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SUSTAINABLE ROADS - PART OF THE TRANSPORT CHAIN IN A GLOBALISED WORLD

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Abstract

The Pan-European transport corridors as an important EU-policy instrument connect the European capitals providing thus a favourable integration of the European area. Slovenia's advantageous position at the crossroads of the Fifth and Tenth Transport Corridor ensures excellent conditions for the integration of the country into the European transport system. The motorway construction in these corridors is in its final phase and the missing railway link to Hungary has been completed. However, the infrastructure networks bring most benefits to major centres located along the corridors, which enable them a favourable connection with other major centres. Contrary to this, smaller centres in the hinterland, which are not connected with the corridors, may get into an even worse competitive situation. The paper presents Slovenia's attempt to use an integrated approach in the transport infrastructure development planning, which includes not only the existing transport demand but also developmental and protection aspects. The first problem to be solved is to find out, which principles should be used in order to choose the potential candidate alignment alternatives, which could reveal the best development effects. The second essential problem is how to select the best candidate alternative. The paper emphasizes the essential methodological novelties, used in Slovenia in the search for these answers and supposed to ensure a selection in line with sustainable development principles. These methods are: formation and evaluation of scenarios and assessment of development effects on the basis of the land use model.

1. INTRODUCTION

The Pan-European transport corridors as an important EU-policy instrument connect the European capitals providing thus a favourable integration of the European Region. Slovenia's advantageous position at the crossroads of the Fifth and Tenth Transport Corridor ensures excellent conditions for the inclusion of the country into the European transport system. The motorway construction in these corridors is in its final phase and the missing railway link to Hungary has been completed.

However, the Pan-European infrastructure networks bring most benefits to major centres located along the corridors, which enable them a favourable connection with other major centres. Contrary to this, smaller centres in the hinterland, which are not connected with the corridors, may get into an even worse competitive situation. The questions of transport infrastructure impacts on the regional development have been extensively dealt with in the literature (OECD, 2002), so from the viewpoint of growth theory as well as from the viewpoint of economic geography. An efficient transport system enables the use of economic and social opportunities, by which it exerts influence on the entire society. A deficient transport system, however, can result in economic costs in the form of reduced or missed opportunities. Naturally, the social and environmental loads connected with the transport system must not be ignored.

In general, transport impacts can be divided into two groups:

a) directs impacts relating to better accessibility of markets due to shorter transport times and lower transport costs for providers or direct users of transport services, and
b) indirect impacts, shown on the level of each individual (wider assortment of products, lower prices, land price premium) or country or region (improved competitiveness, mobility, creation of distribution networks etc).

The improved transport infrastructure means its higher capacities, efficiency and reliability (i.e. a reduction of transport risks, which is particularly important in the era of the integration of manufacturing-service systems into supply chains).

The direct benefits for companies in the area, in which the transport infrastructure efficiency has been improved, are derived from two sources (Goodbody, 2003):

- improved efficiency in the product market, which results in lower purchase costs of input materials and lower delivery costs of manufactured goods, which widens the potential market of these companies; and
- improved labour market efficiency, for the costs of the access of the labour force are reduced, i.e. the accessibility of a certain location for the labour force is improved.

These benefits can improve the market efficiency of existing companies and stimulate the arrival of new companies in the area. The awareness of these facts has been growing in the last 5 years in Slovenia, too. The economic centres, which are not situated directly along the transport corridors, have realised that a low quality level of transport connections with the international corridors means worse competitiveness, in spite of the fact that they fulfill other preconditions, necessary for the development (educated people, land plots necessary for development etc.). As a result of this, an idea has sprung up in the public on the so called Third Development Axis, which should connect the secondary centres between the corridors, as well as their development potentials, and simultaneously bind them with the network of the Pan-European connections, i.e. with the Fifth and Tenth Pan-European Transport Corridors and the Adriatic-Ionic transport axis. By means of improved accessibility and strengthening of institutional and economic connections the competitiveness of the region along this development axis would increase. The third development axis is becoming an instrument, which should contribute to the economic, social and territorial cohesion and more balanced development of the European Area.

In its northern part, the third development basis is connected to the road network of Austrian Carinthia, while through Slovenj Gradec and Velenje it reaches the Fifth Corridor at Celje. Further in the direction towards south it connects with the Tenth Corridor at Novo mesto and runs towards Karlovac, i.e. towards the connection with the Zagreb–Rijeka motorway. The new development transport axis connects the regional centres in the Austrian Carinthia, i.e. Villach and Klagenfurt, with Dravograd, Slovenj Gradec, Velenje, Celje and Novo mesto in Slovenia, and Karlovac and Rijeka in Croatia. It attracts freight and passenger transport from all regions along this axis and leads it further to main European transport routes.

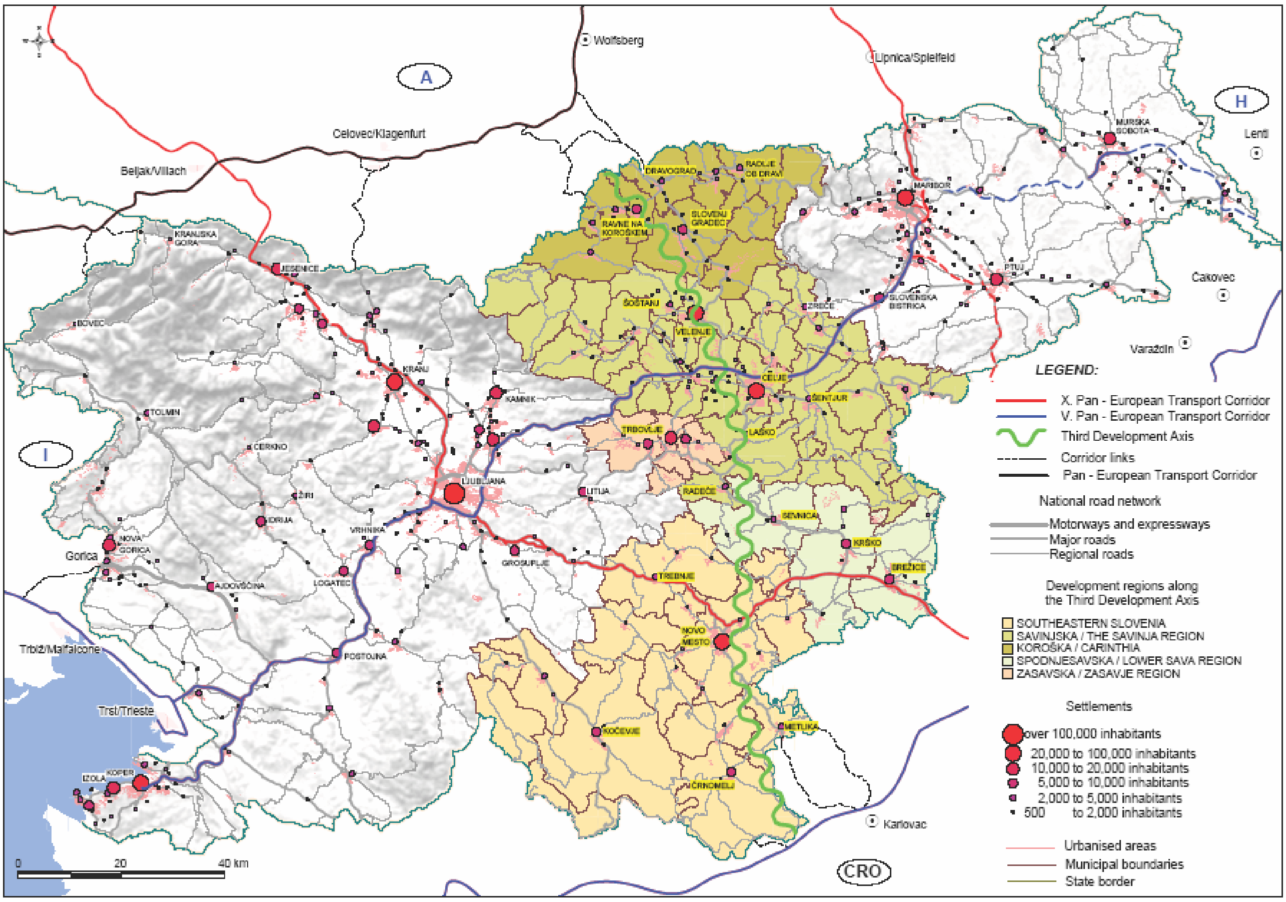


Figure 1 – The spatial position of the third development axis

In 2006, a strategic study was elaborated on the transport infrastructure development in the area of the third development axis in Slovenia (Omega Consult, 2006). The project of the integral development of the third development axis area is from the viewpoint of its content as well as of the area of discussion, an extended research of several development scenarios of transport supply, made for the purpose of ensuring the content- and area-related integrity in putting in place the national development plans. A successful realisation of the development axis does not depend only on an improved transport supply, but requires also the linkage of individual sectorial approaches to a common and coordinated development vision. The aspects of particular importance in dealing integrally with the area along the third development axis are economy, transport, tourism in connection with the cultural landscapes, nature and cultural heritage, as well as urban and environment development.

The purpose of the study was to prepare the technical bases for the definition, evaluation and mutual comparison of particular scenarios of transport supply development in the third development axis and to propose the most adequate scenario, which would ensure an adequate contribution of the transport infrastructure to the sustainable development of the area dealt with. The assessment of the efficiency and successfulness of a particular scenario is performed from the viewpoint of transport efficiency as well as from the environmental, spatial and developmental aspect. In the past the developmental aspect was not adequately dealt with. In spite of the fact that the literature offers several adequate methodologies to deal with this kind of issues, it was dealt with only on the level of descriptive discussion or analysis.

The objectives of the study were:

1. to define the potential scenarios of the transport supply development in the third development axis;
2. to design methodologies and indices for the evaluation of the transport supply development scenarios in the third development axis;
3. to evaluate various transport supply development scenarios in the third development axis on the basis of the indices defined and to propose the selection of the most adequate scenario with giving reasons for the proposal;
4. to define the projects on the improvement of the transport supply in the third development axis for the 2007 – 2013 financial perspective.

In the continuation the paper presents the key parts of the study and its results, its key findings as well as the interpretations of the results obtained.

2. TRANSPORT INFRASTRUCTURE DEVELOPMENT SCENARIOS

In the study presented several methods were used, which had not been implemented in the practice in Slovenia by that date. The first of these methods is intended for the development of the scenarios of the integration of transport links into the area. These scenarios differ from one another with regard to the aims to be attained through the connection of two points in the area. The aims can be very different; they can be even mutually opposing, e.g. provision of connections between individual centres, reduction of transport costs, environment protection etc. Examples of scenarios can thus be: the minimum environmental burden scenario, the minimum investment value scenario, the best possible accessibility scenario and similar. The physical appearance of the scenario in the area is a corridor. The scenario of the transport infrastructure development means the integration of the corridor into the area at certain parameters, which reflect the infrastructure development objectives. Further, the paper presents the setting of a preliminary alignment alternative into the area.

In the last decade, quite a number of trunk roads with far-reaching effects have been built in Slovenia. In the planning of their layout the conventional engineering approach was used. The planner was given certain points, which he had to connect, and certain directions which he had to observe with regard to the environmental protection regime, and then he selected the potential alignment courses with regard to terrain characteristics. In the past, the developmental aspect was thus not adequately observed, i.e. it was paid attention to only on a level of a descriptive discussion or analysis, although the literature offers several adequate methodologies for dealing with this kind of issues. The consequences of such an approach were long discussions on the most adequate alternatives, searching for additional alternatives, discontentedness of local communities, and consequently, such proceedings were long lasting and expensive. Naturally, we will never find out, what the opportunity costs of non-optimal decisions were, due to which the inputs into the transport infrastructure development (most probably) were not optimally utilised. The presented approach to the transport infrastructure development scenarios tries to offer an adequate strategic basis for the planning of arterial roads. It takes into consideration the objectives to be achieved by means of a certain connection in a longer period of time, i.e. the objectives, which are not only transport-related, as well as the methods to achieve these objectives. The selected corridor should ensure not only the best possible conditions for the existing transport, but should enable also better conditions for the future development.

2.1. The procedure of defining the alignment of a road connection

The defining of the connection between two definite points is a procedure, in which a series of restriction factors has to be observed. The procedure presented hereinafter, is in principle adequate for all transport forms. Our wish in selecting the course of the transport connection is to minimise costs on the one hand, and to maximise efficiency on the other hand:

1. The cost minimisation includes the costs throughout the lifetime, which comprises the construction and the operation of the infrastructure. The shortest connection is not necessarily the cheapest one, either due to the terrain characteristics or to environment protection costs.
2. The efficiency maximisation comprises several transport infrastructure aspects or impacts. Although the alignment course is longer, which results in higher investment and operating costs, such an alignment can be more efficient from the viewpoint of the arrangement of activities in the area, environment protection, etc.

The selection of the transport infrastructure courses will always have to be a matter of compromise between the costs and efficiency of this infrastructure. In some cases the shortest alignment may be also the most efficient one, while in other cases it may be difficult to reach a compromise due to the contradiction between the price and efficiency. Therefore a multi-criteria decision procedure is used in the selection of transport corridors. The procedure includes several appropriately weighed aspects, i.e. restrictions in the integration of the corridor in the area (Fig. 2). The applied method is derived from Rodrigue's method (2006).

Rodrigue introduces the following criteria of the integration of the corridor into the area:

1. the terrain, which represents various physical restrictions;
2. the environment, which represents a value, which should be protected, however, in the construction of the transport infrastructure it is necessary to reckon with some environmental damage;
3. the arrangement of economic activities in the area, to which the new infrastructure would primarily serve; and
4. the political aspect (political preferences with regard to the course of the transport connection).

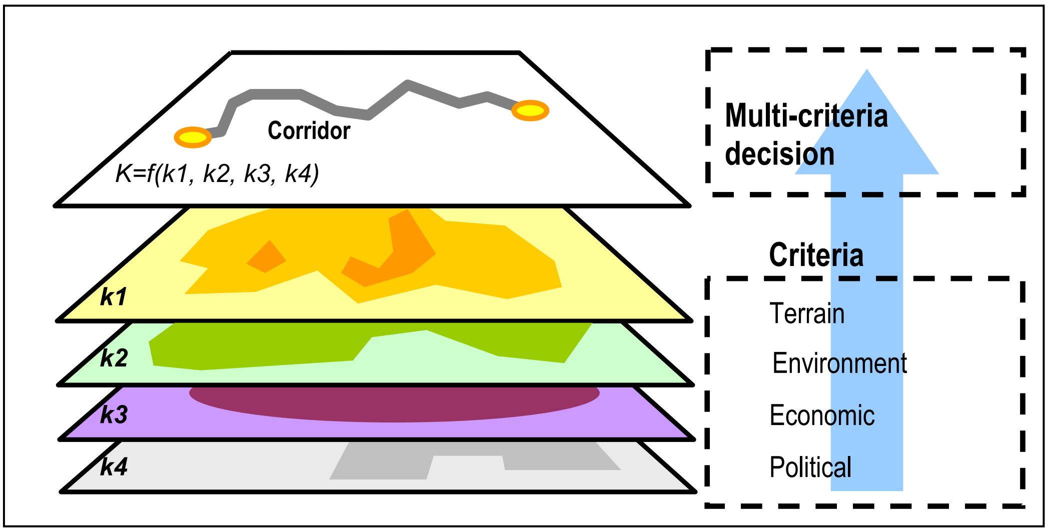


Figure 2 – The procedure of multi-criteria decision making on the integration of the corridor into the area *(Source: Method adapted according to Rodrigue)*

The method is implemented by means of the geographic information system tools. It is of an "open type", which means that the methods allows the inclusion of additional criteria relevant for the integration of the corridor into the area, the impact of which had not been comprised within the criteria mentioned above.

The natural characteristics of the terrain condition the construction costs and the infrastructure operating costs. The main problems are the overcoming of altitude level differences (which extends the length of the alignment and requires the construction of structures such as tunnels, viaducts, cuts, revetment walls etc.), the overcoming of the ground of low bearing capacity and the overcoming of surface water-flows. Each of the above mentioned measures reflects in additional costs per infrastructure construction unit. This enables the selection of an optimum corridor course from the so called technical aspect, that is the minimisation of the costs of construction and operation.

The environment is a value, which we, in principle, should protect. In certain parts it represents an eliminative, i.e. a protected area, in which the transport infrastructure can not be built in any case. In other parts encroachments are permissible, but not desired. In such areas the relative rareness of the protected environment components should be defined and evaluated. This enables the searching of an optimum corridor course at the highest acceptable volume of environmental damage (e.g.: 0.25 units per km).

One of the key motives for the transport infrastructure construction is undoubtedly the economic one. This is stronger in the areas with a greater economic activity (expressed in the number of working places, added value, etc.) and in the areas of greater settlement centres. The initial goal in this case is that the new connection should integrate these economic and settlement centres as much as possible. This may require longer and more expensive alignments due to which it will never be possible to ensure a complete connectedness. However, the level of connectedness can be presented with a parameter of the connectedness of the centres, expressed with a portion of units, comprised in a certain strip along the new connection. This enables the searching of an optimum corridor course at a certain level of the connectedness of particular economic and settlement centres (e.g. 60 % of population within a 5 km strip along the transport connection).

In integrating the new transport connection into a certain area, it is usual that in addition to the views connected to the economic and environmental aspects, individual entities involved have even other views of these problems. These views reflect in the level of desirability or undesirability of the transport connection in a certain area, however, they are usually not a binding or eliminating factor. The desirability level is expressed through public declarations of standpoints (e.g. statements, decisions etc. of local self-management bodies) or through adopted planning documents. In such areas the level of (un)desirability should be estimated and evaluated in the numerical (or also monetary) expression. This enables the searching of an optimum corridor course from the political viewpoint, i.e. the minimization of the costs of construction and operating at given political preferences.

On the basis of the above presented data, it is possible to make a composite map of the area, into which the new transport connection should be integrated. It is proven that the optimum corridor alternative is the alternative, in which the sum of costs at given parameter values of permitted environmental damage and the desired connectedness of particular influence areas, is smallest. Particular transport infrastructure development scenarios will differ from one another with regard to the value of key parameters, which influence the selection of the cheapest route, i.e. the environment protection level and the connectedness level of particular influence areas. The potential scenarios are, for example, a scenario of maximum environment protection (permissible environmental damage near 0), a scenario of maximum accessibility (portion of connected population near 100%); a scenario of minimum costs (environment and connectedness criteria should be excluded from the analysis), etc. Various combinations of parameter values will show the envelopment of potential corridors, inside which it will be possible to select one or several most adequate corridors by means of evaluation.

The necessary digitalized graphic data bases are as follows:

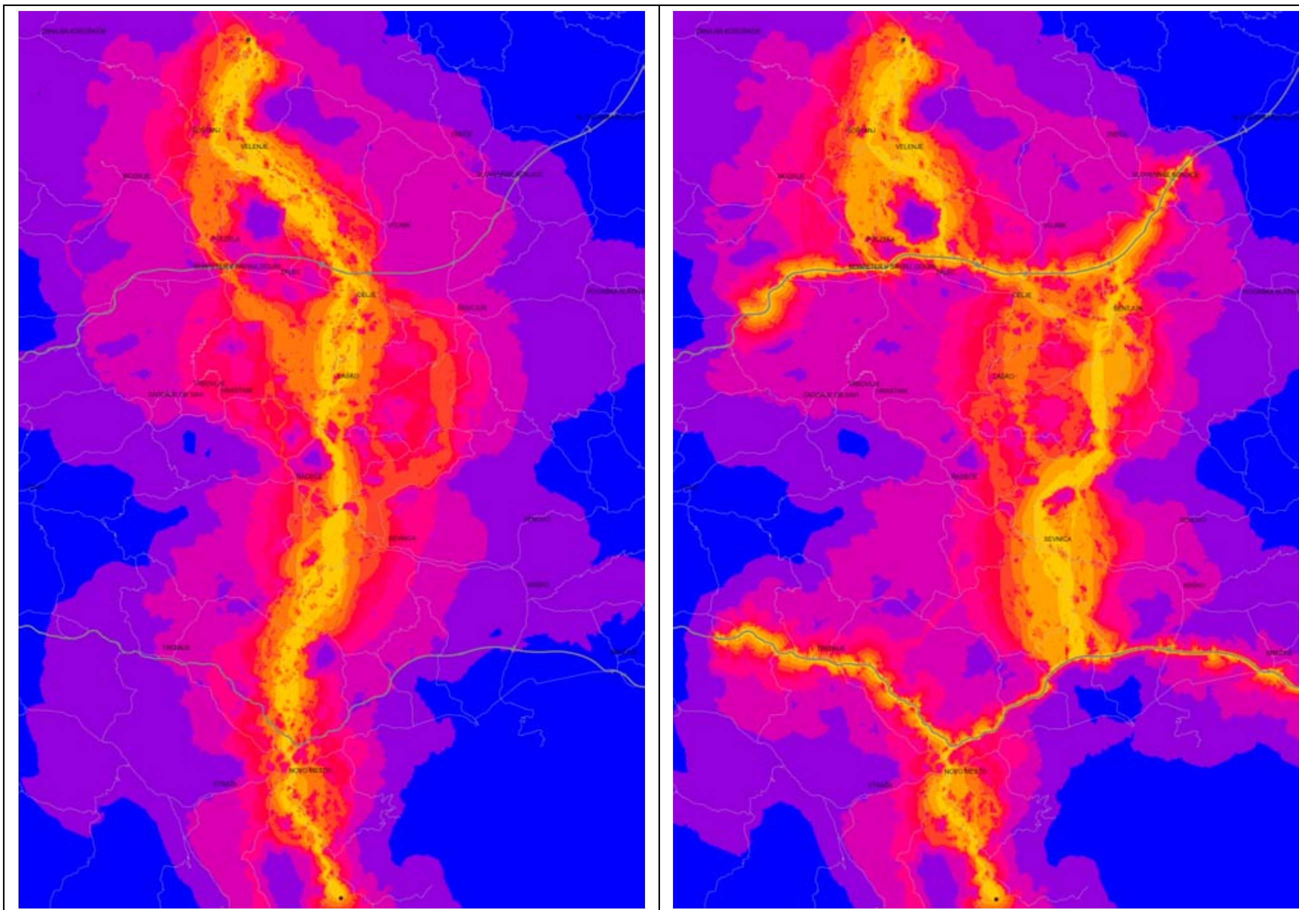
- relief, register of structures,
- population and working places at the level of settlements,
- road network,
- ecologically important areas in Natura 2000, protected nature areas, nature and cultural heritage,
- hinterlands and water protection zones, accumulation lakes and water streams,
- best agricultural land plots, forests (reservations and protection forests),
- endangered zones (floods, landslip and erosions zones),
- zones, intended for the development of business activities and residential construction,
- areas with the political desirability or undesirability of a transport connection.

2.2. Elaborated scenarios

In the elaboration of the models according to particular criteria, two scenarios were prepared: the first one without taking into consideration the motorways and expressways already built, and the second one with taking into consideration the motorways and expressways already built. In the scenario, taking into the consideration the motorways and expressways already built, the area of the third development axis was divided into three parts (the northern, central and southern part – with respect to both motorways); the corridors running through these parts, are not necessarily directly connected to each other. If they are not directly mutually connected, they are connected through the existing motorway or expressway. In the model, the motorways and expressway already built, were assigned a 0 (zero) weight.

The minimum environmental impact scenario

In preparing this scenario, a solution with minimum possible impacts on the nature (environment) was sought. The areas dealt with as areas with a higher environment protection regime were: the Natura 2000 area, ecologically important areas, protected nature areas, natural values, high quality agricultural land plots, forests (reservations), protected forests, water intakes, water protection zones (the narrowest protection zone), cultural heritage. Other protected areas are ecologically important areas (bear area). Each of the groups was assigned its own weight in the model: strictly protected areas obtained a 7-time higher weight than the background, while the rest of the protected areas obtained a twice higher weight than the background. Figure 3 presents the environmental scenarios. The part of the picture with the lightest colour shows the lowest impacts on the environment. This area is suitable for placing into it the alignment of a new thoroughfare.



Without taking motorway into consideration	With taking the motorway into consideration

Figure 3 – Spatial appearance of the minimum environment impact scenario

The minimum investment cost scenario

In preparing this scenario, a solution with a minimum possible investment value was sought. The available data, defining the terrain or areas, which increase construction costs, were used as the starting point. The areas dealt with, are: relief, flood zones, endangered zones (floods, land creeping erosion), accumulation lakes and water streams, register of structures. Each of the groups was assigned its own weight in the model: in the sense of investment, the area, in which it is necessary to build a tunnel or a bridge over the river, has a 7-time higher value than the background, while the rest of the areas have an intermediary value with regard to the estimate of costs, caused by a particular factor. Figure 4 presents the investment scenarios. The part of the picture with the lightest colour shows the lowest construction costs. This area is suitable for placing into it the alignment of a new thoroughfare.

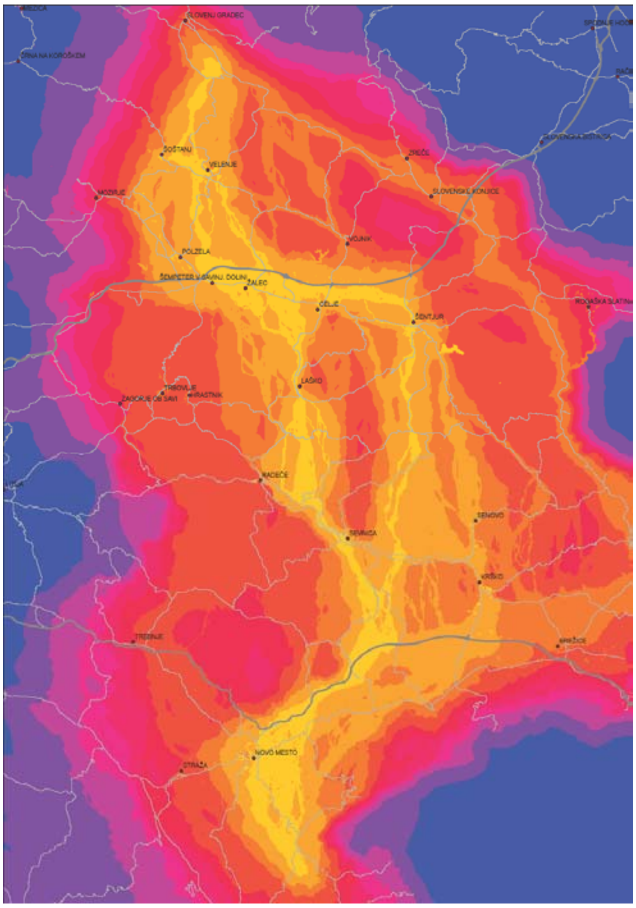
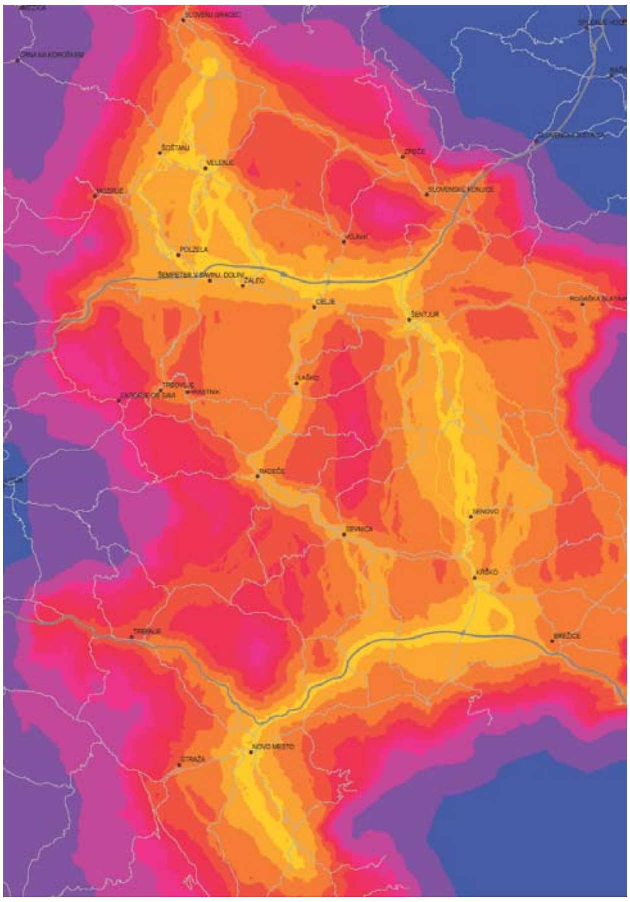
	
Without taking into consideration the motorway	With taking into consideration the motorway

Figure 4 – Spatial appearance of the minimum investment cost scenario

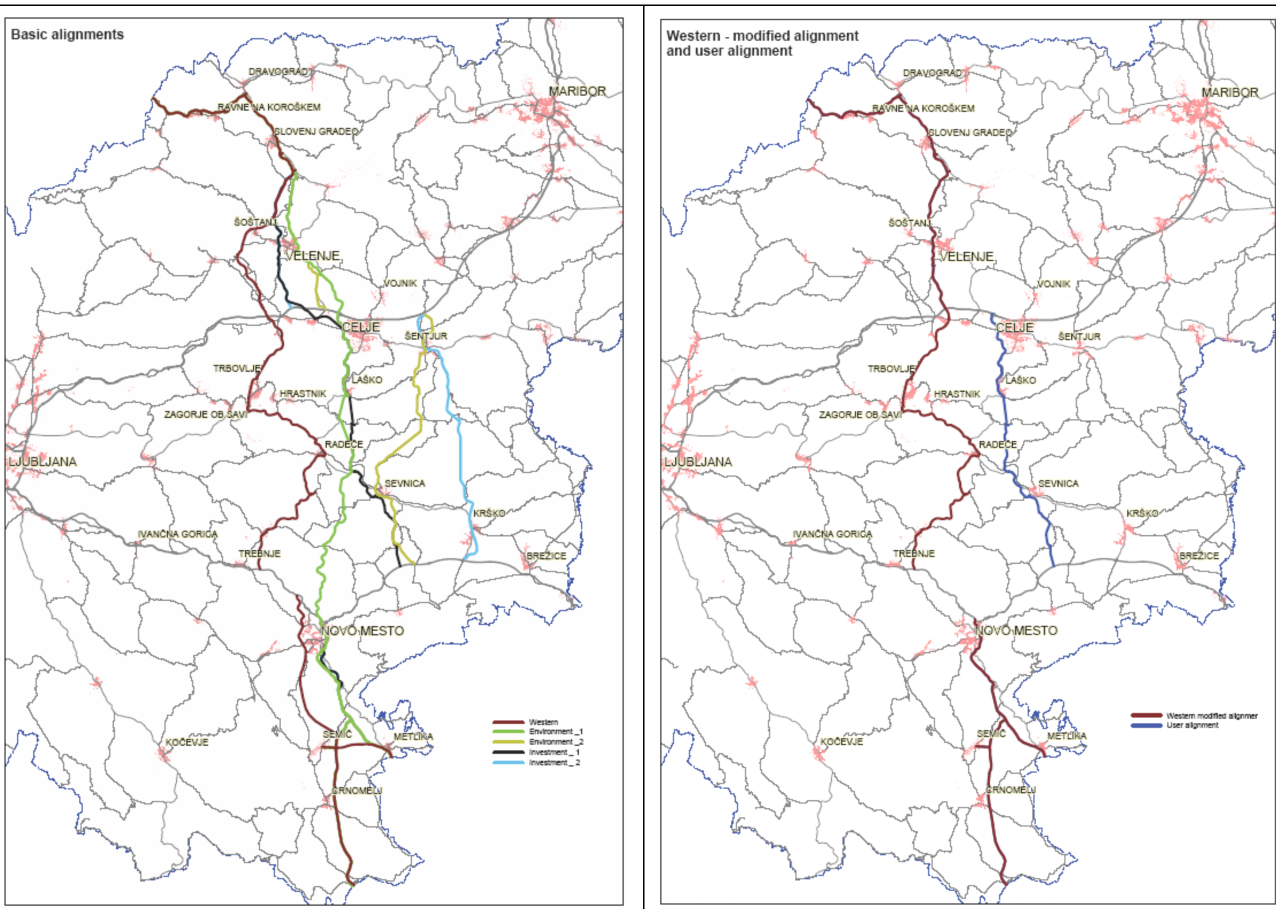
<u>The western connection scenario</u>

The above mentioned scenarios ensure the connectability between regional centres in the central and eastern part of the third development axis area, and do not include towns in the western part. Therefore a separate scenario of the connection of gravitational centres in the western part of the area dealt with was prepared.

<u>Composite scenarios</u>

Two composite scenarios were made of individual basic scenarios, namely the environmental-investment scenario (user scenario) and the scenarios of the modified western connection, which is dealt with partially in the western connection scenario, and partially in the environmental-investment scenario.

The outline alignment courses (Fig. 5) were placed into the corridors, defined in this way, and a 4-level transport model was elaborated and completed with the field research results and with the included new transport connection alternatives. Thus a physical road feasibility under definite alignment requirements (gradient, radius etc.) can be examined; then the assessment of the spatial and environmental impacts, investment cost estimate and user benefit evaluation are elaborated.



Alignments according to the basic scenarios | Composite alignments

Figure 5 – Outline alignments per particular scenarios

3. EVALUATION OF PARTICULAR SCENARIOS

The next step is the evaluation of the potential alignments per particular scenarios. The starting point is the evaluation of all impacts exerted by the planned thoroughfare. The evaluation should be possibly performed from quantifying and monetizing aspects. The alignments are dealt with from three independent aspects, namely from the environment protection aspect, development potential aspect and transport economic efficiency aspect (cost-benefit analysis). All these aspects are combined by means of a multi-criteria analysis, which gives a complete final assessment. The inclusion of the said aspects into the evaluation ensures that the immediate and concrete effects as well as long-term and potential effects of the planned thoroughfares, i.e. the impacts of the new thoroughfare, are integrally dealt with.

3.1. Environmental impacts

The environmental impact assessment is based on the methodology of the strategic environmental assessment, adopted by the European Commission (Directive 2001/42/EC of the European Parliament and of the Council). The environment protection goals were set, the environment status was analysed, probable substantial impacts and mending measures were assessed. The assessment of the environment vulnerability was quantified by means of the indices of the extent of the area of protected environment components, covered by a particular potential corridor, and by the point estimate of the impact of a particular road alignment onto definite environment components (point estimation within a range from 0 – no impact - to 4 – very high impact).

3.2. Development potentials

The development of the transport infrastructure can have a significant impact on the utilisation of the development potentials of a certain geographic area. The main problem in the evaluation of the potential extent of the impact is the fact that it is about the potential impact. It is not possible to expect that the construction of a transport infrastructure of higher capacities and quality alone would bring any special development effects; such effects can be achieved only in coordination with other fields of action (e.g. education, providing of optimum entrepreneurship conditions, capital investments etc.)

In the study, the development potential was assessed on the basis of the indices referring to:

- improvement of accessibility to regional centres, improvement of connectedness between regional centres, in which the TIA (Transport Impact Assessment) methodology was used; and
- results of the land use model in the form of additionally induced working places.

The application of the land use model is the main novelty in the infrastructure development evaluation in Slovenia. In Anglo-Saxon countries, the model has been developing and used since the seventies. The model is based upon the use of Lowry-Garin's system of equations. It is derived from the economic-spatial theory, according to which urban development exerts influence upon road transport, while road projects influence the population travel patterns and the (re)arrangement of activities in the area (Horowitz, 2002). By means of the system of equations it is possible to predict the changes in the rearrangement of working places per particular activities in the area as a consequence of changes in urban policies and infrastructural equipment of this area. The major data inputs are the data on the arrangement of the population and working places according to the activities in the area, transport connections and forecasts of main economic categories (added value growth, productivity and employment per particular activities).

3.3. Economic efficiency

The economic evaluation of the alignments set according to particular scenarios, is based on the cost-benefit calculations. The investment value is considered to be a cost component, while the user cost reduction as a consequence of an improved transport supply in the axis dealt with, is a benefit component. The economic efficiency improvement is presented by means of indices, namely the internal rate of return, net present value, and relative net present value.

4. SCENARIO COMPARISON

A comparison of the results of particular scenarios with the proposal of the selection of the most adequate scenario was performed by means of a multi-criteria analysis. The multi-criteria analysis is a mathematical method, belonging to a group of assessment methods, in which the main analysis purpose is goals and their achievement. The goal achievement is measured with regard to given indices (criteria), which are weighted, and in this way it is possible to obtain a uniform estimate for each particular project (programme, option, alternative) as well as a basis for the comparison of projects (programmes, options, alternatives) inside a group of projects (programmes, options, alternatives). The multi-criteria analysis has the following advantages: it is a transparent and robust method; the adaptability of the selection of goals and criteria allows their later inclusion or exclusion from the analysis; the ascertainment of particular effects can be performed separately; it can be performed by individual experts; due to its transparency, the method can be an efficient means of communication or explanation of the selection of particular projects or programmes; due to the use of point estimation and weighing, the revision traces are preserved and the iterativity of the computation is ensured. The main deficiency of the method is that the setting of weights is to a certain extent subjective, which may have a significant impact upon selection results.

Each particular criterion is defined in its quantitative form, so that the options per particular criteria can be arranged from the best to the worst. The values of criteria for particular options are computationally standardised according to the below formula in such a way that they lie within the interval between 1 and 2:

$$n_{i,j} = 1 + \frac{k_{i,j} - k_{j,\min}}{k_{j,\max} - k_{j,\min}}$$

where $n_{i,j}$ means a computationally standardised value of the j criterion for the i option, while $k_{i,j}$ is the value of the j criterion for the i option, and $k_{j,min}$ is the minimum (worst) value of the j criterion, achieved by any of the options dealt with, and $k_{j,max}$ is the maximum (best) value of the j criterion, achieved by any of the options dealt with. The total estimate is calculated in such a way that the computationally standardised criterion value in a particular option is multiplied by the weight assigned to that criterion according to the below formula:

$$O_i = \sum_{j=1}^{m} n_{i,j} * w_j$$

where O_i means a total estimate for the i alternative, m means a number of options, and w_j means a weight for the j criterion. The best option is the option, in which the sum of the products of the computationally standardised values of the criteria and weight O_i is the highest. Individual indices can be composed of sub-indices. The value of a combined index is calculated by using the above formula correspondingly.

Table 2: Multi-criteria analysis results

	Alternative (i)							
Index (j)	Environ. without MW	Environ. with MW	Invest. without MW	Invest. with MW	Western	Invest./ environ.	Western Modif.	**Weight (wj)**
Development impact index	1,58	1,01	1,83	1,40	2,00	1,00	1,93	33%
Economic efficiency index	1,00	1,14	1,47	1,32	1,40	1,53	2,00	33%
Environment impact index	1,67	2,00	1,29	1,29	1,09	1,40	1,00	33%
Total estimate (Oi)	**1,42**	**1,38**	**1,53**	**1,34**	**1,50**	**1,31**	**1,64**	**100%**

All the solutions dealt with contribute in a greater or smaller extent to solving the weaknesses, i.e. to using the opportunities of the region dealt with. The scenario of the modified western alternative has been proven as the most appropriate one, for it ensures the maximum possible economic efficiency of transport and simultaneously also very good development effects.

5. CONCLUSION

In 2006 the National Assembly of the Republic of Slovenia adopted the Transport Policy Resolution. By means of this document Slovenia started to carry into effect the principle of sustainable mobility. This means that transport systems must meet economic, social and environmental needs of the society, while, simultaneously, their undesired impacts on the economy, society and environment must be reduced.

The paper presents an attempt of Slovenia to use an integrated approach in planning its transport infrastructure development. The approach does not take into account only the existing transport demand, but also definite development and protection aspects. The studies on the integration of thoroughfares into the area, made in the past, have shown that the alternatives proposed and their treatment in the documents can not always give a sufficient answer to the question of the best alternative selection from the viewpoint of sustainable development in the thoroughfare influence area.

The first problem to be solved is which principles should be observed to find potential candidate alignments, which will be able to give the best development effects. The second essential problem is how to select the best alternative from among the candidate alternatives. The paper emphasises some essential methodological novelties, used in Slovenia in searching for the answers, which should ensure the selection in accordance with the sustainable development principles.

In our opinion, the approach presented can essentially contribute to the quality of decision making on the integration of the public transport infrastructure into the area in those cases, in which alternative alignment courses can be substantially different and can have substantially different effects as well as substantially different distribution of the effects in the area. With this the decision maker has been given data and tools for quality-level decision making, however, we have not made the decision instead of him; this still remains his own responsibility, while he has better tools at his disposal. In this way it will be possible also to estimate potential changes in the expected efficiency in the cases, when political preferences in relation to particular corridors are different from those proven by means of the efficiency analysis per particular aspects.

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