Value Engineering and its Application in the Design and Implementation of a Logistics Centre

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ABSTRACT: All large projects, from their inception to their completion, follow certain processes, undergo evaluations of different designs, while at the same time, they ensure project functionality at certain costs acceptable to the owner. The most effective process to manage costs is a process which puts emphasis not only on functionality, but also keeps prices and schedule in check from the project beginning to the completion of construction.

To keep project costs within certain parameters, there is a need to begin the project with a realistic budget and to have reliable pricing data. In addition, during the development phase, the project costs must be recalculated and, if necessary, adjusted (Bína et al., 2011). Another tool to increase the project value or decrease costs is to perform Value Engineering, i.e. an analysis of project functionality, specifications, tender documents and other project aspects, by a team of experts.

This paper describes Value Engineering and how such experts' efforts would be applied on transportation projects.

KEY WORDS: Transport projects, project re-evaluation, Value Engineering.

1 INTRODUCTION

Value engineering (Mandelbaum & Reed, 2006) is trying to find a balance between functionality, quality, safety and costs of construction and subsequent maintenance.

Logistics centre projects, from their beginning to their completion, follow certain processes, undergo evaluations of different designs, while at the same time, they ensure project functionality at certain costs acceptable to the owner.

In the phase of preparation, it is possible that certain proposals, arising from contracting authority or from the requirements of public administration bodies, can lead to cost overruns of the project from the initial pre-estimate. This can happen because of controllable reasons (location, route selection, number of intersections, etc.) or because of reasons where contracting authority has low or no impact (costs of materials, inflation, etc.).

It is necessary to set up a system of individual steps in the preparation and implementation that ensures quality of the management process of the project and of control of project costs. This procedure will ensure optimal relation between the price and functionality while keeping required quality and safety (Khane, 1986).

The most effective process to manage costs is a process which puts emphasis not only on functionality, but also keeps prices and schedule in check from the project inception to the completion of construction.

2 INPUT DATA ANALYSIS

- Commodity flows - for logistics terminal in the region, network of commodity flows (connections with partners in the “hub” terminals), forecasts of new commodity flows:
  - Import and export commodity flows in relation to places of production and consumption, which are located in the operation radius of the terminal, including links to the industrial zone;
  - Commodity flows that have a transit character between logistics terminals of the network;
  - Logistics operations in its own logistics terminal.

Analysis and forecast of commodity flows are an essential pillar of the methodological model. An expert proposal should aim to ensure the passing of analysed commodity flows through logistics terminal.

Forecasting methods, heuristic and expert practices can be used.

- Costs of implementing the logistics terminal;
- Costs of related transport infrastructure, which must correspond with the performance of the logistics terminal. Besides the road and rail infrastructure, it must also grant any necessary access to inland waterways transport, maritime and air transport. An external investment input from the public funds can be used for partial coverage of these costs;
- Costs of land based on size and price (the used site for logistics terminal must be in accordance with the planning documentation). The site must correspond with the spatial requirements of related transport infrastructure and with logistics operations in the terminal;
- Availability of transport corridors for road, rail and water transport. When considering transport corridors, especially in Europe, it is necessary to think about prognosis and schedules of development of new transport corridors.

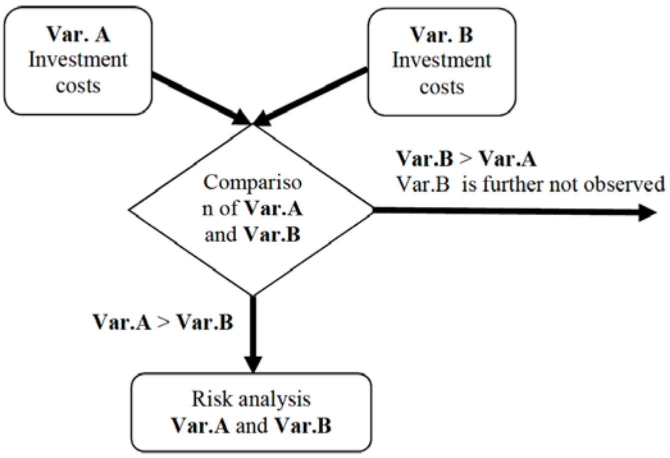

Figure 1: Decision-making process in Var. A and Var. B of related transport networks.
Source: author

- Var. A - external transport networks that exist at the design phase of a logistics terminal. The solution includes a network of road, rail, water and air transport in accordance with the input of technical-economic parameters for a logistic terminal.

- Var. B - external transport networks for which there is a time schedule of implementation and which can be considered for designing a terminal. This option is processed only if the implementation of logistics terminal (PLC) is being prepared in an area with construction of new infrastructure to which it would be beneficial to lead the related transport network.

3 EVALUATION OF ECONOMIC AND SOCIAL BENEFITS

When designing a logistics centre, not only economic benefits should be considered, but the whole society benefits (including intangible ones), too. When considering public support to a project of a public logistics centre, it is obviously necessary that society benefits are quantified at least to the level of the required public support. When implementing multimodal logistics centre, social benefits are achieved - concerning employment, improvement of the environment, lower accident rates, etc.

- Economic benefits of a terminal are divided into three basic groups:
  - Benefits from logistics terminal operations (container terminals, storage, etc.);
  - Benefits from logistics terminal activities;
  - Benefits from non-logistics terminal operations.

A necessity for a new container terminals can be defined by expert estimation. Society benefits can be then calculated (development of the region, new jobs, reducing transport externalities, etc.).

- Society benefits of a terminal (PLC)
  - Creating cooperating technological parks and industrial zones;
  - Increase in economic performance of the adjacent micro-region, towns and municipalities;
  - Improvement of environmental conditions and health because the existence of logistics terminals with access to road and rail transport is a condition for a change in freight transport from road to rail or waterway;
  - Creation of new job opportunities during construction of PLC, related infrastructure and in subsequent operation of PLC, as well as in related technological parks and industrial zones - there is a significant socio-economic effect. Global logistics chains are also a platform for deployment of information technologies from economic point of view. These facts lead to creation of jobs as well to highly qualified jobs;
  - The transfer of freight transport from road to rail network or the network of inland waterways has a significant impact on the environment and health especially in terms of:
    - Reduction of emissions (CO_2);
    - Reduction of noise pollution;
    - Reduction of congestion on the road network in particular, reducing accidents and fatal consequences.

Logistics centres have very similar process structures in contrast to technological parks and industrial zones. The existence of links between technological and logistic parks is very useful for the operation of both parts because of economic reasons and society benefits. The basic criteria for the methodology for designing logistics terminals are shown in Figure 2.

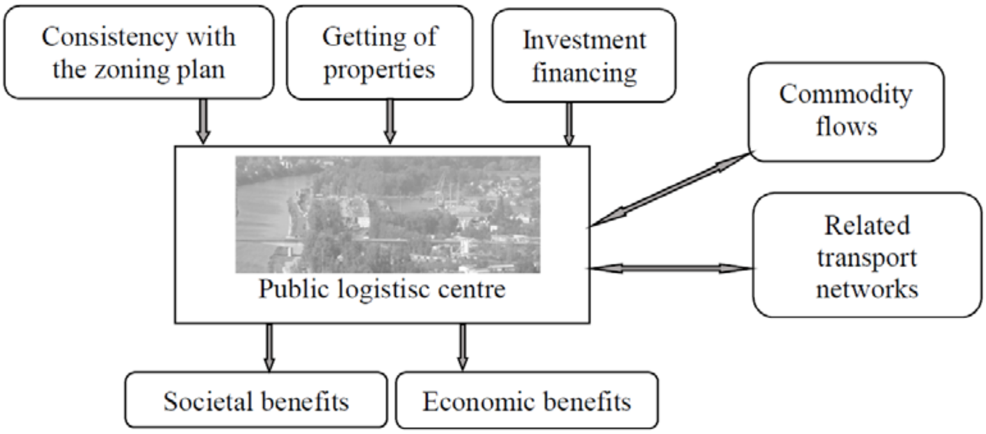

Figure 2: Basic criteria for the methodology for designing logistic terminals.
Source: author

4 RISK ANALYSIS

In terms of transport modes, the risk analysis is performed for road and rail connections, and only in the case when future external transport network is realizable in accordance with the preparation of the construction of a logistics terminal.

When assessing variants of a project, variety of methods can be used to find the optimal solution. For heuristic methodological model of expert design of logistics terminal that does not have exact data on the basis of detailed engineering, the method of risk analysis is chosen. It is based on the evaluation of the level of risks that are brought by individual variants. The significance of risk factors is assessed by a group of experts in two aspects:

In terms of *probability of risk factor occurrence* (P), linear scale is usually selected:

Degree	The occurrence of a risk factor is
1	*Improbable*
2	*Low likelihood*
3	*Highly likely*
4	*Nearly certain*

In terms of impact, i.e. *intensity of negative impact of the occurrence of risk factor* (D), non-linear scale is usually selected:

Degree	Impact of the occurrence is
1	*Negligible*
2	*Minor*
8	*Serious*
16	*Critical*

In terms of significance, it is necessary to consider factors whose occurrence is certain with the critical impact when they occur. The risk factors whose probability of occurrence is indeed improbable or small but negative impact may be up to critical, have to be regarded as significant. For these reasons, the linear scale is chosen instead of the non-linear scales for evaluating the negative impact for the probability of risk factor occurrence.

The interaction between a risk factor and intensity of the impact can be defined as follows:

As a model situation, selected P x D values can be used for determining the acceptability of risk as follows:

P x D	**risk assessment**
1 - 8	risk is acceptable
16-24	risk is conditionally acceptable
32-64	risk is unacceptable

An example illustration is shown in a model example of assessing two variants of road connection of a logistics terminal to an external road network in the above mentioned variants Var. A and Var. B.

Risk factors may be defined as follows:
A - Risk of exceeding investment costs (A)
B - Risk of acceptability of investment cost (B)
C - Risk caused by investment costs (A)
D - Risk caused by investment costs (B)
E - Risk of non-compliance with project parameters (A)
F - Risk of exceeding investment costs (B)
G - Risk of administrative and authorization procedures (A)
H - Risk of higher operating costs (B)
I - Risk of non-compliance with construction schedule (A)
J - Risk of unsecured financing (B)
K - Risk of public disapproval (A)

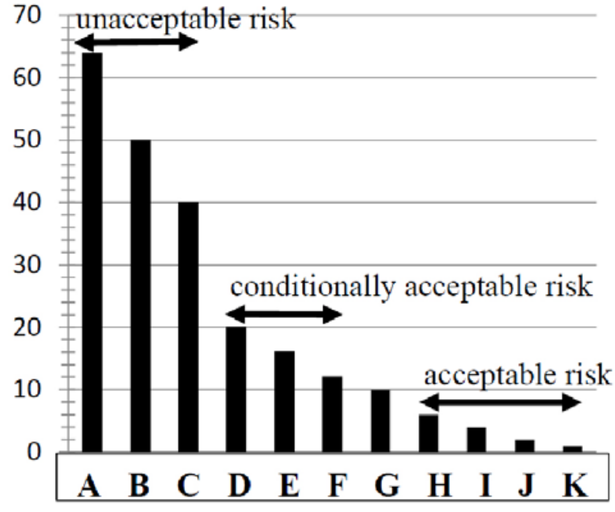

Figure 3: A model of results of risk analysis variants of road connection of a logistic terminal to external road network.
Source: author

An example of evaluating intensity of negative impact of the above mentioned exemplary risk factor “Exceeding the investment costs” can be the maximum value. In some projects that are financially managed by the proposed methodology, the excess of investment costs more than the tolerated deviation would generate an additional necessary step - financial control of the project.

An example shows a situation where the location of the construction is designed on a land with uncertain property relations, which can both mean more financial resources and potential shutdown of the realization of the project.

As it is obvious from the definition of risk analysis, a vital and essential role is played by the level of expert evaluation and qualifications and experience of the expert team members.

Risk Analysis identifies risks of the proposed variants and also defines critical points that need to be addressed during the project implementation. Results of assessment of this sub-model are:

- Final variants of realizable related infrastructure;
- Investment costs of individual final variants;
- Terms of implementation;
- Method of financing.

For the process of risk analysis, the method of Universal Matrix of Risk Analysis can be used. It has two stages: in the first – members of the expert group identify various segments of the project and identify resources which may be risky for these segments. In the other (numerical) stage the seriousness of the danger is estimated by using matrix UMRA and identified risks are quantified by estimated seriousness. It is necessary to identify all risk factors, from the beginning of project preparation to its implementation and its subsequent operation.

5 DEVELOPMENT OF INVESTMENT PLAN, CBA AND PROJECT DOCUMENTATION

5.1 Investment plan

Investment plan is a basis for justification of necessity of action and for the evaluation of its effectiveness. It contains construction technical description including the characteristics of the property and requirements for conditions for efficient use of the acquired assets and for evaluation of project benefits to deal with employment.

Already at this stage, preliminary estimation of costs must be available. It is prepared by experts on projects and construction work prices. Most of these first “estimations” are based on historical data (prices of units and segments, such as number of m^2 of road, bridge in question, etc.). These cost estimations are then used in the process of economic evaluation of usefulness of the project.

For example, to determine the cost of the infrastructure the Perpetual Inventory Method (PIM), method was used. It is based on knowledge of annual costs spent in the past on the road infrastructure, and in this method the pricing regulations 2008 (Moos et al., 2007) were used to determine the value of the motorway network built from 1978 to 1989.

In the next stages of the project preparation and in implementation, changes in the project budget based on project changes must be made (Nováková, 2010). If there is a disproportionate increase in costs compared to the estimated costs on the project, the particular part is returned for reprocessing either at the stage of the engineering preparation or the extra costs of the project must be justified in the implementation stage, and subsequently approved while additional funding is ensured.

In terms of costs data, the designed methodology can operate with:

- Knowledge bases and rules of individual parts of a project;
- Expert estimations of other missing data;

- Acceptance of data from similar projects (historical data);
- Combination of historical data and actual calculated costs.

5.2 Cost-benefit analysis (CBA analysis)

Dynamic methods are used in transport projects for cost-benefit analysis (CBA) of projects due to their multi-year implementation of projects and many years of useful life of these projects. Regarding the economic and analytical evaluation of transport projects, it is necessary to consider the value of money in time. All cash flows are discounted to their present value for comparisons and decision making processes. The analysis includes the evaluation of essential characteristic indicators, on basis of which a decision is made regarding the acceptability or unacceptability of the project.

We use the following terms for calculation of these indicators:

Discount Rate in investment analysis
The discount rate is an interest rate at which commercial banks can obtain loans from the central bank. In economic analyses, the term of *nominal discount rate* is used. It reflects the return on capital, risk level and inflation and is calculated using the formula:

According to nominal discount rates, future cash flows are discounted (recalculated) to the present value.

Net Present Value (NPV)
NPV is defined as a difference between the discounted cash flows from the implemented project, e.g. expected profit after tax, depreciation and other revenues, and capital investments in the project. If the project implementation takes several years (which is common in transport infrastructure projects), investment costs are discounted each year. The discount rate includes the interest rate, inflation rate and risk factors. It is calculated using the formula:

$$NPV = \Sigma CF_n \,.\, \frac{1}{(1+NDR)^{n}} \quad - C$$

where

$CF_{n = 1, 2, \ldots, \mathrm{N}}$ …. discounted sum of all cash flows received from the project
NDR …. nominal discount rate (in %/100)
C …. investment costs of the project

The project is acceptable for NPV ≥ 0, the project is unacceptable for NPV < 0

Internal Rate of Return (IRR)
This indicator evaluates annual profits from the project operation after tax in each year of the project life and an average annual value of fixed assets at net book value during the life of the project. This formula is used:

$$IRR = \frac{\sum_{i=1}^{N} AP_n}{N.AV_n}$$

where

AP_n …. annual profits from the project operation after tax
AV_n …. average annual net book value of the project

individual years of the project life$N$ … years of project life
The project is acceptable for IRR ≥ NDR, the project is unacceptable for IRR < NDR.

Payback period

It is the time (years) when the cash flows from the investment, expressed as a discounted cash flows, will reach the discounted initial capital investments. The payback period is calculated using the following formula:

IC … investment costs of the project
AP_n … annual profits from operation of a project after tax in each year of the project life
annual depreciation of investment costs of the project in each year of the project lifeindividual years of the project life$N$ … years of project life
The project is acceptable if the payback period is lower or equal to the lifetime of the project.

Cost-benefit analysis (CBA) includes the sensitivity analysis, i.e. calculating the impact of significant assumptions and parameters of financial (cash) flows to the values of key indicators of the analysis according to the above mentioned. For each changed assumption we calculate the percentage change in the criteria-indicators.

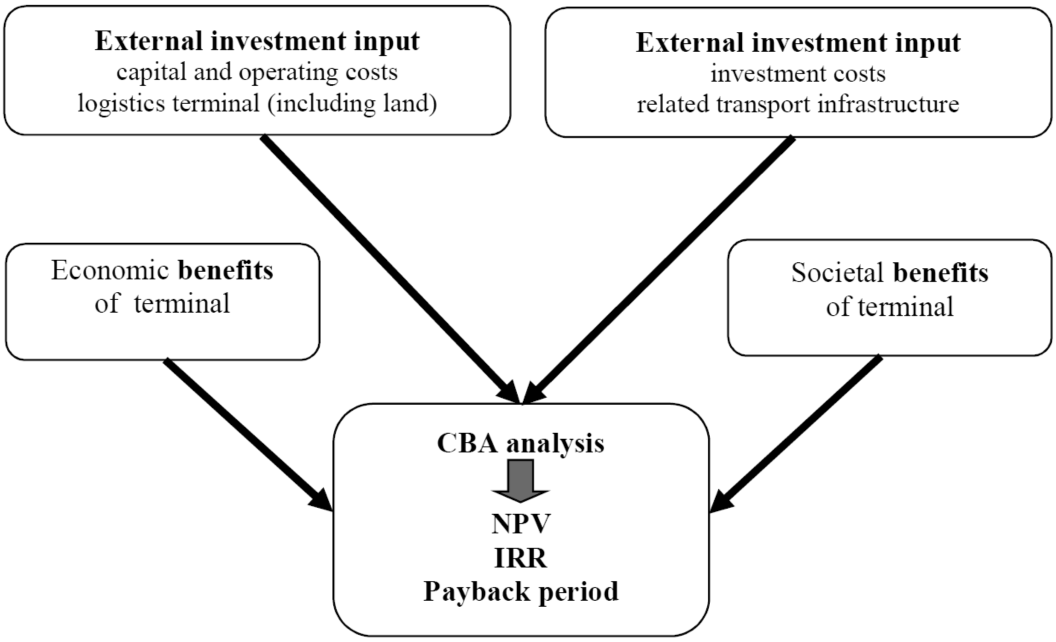

Figure 4: Input parameters for the CBA analysis of logistics terminal.
Source: author

Technical and economic parameters of related transport networks are again designed to provide optimum commodity flows. Changing of these networks is again necessary in the case of a negative result of CBA.

External investment inputs are variable in the case of a negative result of CBA. Regarding the fact that public resources are concerned, they may be changed in the design stage due to effects of external environment.

5.3 Production of project documentation

In case it is decided to implement the project, it is necessary to specify the preparation of the planning permission documentation including the cost calculation, under which the construction is set on specific plots. In addition, surveys are processed - geodetic and geological surveys, and technological process is designed. At this stage, the documentation EIA (Environmental Impact Assessment) - assessment of the impact of the construction on the environment is also prepared. If the result of this calculation is a disproportionate increase in costs compared to the estimated costs of the project, it is necessary to prepare an analysis and justification of this fact.

At this stage, contracting authority can still decide either to reprocess the project or to approve the price increase. The result is an issued planning permission.

The proposed procedure of the financial management of the project operates with these assumptions:

- From the stage when the final planning permission is issued, the cost budget of the project will be monitored throughout the course of the project while the deviation from the cost calculation in the documentation for planning permission may not exceed + -10%;
- In case this deviation is exceeded, a detailed control will follow, and if necessary, the budget will be changed with the current funding for potentially needed increase in the budget.

After the approval of this stage of the project, the next step comes - preparation of the project documentation for building permission and tender documentation including technical specifications and final cost estimates and schedule. These final cost estimates should be processed as transparent as possible and the resulting value of the costs should not be deviated from the offers in the tender procedure of more than 10%. Bigger deviations should be analysed.

6 VALUE ENGINEERING

Value engineering is a system of interconnected specific procedures, knowledge and experience. In this way it is possible to find unnecessary costs of a particular project, i.e. those costs which do not increase usefulness, durability, quality, safety and other characteristics that are necessary for the implementation and subsequent proper use.

The goal of “value engineering” is to eliminate unnecessary costs and thereby to achieve lower project costs, without reducing functionality, safety, quality and other monitored properties of the project.

With “value engineering” or “value management” or “project reassessment” it is possible to find a balance between functionality, quality, safety and price of construction and subsequent maintenance. It is a way to keep costs within expected limits. It is a revision tool of already-designed construction in order to increase the value of the project by analysing the functionality/ specifications, and associated costs. This method is the most effective for complex or non-standard constructions and for constructions where previously validated standard elements cannot be used.

The basis of “value engineering” method is the following formula:

$$value = \frac{function}{cost}$$

where

value	…	lowest cost at which it is possible to achieve the desired properties *financial value in relevant currency*
function	…	minimum requirements for usefulness, durability, quality, security, etc. *expressed as a price in relevant currency*
costs	…	costs spent on the implementation of the project *financial value in relevant currency*

Two conclusions shown in the following diagram come from the above mentioned formula:

- Growth of costs significantly reduces the project value, unless there is an adequate increase in its function;
- In order to increase the project value, costs must be reduced without performance degradation.

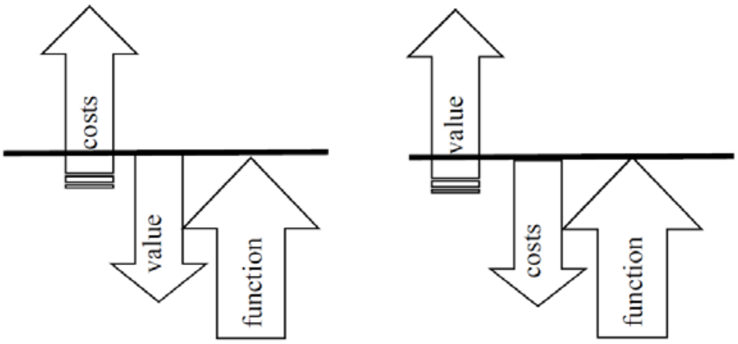

Figure 5: Links between changes in different parts of the formula.
Source: author

It is necessary:

- To use a systematic approach in which the elements of the system and the links between them will be analysed;
- To ensure systematic approach to solutions;
- To analyse the project by a team composed of experts who have relations to the topic.

The entire process of “value engineering” can be divided into several phases:

- Definition of objectives, identification of problems;
- Dealing with problems and proposal of measures;
- Evaluation of conclusions, selection of suitable alternatives.

Before starting the process of “value engineering” it is advisable to use functional analysis (FAST “Function Analysis System Technique”). During the analysis we determine the properties which the project proposal / logistics centre should have. After this analysis, or after determining project properties respectively, it is possible to design various solutions that will reduce costs.

“Value engineering” can be divided into two variants “A”, “B”, i.e. “before starting implementation” and “after starting implementation”:

However, variant “A” has a greater positive impact on the project - that is, before the start of the project. Although variant “B” will help to reduce costs, it cannot eliminate costs already incurred by the preparation of project documentation, etc.

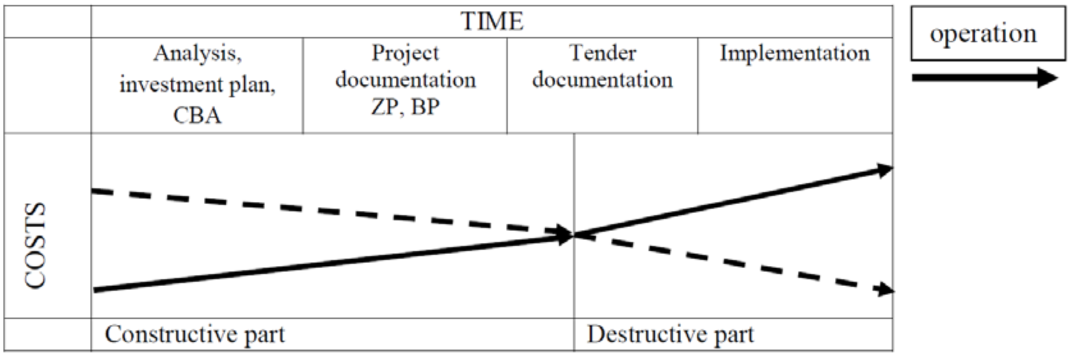

Figure 6: Costs for changes over time
[*]ZP = planning permission; BP = building permission
Source: author

The figure above clearly shows that the final line at which you can significantly use the method of "value engineering" is tender, i.e. detailed, project documentation. At this stage, suggestions to changes can be applied without incurring higher costs.

There are two basic alternatives of Value engineering:

A. <u>At the request of contracting authority</u> - a team of experts will examine the prepared project documentation before processing tender documentation and before the start of tender for project contractors,
B. <u>At the request of contractor</u>, when after signing of a contract with supplier, this contractor comes with a proposal of acceptable savings for the client.

Alternative A) may be used if the project has been prepared for some time and some of the circumstances changed during the preparation of the project documentation. This situation occurs at transport projects very often because the preparation of projects takes several years due to its complexity.

At VE it is necessary to analyse written documents related to technical processes, technologies, specifications of tender documents, project administration, insurance, guarantees and contract draft between contracting authority and construction company.

This version of VE, which is usually carried out at request of contracting authority, is performed by a multidisciplinary group of experts from fields that relate to the topic. A tender should be prepared for processor of VE for each examined contract / project.

Alternative B) may be used in case this option is permitted in the tender documentation and financial conditions for contractors and investors, which depend on the amount of savings, are defined. The tender is held in standard form. Then contractor has the right to propose changes which will reduce the final price of the project implementation, and contractor is also involved in these savings to certain agreed percentage. Contracting authority has the right to accept or reject the proposal. The changes may relate to technological processes, materials, but always under the condition that they will respect the functionality, quality and security of the project. In some cases, proposed changes result in a change in building permission, and thus in a potential prolongation of completion date. It depends on contracting authority's agreement with contractor whether these changes will be accepted. But in large scale constructions the beginnings of each phase can be set so that the deadlines will be met.

The decision criteria whether to use the proposal or not should include the relation between the reimbursement for processing VE and percentage of price reduction of the contract in question and references and qualifications of the processor of VE.

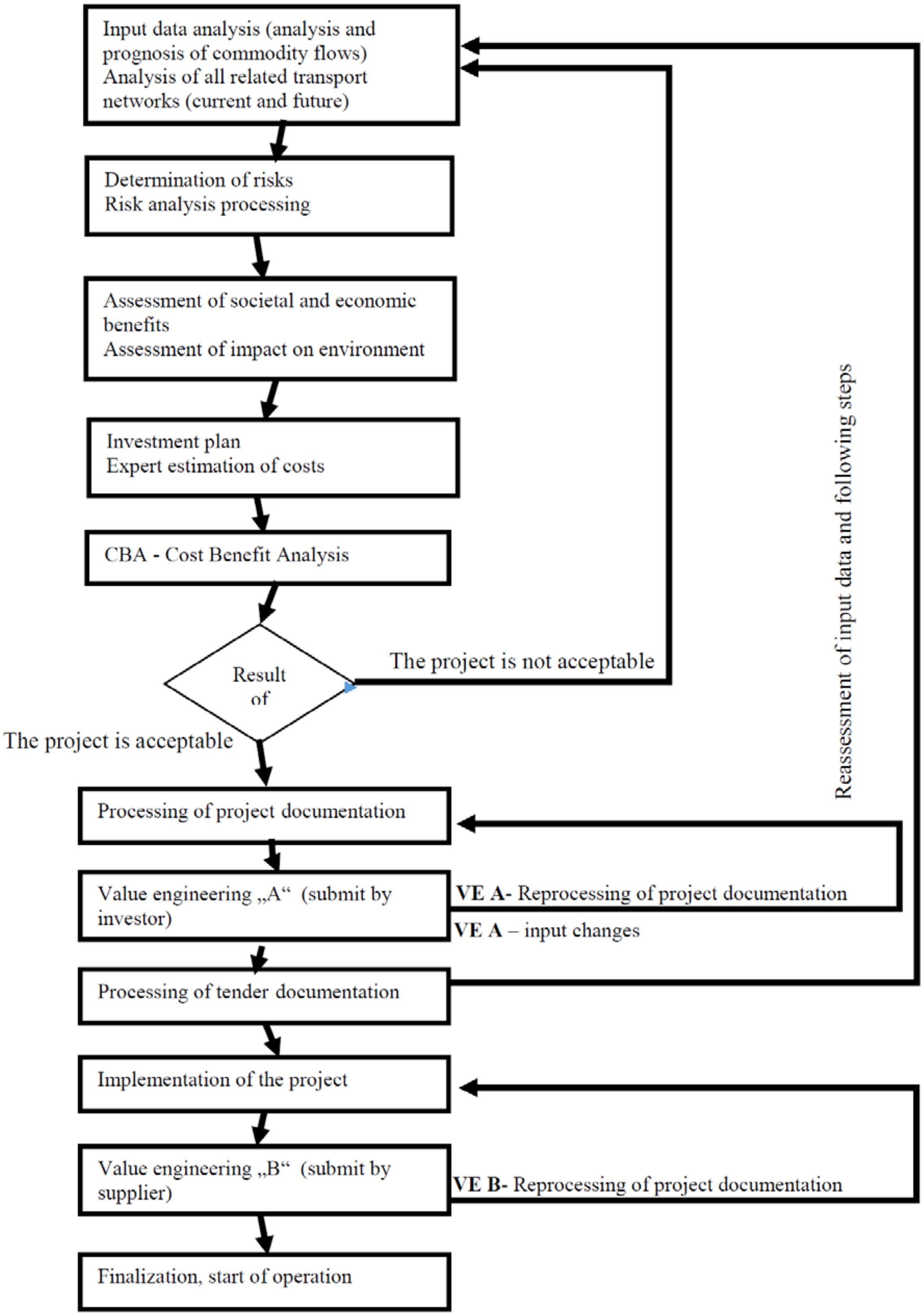

Figure 7: Diagram of project's preparation and implementation.
Source: author

7 CONCLUSION

Financial project management methodology allows to improve financial management in the design and implementation of a logistics centre, but is also applicable to all types of buildings. Once the final planning permission is issued, it is necessary to monitor the expected costs (based on the budget) of the project in the further course of the project. The deviation can be + -10% from the cost calculation in the project documentation for planning permission. In the case of exceeded deviation, it is necessary to perform detailed verification of eligibility of each item, and then provide potential higher implementation funds. In some cases, it may be also possible to reduce costs.

Using this methodology the re-evaluation of the project (Value Engineering - VE “A” VE “B”) may occur twice within the entire process.

An example of effective use of the “value engineering” method can be found in the USA, where public authorities are bound by law to use this method.

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