Methodology of transportation project management

Helena Nováková

Department of Logistics and Management of Transport,
Faculty of Transportation Sciences,
Czech Technical University in Prague, Czech Republic

novakhe2@fd.cvut.cz

Abstract: All large projects, from their inception to their completion, follow certain procedures, when undergoing evaluations of different designs, while at the same time, assuring project functionality at realistic costs which are acceptable to the owner. To keep project costs within certain parameters, there is a need to begin the project with a realistic budget and to have some reliable pricing data. In addition, during the development phase, the project cost must be recalculated and, if necessary, readjusted. Another way to increase the project value or to decrease the cost 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 and benefit transportation projects. The methodology of design of logistics terminal is presented, including related transport network as an example of a large transport project for the use of Value Engineering.

Key words: Transportation projects, Value Engineering

1. Introduction

From the very beginning until its completion, every large transport-related project goes through the previously defined procedures and proposals so ensuring project functionality is confined within a certain price level as envisaged by the assigner.

It is a common practice that these procedures and proposals may, under specific circumstances, increase the cost of the original preliminary estimation, either due to reasons which could have been avoided (location, choice of route, number of crossroads etc.), or because of reasons beyond the reach of the assigner (material price, inflation etc.).

In any case, it is essential to determine that such project management and project cost control processes ensure the most economical completion as soon as possible and which would simultaneously prevent superfluous project cost increases through factors which might have been influenced by the assigner.

Transport projects can be classified as financially demanding and also with regard to the project planning as demanding projects. Due to the necessary control of costs for preparation and implementation of these projects, value project management (Value Engineering) is included in the proposed methodology. Furthermore from the engineering phase of the project to the decision-making phase on implementation of the project, a heuristic expert model that is able to determine various cost items without detailed engineering documentation, is included in the proposed methodology. However, this model has to work with the normative of individual components of transport projects based on historical data of implemented projects, forecasts of construction materials and other documents. The result financially is a significantly cheaper version of the project, to the decision-making phase on implementation of the project. Listed methodology for the preparation of transport projects with the inclusion of a heuristic expert model for the preliminary determination of costs and with the inclusion of the value project management (Value Engineering) has not yet been implemented in the Czech Republic. In recent years, the expert team of the Faculty of Transportation Sciences at Czech Technical University in Prague has been working in collaboration with the Ministry of Transport and other entities. The norms transportation projects 2008 (MOOS, P. et al. (2007)) “Structure of sets of normative standardized of segments of road transport constructions - assessment of the situation in EU countries and other available countries in the form of benchmarking”, which will be one of the inputs to the described methodology if doing updates. The implementation of this methodology to real design practice would not be an easy task, but with regard to the amount of investment funds to transportation projects, the impact could be unexpectedly significant.

The U.S. Department of Transportation Federal Highway Administration, (http://www.fhwa.dot.gov) issued May 25, 2010 the document "FHWA Value Engineering Policy" according to which the Value
Engineering Analysis should be used for all road construction funded from the federal budget. Part of the Web of FHWA also includes pages for Value Engineering. The U.S. Department of Transportation pays crucial attention to the organization of public procurement tenders. Special attention is paid to engineering (expert) estimates that serve as a basic parameter in the organization of tenders. In the material FHWA "Guidelines on Preparing Engineers Estimate's Bid Reviews and Evaluation, January 20, 2004" the process of engineering estimations during the initial phase of project preparation is described. It is emphasized that undervalued estimations of project budgets could result in the subsequent need to ensure additional funding that will impact on the project costs. On the other hand overestimated calculations bind the funds that could be used for other projects. The process of estimation is obviously not an exact science, but the prevailing opinion is that at least 50% the engineering estimation of the projects should not differ from the most advantageous offer by more than + / - 10%. A similar procedure for value project management of the design, implementation, operation and maintenance of bridges has been introduced in Sweden under the name Life-cycle costing, LCC includes very simplified normative of bridges.

It follows that for the proposed methodology described in this paper, in management of traffic projects using expert estimations and the value project management (Value Engineering), standardized methods and certification procedures may not be used. The International Project Management Association - IPMA has a primary function to promote project management as a profession that has a global scope, standards, knowledge and abilities. It brings together project managers across all fields of human activity. It does not organize Value Engineering programs. A similar international organization of PMI (Project Management Institute) offers certification courses for project management including PRINCE2 courses which is the most widely used project management method. Nor is there an offer of Value Engineering and value project management, including expert estimations of primary budgets for tenders. However, it would be appropriate to establish a connection with these international organizations to provide project management and for the inclusion of this methodology, which was established in the research at the Faculty of Transportation of the Czech Technical University in Prague, as a module in their portfolio.

2. Management and cost control process

The most efficient management and cost control procedures are represented by such processes that puts an emphasis not only on the project objective but also on the schedule and price within the frame, ranging from the introductory engineering documentation up to its completion. Project preparation and finalization phase is described in Fig. 1.

![Fig. 1 Project preparation and finalization phase, Source: author](image_url)
It is already the first study (Introductory study) which is expected to include the preliminary cost estimation carried out by experts and specialists regarding prices of projects and construction works. These first “estimations” are mostly taken from historical data (unit and segment prices such as one m$^2$ of a defined road, bridge etc.). These cost estimations are then used in the process of the economic evaluation of the project utility.

The subsequent stages of the engineering preparation and the project realization are bound to involve the revision of the budget of the particular project while taking into account all project modifications.

If an unexpected increase in costs occurs in comparison with the expected project price, the respective part should be either sent back for revision during the engineering preparation stage, or in the finalization stage and there must be provided an explanation concerning the project price increase and the subsequent approval and provision of further financing must be ensured. The advantage of this methodology lies in the fact that it is able, with the expected deviation being 10-30% (the deviation from cost estimation in the Introductory study amounting up to 30% is based on the methodology of the World bank regarding this level of decision-making (Khane, 1986)), to process the basic technical-economic materials for the project in variant arrangement for the decision-making processes, including risk analysis, without the expensive and time-consuming detailed project preparation.

Projects enjoying public support do not usually include preparation stages of engineering documentation in project costs. This methodology is important from the economic point of view since it minimizes the costs of the preparation work before the decision is taken on whether to implement the project or suspend it. In the case that the project is suspended it concerns the so-called “sunk cost”. The same methodology may be used also in the following stage of completion of the approved project based on the elaboration of engineering documentation. Even this stage necessitates the realization of the whole logical frame of the methodological model and if the deviation from the project budget would be more than 30%, an analysis detecting the causes of this deviation must be carried out.

From the cost-related data perspective the suggested methodology may work with:

- knowledge and norm bases associated with individual project parts,
- expert estimations of the other missing data,
- assuming data from analogous projects (historical data),
- combination of historical data and actual calculated costs.

One of the small number of materials intended for expert engineering cost estimations related to road constructions are presented by the **Price norms related to the constructions of road communications 2008** (Cenové normativy staveb pozemních komunikací 2008) [FD ČVUT, 2007]. These price norms were compiled in 2007 by an expert group of the Faculty of Transportation Sciences at Czech Technical University in Prague lead by Prof. Ing. Petr Moos, CSc. on the grounds of the requirement of the Ministry of Transport. It serves above all for the price designation of a transport construction within the stage of the elaboration of its Investment project. In the subsequent stages of construction preparation or its assignment the calculations made by means of these norms may have a comparative function. The necessary precondition allowing the use of these price norms is the knowledge of the evaluated project which should include a brief description within the scope serving as the basis for the evaluation (especially its expert part) in the Annex dealing with the issue of evaluation. Another precondition is the sufficient experience of the author of the price calculation with the project finalization and with the evaluation of projects envisaging the construction of transport infrastructure. In 2009, the above stated norms were sent in the form of a letter of approval by the Ministry of Transport of the Czech Republic to the Road and Highway Directorate of the Czech Republic (ŘSD ČR), a state-funded institution, with the instruction that the RHD should use these norms in compliance with the procedure “Application of price norms in investment process” which had been elaborated as a flowchart by the State Fund of Transport Infrastructure.

**The described proposal of project preparation and proposal according to Fig. no. 1 includes price norms for projects of construction of road communications that may be employed within the stage of Introductory study and Investment project.**

Risk Analysis or Failure Mode and Effect Analysis are employed when evaluating different variants of the project or possibly for risk evaluation concerning the project as a whole. Risk is defined as any factor (risk factor) which may negatively influence the expected results of evaluated variants. For each evaluated project variant, it is necessary to define:

- risk factors standing for any event which may to a certain degree of probability influence the evaluated project variant or the whole project. It is important to distinguish between factors
which are essential and influence the evaluated variant in a significant way, and those which are less relevant or insignificant and may thus be omitted,

- principles of risk evaluation (definition of the relevance of risk factors).

Expert evaluation of the relevance of risk factors is derived from the evaluation of this relevance by a group of experts having sufficient knowledge and experience with the preparation and realization of similar projects in the past. Evaluation of risk factors relevance is carried out within two categories as follows:

- **Probability of risk factor occurrence** when several degrees of probability (e.g. Degree 1 – risk factor occurrence is improbable, up to Degree 5 – risk factor occurrence is highly probable) are usually defined. An example may be the risk factor “Exceeding investment costs” when the probability of this risk factor is evaluated with the evaluated project concerned. Example: construction is situated in a territory where it is possible to expect archaeological findings. However, it is not possible to define their range. Costs of the archaeological research are covered by the investor and it is not possible to estimate in advance either the period, nor the amount of costs,

- **Intensity of risk factor negative impact on the evaluated variant**

With this evaluation, the risk factor is the more relevant, the higher the probability of its occurrence and the higher the intensity of its negative impact on the evaluated project variant or the whole project. An example of the evaluation tracing the intensity of negative impact related to the already mentioned risk factor “Exceeding investment costs” may also be the maximum value since with a great number of projects controlled financially according to the suggested methodology would necessitate financial revision of the whole project in case the investment costs exceeded the given tolerance.

As the definition of risk analysis reveals, a considerable and fundamental role is played by the level of expert evaluation as well as the qualification and experience of expert team members. The result of the whole procedure is the elaborated investment project (Investment project) whose part is the Cost Benefit Analysis (CBA) and possibly Risk analysis. Investment project presents a sufficient basis as for the decision concerning project completion or suspension.

In case of the project completion decision, the assigner shall assign the elaboration of the Documentation for Planning permission (DPP) which is supposed to be much more detailed than the documentation prepared in the investment project (it disposes of basic geodetic and geological research, it deals with technologies, materials, it makes analyses of alternatives etc.). It also contains technical specifications, schedule and detailed calculation of costs. These estimations are prepared already on the grounds of standard procedures related to the calculation of costs of individual items by means of statistical “data base”, which may be used for the budgets of the assigner within a time schedule corresponding to the initiation of the project implementation. The same as with the stage of investment project preparation, concerning an unexpected increase in costs in comparison with the expected final project price, the assigner must be informed immediately of this price increase and the reasons for it. If such a situation should occur, it must concern the situation where the assigner is still able to decide about the project revision or the approval of the given price increase. These cost estimations should not differ to a considerable extent from those cost estimations which would be calculated on the grounds of the final project documentation. This Documentation for Planning permission (DPP) also serves as a basis for the elaboration of Environmental Impact Assessment (EIA) – the evaluation concerning the impact of the construction on the environment. The output of this procedure shall be the issue of an official document according to the building act - Planning permission.

The suggested procedure related to financial project management is based on the following prerequisites:

- **From the stage when a legally effective Area decision has been issued the project cost budget should be monitored in the subsequent stages of the project; any deviation from the cost calculation in DPP should not exceed +/-10%**

- **In case this deviation is exceeded a detailed examination shall be carried out; provided that it will be recognized as legitimate, the project budget shall be changed accordingly so that the financing can be ensured also with regard to the budget increase**

- **The project shall be evaluated twice within the Value Engineering – VE, Variant A and B according to Fig. 1.**
Following the approval of this stage of the project the assigner shall assign the elaboration of project documentation envisaging the obtention of Building permission and tender documentation including technical specifications, in the final cost estimate and schedule. These final cost estimates should be elaborated in a standard table form, they should be transparent and the final sum should not differ from the most favourable offers by more than 10%. Only in exceptional cases may bigger deviations occur. No matter how big such deviations are, it should always become the subject of a detailed analysis.

3. Value Engineering (VE)

A method of maintaining the costs within the expected frame is represented by VE. VE is a form of revision of the already projected construction aiming to detect the value of project by means of a functional/specification analysis and the related costs. VE is employed most efficiently with complex or non-standard constructions as well as with constructions which could not use the previously verified standard elements. VE makes an effort to find the balance among functionality, quality, safety and price of a construction and its subsequent maintenance. This description deals with two basic VE alternatives:

A. On request of the stakeholder/investor, an expert team would carry out a careful review of the elaborated project documentation, before the commencement of a tender procedure on a contracting firm,

B. On request of the stakeholder/investor, after the conclusion of the contract with a supplier, the firm shall come up with a proposal concerning savings acceptable to the assigner.

Alternative A) may be employed in the case that the project was prepared a long time ago and some circumstances have thus changed; or provided that during the preparation of the project documentation the functionality and specification were not optimized continuously; or if the project documentation did not take account of the subsequent maintenance or “life cycle value”. It may happen sometimes that the proposed construction segments took no account of the capacity or specialization of construction firms, or, for instance, that it did not consider the possibility to exclude the bridge construction out of the contract on a highway construction and its inclusion into a separate contract, which may be solved by means of the elaboration of several project documentations. It is also often very important to evaluate whether appropriate material was planned for the large bridge constructions – reinforced concrete, or steel and type of bridge construction in relation to the prices of concrete and steel (it is not unusual to prepare two documentations in the case of unstable prices).

This revision shall then concern the greatest possible unification of small and medium-sized bridges and any other repeated constructions, drainage, slopes, small tunnels, types of material, optimization of maintenance and safety. VE pays great attention also to the analysis of written documents related to technical procedures, technologies, specifications, tender documents, project administration, guarantees and the contract proposal between the assigner and the building firm.

This type of VE is in the majority and carried out by request on behalf of the assigner by a multidisciplinary group of experts operating in all key fields and ranging from engineers to practical building experts, estimators and persons experienced with highway maintenance and the provision of transport in the course of construction works. Every order/project being the subject of examination shall be ensured by a selection procedure on VE processor.

Alternative B) should be used in the case that the documents for a public procurement allow for such a possibility and that payment to a building firm is defined (mostly a percentage division by a price deviation). Building firms shall participate in a selection procedure on the grounds of documents made public and the assigner shall conclude a contract with the selected firm. The subsequently selected firm may offer to the assigner possible alternatives while aiming to reduce the price (deviations from the original documents) and the assigner may either approve or reject such alternatives after their negotiations. It normally concerns technological procedures, changes of type of materials and other proposals while having no impact of project functionality, safety and quality. It is necessary to state that in this case the suggested modifications may lead to changes concerning the building permit and consequently to a delay in the construction. However, as far as large-scale constructions are concerned, the determination of stages may be suggested in a way so that the final term would be met.

This type of VE can be proposed and elaborated on by a building company and then negotiated with the assigner from the technical and price point of view. These proposed changes are most commonly
specific as each building firm has different building methods, purchase possibilities, relationships with subsuppliers etc and it is normal to make use of these proposals. The criteria should include the relation between a payment for VE processing and a percentage related to the reduction of price of the examined order as well as references and the qualification of the VE processor.

4. The methodology of expert design of a logistics center in relation to commodity flows related to the transport network and the calculation of economic efficiency

An example of a large-scale transport infrastructure project is a design of a logistics center and related infrastructure. The use of above described procedure for Value Engineering can generate significant economic savings. The proposed methodology is applicable in using a feasibility study, economic analysis and investment plans of newly designed projects. The advantage of this methodology is that it can provide a technical and an economic basis for logistic centers with an expected deviation of 10-30\% in variant arrangements for decision-making processes including risk analysis without an expensive and time-consuming process of engineering documentation.

This methodology is economically important because of the cost of all the preparatory work before deciding on implementation, or stopping the project because of "sunk costs". For projects with public support they are not usually included in the project cost. The same methodology can also be used in the design of a logistics center in the next phase of the approved project based on the processing of the engineering documentation. Even at this stage it is necessary to implement the entire logical framework of methodological model and if the deviation of CBA parameters is higher than 30 \%, it is necessary to analyze the reasons for this deviation. In terms of cost-benefit data, the proposed methodology must operate with:

- knowledge bases and norms of the individual parts of the project,
- expert estimates of lacked sufficient data,
- taking data from analogous projects.

Individual segments of the proposed methodology include the basic and essential part of the feasibility study, which is a mandatory annex of each application for financial support for projects from public sources. These substantial parts of the feasibility study are:

- Description of the project
- Analysis of the market (in our case commodity flows, and other logistics and transport operations)
- Benefits and costs of the project and the analysis of these costs (CBA Cost Benefits Analysis)
- Funding of the project, including public support
- Risk and sensitivity analysis.

When evaluating the project revenues, commercial societal benefits (including intangible) plus additional economic benefits, should be considered. This procedure is justified by the fact that in the case of projects of intermodal logistics centers, the societal benefits are achieved, and therefore it is justifiable requirement to support projects with public support. This public support should be proportional to the quantified and accepted societal benefits.

In terms of self-financing of investments for the implementation of logistics terminal and related transport infrastructure a form of cooperation between the public and private sectors must be considered. In the logical framework of methodological model of design of logistics terminal, further public support for the actual operation of the terminal is not considered.

In terms of relations of technological and logistics complexes a situation where they are not located in one continuous area, but are placed separately can be considered. Separate locations within the same city or region works on condition of technological, economic and logistical connections. The design methodology focuses only on the logistics centers, which have a very similar process structure in contrast to the technology parks and industrial zones. However, the existence of connections between technology and logistics parks is for the operation of both parts very beneficial because of economic, organizational, and societal reasons.

Within the EU, and the European continent intermodal transport network and network of logistic centers will ensure conditions for the single market and the international mobility of goods from places of production to places of consumption and associated transits.

The proposed methodologies of design of logistics terminal should be based on the philosophy of implementation based on the specified economic parameters, which include the design of its own
logistics terminal and related transport infrastructure and other aspects. The existence of optimally positioned and designed logistics terminal with the existence of commodity flows is an important source of extensive societal savings. The basic criteria for the methodology of design of logistics terminal are shown in Fig. 2.

![Diagram](image.png)

**Fig. 2** The basic criteria for the methodology of design of logistics terminal. *Source: author*

The methodological model logistics terminal is divided into the following main segments that are individually designed and functionally linked to each other. It can be said that this is a decomposition of a heuristic model. Heuristic methods do not work with exact data and calculation methods, but they work with knowledge and experience of experts with the fact that results of it are likely to meet the requirements for this solution. The Knowledge Management, which is a knowledge database that enables the use of expert knowledge in this field, is suitable or even necessary for this methodology. Such knowledge is then used in the preparation of variant models and solutions.

### 5. Conclusion

1. **Methodology of project financing management**

Methodology of project financing management has been suggested in order to ensure significant amelioration of financing management of especially large-scale transport infrastructure projects. This methodology assumes that the cost budget shall be monitored from the stage of the Ground decision issue and during the subsequent course of the project; deviation from cost calculation in DGD should not exceed ±10%.

In case this deviation is exceeded, a detailed examination should be carried out and provided that this deviation if it is not legitimate then the budget should be modified accordingly so that financing would be ensured also in the case of the budget increase.

Project shall be evaluated twice within the frame of Value Engineering – VE), Variant A and B according to Fig. 1.

2. **Value Engineering (VE)**

VE is a form of revision of the already projected construction aiming to detect the value of the project by means of a functional/specification analysis and the related costs. VE is employed most efficiently with complex or non-standard constructions as well as with constructions which could not use the previously verified standard elements. VE makes an effort to find the balance among functionality, quality, safety and price of a construction and its subsequent maintenance. This description deals with two basic VE alternatives:

- A) after the completion of project documentation but before the selection of a building firm,
- B) after the conclusion of the contract with a supplier firm, the firm shall suggest savings acceptable for the assigner from the other parameters point of view
3. It is necessary to ensure maximum standardization of building components as well as standardization of tender documentations including insurance request – “performance bond”.

4. Essential prerequisite for the implementation of the proposed methodology of project financing management consists in the provision of knowledge database processing, updating of norms related to the construction of road communications and other similar data bases.

5. **Price norms related to the Construction of road communications and Methodology of transportation project management**

   In 2012, the update of price norms that were compiled in 2007 by an expert group of the Faculty of Transportation Sciences at Czech Technical University in Prague was performed. The update was made in the context of improving the quality of the preparation of projects of transport infrastructure financed from public funds. According to the price normative in 2012 the Road and Highway Directorate of the Czech Republic (ŘSD ČR) set a base price, which included the real costs of implementing the basic elements of the project plan. This update was approved by the Ministry of Transport of the Czech Republic on March 21, 2013. According to Bina et.al. 2011, the price normative was a basis for a methodology for determination of toll tariffs in the system of electronic tolls in the Czech Republic. The proposed Methodology of the transportation project management has not yet been utilized on a large scale transport project.

   At the moment, the author who is a member of a working group will discuss the application of this methodology in the preparation of the Strategic Plan of the City of Prague in the part headed “Infrastructure”.

**Bibliography**


Bína, L., Lehovec, F., Moos, P., Novakova, H., Karlický, P et.al., 2011: *Report on the Methodology used to Calculate the Maximum Weighted Average Toll prepared in connection with the Notification of the Czech E-Toll System for the European Commission*. Prague, Czech technical University in Prague, Faculty of Transportation Sciences, Deloitte Advisory s.r.o.

Moos, P. - Lehovec, F. - Bína, L. - Skurovec, V., 2007: *Struktura souborů normativů typizovaných úseků silničních dopravních staveb - vyhodnocení situace v zemích EU a dalších dostupných zemích formou benchmarking - Analýza tvorby rozpočtů staveb u projektových a realizačních organizací v ČR*. (Structure of files of normatives of standardized sections of road structures - assessment of the situation in the EU and other of available countries in the form of benchmarking analysis-budgeting of structures in project and implementation organizations in the Czech Republic). Praha, ČVUT Fakulta dopravní

Nováková, H., 2010: *Metodologie návrhu technologických a logistických center, disertační práce. (Methodology of the design of technological and logistics centers, dissertation thesis)*. Praha, ČVUT Fakulta dopravní


[www.rsd.cz](http://www.rsd.cz) - Price norms related to the constructions of road communications

**JEL Classification**: 022, R42