TRANSPORT STRATEGY FOR THE DEVELOPMENT OF A MULTIMODAL TRANSPORT INFRASTRUCTURE NETWORK IN THE ADRIATIC CORRIDOR

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Abstract

A transport strategy is a framework for planning and investment decision-making. The proposed transport strategy is intended to provide a common ground for the development of a multimodal transport infrastructure network adjusted to the expected requirements of passenger and goods transport, which is adjusted for the area of the Adriatic Corridor. It sets the priorities for developing a transport network in the Adriatic Corridor based primarily on political, geographical, demographic and regional (i.e. socio-economic) considerations. The paper provides a methodological framework for selecting the links and nodes that would define the strategic multimodal transport network of the region. The selection of the priority network (consisting of links and nodes related to infrastructure projects) is based on the following criteria: the socioeconomic viability, the political/regional dimension, the infrastructure planning of the TEN-T of the European Commission, the UN-ECE European agreements on road and rail network, the Pan-European transport corridors, the interconnection of all economic and transport activity centers inside the region and their connection with the neighbouring countries. To accomplish this, a Multicriteria Analysis (MCA) is proposed that includes all main criteria. The paper presents some results of the methodology's application for the Adriatic corridor.

Keywords: Corridor development; Multimodal transport network; Investment decision-making; Feasibility study; Cost-benefit analysis; Multicriteria analysis; Objectives-weights
Topic Area: C1 Integrated Planning of Transport Systems

1. Introduction

The Transport Strategy for developing a transport network has always been mainly on the supply side of the multimodal transport market. The European Community supports the development of transport infrastructure through its multi-annual financial framework programs. The next decade should see an expanding European Union with the Central and Eastern European countries and the Baltic States as new members. Transport is proving to be one of the key areas for integrating these countries. There are several gaps in their transport systems and it is unclear how this will affect European transport networks. Recently, the transport strategy for infrastructure development at an international level is following the corridor concept, instead of focusing on the whole transport network.

A corridor is considered not only as a geographical description but also as a regionalised strategy or programme consisting of projects and/or initiatives, which aim to overcome structural gaps in the extended European space. Such projects and/or initiatives are intended to improve or expand the existing transport system in order to support regional development and hence an increase of cohesion – through, primarily, investment in multi-modal infrastructure networks.

According to the transportation planning practices, a corridor is defined as specific section of the network or networks, which creates a transport axis. A proposal for an adaptation of a definition of a corridor, completely integrated to major connections between countries is the following:

A corridor is first a "couloir" or a major axis of international exchanges between countries and regions: this means in particular that a corridor can integrate several routes for the same mode, sometimes part of local networks.

In most cases a corridor is multimodal or quadrimodal, which means that it includes intermodal nodal points (ports, airports, intermodal centres) with maritime alternative routes and air services. This will, in particular, avoid distinction made often between land corridors, maritime corridors and air services.

The aim of this paper is to present a methodology and the results for assessing the development of a Multimodal Transport in the Adriatic Corridor. It sets the priorities for developing a transport network in the Adriatic Corridor based primarily on political, geographical, demographic and regional (i.e. socioeconomic) considerations. Its primary aim is to provide guidance for the realization of national transport plans and for specific feasibility and engineering design studies for these projects selected in the approved investment program. In particular, it provides a framework for selecting the links and nodes that would define the strategic multimodal transport network of the region.

For the Adriatic Corridor a feasibility study was elaborated called «Corridoio Adriatico», which is based on the «Protocollo d'Intesa»[1] (agreement protocol) signed in October 1995 by the seven Italian regions of the Adriatic (Friuli-Venezia Giulia, Veneto, Emilia-Romagna, Marche, Abruzzo, Molise, Puglia). The strategic target for which the seven regions decided to co-operate was to produce a joint *feasibility study (Bonifica-CSST, 1999)*. This was undertaken in order to support the case for the Adriatic Corridor being included in the Pan-European Networks, along with those corridors already agreed upon by the European conferences in Crete 1994, and Helsinki 1997.

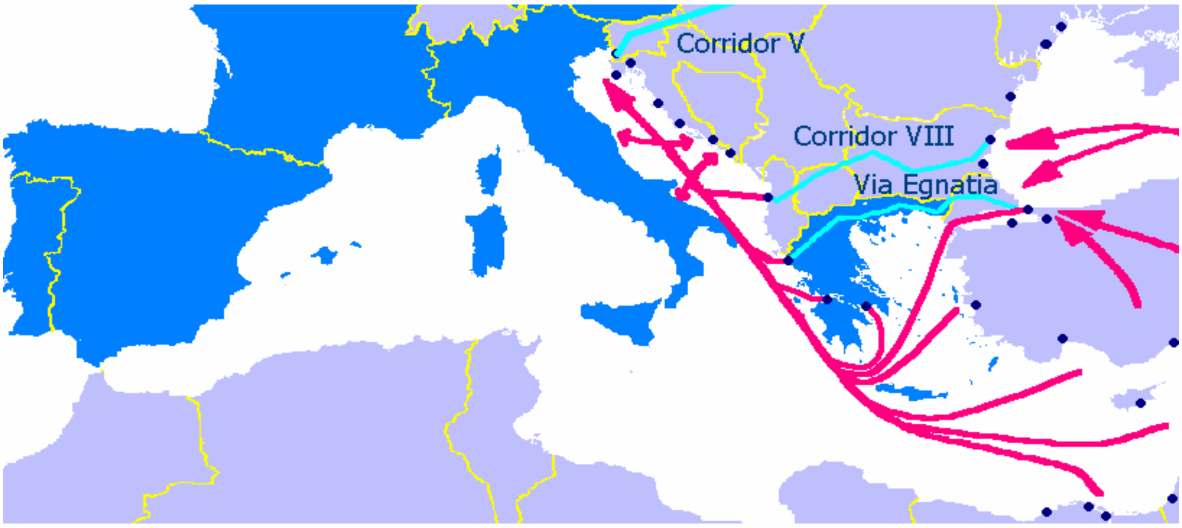

Figure 1: Graph of potential movement scenarios

[1] «Protocollo d'Intesa tra le regioni adriatiche allo scopo di promuovere e sostenere la realizzazione del Corridoio Adriatico nell'ambito delle reti transeuropee di trasporto» (Agreement protocol among Adriatic regions with the aim of supporting and promoting the Adriatic corridor within the framework of Trans-European networks of transport.), October 1995.

Such a framework puts emphasis to the solution of border crossings, since it is obvious that the facilitation of trade and traffic flows brought about by infrastructure improvements is useless if border crossings continue to act as bottlenecks. Environmental concerns are taken into account so as to avoid environmental degradation.

With the implementation of the proposed strategy, the Adriatic Corridor could serve as a pathway to the movement of freight and passengers between various countries (i.e. Greece, Turkey, Balkans) and regions that are within its wider zone of influence.

2. Methodological considerations

Several studies have been done so far relating to the assessment of Transport infrastructure of Corridor development. The Maastricht Treaty gave formal recognition to their importance for the Union and its Member States by providing a specific section (Title XII) to Trans-European Networks (TEN). Moreover the Maastricht Treaty stipulates that in the field of trans-European networks "the Community may decide to cooperate with third countries to promote projects of mutual interest and to ensure the interoperability of networks".

Pan-European Transport Corridors and Areas were designed and agreed at Crete in 1994 and Helsinki in 1997. There are at the moment 10 corridors and 4 transport areas, some of which connect Europe with the Russian Federation, Ukraine and Belarus as well as the Barents Sea Region, which by the way is holding its Steering Committee Meeting this afternoon. The Memorandum of Understanding for the last corridor was signed in September 2002. After enlargement two-thirds of the existing Pan-European Corridors will be within the territory of the EU and only one-third of the corridors will be outside EU territory, mostly in the wider European countries. For this reason alone a fundamental re-assessment of future corridor development and management is needed *(Commission of the European Communities, 1997).*

The number of corridors should probably be limited to a level, which is manageable and affordable in terms of financing. The net result of the revision could be a series of streamlined corridors starting in the heartland of the EU and extending ultimately to Asia and the farther ends of the Mediterranean. These redefined corridors or axes, would need close and systematic supervision in order to be realised in a reasonable amount of time. A number of useful management techniques have been developed for the corridors. These structures (MOU's, steering committees etc.) are expected to make progress with the identification of inventories, bottlenecks and priority projects.

Strategic Assessment of Corridor Developments are the main Research and Demonstration Activities of CODE-TEN *(Strategic Assessment of Corridor Developments, TEN Improvements and Extensions to the CEEC/CIS, CODE-TEN, 1998).* The objective of the CODE-TEN is to apply the scenario approach to the study of TEN developments and corridor extensions to the CEEC/CIS, paying particular attention to the marginal long-term effects and, in particular, "the spatial distribution of environmental and socio-economic impacts". The main output of the CODE-TEN is the development of a comprehensive policy-assessment methodology and accompanying decision-making assistance tools. The policy programmes/strategies in selected corridor extensions to CEEC/CIS and their impact on TEN developments are the subject of political, economic and environmental assessment in CODE-TEN.

In the framework of the CODE-TEN project, the methodology (Figure 2) is applied to a large number of corridors, with varying levels of data availability and reliability. It is divided into two main directions, namely the Measuring Accessibility and the Displaying Accessibility Improvements. Both directions are applied for each alternative corridor. In relation with Measuring Accessibility the methodology reflects results of transport investments in the two main dimensions covered by strategic territorial impacts, considering the situations of the improvement/construction before and after the infrastructure:

- Demographic Accessibility
- Economic Accessibility, i.e. potential gain of economic efficiency by reduction of transport
- Costs in referred imports and exports.

Both these indicators express the number of “partners” that can be reached (from each basis region) in a pre-specified travel time threshold associated with the 24-hour cycle of human activity. The basic regions to be considered are crossed by the new infrastructure and maybe the neighbouring regions of those. This decision-making requires careful analysis and involves different criteria for each case study.

For demographic accessibility, the population (inhabitants) living in each region within reach is used as the weight of each partner region, whereas for economical accessibility the potential trade volumes (expressed in monetary units) are used. So, the gains in economic accessibility are interpreted in connection with the reduction of transport costs in imports and exports (trade volumes).

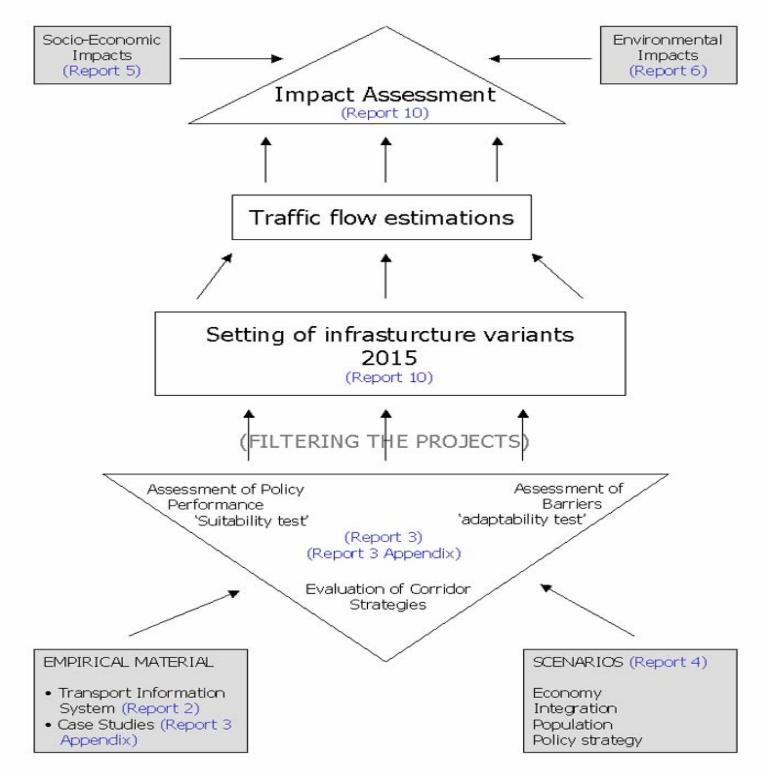

Figure 2. The work methodology of CODE-TEN
Source: CODE-TEN, 1998

The indices developed have to measure change for passenger and freight transport, taking into consideration permanently available transport options (road) as well as options that are made available only at pre-specified times (e.g. in rail and shipping). However, the calculation of economic accessibility indicators based on passenger transport can also be pertinent e.g. an economy of services. The implementation of such methodology requires the:

- Elaboration of a Transport Information System, which is developed as an integrated database with interfaces and which includes information for the countries under study
- Handling of a Geographic Information System for convenient representation of the key aspects under study and computation of the indices.

3. Methodology

The transport strategy as it is applied on a Corridor level, it is a framework for planning and investment decision-making. It sets the priorities of projects' implementation for developing a transport corridor, such as the Adriatic Corridor. Although some of the criteria are based primarily on political, geographical, demographic and regional considerations, the application of a proper assessment/evaluation methodology is a requirement.

The methodology introduces an approach and a model to perform such an evaluation, which is the core activity for the development of transport strategy at the corridor level. The method has the characteristics of multicriteria and cost/benefit analysis *(Tsamboulas D., 1999).* It is capable of receiving inputs concerning preferences of the actors involved and it can generate outputs permitting the evaluation/appraisal of direct impacts as well the assessment of indirect effects on social and physical environment.

It is noted that the TINA network for accession countries to European Union, as well as the UNECE *(UNECE, 2002)* has adopted a rather straightforward method, which is uses the CBA method. However such method has limitations, especially if other criteria besides the monetarized ones are introduced in the evaluation. On the other hand, since there is s need to prioritize the projects (and combinations of them) the MCA is more appropriate *(Cook et al., 1978; Raiffa, 1976).*

3.1 Formulation of the methodology

The proposed methodology follows a framework, comprising four steps *(Beuthe et al., 1998)*:

- Value tree:
  a) *Objectives*: definition of basic goal(s) and/or objective(s)
  b) *Criteria*: description of the appraisal variables and their corresponding functions
  c) *Structure*: definition of how the criteria are related
- *Weighting:* prioritisation of the criteria in the appraisal (necessary only for Multi-Criteria Analysis - MCA)
  - *Evaluation and ranking:* utilisation of criteria, weights and structure to meet the objectives
- *Presentation of results:* analytical, monetary output, graphical representation, etc.

In a given decision situation alternative transport projects can be evaluated following the above steps of the methodology and by receiving "scores" (or monetary values in the case of Cost-Benefit Analysis - CBA) corresponding to the criteria employed by the method (Table 1).

Table 1. Initiatives/Infrastructure Project Profiles

Inter-modal project**	VARIABLES*
Impacts	
Core impacts	
A1 Investment costs	Planning costs, Real estate acquisition costs, Construction costs (buildings, internal transport infrastructure etc), Equipment acquisition costs (transhipment equipment, information systems, specialized vehicles etc), information/control systems costs. Disruption costs
A2 System operating and maintenance costs	Administrative and monitoring costs, security costs, periodical maintenance of premises and equipment or renewal costs, cleaning
A3 Vehicle operating & maintenance costs	Costs related to the maintenance of vehicles, the operations of vehicles and equipment; Energy consumption related to the Freight Village/Terminal operations
A4 Generalised net user benefits	Improvement of transport cost and transport quality parameters: Minimization of transport means used and maximization of transport means productivity, Time savings-improvement in speed and reliability (access time, waiting time, handling time), Change in charges and shipment handling costs
A5 Safety	Fatalities, severe and slight injuries, damage only accidents
A6 Local environment	Noise (L_{eq}, L_{10}), local & regional air pollution (SO_2, NOx, CO), vibrations (indication of high, medium, low). Landscape changes. Aesthetic parameters. Inconveniences from traffic congestion in surroundings
A7 Revenue	Income from sales of services (parking, storage services, transhipment services, cargo management, customs, etc), Rent of facilities, Concession of space and/or facilities
Non-core, non-strategic impacts	
B1 Service quality	Indication of high, medium, low
B2 Landscape	Indication of severe, moderate, slight visual intrusion of terminals
B3 Goods handling	Indication of good, medium or bad
Strategic, territorial impacts	
C1 Strategic territorial environment	Special sites (indication of severe, moderate, slight impact on archaeological sites, national parks, etc.)
C2 Strategic economic development National, regional and local)	Changes in Economic Output (in ECU) and Employment (in thousands of jobs). Land use (indication of positive, negative, neutral conformity with the existing land use plan)
Strategic, non-territorial impacts	
D1 Private financial attractiveness	Financial internal rate of return (IRR) or Return on Equity (ROE)
D2 Other strategic policy and planning impacts	Indication of positive, negative, neutral conformity with other strategic policy and planning concerns. Attraction of traffic for transhipment and related activities
D3 Technology development	Expert judgement

3.2 Characteristics of the method

The main characteristics of the assessment procedure are the following (Figure 3):

- A hierarchical approach is used
- It combines Cost-benefit Analysis (CBA) and Multi-Criteria Analysis (MCA)
- It allows CBA to be used as a stand alone procedure, if desired

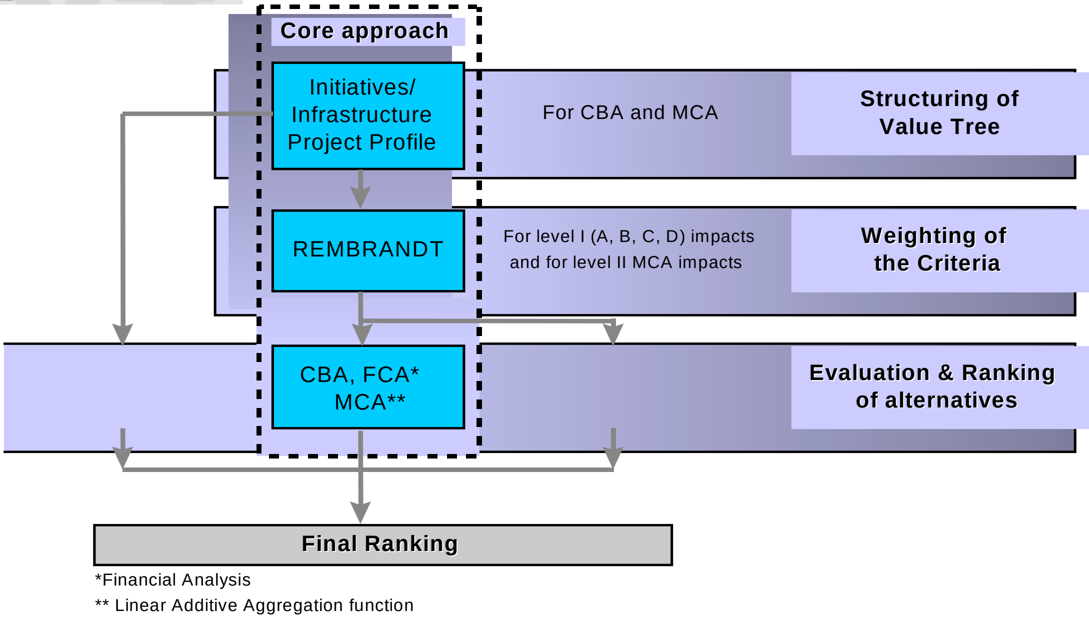

Figure 3. The proposed general methodological framework

The CBA is performed within the assessment tool. The proposed methodology allows for:

(i) a conventional CBA, where by making no use of the MCA, one could include all impacts that can be valued in monetary terms, and

(ii) a "custom" CBA, where non-monetary impacts used in the MCA, are excluded (e.g. environmental impacts, etc.).

The balance between CBA and MCA methods is achieved by keeping things separate all the way to the end, until making the final decision. When using a MCA method, the result of the CBA may then be used as one of the main criteria in the MCA assessment. *(EUNET, 1998)*. This approach will provide a link between CBA and the other criteria leading also indirectly to a monetary measure of alternative projects, taking into account the MCA criteria.

The selected multicriteria process consists of a linear additive model presented in hierarchical form *(Saaty, 1980)*. Since the recommended MCA model should be a practical, stand-alone tool in the sense of being easy to understand and permitting a full ranking of candidate projects (without being influenced by the particular set of projects considered), a blend of decision tools, namely pairwise comparisons and a linear additive aggregation function are used as a core approach for the problem situations that the tool would need to solve *(Lootsma, 1992; Olson et al, 1995)*.

3.3 Detailed framework

In the proposed methodology, the hierarchy is structured in four levels, of which the final three would be undertaken via the MCA route and the first one through CBA (Figure 4):

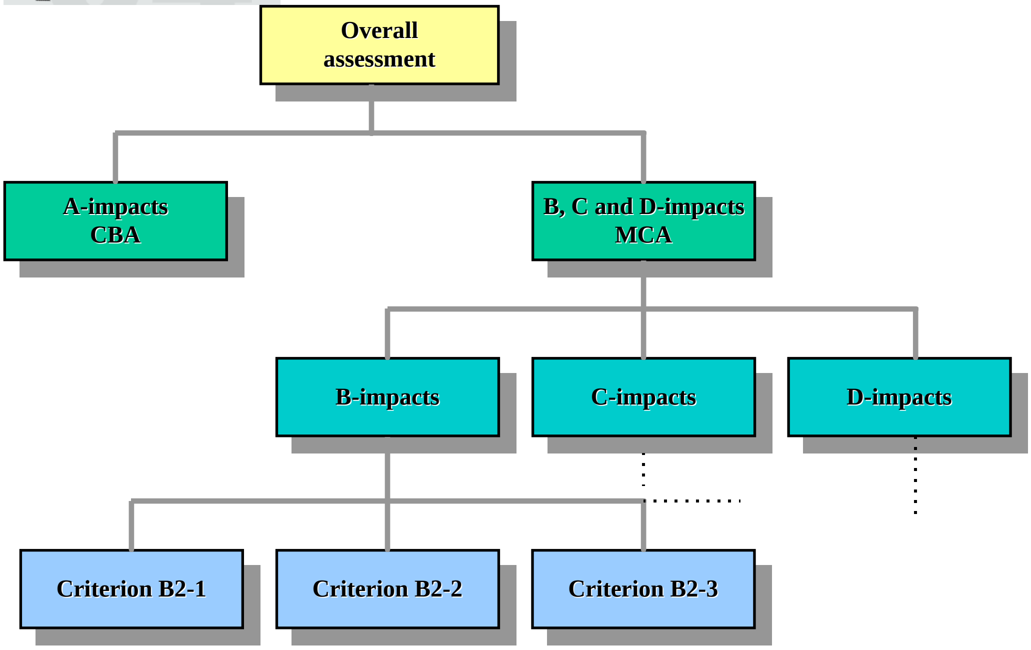

Figure 4. Assessment methodology
Source: "An operational report for the assessment methodology", EUNET-Internal working note.

Table 2. Categorization of impacts

Core impacts	(A-impacts)
Non-core, non-strategic impacts	(B-impacts)
Strategic, territorial impacts	(C-impacts)
Strategic, non-territorial impacts	(D-impacts)

There are four main types of situations a decision-maker may encounter when assessing transport initiatives: (i) Proposed changes in a single mode which have little or no impacts on other modes; (ii) Proposed changes in a single mode which have impacts on other modes, but where the decision maker is only interested, for assessment purposes, in the changes in that mode; (iii) Proposed changes in a single mode which have impacts on other modes and where the decision maker wants to assess the combined impacts across all modes; (iv) Proposed multi modal changes which have multi modal effects and where the decision maker wants to assess the combined impacts.

In the proposed methodology pair wise comparisons are considered for weight estimation alone. It must be noted that the weighting process described here represents the main basic options offered by the methodology at the weighting stage. As an alternative, it would be theoretically possible to present the user with a set of default weights. Fuller discussion of this and an example of how default weights could be developed is given below.

The *REMBRANDT* process *(Lootsma F.A., 1992)*, which can be used for weighting level I (A, B, C, D) impact groups (Table 2) and level II MCA impacts, can be completed in the following steps. The user states his/her preferences for each pairwise comparison on an -8 to +8 scale, (with zero for indifference):

Table 3 Criteria

Criteria	C_1	C_2	C_3	...	C_j	...	C_n
C_1	v_{11}	v_{12}	v_{13}	...	v_{1j}	...	v_{1n}
C_2	v_{21}	v_{22}	v_{23}	...	v_{2j}	...	v_{2n}
...	...	...	...	...	...	...	...
C_i	v_{i1}	v_{i2}	v_{i3}	...	v_{ij}	...	v_{in}
...	...	...	...	...	...	...	...
C_n	v_{n1}	v_{n2}	v_{n3}	...	v_{nj}	...	v_{nn}

After the ratio matrix is obtained, its elements v_{ij} are transformed (Table 3) using the operator *exp (0,347*v_{ij}*)* to generate a set of values r_{ij} on the logarithmic scale (Table 4):

Table 4 Criteria on logarithmic scale

Criteria	C_1	C_2	C_3	...	C_j	...	C_n
C_1	r_{11}	r_{12}	r_{13}	...	r_{1j}	...	r_{1n}
C_2	r_{21}	r_{22}	r_{23}	...	r_{2j}	...	r_{2n}
...	...	...	...	...	...	...	...
C_i	r_{i1}	r_{i2}	r_{i3}	...	r_{ij}	...	r_{in}
...	...	...	...	...	...	...	...
C_n	r_{n1}	r_{n2}	r_{n3}	...	r_{nj}	...	r_{nn}

The geometric mean of the rows $w_i = \left(\prod_{j=1}^{n} r_{ij}\right)^{1/n}$ (1) then gives the solution which minimizes the sum of squared errors from a logarithmic regression designed to best fit the decision-maker's expressed preferences *(Lootsma F.A., 1992).*

In many cases however, (e.g., sensitivity testing) it will be necessary to re-scale weights if any single weight is changed. This should be done automatically, according to a simple proportionality formula, leaving the relativities between all other weights unchanged. In terms of practical implementation, the user will need to be aware that other numerical weights within the MCA will adjust. The modified weights can be calculated from equation 1:

$$W_i^a = W_i^b \pm \left(W_i^b \cdot x\right) \qquad (2)$$

Where W_i^a is the modified weight for each of the remaining criteria i, W_i^b is the original weight (before modification) and x a value equal to:

$$x = \left|1 - \left(\left(1 - W_j^m\right) \Big/ \sum_{i=1}^{k-1} W_i^b\right)\right| \qquad (3)$$

Where W_j^m is the modified weight for criterion j, k is the total number of criteria and $\sum_{i=1}^{k-1} W_i^b$ is the sum of i which are different from j.

Note that if $W_j^m > W_j^b$ (i.e. the user increases the weight of criterion j), the minus (-) sign must be used at equation 1, while if $W_j^m < W_j^b$ then the plus (+) sign should be used.

In the methodology, each weight scheme is two-fold (two level), consisting of a set of weights for the A, B, C and D impact groups (level 1) and a set of weights within each group (level 2), exempt the core impacts group (A), the weights of which are not needed, since CBA application produces one criterion, combining all core impacts.

Evaluation and Ranking

The proposed methodology consists of a core evaluation method with a series of alternative or additional procedures to the core process. The core is relatively straightforward and it provides a default position. In addition, a series of innovative and/or supplementary procedures, which represent important steps forward in transport evaluation methodology, are proposed. The core method is three-fold, comprising:

i. Cost-Benefit Analysis within clearly defined boundaries;
ii. a Financial Appraisal focused on the potential private financing attractiveness of the project, and
iii. the broader Multi-Criteria Analysis incorporating the full range of criteria.

It is understood that for a combined CBA/MCA evaluation, CBA (and more specifically NPV) will be used as a criterion in the MCA, after being appropriately weighted. In this case and if the decision-maker's overall objective is to assess projects and not necessarily to rank them, then the MCA score can be used alone. Additionally, if the objective is to rank infrastructure projects under budget constraints then it is suggested to use the ratio: $\Lambda = NPV/\text{total costs really spent}$

General framework of Cost Benefit Analysis

In general cost benefit analysis measures as far as possible, the costs and benefits of a policy or action. Since the resource cost of policies or actions are invariably in money terms, comparison in cost-benefit analysis is undertaken by measuring benefits in money terms. There are two fundamental features in CBA. First, it forces the analyst to list the pros and cons of any policy or action. Second, the listing must reflect some goal. It is common that the ultimate goal in CBA is that of increasing the society's welfare. This implies that anything contributing to gains in the society and anything detracting from it is a cost. In CBA care has to be taken neither to double-count nor to count as a benefit to society a simple transfer from one member of the community to the other. However, such a transfer will be relevant when considering and understanding the incidence of impacts.

The basic rule of CBA can be formulated as follows:

$$NSB = B - C > 0 \qquad (4)$$

Where NSB is net social benefits, B is the benefit and C is cost.

The basic rule above implies that a policy is desirable if the net social benefit is positive i.e. benefits greater than costs. Since benefits and costs might occur at a later time after the project has been realized, time is readily introduced in the equation above as:

$$NPV = \sum_{t=0}^{T} \left(B_t - C_t\right) \cdot \left(1 + r\right)^{-t} \qquad (5)$$

Where NPV is the net present value of the social benefits, B_t the benefits in year t, C_t costs in year t, T the time horizon and r the rate of social discount. The rule then is that the present value of social benefits be greater than zero.

The CBA component

CBA is conceived as a multi-modal analysis, which will identify the costs and benefits of a Trans-European Network project across all modes in relation to a fixed set of potential impacts, shown in Table 5.

Table 5. Impacts to be Included within the Cost-Benefit Analysis

Investment Costs
System Operating and Maintenance Costs
Vehicle Operating Costs
Safety
Passenger and Freight Transit Time
Revenue
Regional Air Pollution
Global Air Pollution

Inputs to the CBA will include transport flows, journey times, numbers of accidents and casualties, and forecast emissions of atmospheric pollutants from the transport model, transport costs, appraisal values of time, safety and air pollutants. The appraiser will also be involved in inputting investment costs, which will normally be project-specific, and inputting the appraisal parameters including the Investment Start Year, Investment Period, Opening Year, Operating Period, Appraisal Period and Discount Rate. In addition, the appraiser may wish to introduce new information on the monetary value of impacts. This could refer to two situations, either where research developments allow impacts, which have not been monetised traditionally to be reliably, monetised or where there is updated information on the existing values of impacts. Either situation would not affect the overall structure, but in the first case could lead to some changes in the impact list for the CBA.

Appraisal values will be on a resource cost basis throughout (i.e. market prices net of indirect taxes and subsidies). In order to take into account uncertainty over future economic growth, the CBA will accept transport model outputs and other data for three different scenarios in each forecast year, i.e. High, Low and a Central Estimate of Economic Growth, and produce ranges as well as central estimates in its outputs. The outputs of the CBA are proposed to comprise Summary Measures (Net Present Value, Benefit/Cost Ratio and Internal Rate of Return), Graphical outputs showing net benefit streams over time, and Matrix output showing a range of different disaggregations of the outputs.

The Present Values of Costs (or Benefits) on each of the above CBA impacts will be passed to the MCA to inform the corresponding criteria of Investment Cost, Safety and so on. The detailed outputs of the CBA would be available to the user alongside the outputs of the MCA.

The MCA component

The MCA model is a stand-alone model in the sense of permitting a full ranking of candidate projects in terms of the combined B, C and D impacts. The combination of the CBA and MCA elements forms one of the innovative aspects of the methodology. In summary this involves carrying present values of benefits from CBA outputs to the MCA and the financial IRR from the Financial Appraisal to the MCA as described above.

The MCA evaluation model is expressed as *(EUNET, 1998)*:

$$\text{Rank}(A_i,\ O(C_{i1},\ \dots\ C_{im})),\ i=1,n \qquad (6)$$

Where, A_i are the n transport initiatives under the aggregation function *O* (c_{ij}) defined over the m criteria using the scores c_{ij}.

The selection of the appropriate aggregation function depends on the objective. Additive functions are the simplest to use and the easiest to understand, but they may exhibit the following problem: it is possible for at least one score to be of forbidding low quality, whilst the overall score may not reflect such a low ranking and vice versa (due to compensation between the criteria). The alternative product functions do not exhibit this problem, but they are more difficult to understand since they are highly non-linear. A combination of all types of functions is possible, but this would be at the expense of simplicity and transparency. In the proposed methodology an additive function is used for reasons of simplicity and better intuitive understanding. In order to overcome the related problem of forbidding low and/or high scores, a check should be made of the alternatives' scores with respect to a set of thresholds that are previously identified and stored for each impact. If a project is found having at least one impact score below the pre-defined threshold it is automatically flagged. The aggregation function is of the form:

$$O_i = \sum_{j=1}^{n} w_j c_j \left(x_{ij}\right) \qquad (7)$$

This model is additive, linear in the weights (w_j), and in the criteria functions c_j. The c_j linear functions are simple transformation graphs spanning over the most probable values of a criterion and yielding 0 for the lowest feasible and 100 for the highest feasible level for that criterion. Note that in the above, x_{ij} represent the different values of the physical parameters employed in each criterion.

The objective is to seek criteria measures which are at least ordinal and, ideally, in interval/ratio scale measures. Purely verbal assessments are avoided. Where judgements are required, they have to be translated to a common scale with associated verbal descriptions of typical situations corresponding to some or all of the integer scale points.

The scores are assessed independently with respect to weights. Their scale is used as a quality index where higher numbers mean preferable projects. Score levels may be estimated either directly or judgementally on to the $0 \rightarrow 100$ scale, or by using the c_j functions (usually for criteria which have some direct interval/ratio scale measurement).

Finally, for the evaluation and ranking of the alternatives each alternative gets a final score as derived from the function *O* (c_{ij}) and thus, they are ranked first, second, third and so on. The core approach, apart from being a reasonably common form of aggregation within the multicriteria literature, is also consistent with the idea that the relative influence of different dimensions of impact should be constant and predictable.

The construction of the appraisal matrix

Construction of the MCA matrix

The measurement of the impacts can be either on a quantitative or a qualitative basis. In the first case, once the measurement is carried out, standardization is undertaken, in order for the values to be led back to an interval (0.1). When the measurement scale is different for every criterion, the standardization of the appraisals proceeded. The methods *(Tsamboulas D., 1999)* that can be used in this phase are:

(a) Min-Max

The method of the **"Min-Max"** is based on the difference between the appraisal of every alternative and the minimal performance for the same criterion consists. This difference is achieved by dividing the minimum and maximum ratings. The values produced from the normalization fall into the range 0-1.

This method however, has a main disadvantage, since each alternative value is equal to one in the case when all selected criterions have the same input. This causes loss of information, since independently from the input the output is always the same without indicating the differences between the different criterions. On the other hand if the criterions selected have different inputs the result produced is always zero.

(b) Zero-Max

This method compares all alternatives based on their maximum values allowing the data that produce these values to be taken into consideration. Through this it is possible to evaluate the difference of the alternatives from the initial data.

(c) *Sum*

A third alternative method is *"Sum"* which refers to different alternatives of a project and the criteria-objectives, as shown in the Table 5. In this method the sum of weights of each criterion is calculated. The alternative with the highest sum of weights is actually the alternative, which is most suitable to be used.

As far as the measurements of qualitative scale are concerned it is necessary to transform the appraisals in numerical values comprised between 0 and 1.

4. Application of the methodology

4.1 Project bundles/ combinations

Regarding the Adriatic Corridor, 5 combinations of project bundles were considered, each of which exhibits a series of projects that constitute the missing links in the corridor. These are:

PS1: Investments to complete and improve the road axes North-South

PS2: Investments to complete and improve the road axes traversing the Corridor

PF1: Investments to complete and improve the rail axes North-South

PI1: Investments to complete and improve the road and rail infrastructure integration

PP1: Investments of Corridors, including the road and rail infrastructure integration and investments of inland waterway

4.2 Scenarios for forecasting

For the forecasted transport volumes scenarios were considered (Table 6) which consists of combinations of the following:

- future economic and traffic growth rates
- trends in fuel prices
- the speed of development of the rest of the transport network
- the speed of integration with the EU and/or the world economy

4.3 Results from CBA application

In presenting the results of the cost-benefit analysis, the key information to report will be:

- initial assumptions and scenario definitions;
- CBA parameters (including Start Year, Opening Year);
- Summary Measures of social value;
- disaggregated CBA results, highlighting the following distributional issues within the overall costs and benefits:

– shares of international traffic versus domestic traffic in user benefits
– users benefits versus net impact on operators
– shares of user benefits by mode
– composition of user benefit by item of benefit (Time, VOCs, etc)
– shares of time savings made up by personal travel in working time, personal travel in non-working time and freight movement;
– shares of operator costs and revenue by mode
– investment costs by group (that is, private operators, national government, financial institutions)

Table 6 presents the results of the CBA application for each combination of project bundles and scenario.

Table 6. Values assumed from the economic indicators in the different scenarios

	CRITERIA	**PROJECTS**					
		PS1	**PS2**	**PS1+PS2**	**PF1**	**PI1+PF1-PF1/PS1**	**PI1+PF1-PF0/PS1**
SRI	Tendential	14,30%	7,10%	10,40%	10,30%	21,20%	13%
	Optimistic	21,90%	9,90%	14,10%	11,60%	26,30%	17,70%
	A	16,80%	8,40%	12,20%	11%	23,40%	14,70%
	B	14,10%	6,30%	10%	9,50%	21,20%	12,90%
	C	11,70%	6,60%	9,40%	8,70%	20,70%	12,60%
	D	13,90%	7,10%	10,20%	8%	18,30%	10,50%
	E	12,20%	5,50%	8,60%	8,10%	18,90%	11%
	F	11,80%	5,20%	8,20%	7,70%	18,40%	10,60%
	G	9,80%	3,70%	6,50%	6,20%	16,30%	8,70%
B/C	Tendential	2,13	1,03	1,48	1,45	4,37	1,95
	Optimistic	4,28	1,42	2,16	1,77	6,48	2,89
	A	2,39	1,15	1,66	1,56	4,63	2,09
	B	2,13	1,03	1,48	1,45	4,37	1,95
	C	1,67	0,97	1,34	1,29	4,21	1,88
	D	2,06	1,02	1,44	1,18	3,44	1,54
	E	1,78	0,86	1,24	1,21	3,64	1,63
	F	1,7	0,82	1,19	1,16	3,50	1,56
	G	1,42	0,69	0,99	0,97	2,91	1,30

4.4 Results of the MCA application

The introduced criteria are related to six (6) objectives, some of which have sub-objectives:

- Economic feasibility
- Accidents (mainly road)
- Environmental impacts
- Employment
- Alleviation of inequalities "north-south"
- Financial viability

The results are presented in three parts: final weights of criteria in total of objectives, final weights of objectives and final weights of criteria into each objective. It is noticed that each objective is characterized by a colour.

Final weights of criteria in total of objectives:

Final weights of criteria are given by the final matrix of sheet-1 (Final Matrix of Average Weights).

Final weights of objectives:

Final weight of each objective is calculated as sum of its criteria weights, so that they can sum up to 100.

Final weights of criteria into each objective:

In this stage, it is supposed that each objective has a weight equal to 100%, and proportionally, the weights of its criteria emerge to add up to 100 for this objective.

Tables 7 presents the weights of each criterion for each of the 6 objectives, and Table 8 and Figure 5, the aggregated weights for each objective.

Table 7. Criteria - Weights

Criteria	***Final Weights***
O1-C1	8,25%
O1-C2	6,86%
O2-C1	8,72%
O2-C2	12,66%
O2-C3	22,24%
O3-C1	4,71%
O3-C2	4,99%
O3-C3	3,97%
O3-C4	4,63%
O4-C1	2,78%
O4-C2	3,72%
O5-C1	3,41%
O5-C2	5,26%
O6-C1	3,97%
O6-C2	3,83%
	100,00%

Table 8. Objectives - Weights

Objective	***Final Weights***
O1	15,11%
O2	43,62%
O3	18,30%
O4	6,51%
O5	8,67%
O6	7,80%
	100,00%

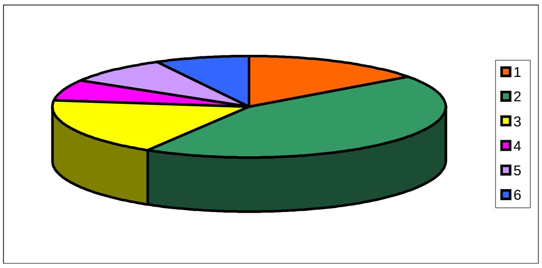

Figure 5 Objectives – Weights

Finally, Table 9 presents the criteria for the combination of project bundles and objectives, as well the results from the application of method "SUM". According to the above, when "Multi-criteria Analysis" is applied project PP1 produces the best results.

Table 9 Results of method "SOMMA"

	OBJECTIVE 1	OBJECTIVE 2			OBJECTIVE 3		OBJECTIVE 4		OBJECTIVE 5	OBJECTIVE 6	SUM
CRITERIA	Criteria on Economic terms	Number of accidents	Number of injured	Number of deaths	Consumption of energy	Radiation of CO_2	Mm/year during the construction	Mm/year after the construction	Inequality between North-South	Criteria on Financial terms	
PS1	0,227	0,128	0,128	0,13	0,013	0,062	0,202	0,255	0,201	0,535	1,881
PS2	0,113	0,016	0,016	0,016	0,028	0,117	0,204	0,182	0,196	0,262	1,15
PF1	0,163	0,012	0,004	0,04	0,283	0,214	0,409	0,155	0,194	0,246	1,72
PI1	0,337	0,493	0,502	0,459	0,496	-0,606	0,072	0,285	0,211	-0,082	2,167
PP1	0,16	0,352	0,351	0,356	0,18	1,213	0,113	0,123	0,198	0,039	3,085

5. Summary and conclusions

The objective of the appraisal methodology developed is to take some steps towards the development of a shared methodology for the appraisal of transport initiatives in Europe. The main conclusions arising from the methodology presentation can be summarized as follows:

An effective appraisal framework and methodology is presented which is philosophically sound, and aiming to support decision making in strategic transport planning.

The proposed methodology is capable of receiving inputs concerning preferences of the actors involved and it can generate outputs permitting the evaluation/appraisal of direct impacts as well the assessment of indirect effects on social and physical environment.

The methodology is easy to use by the decision-makers and has the potential to be a decision support tool for the selection among different transport initiatives.

The proposed methodology shares the characteristics of multicriteria and cost/benefit analysis. Philosophically it is based on the assumption that the decision-maker has originally a clear picture of his/her preferences, which can be subject to change in the light of new information during the decision process. As such, the proposed methodology can be thought as a blend of search and learning oriented procedures.

The methodology presents a series of features allowing for a high degree of flexibility, consistency and reliability. The decision maker can choose between default structures of generic strategies or create new weight profiles.

The paper has identified appropriate criteria for the evaluation/appraisal of different transport initiatives. Further refinement and detailed development of the decision tree is a matter of discussion and can proceed independently from the development of the appraisal methodology as a whole.

The methodology has proven to be robust, since it is applied the Adriatic Corridor, with sound results, although the corridor is complex one:

- The Adriatic Corridor is a multimodal corridor that exhibits high volumes of international traffic, most of which is transit
- The Adriatic Corridor crosses seven regions in Italy, which express various priorities in the comparisons of the relative importance of object and the criteria.
- The above seven regions are also influenced from social issues which cannot be expressed and taken easily under consideration. However, elements such as population and Gross Domestic Product influence the results of such an analysis

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