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Integral Risk Management for DBFM Tenders and Contracts in the Netherlands

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Abstract. This paper presents an overview of an integral risk management approach with emphasis on the relationships with the costing and scheduling processes. Forms of uncertainty related to project planning are classified and implemented in the probabilistic costing and scheduling processes. Furthermore, the importance of the integral probabilistic analysis is explained for (large-scale) Design, Build, Finance and Maintain (DBFM) contracts. Finally, the paper concludes with recent developments on how to improve the integrated probabilistic approach.

Keywords. Probabilistic analysis, Integral risk management, DBFM contracts

1. Introduction

1.1. Why integral risk management?

The use of Design, Build, Finance and Maintain (DBFM) contracts for (large-scale) infrastructural projects in the Netherlands has increased significantly in recent years. The Dutch Ministry of Transport (Rijkswaterstaat-RWS) uses this type of contract for recent works, such as the reconstruction of the Schiphol Airport – Amsterdam – Almere (SAA) road corridor and the development of locks.

Within these complex contracts most risks are transferred to the Contractor. With respect to Design and Construct (D&C) contracts the risk profile for the Contractor has increased significantly. Additional to the financing and maintenance risks, the soil related risks are typically made full responsibility for the Contractor. Integral Risk Management (IRM) is a must for correctly evaluating these risks in the tender phase and controlling them in the contract phase.

1.2. Multidisciplinary approach

The practice of risk management in the infrastructure industry draws from many disciplines including, but not limited to systems engineering, costing and scheduling. The level of interaction between these disciplines is dependent upon project characteristics and context.

With regard to DBFM type contracts, which typically are of long duration and have a high degree of exposure both political and related to stakeholders, a risk impact assessment on project schedule and costs is essential. Clients and Contractors therefore emphasize the need to integrate risk management in the project decision-making process, in order to ensure completion of the project within budget and schedule, as well as according to pre-set safety and quality standards. In some tenders the integration of project risk controls is also part of the Economically Most Advantageous Solution (EMAS) criteria. The establishment of risk management into the decision-making process, using a central risk register, provides a cohesive integrated risk management environment.

1.3. Paper set up

This paper describes the IRM approach with emphasis on the relations between risk management, systems engineering, costing and scheduling.

Firstly, the concept and process of IRM is briefly presented, including the central role of the risk register. The core of the paper consist of presenting the background of probabilistic costing and scheduling as part of IRM. It provides a concise description of the required steps to execute the analysis, after which the role of the analysis in DBFM type tenders is explained.

The paper concludes with recent developments to improve the IRM approach.

2. IRM concept and process

2.1. Concept

Risk management is defined as a generic process that coordinates activities to manage and control a project related to risks (ISO, 2009). Its purpose is to identify, analyze, treat and monitor the risks continuously throughout the system life cycle and to communicate the assessment of risks to relevant stakeholders. Risk management deals with both risks and opportunities, which are defined as future uncertainties on achieving project objectives. A risk is defined as an unwanted event resulting in damage or loss, whereas an opportunity is a wanted event resulting in benefit or profit.

Risk management is most effective if the entire team and stakeholders are in support of the process, including understanding of priorities and critical areas in the project.

The goal of risk management before contract award (during the tender phase) is twofold. Firstly, risk management contributes to the EMAS deliverables such as the traffic hindrance plan and the development of the risk mitigation plan. Secondly, project buffers are estimated to reserve time and budget for the occurrence of risks and other scheduling and costing uncertainties. The integration of the probabilistic analysis with the central risk register is an essential item in order to formulate a sharp but realistic bid in cost and time.

2.2. Process

In order to manage and formulate risks explicitly, Contractors should tailor the risk management process to fit their unique project. The IRM approach consists of seven generic steps, based on the Dutch RISMAN method (van Well-Stam et al. 2003) illustrated in Figure 1.

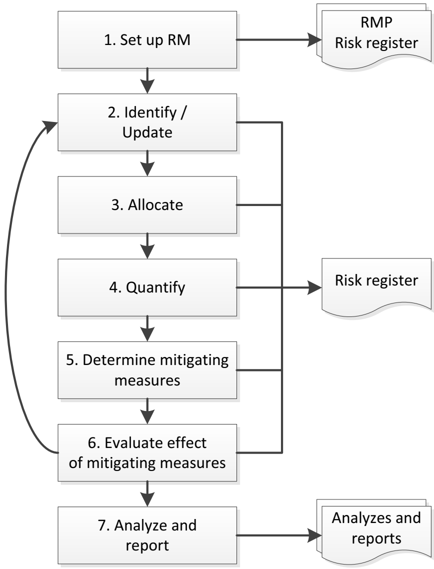

Figure 1. IRM process.

1-The first step in the IRM process specifies the project specific activities in the Risk Management Plan (RMP). The set up of the central risk register starts with the formulation of project-specific risk categories (eg. discipline, phase), criteria (eg. cost, time) and threshold values. When these items are clearly defined, the risk register acts as a file for all identified risks and opportunities.

2-The second step concerns the application of risk identification techniques. This examination can be done through decomposition of the project into manageable elements. In order to cover all aspects of the project each element is examined for risks from seven perspectives (technical, legal, organizational, political, financial, spatial and social) such that a complete as possible risk identification is executed. The identified risks are formulated as events with probability, cause and consequence in the risk register.

3-The third step in the IRM process focuses on the allocation of risks, which is done by selecting the party that is best suited to bear the risk and/or execute the mitigating measures. Internal allocation refers to responsibilities in the Contractor's organization. External allocation is done in accordance with the Client. The allocation of responsibilities helps to create support and a pro-active attitude in risk control.

4-The fourth step involves the quantification of risks. It is an essential part for risk prioritizing and serves as input for the probabilistic costing and scheduling analysis. Three approaches can be applied: qualitative, semi-quantitative and fully quantitative. With respect to the probabilistic analysis, only the fully quantitative approach determines a set of values for probability, cost and time. These values are documented in central risk register and serve as input for probabilistic costing and scheduling.

5/6-The fifth and sixth step of the IRM process elaborate on risk response strategies: preventive and corrective mitigating measures. Preventive measures reduce the probability and/or consequence before the risk occurs, whereas corrective measures deal with the effect of the consequences after the risk occurred. Preventive measures form part of the bid and become scope for the contract phase. The required budget for the corrective measures is estimated on basis of the residual risk profile with aid of the probabilistic analysis and thus form the project buffers. In time, as the project makes progress, the risk profile will change and updates in the risk register are required. This illustrates the cyclic process of IRM.

7-The final step provides insight in the top risks and opportunities. At this point, the risk register is linked to the costing and scheduling process for the probabilistic assessments.

3. Interfaces between disciplines

3.1. Systems Engineering

The IRM and Systems Engineering (SE) processes have a strong relationship with project scheduling. Whereas the latter process supports the realization of a successful project, the SE process focuses in particular on the required functionalities of the project and its context. It ensures that all aspects of the project are considered and integrated. This approach lays the basis for the Work Breakdown Structure (WBS) which purpose is to decompose the project into manageable work packages, Figure 2.

A work package consist of a cluster of activities that are linked to a physical element from the object tree. Therefore, as a whole, these activities should fit within the project schedule and budget. Each work package also entails relevant information about its functions and related risks. SE provides the framework for an integrated environment to manage the interfaces between risk management, costing and scheduling.

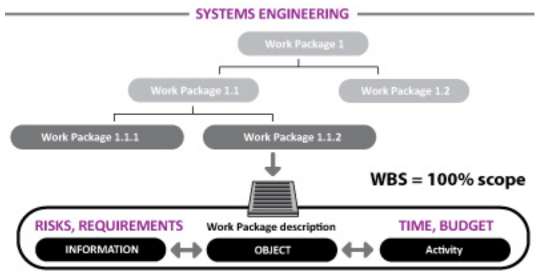

Figure 2. SE-WBS interfaces.

3.2. Quantitative risk register

Integration of the quantitative risk register with the costing and scheduling process is an essential part in order to execute the (integral) probabilistic analysis. Additional to the events in the risk register, uncertainties in project scheduling and costing have to be identified which should be taken into account in the analysis. Figure 3 illustrates the process of an integral probabilistic approach.

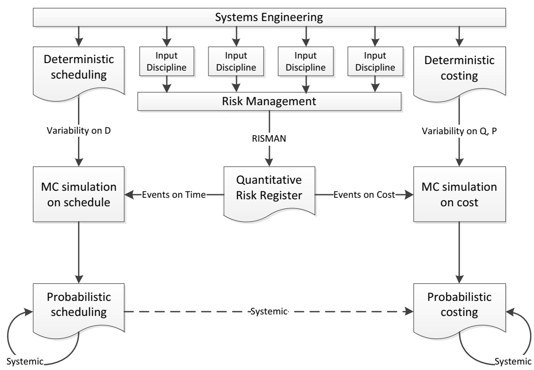

Figure 3. Integral probabilistic approach.

4. Probabilistic analysis

4.1. Uncertainty classification

In order to assess uncertainty in project schedule and budget, probabilistic techniques are frequently employed in management and control of large-scale infrastructural projects. These probabilistic techniques aim to statistically control the project schedule and budget by taking the random character of events and the spread of activities and cost items into account.

Uncertainty in the estimate of project duration and costs can be classified in various ways. According to the Dutch Standaard Systematiek Kostenramingen or standard system cost estimates (SSK2010) principles, three types of uncertainty can be distinguished (CROW, 2010). A fourth type of uncertainty originates from the dependence between risks, cost and time variables (Chapman and Ward, 2011). Recognizing these four types helps to manage and control the sources of uncertainty effectively.

1-Ambiguity uncertainty is the dominant form of uncertainty in the early phase of the asset life cycle and concerns the lack of knowledge about the project scope. Therefore several design variants are considered which are separately estimated and planned. Ambiguity uncertainty should be distinguished because, unlike other forms of uncertainty, it requires its own cost and schedule analysis. Ambiguity uncertainty is typically in the span of control of the Client.

2-Inherent variability originates from the spread or bandwidth on duration and costs of activities. The cause lies in natural randomness, market conditions and efficiency uncertainties, e.g. spread on the amount of sand to be excavated or spread on the cost of sheet pile walls.

3-Event uncertainty involves risk and opportunity events which are characterized by two possible states. A state in which the event occurs and has impact on project objectives and a state in which the event doesn't occur. More precise, it means there is a probability that additional costs or time has to be added or subtracted to the project budget and/or schedule. These events, risks and opportunities, are identified with the IRM approach and administered in the risk register.

4-Systemic uncertainty involves functional dependencies such as the direct link between costs and time and statistical dependencies involving the statistical relation (correlation) between random variables or events in the project.

4.2. Scheduling

4.2.1. Deterministic scheduling

Traditional scheduling has been around since Henry Gantt developed the first Gantt chart for the construction of the Hoover-dam and American Interstate highways in 1910. The Gantt chart is a graphical representation in time, in which a list of activity durations are showed in horizontal bars. It provides an overview of the sequence and timing of activities and insight into the total required and available project duration. The introduction of milestones, as diamond shapes completed Gantt's view of project scheduling.

In project scheduling usually not all activities succeed each other in time and logical relationships are identified between activities. This led to the development of the Critical Path Method (CPM), which calculates a shortest, or critical, path between the start of the project and it's last activity. Hence, CPM determines the earliest possible delivery of the project. Other activities in the project, whilst not being part of the critical path, can be delayed without impact on the end date. This delay is expressed as float in time. A total float of 0 (zero) days forms the basis for the critical path. A project schedule without added uncertainties is referred to as the deterministic schedule.

4.2.2. Probabilistic scheduling

As schedules became more extensive, complex examination of the project was accomplished through a more structured approach. Logical relationships, work packages and forms of duration uncertainty were added via a WBS.

In order to produce an adequate schedule, three important uncertainty aspects have to be considered as illustrated in Figure 3. The first aspect is the choice on distribution type used to represent the inherent variability on activity duration. The second aspect integrates risk event uncertainty, including mitigating measures, from the risk register into the schedule network. The last aspect includes the systemic uncertainties: the functional and statistical dependence between the activities in the model. After this the Monte Carlo technique is applied to run the model many times (typically >3000 times) to establish the probability of achieving the preset milestones.

Linking the identified risks to their appropriate activities provides insight into the potential impact on the critical path and the required risk mitigating actions. Risks can be accepted or mitigated in preventive or corrective manners. Active risk control may save costs but requires a pro-active approach of the IRM.

4.3. Costing

4.3.1. Deterministic costing

Project budget estimates are traditionally based on the summation of individual cost items from the WBS. Most cost items are estimated by multiplication of quantities (units) and prices per unit. Other cost items are time related and thus dependent on the project duration, such as site overhead, project management and rented equipment.

A detailed cost estimate in an infrastructural project is organized in direct and indirect costs. Direct cost are expenses directly linked to work packages in the WBS and indirect costs are incurred in order to manage the elements of direct cost. Direct cost make up the bulk of any infrastructural project e.g. materials, labor, equipment and subcontractor work. Indirect costs consist of job supervision, site office facilities, permits and fees. They are typically calculated as an additional percentage over the direct costs. Most indirect cost items are time dependent.

4.3.2. Probabilistic costing

The probabilistic costing process is largely similar to the probabilistic scheduling process, with the exception of absence of a logical relationship network (functional dependence). Therefore the same uncertainty aspects (variability/spread on units and rates and events/risks on costs) have to be considered to produce an adequate cost model suited to perform a Monte Carlo analysis.

5. DBFM tendering and contracting

The requirement for probabilistic scheduling by RWS and Prorail (Dutch government organisation taking care of maintenance and extension of the national railway network infrastructure) originates from the early 2000's as part of the High Speed Railway Line (HSL) and Betuweroute contract specifications. As of this time RWS requires contractual milestones to be achieved with a typically 85% level of certainty. This was further elaborated under the Project Planning Infrastructure program (PPI) which aimed to achieve more reliable time related forecasts of the projects. These control requirements currently do not exist for probabilistic costing. The final bid price still has to be provided as a deterministic value only. Usually Contractors, in a competitive environment, apply a bid price which is based on a 70% level of certainty.

The changing outsourcing strategy of RWS resulted in the introduction of DBFM contracts. This contract type transfers project financing and long term maintenance into the Contractor's scope of work. This results in an significant increase of the risk profile. Therefore, it is important to have a realistic and robust integrated schedule and cost model including uncertainties at the moment of the financial close. Consequently, the proposed schedule forms the basis for project financing by the banks and cannot, or only under very strict conditions, be changed.

A high-quality probabilistic time and cost integrated schedule provides the basis for DBFM tenders and contracts. Being consistent with all cost drivers in the anticipated project forms the backbone for all derived project control aspects. Optimizing the project requires the integration of all project disciplines in the probabilistic schedule.

6. Integrated cost-schedule analysis

In order to analyze the link between probabilistic costing and the probabilistic schedule, a cost-loaded schedule should be developed. A cost-loaded schedule links direct cost items to their activities in the project schedule via the WBS.

Hammock activities are used to link indirect cost items into the analysis. Using a cost loaded schedule as a basis allows an integrated cost-schedule probabilistic analysis producing a result for both project schedule and budget simultaneously.

This integration enables the Monte Carlo analysis to evaluate the cost effect of schedule uncertainty. Especially in large-scale infrastructural projects integration of project schedule, cost items and the risk register is important as most risks impact the project schedule, many cost items are time dependent and cost and time aspects are trade-offs and therefore important for the risk response strategy (AACE, 2011).

The majority of current DBFM projects show that linking risks events on cost and time is only performed on a rudimentary level in the risk register. As a result the impact of schedule uncertainty on indirect costs, which are commonly not directly linked via the risk register, is much harder to evaluate. Moreover, due to the arrangement of activities in the network, not every form of schedule uncertainty has an impact on the total project duration. The integrated cost-schedule probabilistic analysis improves the quality of the project cost estimate by adding the effect of time dependent costs.

7. Conclusion

In this paper the importance of establishing IRM into the decision-making process in tenders and contracts is demonstrated.

Although project budgets and schedules tend to converge during the course of a project, many uncertainties vary and remain present as long as the project is not completed. Probabilistic methods explicitly define the (remaining) uncertainties and quantify their impact on project objectives. It enables management with a basis for decision-making under uncertainty about:

- The likelihood of completing the project on budget and on time.
- The requisite contingency needed to provide the desired amount of certainty.
- The most important sources of uncertainty such that a contingency plan can be developed.

Uncertainties are quantified and analyzed together with the risks and opportunities through the means of a probabilistic costing and scheduling analysis. Currently these analyses are linked on a rudimentary level. This causes difficulties in the estimates of time-dependent direct and especially indirect cost items. The 'improved' cost-schedule integration is an effort to understand the combined and interrelated effects of cost and time uncertainty.

An integral probabilistic approach offers a more realistic and robust schedule and cost model for the financial close in a DBFM type tender. It is expected that the integral probabilistic cost-schedule analysis provides better control of the project involved.

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