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# IMPLEMENTATION OF RELEVANT METHODS IN ASSESSING TRAFFIC-TECHNOLOGICAL PROJECTS

*ABSTRACT*

*The assessment of investment traffic-technological projects means a set of activities whose basic aim is to determine the justification and feasibility of the projects. The decision-making process, including the decision-making on investments is an extremely complex process, and the decision-maker has to have a vision of the future and make decisions accordingly in a modern and flexible manner. Therefore, the decisions need to be the result of a planning and research process based on relevant scientific methods. The work includes the selected, analysed and presented methods of cost-benefit analysis, methods of multi-criteria decision-making and SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis methods. Regarding the basic characteristics, the mentioned methods have been compared, the order of their implementation has been determined, and then they have been implemented in assessing the traffic-technological projects of reconstruction with the aim of selecting the optimal variant solution.*

*KEY WORDS*

*traffic-technological projects, project assessment methods, SWOT analysis, cost-benefit analysis, multi-criteria analysis, traffic infrastructure*

## 1. INTRODUCTION

Traffic-technological projects that refer to investments into the traffic infrastructure represent investment projects that have a number of specific characteristics. These are the projects that are of extremely long-term duration (some thirty years), they are not profit-oriented, as a rule they are funded by the government or local administration, and the primary benefit goes to the social community.

The assessment of traffic-technological investment projects means a number of activities whose aim is to determine the justification and feasibility of the project. In operative sense, the assessment can be defined as the phase of planning the investment project in which certain activities are performed, such as defining the objectives of development within which the investment project is planned, defining of criteria and the selection of methods for project assessment, developing of documentation and information basis for the application of the assessment methods, implementation of criteria and methods, proposal of the order of implementing the projects, making of investment decision (positive or negative). [1]

Making the investment decision is an extremely complex process, and represents the result of a selection among several possible decisions that are available. This means that the decision-making process is in close relation with the optimization process, whose basic task is to select the best solution from a number of possible (or favourable) ones, regarding the adopted criterion, whereas from the mathematical aspect the term optimization means searching for the extreme criterion function under the given conditions and restrictions.

Therefore, in order to make a high-quality investment decision in the field of transport, the assessment and evaluation of the traffic-technological projects should be based on relevant scientific methods.

## 2. TRAFFIC-TECHNOLOGICAL INVESTMENT PROJECTS

Investment project represents a well thought set of related and time-distributed interdisciplinary activi-

ties which are used to plan the realization of development objectives and within which the capital is used.

As part of investment projects the information--documentation basis for making investment decisions is made, and it includes a number of different procedures during the defined time period of the project, and regarding the resulting effects, it is considered and assessed from the aspect of the investor (financial-market analysis), but also of the social community as a whole (social-economic analysis). [2]

Investment project is the basic guideline of every entrepreneurial venture, since only by planning and analysing all the details of the future venture is it possible to see whether the realization of the investment idea is justified and realistic. Also, the development of the Investment projects is legally regulated (Act on Public Purchase)[1]. [3]

Since traffic-technological projects are in one part also investment projects, because they serve the investor in the assessment of the profitability of building a facility, all this shows their significance in the investment process, which requires the application of scientific methods in their development and selection, in order to obtain high-level quality of project documentation, including the project itself, which is the only way of finding long-term high-quality solutions.

## 3. METHODS FOR ASSESSMENT OF TRAFFIC-TECHNOLOGICAL INVESTMENT PROJECTS

Methods applied in the process of assessing the traffic-technological investment projects, including making of investment decisions, are numerous, and usually differ in optimization criteria. The projects, namely, can be assessed through the prism of one criterion, as well as on the basis of several criteria. The most frequent optimization criterion is of economic character. However, for the purpose of long-term and high-quality solutions the introduction of several optimization criteria is necessary. Thus, apart from the economic criterion, the technological, technical, ecological and a number of other criteria are also significant.

Regarding the wide range of methods, the work presents and applies three methods; SWOT analysis, cost-benefit analysis and multi-criteria analysis.

### 3.1. SWOT[2] analysis

SWOT analysis is an advanced method for analysing the selected strategies and situations, and represents a comprehensive description of the characteristics of the object of analysis and as such it can be part of analytical decision-making. This method is used to analyse the factors that determine the strength of the object of analysis, its weaknesses, unused opportunities and possible threats, i. e. dangers, and their critical analysis gives the basis for developing a strategy. The answers obtained by the SWOT analysis should be used in the next phase to make important strategic decisions, define the mission and vision, future objectives, and the strategy which will all help in realising the set objectives. In this method, the data are organised in the so-called SWOT matrix (Table 1).

**Table 1 - The basic SWOT matrix**

| Internal factors / External factors | Strengths (S) | Weaknesses (W) |
|---|---|---|
| Opportunities (O) | S – O strategy | W – O strategy |
| Threats (T) | S – T strategy | W – T strategy |

### 3.2 Cost-benefit analysis

The cost-benefit analysis is a methodological procedure for making rational investment decisions and represents a procedure of determining the social costs and social benefits in the public sector. The focus is on maximizing social benefits. The function of objective is usually the growth of social product, national revenue or raising of quality of the public good. The cost--benefit analysis provides the assessment of relative value of changes in relation to the existing or proposed situations or projects. It is used to methodologically examine the costs, benefits and risks of all the options, and to determine the cost-most efficient methods of achieving the set goals. The basic characteristic of this method is to determine, harmonise and evaluate all the advantages and drawbacks of a project, in order to use this basis to determine the outcome of the investment project, which allows making of the decision about the realization of the project. The relation between the costs and benefits should be the criterion of making the decision about the economic justification of the project.

The cost-efficiency of several years of investments, i. e. long-term investments, is evaluated by means of several indicators which are usually:

- internal rate of return,
- net present value,
- relative net present value, and
- payback period. [4]

### 3.3 Multi-criteria analysis (Analytical Hierarchical Process)

Multi-criteria decision-making represents an optimization process of one or several functions of objective on a set of possible solutions. From the aspect of its description using the mathematical model, multi-criteria decision-making is divided into multi-objective decision-making and multi-attribute decision-making (multi-criteria analysis).

The mathematical model of the multi-criteria analysis is expressed in the following form:

$$\max\{f_1(x), f_2(x), \ldots f_k(x) k \geq 2\}, \quad k \geq 2 \tag{1}$$

with constraints:

$$x \in A = [a_1, a_2, \ldots, a_m] \tag{2}$$

where:

$k$ – number of criteria, $j = 1, 2, \ldots, k$
$m$ – number of alternatives, $i = 1, 2, \ldots, m$
$f_j$ – criteria, $j = 1, 2, \ldots, n$
$a_i$ – alternatives for consideration, $i = 1, 2, \ldots, m$
$A$ – set of all alternatives

Usually the multi-criteria analysis model is presented by an adequate matrix of the criteria values for single alternatives.

For the solving of multi-criteria analysis problem, the methods ELEKTRE I–IV, PROMETHE I–IV, Analytic Hierarchy Process (AHP) and the multi-criteria Compromise Ranking method (VIKOR) are usually applied.

The Analytic Hierarchy Process (AHP method) is one of the most frequently used methods of multi-criteria analysis. It allows for the flexibility of the decision-making process and assists the decision-makers in setting the priorities, and in making the best decision taking into consideration both the qualitative and the quantitative aspects of the decision.

The procedure of determining the best variant by using the Analytic Hierarchy Process understands: [5]

- defining of hierarchical structure based on the determined function of objective, alternative, criteria and sub-criteria (Figure 1),

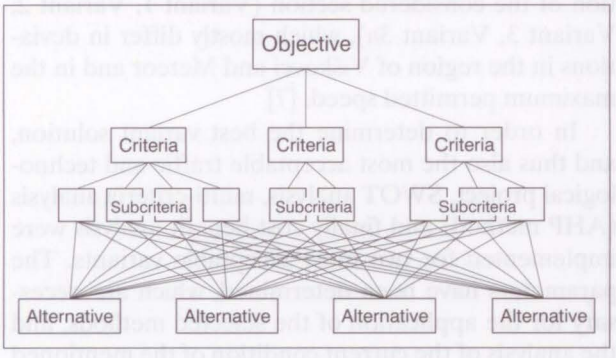


Figure 1 - Hierarchy of decision-making

- defining of the relative importance of criteria (and sub-criteria) compared to the objective of research, i. e. criteria ranking (Saaty scale)[3],
- ranking of alternatives regarding single criteria,
- calculation of the total priority for each alternative,
- verification of consistency,
- selection of the best alternative based on the defined total weight priority vector by synthesis of all weight vectors, and it is described by the following expression:

$$W_i = \sum_{j=1}^{n} c_j w_{ij}, \quad \forall i = 1, \ldots, m \tag{4}$$

where:

$W_i$ – weight, priority of alternative $i$,
$c_j$ – weight of criterion $j$ ($j = 1, 2, \ldots, n$),
$w_{ij}$ – weight of alternative $i$ regarding criterion $j$
$m$ – number of alternatives
$n$ – number of criteria.

For the solving of the problems of multi-criteria analysis the software packages have been developed as tools that assist the decision-maker. AHP method has been implemented in the software package Expert Choice which fully supports all the steps characteristic for its application. Special significance of the program lies in the possibility of performing detailed analyses of sensitivity that are based on the visualization of the consequences of the changes of input parameters, and is presented through four options (Performance, Gradient, Dynamic, Head to Head). [6]

### 3.4 Comparison of the mentioned methods and order of their implementation

After having selected the scientific methods that are applied in order to evaluate and assess the projects, it is essential to determine also the order of their implementation. The selected methods in the work have seemingly no major common contact points and differ completely regarding their characteristics and principles. However, although essentially different, if they are applied in combination, then they supplement each other and thus gain in significance.

SWOT analysis is used when it is necessary to give qualitative description of the object of study, analysing the factors that determine the strength of the object of analysis, weaknesses, unused opportunities and possible threats i. e. dangers, whose critical analysis and confrontation provide the basis for the development of a strategy. Since this analysis does not give any specific answers, but rather represents the method of efficient organization of information and sensitive characteristics as the database for the building of a business strategy and operative plans, it may in this way be

the basis for the application of other methods, including the method of cost-benefit analysis, as well as the multi-criteria decision-making method. The cost-benefit analysis is an almost ideal method for the presentation of parameters through a financial prism, since this method can be used to reduce all the parameters to the common denominator – money. The multi-criteria decision-making methods are used when all the indicators cannot be presented through a single criterion (usually through the prism of money), but the weights of certain criteria are rather determined in various ways, and evaluated or distributed within individual criterion.

Based on this, the order of the implementation of the mentioned methods in the evaluation and assessment of the traffic and technological projects can be determined. The idea is to apply first the SWOT analysis, and thus present single variants qualitatively and thus rank them. Then, independently of the SWOT analysis results, follow the methods of multi-criteria decision-making, i. e. multi-criteria analysis and finally the cost-benefit analysis.

The proposed order of implementing the selected methods does not have to be only such, but depends on the projects that are evaluated. Therefore, the variant is also acceptable according to which the second step applies the cost-benefit analysis, and in the third the multi-criteria analysis. In this case, the economic criterion is one of the defined criteria of the multi-criteria analysis, and its sub-criteria can then be economic indicators in the dynamic approach, and these are the internal rate of return, net present value, relative net present value and the payback period.

Furthermore, if a greater number of projects is evaluated with the final aim of selecting the most acceptable one, it is not necessary to evaluate every project by each selected method, but some projects can be eliminated already after the first or second step, i. e. after the application of the SWOT and multi-criteria analyses.

## 4. APPLICATION OF SELECTED METHODS IN SOLVING A CONCRETE TRAFFIC PROBLEM (CASE STUDY OF SELECTING THE RAILWAY LINE RECONSTRUCTION VARIANT)

In order to avoid the mentioned methods becoming an end in itself, it is necessary to consider the possibilities of their implementation in solving concrete traffic problems. Therefore, they are applied for the purpose of traffic and technological investment projects and the selection of the best variant solution.

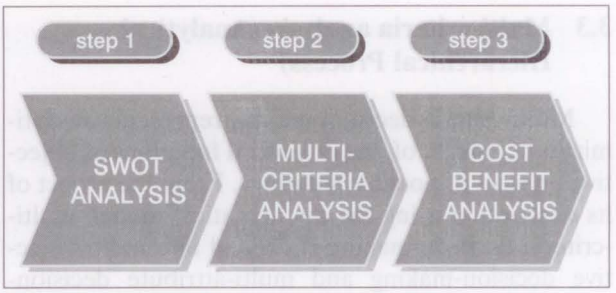


Figure 2 - Order of implementing the selected methods

Croatia plays an important role within the international traffic routes, and apart from the most significant Corridor X, Corridor V. c is also of great importance. Line section Osijek – Strizivojna/Vrpolje, as part of Corridor V. c, has to satisfy certain technical and exploitation criteria, and since it is in extremely poor condition, it has to be reconstructed and modernized, in order to satisfy the stipulated parameters of AGC and AGTC agreements.

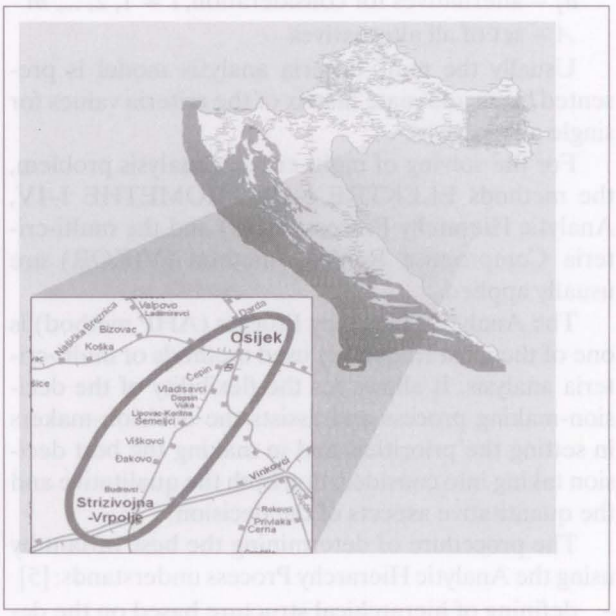


Figure 3 - Position of the line section Osijek – Strizivojna/Vrpolje

There are four solution variants for the reconstruction of the considered section (Variant 1, Variant 2, Variant 3, Variant 3a), which mostly differ in deviations in the region of Viškovci and Meteor and in the maximum permitted speed. [7]

In order to determine the best variant solution, and thus also the most acceptable traffic and technological project, SWOT analysis, multi-criteria analysis (AHP method) and finally cost-benefit analysis were implemented for two most acceptable variants. The parameters have been determined, which are necessary for the application of the selected methods, and the analysis of the current condition of the mentioned section, basic characteristics of the future condition of

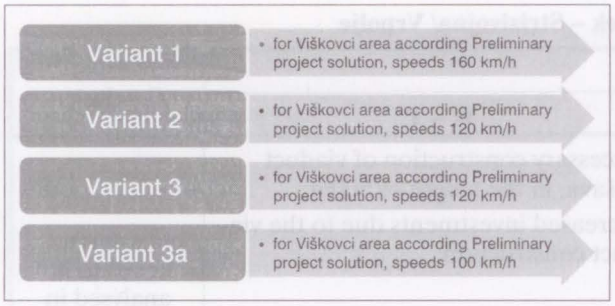


Figure 4 - Variants of technical-technological solutions on railway line route

the railway line, and technical and technological characteristics of the variant solutions are determined.

The line reconstruction will ensure new quality of service in railway transport (safety, reliability, comfort, wide range of additional services onboard train and at stations), competitiveness on the market in the sphere of passenger and cargo transport (acceptable length of travel and price of transport), more efficient railway transport, connection of states and regions across borders, and will also have positive effect on the environmental protection. [8]

### 4.1 Application of SWOT analysis

SWOT analysis defines the strengths, weaknesses, opportunities, and threats of every variant, and these are presented in the so-called modified SWOT matrix (Table 2). This analysis has shown that Variants 1 and 3, regarding technical and technological characteristics, are acceptable, and need to be analysed further in more detail, whereas Variants 2 and 3a have extremely poor technical and technological characteristics. It is therefore suggested that they should be left out from further analysis.

### 4.2 Application of multi-criteria analysis (AHP)

After having evaluated the project by SWOT analysis, in the next step the projects are evaluated by the multi-criteria analysis. The hierarchic structure of the multi-criteria analysis model used in the selection of the reconstruction projects on the line section Osijek – Strizivojna/Vrpolje is presented schematically in Figure 6.

The results of calculating the weights of criteria and alternatives regarding single criterion, are presented in Figure 7.

After having calculated the alternatives priority regarding single criterion, a calculation of the total priorities of alternatives is performed in order to obtain a final solution, i. e. the best alternative, according to template (4). Finally, the alternative priorities have been obtained (Figure 8), according to which Variant 1 has the highest weight (weight 0.45036).

By applying the Analytic Hierarchic Process as the multi-criteria analysis method with the aim of selecting the reconstruction project on the line section Osijek – Strizivojna/Vrpolje a result has been obtained according to which the best project is Variant 1, i. e. project which allows speeds of 160 km/h in the area of Viškovci and Meteor.

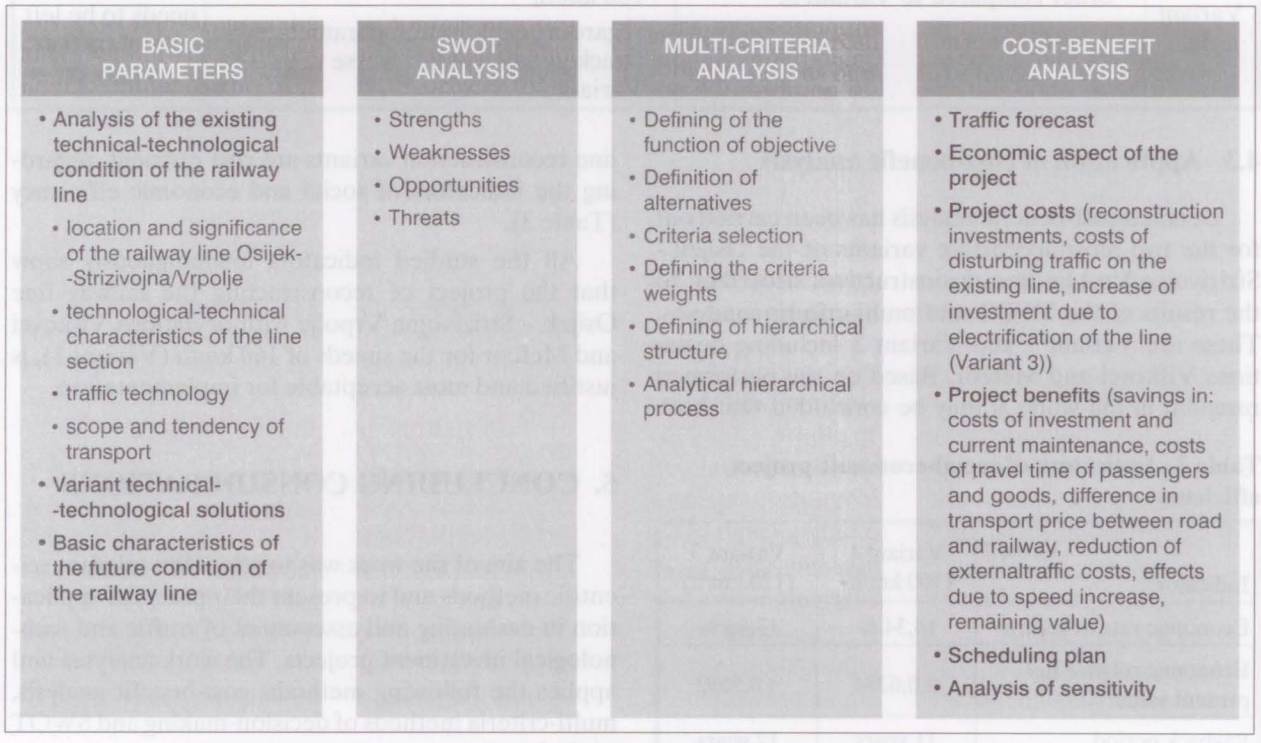


Figure 5 - Parameters relevant for the application of selected methods

**Table 2 - "Modified" SWOT matrix for railway line Osijek – Strizivojna/ Vrpolje**

| Variant | Strategy | | Conclusion |
|---|---|---|---|
| | S – O | W – T | |
| Variant 1 | – allows maximal speeds of 160km/h,<br>– provides best exploitation conditions because the track level and track geometry are much more favourable not only in relation to the existing line but also in relation to other variants<br>– at Viškovci there is no level crossing, thus increasing safety. | – necessary construction of viaduct Jošava, in the length of 500m,<br>– increased investments due to the viaduct construction. | this variant needs to be analysed in more detail |
| Variant 2 | | – allows maximal permitted speeds of 120 km/h,<br>– regarding exploitation parameters – track level and track geometry it is worse than Variant 1,<br>– acc. to this variant, a viaduct is required almost the same length as according to Variant 1 (500m). | this variant needs to be left out of further analysis |
| Variant 3 | – according to exploitation parameters (track level and track geometry) it is better than Variant 2,<br>– regarding investments it is less than in Variant 1 | – allows maximal permitted speeds of 120 km/h,<br>– regarding exploitation parameters (track level and track geometry) it is worse than Variant 1,<br>– it requires viaduct of the length of about 200m,<br>– significant restoration of swamp land in front and behind the viaduct. | this variant needs to be analysed in more detail |
| Variant 3a | – regarding investments it is of lower order compared to Variant 3. | – allows maximal permitted speeds of 100 km/h,<br>– regarding exploitation parameters (track geometry) it is worse than Variant 3. | this variant needs to be left out of further analysis |

### 4.3 Application of cost-benefit analysis

Detailed cost-benefit analysis has been carried out for the two most acceptable variants of the Osijek - Strizivojna/Vrpolje line reconstruction, according to the results of the SWOT and multi-criteria analyses. These are Variant 1 and Variant 3 including deviations Viškovci and Meteor. Based on the performed research in the work, it may be concluded that both line reconstruction variants are cost-efficient, regarding the indicators of social and economic efficiency (Table 3).

**Table 3 - Indicators of social-economic project efficiency**

| Variant / Indicator | Variant 1 (160 km/h) | Variant 3 (120 km/h) |
|---|---|---|
| Economic rate of return | 14,34 % | 13,86 % |
| Economic relative net present value | +0,6284 | +0,5693 |
| Payback period | 11 years | 12 years |

All the studied indicators unambiguously show that the project of reconstructing the railway line Osijek – Strizivojna/Vrpolje with deviations Viškovci and Meteor for the speeds of 160 km/h (Variant 1), is justified and most acceptable for implementation.

## 5. CONCLUDING CONSIDERATIONS

The aim of the work was to select the relevant scientific methods and to present their practical application in evaluating and assessment of traffic and technological investment projects. The work analyses and applies the following methods: cost-benefit analysis, multi-criteria methods of decision-making and SWOT analysis.

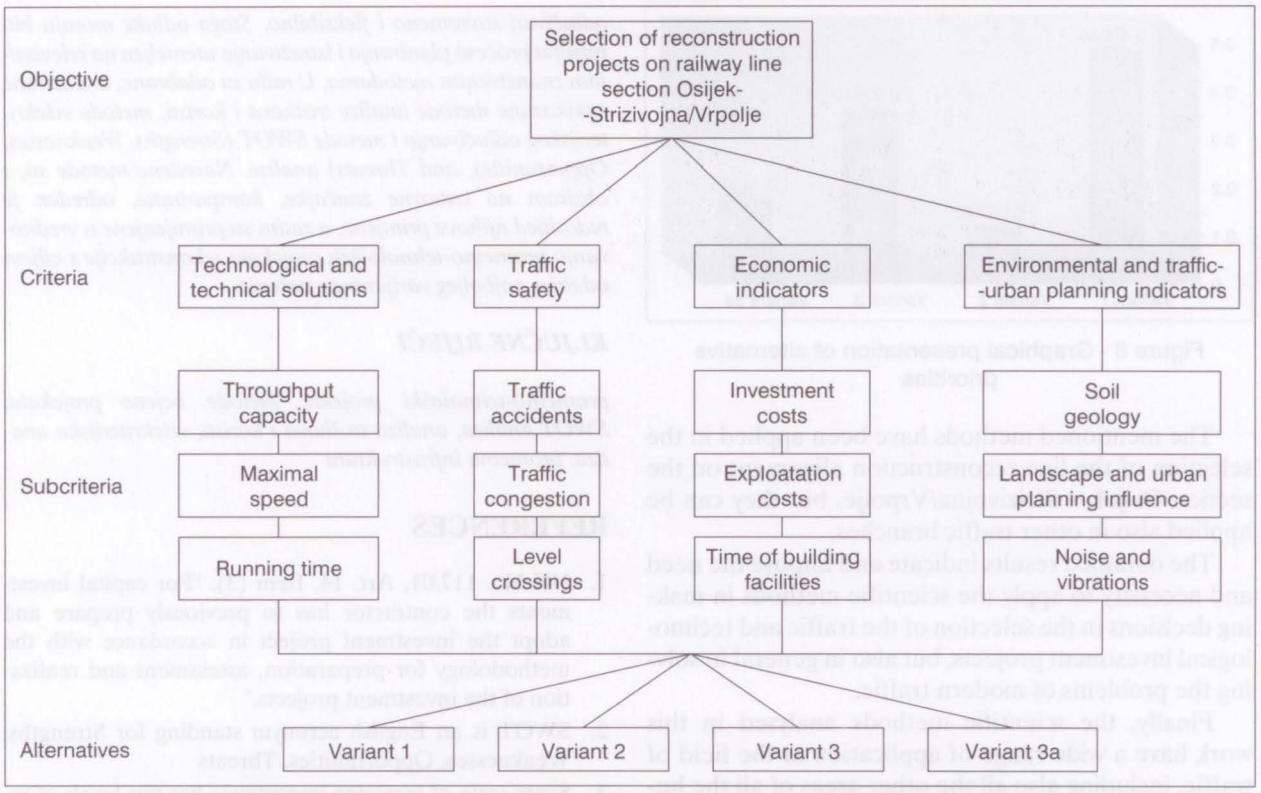


**Figure 6 - Hierarchic structure of multi-criteria analysis model in the selection of reconstruction projects on the line section Osijek – Strizivojna/Vrpolje**

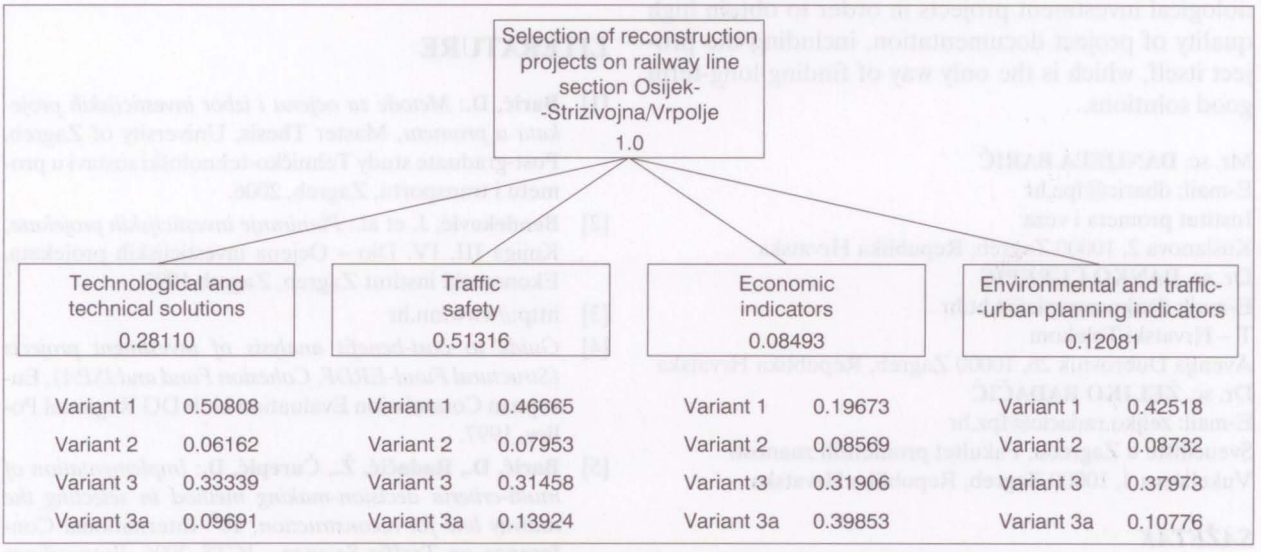


**Figure 7 - Weights of criteria and alternatives depending on single criteria**

Regarding the optimization criteria, there is no universal method. The usual criterion of optimization is of economic character, i. e. financial value, and on this single criterion the cost-benefit analysis is based, i. e. it presents the parameters through a financial prism. Since every element cannot be always expressed and evaluated financially (e. g. impact on the environment as external traffic effect), all the indicators cannot be presented through one criterion, i. e. reduced to a common denominator and presented through the prism of money; therefore, there is a need to introduce several criteria, which is the basic characteristic of the multi-criteria analysis. SWOT analysis gives a qualitative description of the objects of research.

Since no method is universal, they should be applied in combination, with the aim of obtaining maximally correct data, which are the basis for making a high-quality investment decision, with focus on determining the order of the application of each one.

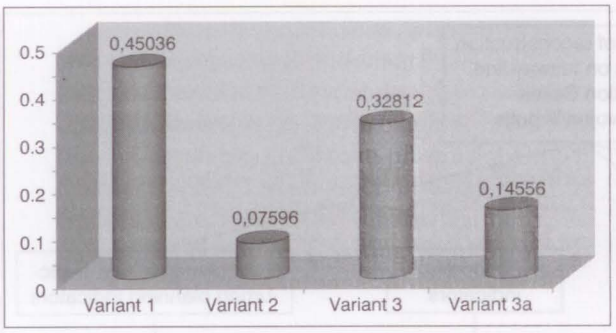


Figure 8 - Graphical presentation of alternative priorities

The mentioned methods have been applied in the selection of the line reconstruction alignment on the section Osijek – Strizivojna/Vrpolje, but they can be applied also in other traffic branches.

The obtained results indicate and impose the need and necessity to apply the scientific methods in making decisions in the selection of the traffic and technological investment projects, but also in general in solving the problems of modern traffic.

Finally, the scientific methods analysed in this work have a wide range of application in the field of traffic, including also all the other areas of all the human activities. This implies the necessity and need for their changes in the evaluation of the traffic and technological investment projects in order to obtain high quality of project documentation, including the project itself, which is the only way of finding long-term good solutions.

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***SAŽETAK***

***PRIMJENA RELEVANTNIH METODA KOD OCJENE PROMETNO-TEHNOLOŠKIH PROJEKATA***

*Ocjena investicijskih prometno- tehnoloških projekata podrazumijeva skup aktivnosti čiji je osnovni cilj utvrditi opravdanost i prihvatljivost projekta. Proces odlučivanja, a time i donošenja investicijske odluke izrazito je složen, a donositelj odluke, mora imati viziju budućnosti, pa u skladu s time i odlučivati suvremeno i fleksibilno. Stoga odluke moraju biti rezultat procesa planiranja i istraživanja utemeljen na relevantnim znanstvenim metodama. U radu su odabrane, analizirane i prikazane metode analize troškova i koristi, metode višekriterijskog odlučivanja i metode SWOT (Strengths, Weaknesses, Opportunities, and Threats) analize. Navedene metode su, s obzirom na osnovne značajke, komparirane, određen je redoslijed njihove primjene, a zatim su primijenjene u vrednovanju prometno-tehnoloških projekata rekonstrukcije s ciljem odabira najboljeg varijantnog rješenja.*

***KLJUČNE RIJEČI***

*prometno-tehnološki projekti, metode ocjene projekata, SWOT analiza, analiza troškova i koristi, višekriterijska analiza, prometna infrastruktura*

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