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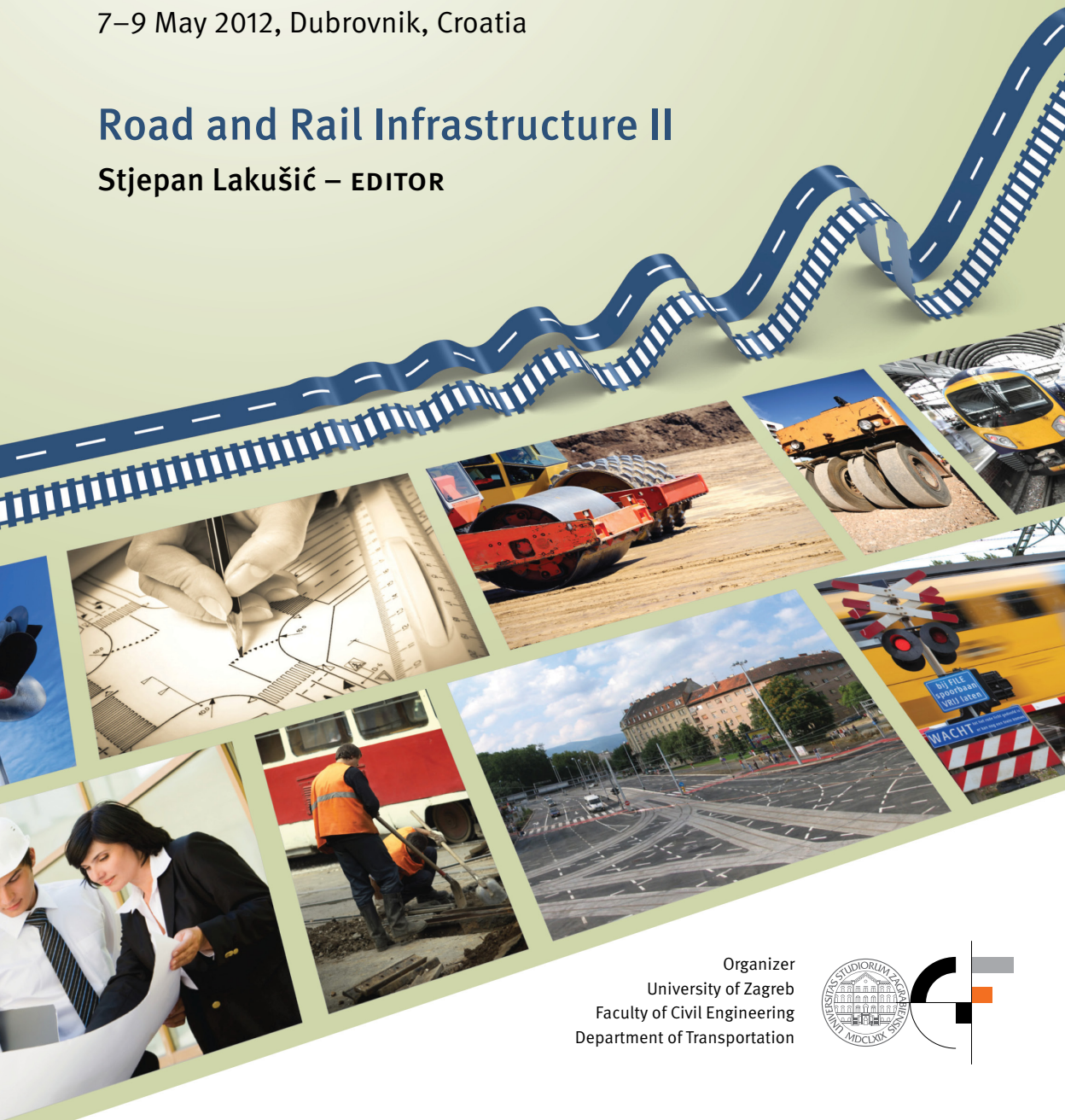
# Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR

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# ONE MODEL FOR RAIL INFRASTRUCTURE PROJECTS SELECTION

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## Abstract

The transport investment projects are high investments with long–term effects. Rail infrastructure projects are very important for economic and social development of the country. They influence on strengthen the competitiveness of railways in the transport market, as the only sustainable mode of transport. This paper researches the problem of railway infrastructure projects selection, such multicriteria problem. Considered projects are infrastructure projects of doubling rail tracks of Corridor 10 through Serbia. The aim of the model is the project selection and allocation of financial resources, based on their total contribution to company goals. The degree of effectiveness of each project individually is measured, whereby the selection of projects is made by the relative relationship. Beside economic and technological criteria for the transport project selection, developed model takes into consideration the impacts of relevant exterior projects. Their realization is uncertain and it's expressed by the initial probabilities of realization. For the project selection problems authors suggest application of the Analytic Network Process, the approach which enables the development of models with network structures, in which the elements' interdependence present.

*Keywords: Project selection, rail projects, multicriterial decision making method, analytic network process*

## 1 Introduction

Models for selection and ranking railway infrastructure projects are very complex due to various relevant criteria, numerous external factors, and several stakeholders with different preferences, huge financial resources needed for investment and limited budget.
Considering external factors, especially important are relevant exterior projects. These projects can be: national or domestic projects, infrastructure projects, social or ecological projects, etc. It's possible to define different relevance of these projects on the projects for ranking. Choosing the relevant exterior projects should be done by company management or by experts.
For considered rail network in Serbia, one of the relevant exterior projects is the forthcoming privatization and improvement of the Port of Bar. Realization of this project would increase the volume of freight transport from Montenegro, through Serbia, to Hungary.
Railway infrastructure projects are important for economical and social development of a country. They also influence on strengthen the competitiveness of railways in the transport market.
Rail network in Serbia was developed in 1884. More than 55% of the rail lines were constructed in the 19th century. Mostly current allowed rail speed has been significantly decreased. Average permissible speed on the Corridor 10 is about 82 km/h, but the average speed of

the fastest trains is some over 60 km/h. There is huge difference between design and current train speed for the more than 90% rail lines in Serbia. On Corridor 10, which should be the best maintained part of the network, designed speed differs from the current speed for 15 and 40%. All these parts of the rail network can be considered as bottlenecks. Analyzing current conditions of the network and defining the priority sections, the importance of the infrastructure projects is obviously. Rail Corridor 10 from the north by north westerly to south by south easterly running TEN corridor X (Salzburg–Ljubljana–Zagreb–)Šid–Belgrade–Niš–Preševo (–Skopje–Veles–Thessaloniki) with branches over Subotica on the Hungarian and Dimitrovgrad on the Bulgarian border, presents the backbone of the Serbian rail network. Together, this represents a length of 872 km.
Project selection can be done before or after project ranking, like in this paper. Project selection is especially important in condition with constrained financial budget. The adequate project selection influences on the efficiency of using available equipment, financial and human resources. Choosing the method for project selection should be in accordance with: company strategy, available information (for instance, after defining the relevant criteria some needed data may be missed, so their values can be assumption), available time period for decision making, and amount of funds which will be dedicated to investment plan.

## 2 Brief literature review

According to literature [1], Cost–benefit analysis, CBA, is the most used approach for evaluation of transport projects in Europe. However, by reviewing the relevant literature from the last decade, which critically compares the CBA, as a single–criteria approach, with multicriteria decision making methods, MCDM, general conclusion is that modern characteristics of the evaluation transport projects require multicriterial approach. For instance, by opening the market, numerous stakeholders become interested for transport infrastructure projects. By applying the MCDM, many costs can be presented in original form; in practice usually it's very difficult to monetize them.

### 2.1 Transport projects' selection

Wey and Wu (2007) suggested an integrated approach for the problem of transport infrastructure projects selection [2]. They used: fuzzy Delphi, ANP and zero–one goal programming methods. In order to overcome some shortcoming of goal programming, the ANP approach is applied in this paper. The ANP takes into consideration the interdependent relations among the system's elements. Transportation projects in Taiwan were considered as the alternatives in the developed model.
Tudela, Akiki and Cisternas (2006) applied 2 approaches for transport project selection [3]. The authors compared the output of CBA and AHP approach. The obtained results were not the same but decision makers choose the suggestion of the AHP approach. Although CBA has been widely used for the transport project selection, there are some constrains of this method. Noise, accidents and air pollution are just some of the project impacts which is very difficult to include into CBA.
Piantanakulchai (2005) applied the ANP with the aim to deal with interdependent relationship within the multi–objective and multi–stakeholders in environment [4]. The goal of developed model was the selection of the highway corridor in Thailand. Considered criteria were: economic, engineering and construction, traffic and transportation, environment, land use and social.
Shang, Tjader and Ding (2004) compared the AHP and ANP approach for the transport project selection [5]. The decision makers chose the ANP for developing the model for transport project selection on one of China's oldest cities. Defined relevant criteria were: benefits, opportunities, costs and risks. In this paper, it's emphasized that ANP approach is better than

conventional evaluation methods as it allows feedback and interdependence among various decision levels and criteria. The authors mentioned a limitation of the proposed approach, i.e. when the model is large, it is time–consuming.
Yedla and Shrestha (2003) developed a model for transport project selection. Considered relevant criteria were: potential energy saving, potential reduction of emissions, cost, and availability of technology, adaptability of options and difficulties of implementation. The model includes environmental experts, energy experts, users and government, car associations, car research centers, and local agencies for implementation [6].
Ferrari (2003) suggested the AHP approach for transport project selection, and emphasized that the projects' attributes are their impacts, which should be considered from the point of view of the stakeholders [7].

### 2.2 Railway projects' selection

Chang, Wey and Tseng (2009) developed the model for the revitalization project selection relating to the Alishan Forest Railway in Taiwan [8]. The relevant criteria were: benefits, opportunities, costs and risks. The considered problem has been solved by fuzzy Delphi, ANP approach and zero–one goal programming.
Longo et al. (2009) developed models using AHP and ANP approaches. The case study was a rail infrastructure, the selection among the potential options regarding a new railway connection [9]. The authors considered following criteria: costs (project costs), transportation efficiency (safety, running efficiency – capacity and reliability), environmental impacts (natural, physical and urban resources) and procedural aspects (modification of the original project and interferences on the existing network). The obtained results were the same. The ANP approach allows taking into account the interdependences of the elements of the upper level – criteria, from the lower level elements – alternatives. The ANP is quite more complex to apply; the analysis of the problem has to be much more detailed compared to the requirements of the AHP approach. This makes the practical application of the ANP approach more problematic. However, AHP framework is often very rigid, and not flexible enough to describe in detail the decision makers' opinions.
Gercek, Karpak and Kilincaslan (2004) analyzed the alternatives for rail transit network in Istanbul [10]. The developed model used the AHP approach. The decision makers made a new option by combining the two similar alternatives for rail transit network. The sensitive analysis has been done, based on different criteria weight, which is very important for decision making process.

## 3 Model for rail projects' selection

This section presents the methodology of project selection using the ANP approach [11]. The projects of PE 'Serbian Railways' are alternatives in developed model. The projects include doubling rail trucks of rail Corridor 10 through Serbia (figure 1). The aim of the model is the project selection (table 1), i.e. allocation of the financial resources, based on the total contribution of the projects to the company goals and objectives. The degree of effectiveness for each project should be calculated.
Model is developed by applying the commercial client–oriented software 'SuperDecisions'. The relevant criteria are named in table 2; their relations are presented in table 3, whereby mark '=' shows the direction of the influence.
Software 'SuperDecisions' calculates the total performance of one project presenting the project contribution to company's objectives and goals. Maximal value is '1', which describes an ideal project according to all relevant criteria. All these values of projects' performances should be transferred to Excel. The first column of this table presents the projects, thereafter the performances calculated by the ANP approach, and in the third column total projects'

costs are showed. The project effectiveness is presented in the fourth column. The following column presents chosen projects (1), i.e. those which are eliminated from the investment plan because of the limited budget (0). Finally, the last column shows the total effect of the accepted investment plan of the company. The next step is the optimization of the available company's financial resources. We assumed that a company has 2.5 billions € for investments. By activation of the 'Solver' application, it's possible to optimize available financial resources.

The set of the selected projects for the realization is the obtained result of the model, based on the considered criteria, in conditions of limited financial resources. In considered example, chosen projects are: $D_1$, $D_2$, $D_3$ and $D_5$ (table 4).


**Figure 1** Rail Corridor 10 through Serbia

**Table 1** Considered alternatives.

| No. | Alternative | |
|---|---|---|
| 1 | $D_1$ | Subotica – Stara Pazova |
| 2 | $D_2$ | Resnik – Mladenovac – Velika Plana |
| 3 | $D_3$ | Stalać – Đunis |
| 4 | $D_4$ | Resnik – Mali Požarevac – Velika Plana |
| 5 | $D_5$ | Niš – Preševo |
| 6 | $D_6$ | Niš – Dimitrovgrad |

**Table 2** Relevant criteria.

| No. | Criteria | |
|---|---|---|
| 1 | $C_1$ | Average revenue per train [€] |
| 2 | $C_2$ | Criteria of speed restriction – travel time lost [train hours/km] |
| 3 | $C_3$ | Criteria of traffic volume [train/day] |
| 4 | $C_4$ | Criteria of rail infrastructure capacity utilization – the percent of rail line capacity utilization [%] |
| 5 | $C_5$ | Exterior projects |

**Table 3** Criteria cross–impact.

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ |
|---|---|---|---|---|---|
| $C_1$ | / | | | | |
| $C_2$ | ↑ | / | ↑ | ↑ | ↑ |
| $C_3$ | ↑ | ↑ | / | ↑ | ↑ |
| $C_4$ | | ↑ | ↑ | / | |
| $C_5$ | ↑ | | ↑ | | / |

**Table 4** Final results of considered model for rail project selection

| | Total (from ANP ratings) | Cost/ Project (in '000's) | Effectiveness (Normalized)*100 | Decision variable | Cost (in '000's) | Performance (effectiveness) |
|---|---|---|---|---|---|---|
| $D_1$ | 0.593 | 125 | 60 | 1 | 125 | 60 |
| $D_2$ | 0.956 | 519 | 100 | 1 | 519 | 100 |
| $D_3$ | 0.501 | 620 | 52 | 1 | 620 | 52 |
| $D_4$ | 0.306 | 886 | 32 | 0 | 0 | 0 |
| $D_5$ | 0.317 | 670 | 33 | 1 | 670 | 33 |
| $6_5$ | 0.296 | 750 | 31 | 0 | 0 | 0 |
| | | | | Total | 1934 | 248 |
| | | | | | | Performance score |
| | | | | Available | 2500,000 | |

## 4 Conclusions

The problem of selection and prioritization transport infrastructure projects is the crucial issue for all transport networks worldwide. The model of rail infrastructure projects is complex due to many various relevant criteria, numerous stakeholders and limited financial budget.
This paper presents the model for rail infrastructure project selection using the ANP approach. Developed model considered the single rail trucks of Corridor 10 through Serbia. Using the multicriterial approach, the ANP, the sections of this network were ranked based on relevant criteria.

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