the port of Bakar and combined traffic within the Adriatic – Danube Region initiative (connection to the Pan European corridor VII, the Danube River and further on to the system Danube River – Maine – Raine). Table 3 gives the cargo traffic forecast on the new high performance railway line Botovo-Zagreb-Rijeka for scenario III-a, which was used in the technological design as the basis for determination of the capacity and in the economic and financial analyses for the calculation of the internal rate of cost-effectiveness.

### 3.3 Passenger traffic forecast

The forecast of the passenger traffic increase was based on the results of the construction of the new railway with flatland line characteristics, which significantly improves the conditions of exploitation and shortens the travel time. This way the railway can equally match the conditions of road transport between Zagreb and Rijeka, i.e. offers better conditions if travel is compared from the center of Zagreb to the center of Rijeka (where bus and railway terminals are situated in both towns).

The forecast is also based on the introduction of new trains on international and national routes toward Hungary, Italy and Bosnia and Herzegovina and Greece, as well as on the increase of passengers in internal and suburban transport.

The passenger traffic forecast was prepared in three options in the Study. Option 2 was taken as the basis for further analyses. This variant forecasts an increase in traffic, which would be the result of the following: improvement in the level of services, improvement of the overall living standard of the population, completion of construction of infrastructure and structures in the vicinity and the zone of influence of the new railway, influence of price increase of petrol as well as favorable influence of railway on the environment as proposed to the competitive road transport.

**Table 3** Cargo traffic forecast on the Corridor V<sub>B</sub> – scenario III-a

Traffic forecast - scenario III-a	2016	2021	2031
Railway line: Krasica - Drežnica	9.506.431	14.193.974	29.949.517
Railway line: Split - Drežnica	2.514.052	2.587.940	5.067.000
Railway line: Drežnica - Goljak	12.020.483	16.626.291	34.453.517
Railway line: Karlovac - Goljak	396.000	400.000	660.000
Railway line: Goljak - Horvati	12.416.483	17.026.291	35.113.517
Railway line: D. Selo - Gradec	5.545.853	7.604.836	15.683.540
Railway line: Gradec - Križevci	5.355.853	5.584.836	15.378.540
Railway line: Gradec - Bjelovar	190.000	220.000	305.000
Railway line: Križevci - Bjelovar	70.000	850.000	1.115.000
Railway line: Križevci - Koprivnica	5.425.853	6.434.836	15.493.540
Railway line: Koprivnica - Botovo	4.988.087	6.839.990	14.106.190

**Table 4** Passenger traffic forecast on the Corridor V<sub>B</sub> in Croatia- option 2 – in million passengers

Traffic forecast - scenario III-a	2016.	2021.	2031.
Railway line: Krasica - Drežnica	3,00	3,64	5,06
Railway line: Split - Drežnica	2,40	2,70	3,05
Railway line: Drežnica - Goljak	4,90	5,78	8,76
Railway line: Goljak - Horvati	4,40	5,40	8,00
Railway line: D. Selo - Gradec	3,58	4,10	5,10
Railway line: Gradec - Križevci	2,67	3,16	3,95
Railway line: Gradec - Bjelovar	0,91	0,94	1,15
Railway line: Križevci - Bjelovar	0,22	0,31	0,45
Railway line: Križevci - Koprivnica	2,89	3,47	4,40
Railway line: Koprivnica - Botovo	0,54	1,10	1,86

## 4 Elements of construction solutions of the railway line

### 4.1 Planned route of the new railway line on part of the Corridor V<sub>B</sub>

The policy of constructing a Trans-European Transport Network (TEN-T) was revised in the year 2004, focusing the activities on 30 priority trans-national axes and projects. At this time the focus was placed on the integration of the transport networks of newly accepted states into the TEN. Having in mind that this network was formed in 2004, it did not include Croatia. During the pre-accession activities undertaken by Croatia regarding the transport infrastructure, it was agreed that the TEN network be extended on Croatian as well. Thus, the new railway line toward Rijeka, as well as other railway lines in corridors X, Xa and Vc, shall become a part of the Danube Corridor (VI) and a part of the TEN-T network as well.

Corridor V<sub>B</sub> is a branch of the Corridor v, (Venice – Trieste/Kopar – Ljubljana – Budapest – Uzgorod – Lvov), and also includes the section Rijeka – Zagreb – Budapest. Its role in Croatian transport network and its main characteristics are multiple. It is also very important in Croatian connection with Europe, because of the following:

- It is the shortest route between Budapest (as a regional center) and the Croatian Port of Rijeka,
- It connects Rijeka, through Budapest, with the East European countries, thus Rijeka becomes the nearest sea port to these countries,
- Through Corridor X which intersects with Corridor v, branch B, it connects to the states west and east of Croatia.

## 4.2 Position of the railway transport route from the state borderline (Hungary) to Rijeka (Istria, Slovenia)

According to the traffic – technological and geographic characteristics, the subject railway route from the Hungarian border – Botovo – Koprivnica – Dugo Selo – Zagreb – Karlovac – Drežnica – Krasica – Rijeka – (Istria, Slovenia) consists of 4 sectors:

- 1 Sector I – State borderline – Botovo – Koprivnica – Dugo Selo
- 2 Sector II – Zagreb Railway Junction with connections to Corridor X
- 3 Sector III – Hrvatski Leskovac – Karlovac – Drežnica – Krasica
- 4 Sector IV – Railway Junction Rijeka with branches to Istria and Slovenia.

In Sector I, the subject transport route corresponds to the existing railway line M201 - State Borderline – Botovo – Koprivnica – Dugo Selo. In this Sector, second track has to be constructed along the already existing track which has to be reconstructed for the speed of 160km/h. Also respective reconstruction of railway stations and terminals has to be done, as well as modernization and additional installation of signaling, safety and telecommunication equipment. In Sector II (Zagreb Railway Junction) the subject transport route passes through the area of the Zagreb Railway Junction. The largest percentage of long-distance cargo and passenger traffic passes through this Sector, and it also has the most intense suburban passenger traffic in Croatia. Without large scale and radical interventions and reconstruction, the Zagreb Railway Junction will not be able to accept any significant increase in railway traffic of any kind (local suburban passenger traffic or local cargo traffic, long-distance traffic or transiting passenger or cargo traffic). To fulfill all these requirements and in order to enable uninterrupted traffic flow through the Zagreb Junction, new structures have to be constructed and old ones reconstructed in this area as well, parallel to construction of railway lines in the corridor, which connect to the junction.

A new double track railway line is to be constructed in Sector III, from Hrvatski Leskovac – Karlovac – Drežnica – Krasica. In the Karlovac area, the new passenger traffic would partially pass through the town itself, while the cargo traffic would bypass the town. A single track connection to the existing railway line Zagreb – Rijeka and the existing line Oštarije – Studenci – Gospić – Knin – Split Suburb /Zadar/ Šibenik would be constructed in the Skradnik area (the future railway corridor 4 of the Trans-European Railway Network in Croatia). The new terminal Krasica would connect to the existing line Zagreb Main Terminal – Rijeka with a connecting line Krasica – Tijani.

In Sector IV (Rijeka Junction) a connection must be constructed for the subject transport route to existing and future railway and port capacities in the wider Rijeka area, as well as to the existing and future passenger traffic capacities in the wider Rijeka area, and to the existing line toward Slovenia and Istria. New structures and reconstruction of existing capacities must also be done in the Zagreb Junction area, because it will not be able to accept the planned amount of cargo and passenger traffic after the new railway line is constructed. Also, it will not be able to guarantee uninterrupted and free flow of the planned amount of traffic toward Istria and Slovenia. The most important works would be the construction of the new connecting line Krasica – Ivani, with a connection to the existing line Škrljevo – Bakar, construction of a new bypass and connecting line Krasica – Tijani – Matulji – Borut, and a connecting line from Krasica to the planned new port structures on the Island of Krk.

Figure 3 shows the new railway line in Sector III, Zagreb - Rijeka.

The Project of modernization and construction of the new railway line from the State Borderline to Botovo – Zagreb – Rijeka includes also the reconstruction, rehabilitation and construction of railway line, treated in two separate transport and technological units, also with an overview of the Zagreb and Rijeka Railway Junctions:

- Sector I: Dugo Selo - Botovo - State Borderline (L = 78,87km)
  - Section 1. Dugo Selo – Križevci (L = 36,93km)
  - Section 2. Križevci – Botovo – DG (L = 41,94km).

- Sector II: Zagreb Railway Junction
- Sector III: Hrvatski Leskovac – Skradnik – Krasica (L = 148,095 km)
  - Section 1. Hrv. Leskovac – Belaj (L = 50,325 km)
  - Section 2. Belaj – Skradnik (L = 31,6 km)
  - Section 3. Skradnik – Krasica (L = 66,17 km).
- Sector IV: Rijeka Railway Junction



Figure 3 Proposed variant for construction of the new flatland railway line in sector III Zagreb-Rijeka (option 1C)

#### 4.3 Design elements and other route parameters

According to the recommendations of the Union International des Chemins de fer-a (UIC-a) three main speeds are accepted for the European Railway network:

- $V=250\text{km/h}$  and over, for the new major railway lines
- $V=200\text{km/h} + 25\%$ , for very fast railway lines with mixed traffic
- $V=160\text{km/h}$ , for reconstructed railway lines with mixed traffic

The new railway line is intended for mixed railway traffic, with an emphasis on transport of large quantities of cargo whose starting point or end destination is the Port of Rijeka.

With this in mind, the technical parameters for railway design must be in accordance with the modern, high performance railway lines intended for mixed traffic, which at the same time enable traffic of passenger trains at speeds up to  $200\text{km/h}$ , as well as cargo trains with speeds up to  $120\text{km/h}$  (in the future up to  $140\text{km/h}$ ).

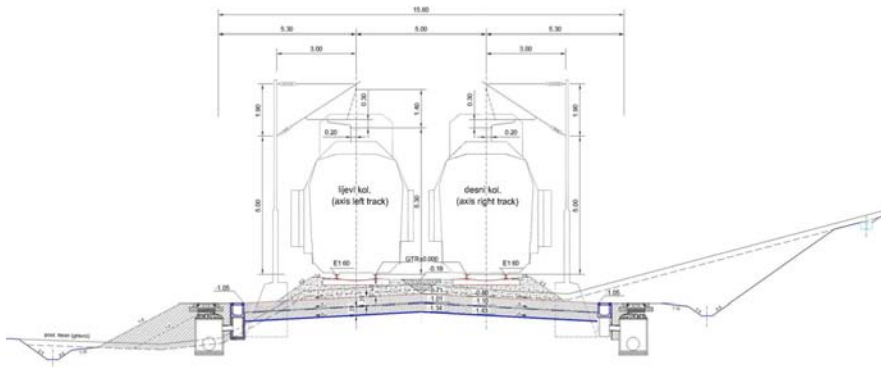


Figure 4 Cross section elements of the new flatland railway line

#### 4.4 Chosen geometry route elements

The limit elements of the open route (plan and elevation element) are defined by preliminary documentation and terms of reference:

- Design speed
    - $V_{max} = 160$  (200) km/h.
    - $V_{teretni} = 100$  km/h.
  - Smallest curve  $R_{min} = 3500$  m (tunnels 6500 m)
  - Greatest level line gradient
    - Flatland route  $i_{max} = 12.5$  mm/m
    - Mountainous route  $i_{max} = 12.5$  ‰ (tunnels 8 ‰)
  - Width of formation level 12,00 m
  - Distance between tracks 5,0 m (in tunnel 25,0 m)
  - Allowed axle load 250 kN
  - Length of stopping lane 1500 m
  - Load of railway bridges and culverts:
    - Standard ENV-1991-3- Basis for analysis and influence on structures;
  - Traffic loads
    - UIC CODE 700/OR , UIC CODE 702/OR
  - Rails 60E1
  - Prestressed RC sleepers length 260 cm
  - Elastic fastenings
  - Minimum thickness of ballast is 30 cm under the concrete sleeper under the lower rail, and on bridges 40 cm under the lower rail.
- Other parameters necessary for design development:
- Smallest distance between tracks in railway terminals or stations is 5,0 m (if the platform is lateral), i.e. 9,5 m (if the platform is an island),
  - Length of platform in suburban railway stations (Zagreb – Karlovac, around Rijeka) 160 m, other stations 80 m , with the possibility of extension to 160 m
  - In railway terminals, the length of lateral platforms is 400 m and minimum width 4,5 m (only for railway terminals where ICE trains stop for passengers),
  - Every railway terminal has underpasses with exists at lateral platforms.
  - The safety area (refuge in case of accidents in a tunnel) 3,0 m from the border of the free driving clearance.

- Height of the contact grid is minimum 1,10m with a distance between contact points of max 50m.
- Smallest tunnel clearance height is 6,90m in the normal contact grid area, and 7,30m in the extended contact grid area.
- For single track tunnels, excavation surface is 66.4 m<sup>2</sup>, and clear span opening surface is 49.5 m<sup>2</sup>.
- Two track tunnel, together with an emergency evacuation passage has an excavation surface of 123,6 m<sup>2</sup>, and clear span surface of 79,4+ 30m<sup>2</sup>.

#### 4.5 Technical solution elements

The railway line drainage is based on the drainage needs of the railway line body, preservation and regulation of the existing water regime in the wider catchment area as well as on the protection of environment from negative influences.

Internal drainage is the drainage system where precipitations falling on the catchment surfaces are freely or collectively taken by means of open, impermeable canals outside the traffic area, filtered to the required level and discharged into the surroundings.

In order to overcome obstacles created due to the indented terrain, watercourses etc., and in order to preserve the environment and existing road network, several railway structures need to be constructed. The design documentation makes a distinction between structures in the railway track: viaducts, bridges, culverts and underpasses, and overpasses. Proposed solutions, based on the national and foreign experiences, fall into the most used types of structures on railways.

With respect to the high categorization and demanding technical elements, the terrain relief complexity and importance of the area through which the railway passes, there are several tunnel structures on the railway line route.

Since two single track tunnel tubes are considered safer with respect to fire occurrence in tunnels, (Figure 5.), because of very complex relief situation on the route, environmental protection measures and defined geometry elements of the railway line, the railway line axes are permanently apart for at least 20m. This situation creates all tunnels to be single tracked, which is very good from the safety point of view as well as cost effectiveness (construction of a service tunnel is not necessary, no influence on the railway line capacity, technical stations can be installed between tracks, no need for additional widening).

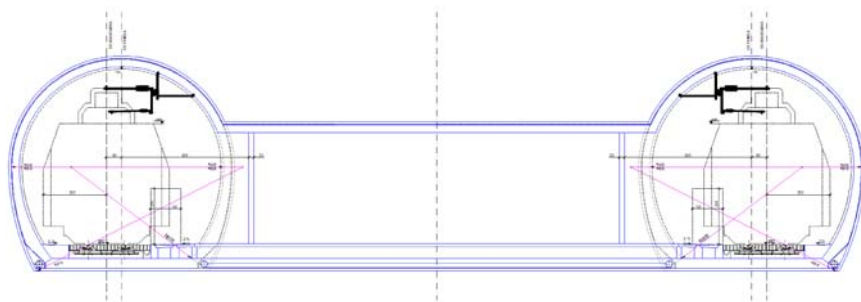


Figure 5 Cross section elements of railway line in a tunnel

Tunnels can be found on section 3 of Sector III, from Skradnik to Krasica. Percentage of tunnels in this variant (c) is approximately 69,09 %, i.e. 45,72km. The longest tunnel is Kapela 2 – 14,4km.

## 4.6 Economic indicators

Construction costs of the railway line from the state borderline with Hungary to Rijeka include the following: Railway line routes, terminals and stations, buildings and structures, tunnels, drainage system, railway crossings and intersections, installations, power supply, signs and signaling equipment, environmental protection, land acquisition, design development, supervision and contingencies. Planned costs are expressed in table 5. The evaluation procedure of the project for construction of the new railway line from the State borderline to - Botovo – Zagreb – Rijeka, is defined in accordance with the *Council Directive 91/440/EEC on the Development of Community's Railways (31991L0440)*. The basis for economic and financial evaluation of the railway line is the cost and benefit flow in the 30-year period, including: operating costs, overhead expenses, costs of passenger travel time and maintenance costs. Modern methods of evaluating the project investment costs are based on the calculation with discounted values, which contributes to the realistic evaluation, i.e. taking the time preference, i.e. evaluating the project in its dynamic form. The Internal rate of return method was taken to evaluate the project.

Economic and financial feasibility of construction of the new railway line from the state borderline to Botovo – Zagreb – Rijeka is based on the cost and benefit analysis, commonly used to assess the investment projects in the field of railway infrastructure. In other words, quantitative and qualitative basis of the analysis were the total costs and income of the existing railway line State Borderline to Botovo – Zagreb – Rijeka; total costs and income of the new railway line, i.e. their positive difference, or overall expected benefits and costs of construction.

**Table 5** Outline of investment costs per sector and section of the railway line

<b>INVESTMENT COSTS (€)</b>	
<b>SECTOR I: DUGO SELO - DG (BOTOVO)</b>	
DUGO SELO - KRIŽEVCI	191.365.200,00
KRIŽEVCI - DG (BOTOVO)	278.284.476,60
<b>TOTAL</b>	<b>469.649.676,60</b>
<b>SECTOR II: ZAGREB RAILWAY JUNCTION</b>	
<b>TOTAL</b>	<b>278.744.343,32</b>
<b>SECTOR III: HRV. LESKOVAC - KRASICA</b>	
HRV. LESKOVAC - BELAJ	587.024.320,80
BELAJ - SKRADNIK	432.995.611,81
SKRADNIK - KRASICA	1.444.577.693,43
<b>TOTAL</b>	<b>2.464.597.626,04</b>
<b>SECTOR IV: RIJEKA JUNCTION</b>	
M202 ŠKRLJEVO - RIJEKA	80.460.818,51
M202 RIJEKA - JURDANI	137.615.376,23
NEW LINE KRASICA - TIJANI - IVANI	165.501.578,97
NEW CARGO BYPASS KRASICA - TIJANI - MATULJI	400.116.600,00
NEW CARGO BYPASS MATULJI - TUNNEL UČKA - BORUT	225.003.378,60
<b>TOTAL</b>	<b>1.008.697.752,31</b>
<b>GRAND TOTAL</b>	<b>4.221.689.398,27</b>

Evaluation of the new railway line was done as follows:

- From the point of view of society which expects lower transportation costs from this project, i.e. a basis for a cheaper and socially more rational transport of cargo and passengers in corridor  $v_b$ : Railway line Zagreb – Rijeka and Zagreb – Botovo (state borderline),

- From the point of view of the railway company, the operator and manager of passenger and cargo transport services, they expect more work and higher income and relatively lower transport costs.

## 5 Conclusion

Construction of a flatland railway line in the corridor  $v_8$  through Croatia, gives a new entrance into Europe and the subject area from the northeast side. This direction bypasses the Alps on the east side, representing a very good connection since it is only 12% longer (app. 60km) than the direction through the Alps, it is very interesting as an alternative route toward the North Adriatic area and the Southeast and Central Europe. The planned corridor of this high performance railway line from the State Borderline (Botovo) – Zagreb – Rijeka is included in the Development plans of the Croatian Railways, it was decided that the line shall be a double track line in its complete length, designed for speed of 160 (200)km/h. The new railway line would shorten the travel time between Botovo and Rijeka to some two hours and the preconditions are being created to enable the new railway capacity between 28 and 32 million tons of cargo per year. Cargo traffic forecast is based on the fact that the construction of the new railway line and ultimately new capacities in the Port of Rijeka would significantly increase the quality and competitiveness of the Rijeka traffic route. Scenario III-a was taken as a realistic forecast of the cargo traffic on the new high performance railway line Botovo – Zagreb – Rijeka. Passenger traffic forecast was made in three variants, the one most realistic was variant no. 2. All traffic forecast variants and scenarios were presented in the “Traffic technology and transport for the High performance railway line from the state borderline – Zagreb – Rijeka, prepared by ŽPD, Zagreb, 2008”. Based on the analyses implemented in the Feasibility Study, it can be concluded that the modernization and construction of the high performance railway line from the state borderline - Botovo – Zagreb – Rijeka is completely justified from the economic (socio-economic) and financial (financial-market) aspect, since their internal rates of cost-effectiveness are at the level of 9% in this Sector, and in the Sector south - at the level of 6%. The new railway line would not only fulfill the total traffic demands but it also means the decrease of transportation costs, primarily because of excellent exploitation conditions of the new route and the shorter travel time between Zagreb and Rijeka.

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