

Methodological tools for project risk management

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Abstract. The increasing size and complexity of acquisition and development projects in both the public and private sectors have begun to exceed the capabilities of traditional management techniques to control them. With every new technological development or engineering feat, human endeavours inevitably increase in their complexity and ambition. This trend has led to an explosion in the size and sophistication of projects by government and private industry to develop and acquire technology-based systems. These systems are characterised by the often unpredictable interaction of people, organisations, and hardware. This complexity has imposed a complementary rise in the level of adverse events, particularly in acquisition projects, that I often difficult to identify, analyse, and manage. Indeed, managing the risk associated with the acquisition of large-scale technology-based systems has become a challenging task. Such risks cost overrun, time delay in project completion, and not meeting a project's performance criteria. This paper presents the scientific results regarding to principles and guidelines necessary to conduct risk management in an adaptable and repeatable framework, showing the tools and method developed in the course of conducting risk management on many different projects.

1 Introduction

Project risk management, when implemented correctly, can reap tremendous benefits in terms of reducing programmatic and technical risks. The U.S. Navy's E-6 program is one example of how project risk management can work. Any reductions achieved in cost and schedule overrun as well as improvements in technical performance will go a long way in improving the perceived value of any organization. This means more interest on the part of stockholders and clients for corporations as well as the public and policymakers for government agencies. Thus, project risk management has a definite place in the knowledge base of any major organization. For example, several reports issued by the Government Accounting Office (GAO) and papers published in archival journals document the many major acquisition projects by both government and the private sector that were completed

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behind schedule, well over budget, and not up to promised performance standards. This untenable mismanagement situation has provided an impetus for the development and acquisition project. There is a growing body of literature on project risk management composed of a myriad of different approaches and methodologies. Sage, for example, presents risk from a life cycle perspective, emphasizing the importance of considering the entire project life cycle when implementing project risk management. He discusses the type of risk that can occur and the impact they have on one another. R. Chapman emphasizes the importance of the risk identification process and advocates that a team-based approach is necessary to properly identify project risks. He presents several methods for eliciting sources of risk and discusses how the risk identification process affects the subsequent management of project risks. Two other methods worthy of note are continuous risk management and team risk management, both developed by the Software Engineering Institute at Carnegie Mellon University. These methods aim to engage the entire organization in the risk management process by continuously monitoring the risks to the project in order to manage them before they become major problems. In general, there is no one right way to conduct project risk management. Often the best approach for any given project is driven by the unique characteristics of the project. Regardless, there are certain principles that apply universally to all risk management projects [1-3].

2 General considerations regarding the main definitions/principles and methods of project risk management

Definitions and principles [4-6]

- Types of Risk That Threaten a Project: Two basic types of risk – technical risk and programmatic risk – characterize all projects. *Technical risk* – denotes the risk that a project will fail to meet its performance criteria. This encompasses the realm of hardware and software failures, requirements shortfalls, and the like. *Programmatic risk* – has two major subcomponents: cost overrun (the project exceeds its budget or operating costs) and delay in schedule (the project exceeds its projected completion schedule). In all cases, risk is defined as the probability and severity of adverse effects. For example, cost risk includes probability and the associated level of cost overrun (see Figure 1). The two-dimensional components of risk capture its complex nature, but they also make risk a more difficult entity with which to work.

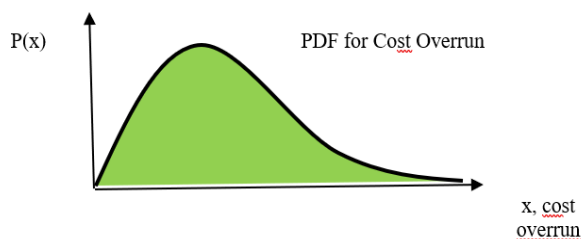


Fig. 1. Probability density function for cost overrun.

- Participating Parties: Numerous parties stake in the outcome of large-scale acquisition projects, including, but not limited to, the contractor, the customer, the user, and the analyst. These parties must meet collectively and periodically to ensure that proper risk management is being conducted. No party may be ignored because each brings different perspectives and background knowledge.

- **Project Life Cycle**: an often-neglected concept in project risk management is the consideration of the entire project life cycle; in the past, risk management has been conducted only on the final product. Manufacturing firms, for example, commonly conduct a failure mode and effects analysis and failure mode, effects, and criticality analysis on the product and the assembly line, but ignore the product development and design process. Doing so neglects the risks inherent in requirements definition, development, acquisition, and phase-out or upgrade. Sage discusses the different types of risk inherent to various stages of the life cycle, such as acquisition schedule risk and fielded system supportability risk and notes that these risk to life cycle process itself. While concepts such as value engineering and life cycle cost analysis are often employed to assess the intended functionality and cost over the life cycle of the acquisition, analysing risk over the project life cycle can also yield substantial benefits. Ignoring important stages of the life cycle can lead to substantial problems in terms of programmatic risk for both product development at the beginning of the life cycle and for product upgrade or replacement at the end. If major risks are not handled sufficiently early, they may magnify their effects later in the project.
- **Continuous Risk Management**: once the technical and programmatic risks have been identify and prioritized, the process of risk management can commence in earnest. The sources and consequences of emerging problems continue to evolve and change as the project progresses. As more information is obtained about a particular risk, the priority might change; therefore, it is necessary to constantly monitor all risk associated with the project. However, since it is prohibitively expensive, and often impractical to assess and monitor all possible risks, only those most critical to the project are commonly monitored and managed. In sum, the entire set of risks should be re-examined periodically to ensure that the set of critical risks is still a valid set.
- **Team Risk Management**: managing the risks inherent in any system is contingent upon having sufficient knowledge of the system's structure and operations. Indeed, this knowledge is imperative in order to comprehensively identify the risks to an acquisition project, accurately estimate the probabilities of failure, and correctly predict the consequence of those failures. Team risk management brings together all of the disparate parties in the risk management effort. According to Katzenbach and Smith *"A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable"*. When conducting the risk management process in teams, participants are imputed with a common purpose.

3 Project risk management methods

Changing and evolving risk over the project life cycle are major inhibitors to effectively managing risks. These changes occur due to the predictive nature of risk management and to changes in the priorities and requirements of a project. Without a stationary set of critical risks, risk management becomes more challenging and the risks to a project require constant monitoring to ensure that they remain under control. However, the main methodological tools used in this field are the following [7-9]:

- **Risk Tracking**: Given a set of risks to a project and set of strategies to manage them, it is necessary to track the status of critical systems to monitor the effectiveness of those strategies. To that end, it is important to identify meaningful risk metrics.
- **Risk Identification**: Several systemic methods and approaches are available for identifying and tracking risks. While techniques such as failure modes and effects

analysis and fault trees well for mechanical devices, large socioecological systems, including acquisition projects, require a more broad-based, multifaceted approach.

- **Risk Filtration:** Since it would be prohibitively expensive in terms of both time and resources to model and track every source of risk to a complex system, a method capable of filtering out less critical risks and prioritizing the remainders is necessary. Indeed, a process that discriminates between critical and mundane risks allows for the best allocation of resources for their management.
- **Risk Assessment:** Once the set of critical risks has been identified, a more in-depth analysis of those risks is required in order to properly manage them. In the case of simple point failures, this may require testing a sample of the field component to determine probability distribution. In the case of complex subsystems, it may require building a model of the subsystem and using Monte Carlo simulation. If the problem cannot be quantified, it may require analysis based on expert evidence using fractal or triangular distributions.
- **Risk Management:** Once the analysis and decision-makers have thoroughly analysed the critical the critical set o risks, they are in a better position to determine the best course of action to mitigate those risks. The participating parties identify all viable options available to manage (prevent, mitigate, transfer, or accept) the identify risks. The options must then be traded off against one another in terms of cost, risk, benefit, and any other relevant criteria.
- **Iteration:** As with any other type o analysis, it is unlikely that the analysis, decision-makers and other participants did everything right the first time. Therefore, it is necessary to repeat periodically the entire risk assessment and management process with the engagement of the project's participants.

4 Model of decision tool for project risk management

The process of selecting contractors is in itself quite complex; it is driven by legal, organizational, technical, financial, and other considerations – all of which serve of source of risk. Figure 2 represents the conceptualization of the quantitative framework which was developed in this paper, and which can be viewed in terms of 4 major phases [10-13]:

- **Phase I:** This phase will be demonstrate through the construction of the probability density functions (using the fractile method and triangular distribution) and through the assessment of extreme events by calculating the conditional expected value of extreme events to supplement the common unconditional expected value of cost overrun.
- **Phase II:** Through the use of the taxonomy-based questionnaire, interviews, and quantification of extreme events. This phase provides a mechanism to (1) probe the sources of risk and uncertainties, (2) identify and evaluate the assumptions that have generated the variances for each bidding contractor, (3) construct the conditional expected value of risk of extreme events.
- **Phase III:** In this phase, an analysis and comparison are conduct on the significance and validity of the contractor's assumptions for the likelihood of technical or non-technical risks. In comparing assumptions, a number of issues may be address: stability of the requirements; precedence of the requirements; need for research about solutions; politics and stability of funding; overall knowledge and the lack thereof; level of experience of key personnel; maturity of technology; maturity of the organization.
- **Phase IV:** This phase is the completion step where conclusions are drawn based on the accumulated evidence. Expert judgment is used in this phase in conjunction with multiobjective trade-off analysis methods, such as the surrogate worth trade-

off method. Adopting the systemic proposed acquisition process should markedly reduce the likelihood of major and catastrophic technical and non-technical risks. The ultimate objective of the quantitative framework is to minimize the following three objectives or indices of performance: minimizing the: risk of project cost overrun/risk of project completion time delay/risk of not meeting performance criteria.

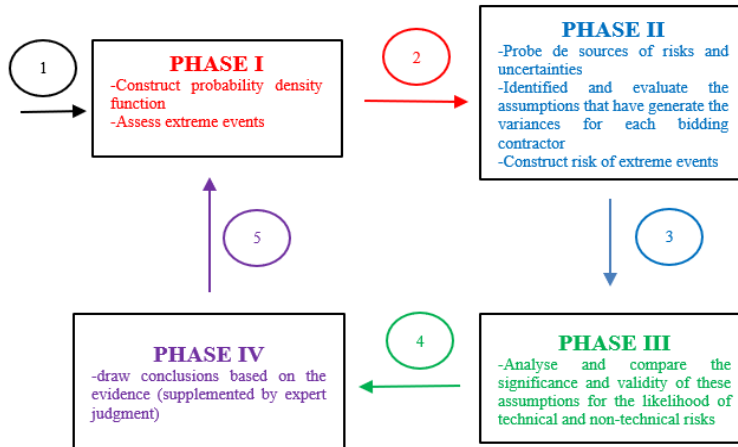


Fig. 2. Model of Decision Tool for Project Risk Management, Note: 1-(Use:Triangular distributions/Fractile method); 2-(Use:Taxonomy/Interview); 3-(Use:Independent Verification and Validation Team/Risk Filtering, Rancking and Management/Comparative Analysis); 4-(Use:Multiobjective Trade-off Analysis); 5-(Use:Bidding contractors).

5 Conclusions

Project risk management, when implemented correctly, can reap tremendous benefits in terms of reducing programmatic and technical risks.

Controlling the cost and time schedule of major projects has been and continues to be a major problem facing governmental and non-governmental acquisition managers. Because of the close influence and interaction between software technical and non-technical risks and the diverse sources and causes that constitute the driving force behind these risks, the acquisition's managers job is complicated.

The model of Decision Tool for Project Risk Management described in this paper is designed to provide a systematic means of addressing risk to acquisition or development projects. By providing methods for identifying, filtering, and tracking risks, it provides a means of addressing the complex and often qualitative nature of the large-scale sociotechnological systems that characterize major development and acquisition projects.

One of the major premises is that a careful, systemic, and analytically based process for contractor selection is imperative to prevent major risks of cost overruns and time delays.

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