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RISK MANAGEMENT FOR LARGE INFRASTRUCTURE PROJECTS USING PROBABILISTIC METHODS

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Introduction

Not only in the financial world risk-management is the order of the day, but also in the construction of large infrastructure projects. This is particularly true for projects with a large share of underground structures, where the risks are generally high. A comprehensive risk management system can help to identify the risks and minimize their consequences.

For the owners of large infrastructure projects it is of vital interest to know in advance the final cost as accurate as possible. To achieve this, the authors propose to quantify risks by using probabilistic methods (instead a single deterministic figure) and to consider the uncertainties related to the basic cost estimate by using the same approach. The result is a probabilistic distribution for the basic cost and a probabilistic distribution for the cost of risks. To support this process through all stages of a project the authors developed a special software called **RIAAT** ***Risk Administration and Analysis Tool.*** It supports the risk management process from identification and assessment of risks through modelling of distribution density to aggregation. The advantage of a probabilistic approach lies in the fact that by using values lying within a bandwidth and modelled by a defined distribution density the reality can be modelled better than by using deterministic figures.

Applying Probabilistic Methods in Engeneering

Commercial software for risk analysis (e.g. @risk, Crystal Ball) provides a number of density distribution functions for modelling uncertainty. The problem with most of them is that they are too sophisticated for the purpose of cost estimation and risk assessment in civil engineering and require input data and parameters, which are not available for the sort of projects we are looking at. What is missing in all of them are features for the administration and traceable documentation of risks over the various project phases.

Based on earlier works and experience from research and encouraged by the positive feedback from pilot projects the authors choose for their method an approach that is appropriate to the engineering mind: using mainly rectangle and triangle distributions. One of the advantages of the Triangular function is that it requires only three input data: expected (most likely) value, minimal and maximal value.

Considering this fact and taking into account that the probability of occurrence for a typical tunnelling risk like a cave-in cannot be deducted from statistics, asking for an

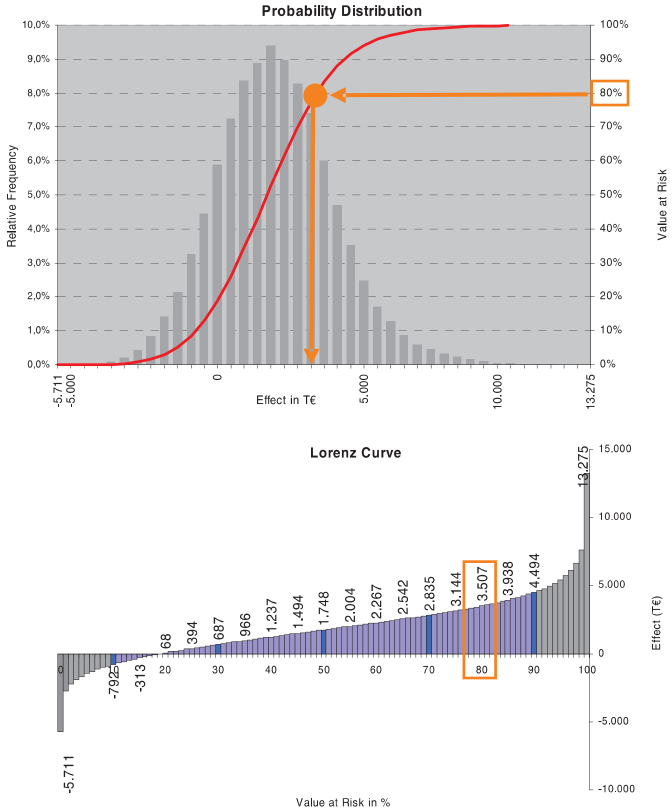

Fig. 1 – Probability Distribution and Lorenz Curve for aggregated risks displaying the same result

expert opinion is often the only way to assess the probability of occurrence and the consequences of a risk. Most experts will be able to indicate the probability of occurrence within a bandwidth – e.g. between 10 and 40% with a value most likely to be expected at 20% – as well as the consequences in time and cost within certain limits, this time with a minimal and maximal value plus an estimate for the value most likely to be expected. In this as in other cases where subjective probabilities have to be modelled the use of a triangle distribution will be the best solution.

As soon as the distribution densities for the identified risks are determined they can be aggregated using Monte-Carlo-Simulation or Latin Hypercube-Sampling. The result will be again a probability distribution which displays the overall risk potential. With the figures and distribution curve available the owner can decide, which potential of the risk shall be included in the budget.

Following the general rules of Austrian guidelines and in close cooperation with the project organisation of ÖBB (Austrian Federal Railways) for the Koralm Tunnel the authors have developed their ***Risk Administration and Analysis Tool* RIAAT.** It was designed with the purpose of giving computerised support for the whole risk management process and was applied with great success for the risk analysis in the pre-tendering phase of this 38 km long railway-tunnel in south Austria.

For each stage of the project a new cycle of risk analysis will be performed. Except from the initial step, where risk catalogues and other basics have to be determined and the risk catalogue has to be set up and risks identified for the first time, the following cycles are mainly performed by updating. Only between the tender design / final design and project execution stage substantial modifications are required. The reason is that a number of risks, which were originally contained in the portfolio, are reduced or avoided by measures provided in the final design. Others are considered in the contract and thus transferred partly to the contractor.

RIAAT provides catalogues for risk identification purpose, which is structured in three or more levels depending on the complexity of the project. This approach allows for assessing and aggregating the risks form bottom up. A clear structure like the tree structure is also helpful in avoiding redundancies while defining the risks.

Risks are characterised in RIAAT through the probability of occurrence and the financial consequences.

The financial consequences are detailed in elements. Each element consists of two factors – quantity and price / cost – each of them can be modelled individually through a distribution density. Additional flexibility in modelling distribution densities (beside the standard functions) is provided by a module called BUILD. This module allows modelling distribution densities for special cases. If RIAAT is used for cost finding most procedures are very similar to those described above.

RIAAT provides the means for a comprehensive documentation, which allows for tracking individual risks and the total risk potential over all phases of the project execution. The standard report contains elements like the risk catalogue, diagrams visualising and comparing individual risks by using popular analysing methods and the final aggregation including the costs of risk avoidance or mitigation and finally a detailed description of the financial consequences. If required a statistical overview of the change in risk potential over the project phases is also available.

Conclusion

Risk analysis and risk management for large infrastructure projects using probabilistic methods offer great advantages for clients and owners. The software developed by the authors, combines tools for risk analysis with methods for comprehensive administration and traceable documentation of changes and updates of risks over the various stages from project development to project execution. Combined with a cost estimate considering uncertainties related to quantities and costs, it provides the owner with a solid basis for budgeting, risk management and cost control.