Project Risk Analysis for Information Systems

Intaver Institute Inc.

sales@intaver.com
www.intaver.com

Development and operation of information systems has significant risks and uncertainties. To minimize the impact and reduce the probability of such risks organizations involved in development of information systems applied project risk analysis and risk management processes. The paper describes how the project risk analysis process is tailored for information system projects. It expands the scope of traditional project risk analysis by utilizing an enterprise risk register. Risks are assigned to different projects within a portfolio, and to different tasks within projects. Quantitative risk analysis using Monte Carlo simulations helps to determine risk adjusted project schedules, rank risks within risk register, and determine efficiency of risk mitigation and response efforts. The process was applied as part of the project management of multiple information system projects worldwide.

Introduction

Most information system projects include significant research and development components. Such projects have substantial risks and uncertainties. Such risks can affect project schedules and costs, as well as other objectives such as security, technical performance, and others. Many information system projects are delayed, completed over budget or even canceled and lead to significant losses for organizations .

One of the solutions to improve management of information system projects is project risk analysis using Monte Carlo simulations (Agarwal and Virine 2017). Monte Carlo simulations of project schedules have become one of the foundations of quantitative project risk analysis (Salkeld 2016, Vanhoucke 2016, Wanner 2013). Monte Carlo method is used to approximate the distribution of potential results based on probabilistic inputs. Each simulation is generated by randomly pulling a sample value for each input variable, such as task duration or cost from its probability distribution. These input sample values are then used to calculate the results: project duration, start and finish times, success rate, work, cost, and others. This procedure is iterated until the probability distributions are adequate enough to represent the full range of possible outcomes (Kashyap, H. 2016).

This 'traditional' Monte Carlo method for schedule risk analysis based on statistical distributions of task durations, cost and other parameters has a number of short comings (Vose 2008). Particularly defining distributions is not a trivial process. It is difficult to elicit distribution parameters from subject matter experts. Also project managers perform certain recovery actions when a project slips. These actions in most cases are not taken into account by Monte Carlo (Williams, 2004).

The one of the solutions is to combine risk events with statistical distributions. Project risk analysis with events has been used since the early 2000s (Virine & Trumper 2013). This approach is sometimes referred to as "Risk Drivers" (Hulett 2009, Hulett 2011). From the computational perspective, using statistical distributions and risk events are very similar. Such event-driven project risk analysis based on Monte Carlo simulation would be applicable for the analysis of information system projects.

Quantitative Risk Analysis Process

Quantitative schedule and cost risk analysis involves five basic steps:

1. Risk identification and determining risk properties including risk probability and impact
2. Assigning risks and uncertainties to project activities and resources
3. Running Monte Carlo simulation of project schedules using critical path method
4. Analyzing the results: creating a risk adjusted project schedule, determining critical tasks and critical risks, determining the probability that the project will be completed on time and on budget.
5. Measuring effectiveness of project controls with risks and uncertainties.

Figure 1 shows quantitative schedule and cost risk analysis.

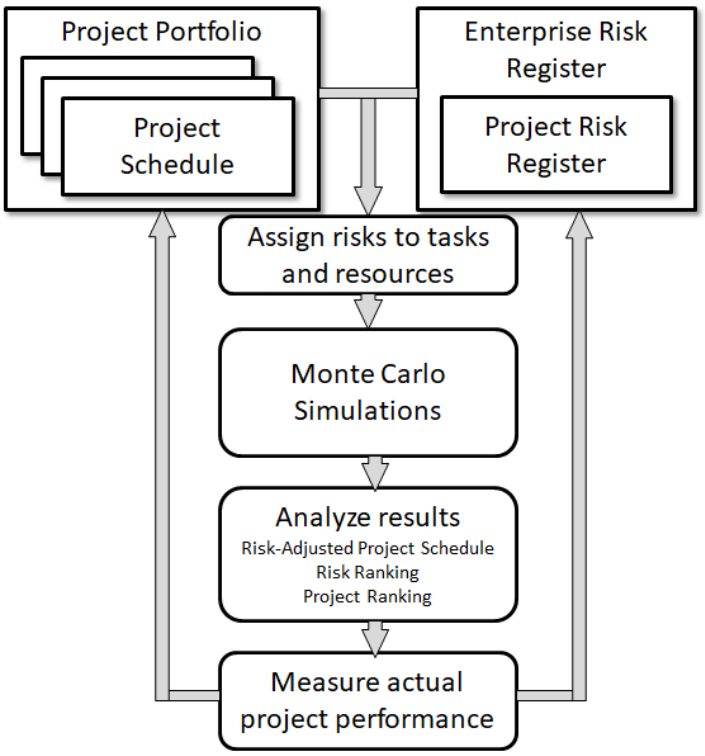

Figure 1. Quantitative schedule and cost risk analysis

The process is actively used in different industries, including aerospace and defense, pharmaceutical, construction, oil and gas, financial services, and others. However application of project risk analysis to management of information systems remains limited because of the following reasons (Sherer, Susan & Alter, Steven 2004):

1. Significant epistemic uncertainties. Such uncertainties are related to the lack of knowledge about events in the future because they have not been performed. For example, in the construction industry there are records of similar projects. Estimation of the probabilities and impacts of future events can be reliably done based on the historical data. In projects related to research and development, such as information system projects, many activities are completely new and without precedent. In such environments, many project managers believe that risk analysis would not be beneficial.
2. Significant chance of requirement changes. In many cases, new requirements are generated during information system development, which makes risk identification and analysis complex.
3. Risks in information system projects affect multiple categories with different probabilities and impacts. For example, risks could affect not only project schedule and cost, but also security, technology, potential litigation, etc. Capturing and defining such information is complex.

4. Development of information systems usually involves, not one, but multiple projects, which are part of large project portfolio. Projects within a portfolio could be interlinked and share the same set of risks.
5. Information system projects have complex relationships between risks events. Different risks may have multiple triggers and multiple residual risks. Risks can form a chain of events that would complicate the modeling of such risks.
6. Many information system projects are performed by agile methods; a traditional risk analysis process cannot be directly applied to agile project management.

In order to address these challenges traditional risk analysis process should be tailored for information system projects.

Risk Analysis Process for Information Systems

Project risk analysis process for information system includes the following steps.

1. Risk Identification. Risks in information projects are identified primarily based on expert judgment elicitation techniques (Zondervan-Zwijnenburg, Mariëlle et al. 2017). Judgment elicitation involves interviewing experts by moderators. Risks can also be identified based on historical data, however for information system projects historical risk data may not be universally available. There are a number of techniques for risk identification including consensus, Dephi, brainstorming, dialectic, decision conferencing, and others (Virine and Trumper 2019). During the risk identification process, different risk properties and attributes should be determined. Figure 2 shows a complete list of possible risk attributes. Risk properties, risk cost, risk mitigation and response plants are determined during the risk identification phase. For information system projects it is important to define as many properties as possible, because they will be used in a relevance analysis during risk assignment step. Risks with their properties are recorded in an enterprise Risk Register.

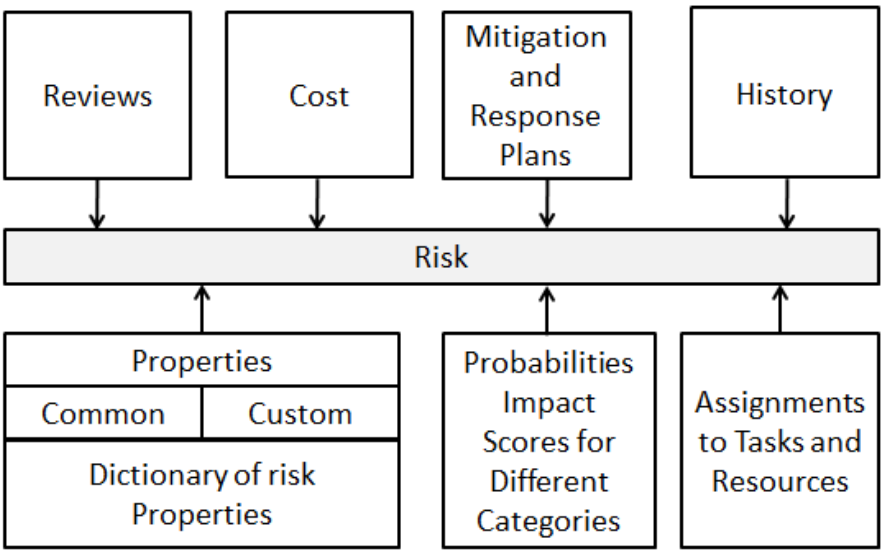

Figure 2. Complete List of Risk Attributes

2. Risk Assignment. During this step, risks from this register will be assigned to different projects within information system portfolio and to different tasks and resources within the project (Virine and Trumper 2017). Relevance analysis is applied to determine to which tasks and resources a risk will be assigned. The relevance analysis will be also used to determine risk probability and impact for different categories. Categories can include schedule, cost, quality, safety, security, technology, public relations, etc. In most cases risks will affect multiple categories. Risk impacts show what will happen with a task if the risk occurs. For example, duration can increase by 10% or security can be reduced by 20%. Relevance

analysis is performed using Bayesian methods, which is an important feature of risk analysis of information systems since risks from the Risk Register may not be fully relevant to particular projects or tasks. Figure 3 shows project Gantt chart with risk assignments. On this chart risks are shown as arrows.

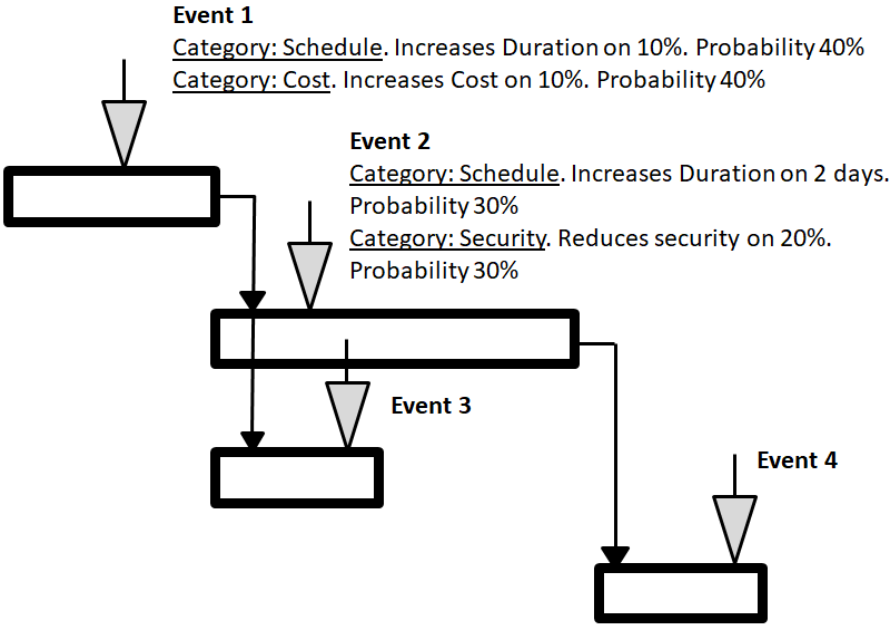

Figure 3. Project Gantt Chart With Risk Assignments

3. Determine the relationship between risks. This is an important step for information system where relationships between risks can be very complex. On this example, Event 1 triggers Event 2, and Event 2 triggers Event 4 (Figure 4). It constitutes an event chain. Results of the analysis of project schedules with event chains can be significantly different than without them. Event chains are very common in information system projects, when one problem can lead to multiple failures.

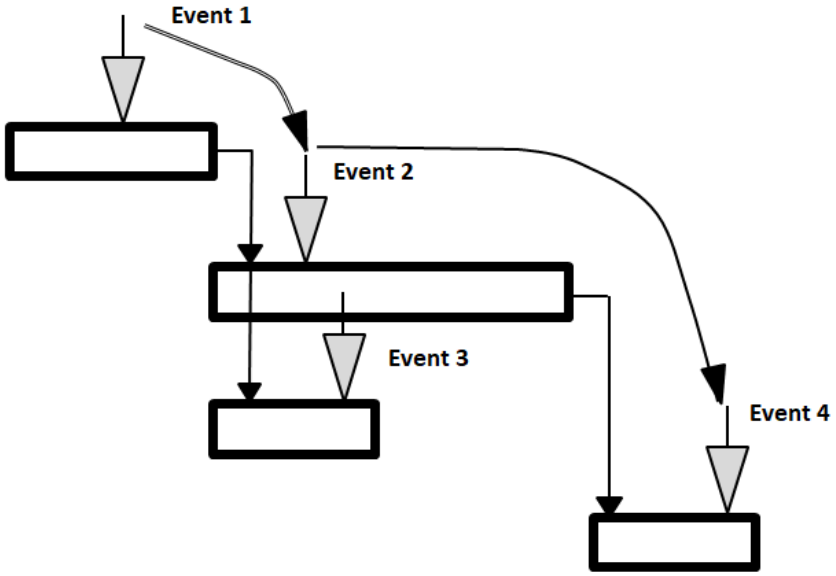

Figure 4. Project Schedule with Events and Event Chains

4. Monte Carlo schedule risks analysis. After events and event chains are defined, quantitative analysis using Monte Carlo simulation can be performed to quantify the cumulative effect of the events. Probabilities and impacts of risks assigned to activities are used as input data for Monte Carlo simulation of the project schedule. Monte Carlo simulations are performed by running Critical Path Method (CPM) calculation multiple times (Avlijas 2018).
5. Risk Adjusted Project Schedules. The results of a Monte Carlo schedule risk analysis can be presented as a risk adjusted project schedule. Risk adjusted project schedules can be created using mean duration, start and finish time, or a particular percentile of statistical distributions for start, finish time, and duration. It is very convenient to show a risk adjusted project schedule alongside the original deterministic (no uncertainties) project schedule. Both schedules can be shown on a single Gantt chart. This helps to highlight how uncertainties can impact project schedules. In most cases, project activities can be delayed ("shifted to the right") because of threats, but they can also be shorter because of opportunities or task cancelations. On Figure 5 the original schedule is shown as a white bar and the risk adjusted project schedule are darker bars. Results of Monte Carlo simulations can be used to calculate confidence probabilities of the project meeting commitments. For example, the schedule created using 70th percentile of duration, start and finish time can become a project baseline. This means that if the project schedule is followed there is 70% chance that project will be completed before a certain date. It gives project managers a greater certainty that certain project commitments will be met. This is especially important as part of project bidding process. The results of Monte Carlo simulations can be also used to calculate contingency buffers for each phase of the project and full projects.

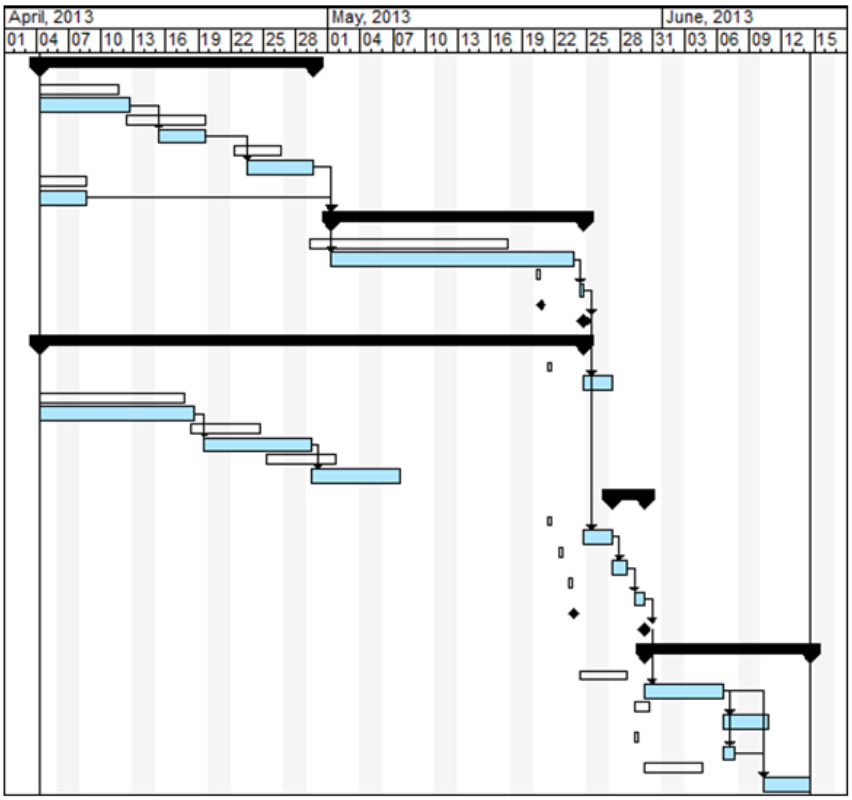

Figure 5. Risk Adjusted Project Schedule

6. Sensitivity Analysis. Sensitivity analysis calculates the correlation between uncertainties in tasks and the project. This correlation is normally calculated using the Spearman correlation coefficient. Monte Carlo simulations provide a set of results of cost and schedule for tasks

and the project, the sensitivity analysis uses the results to generate correlations between the data sets. Sensitivity analysis helps to determine crucial tasks or tasks which have the most potential to affect the project parameters such as duration or cost. The results of the sensitivity analysis are normally shown using a tornado diagram.

7. Mitigation and response planning. Critical risks identified by sensitivity analysis can be mitigated. Essentially, mitigation plans are the activities or small project schedules, which will be executed to reduce probability and impacts of risks. Response plans are executed if a risk occurs. It is possible to determine cost and duration of mitigation efforts as well as efficiency of mitigation efforts. Mitigation and response planning is a critical step of project risks analysis of information system projects because it is intended to reduce the chance of project delays and cost overruns.
8. Project risk analysis on different project milestones. Project risk analysis should be repeated on a regular basis during the course of a project based on actual project data and include any changes to the probability or impact of your risks. The probability and impact of risks can be reassessed based on actual project performance measurement and provides up to date forecasts of project duration, cost, or other parameters.

Project Risk Analysis and Agile Project Management

Agile project management is a framework, which is focused on delivery of working products thought iterative development. Agile project management is actively used in information system projects, particularly in software development. Agile methodology by definition is designed to mitigate risks and provide risk response in the environment where project has uncertainties. In agile project management risk mitigations and responses are planned based on results of actual project performance, rather than at the inception phase of the project. Also agile projects define a backlog of issues that needs to be resolved in each iteration.

If quantitative risk analysis is properly adapted to agile projects, it would be a valuable planning tool. Here is how quantitative risk analysis process can be tailored for agile project management (Intaver Institute 2018):

- Assign issues from the backlog of issues to the specific iteration in which this issue is planned to be resolved. Issues are defined as risk events with probability 100%. For example, the issue “poor hardware performance” could delay the iteration between one to two weeks, this impact is defined by a statistical distribution.
- Assign a deadline to each project iteration. For example, each iteration runs two for weeks.
- Perform Monte Carlo simulations of the project schedule; if the success rate of completing the iteration before the deadline has a very low success rate, the resolution of the issue can be moved to the next iteration.
- If the issue is resolved, in can be removed from the backlog or converted to lesson learned.
- Probabilistic and conditional branching can be used for iteration planning. For example, if issues may cause a significant delay of an iteration, a new iteration can be planned to account for the delay.

Quantitative risk analysis with Monte Carlo simulation can be performed in real time during scrum meetings at the process of iteration planning. Based on the result of the risk analysis, the decision should be made: skip the issue, add additional iterations, extend the duration of the iteration, change project scope, etc. A similar approach to real time assessment and making decisions on the spot is used in decision conferencing (Edwards, Miles, and von Winterfeldt 2007).

Conclusions

Project risk analysis is a process, which aims to improve project management of information systema. Project risk analysis helps to determine a chance that project will be completed on time and on budget. It also helps to prioritize risks, determine efficiency of risk mitigation and risk response efforts. Risk analysis is conducted on different phases of project with taking in account actual project

performance. Project risk analysis is used in many industries; however, it has some specific features for managing information systems:

- Development of information systems in many cases is not a single project, but a project portfolio with multiple interlinked projects sharing the same Risk Register.
- Assignment of risks to project, tasks and resources, as well as determining risk probabilities and impacts includes relevance analysis; to use relevance analysis risk attributes or properties should be determined.
- In information system projects most risks are related to each other. They form event chains which may significantly affect the results of risk analysis.
- The same risks usually affect multiple categories, such as schedule, cost, security, safety, etc.
- Risk mitigation and response planning is a critical step of project risk analysis process because many risks in information system project have very high probability and impact. For the same reason risk analysis should be performed on a regular basis as part of project control.
- Agile project management can benefit from quantitative risk analysis. The risk analysis can determine a chance that project iteration can be completed on time.

The described methodology is implemented in software applications and actively used for risk analysis of information systems in USA and worldwide.

References

Agarwal, R. and Virine, L. 2017. Monte Carlo Project Risk Analysis. In Raydugin, Y. (ed) *Handbook of Research on Leveraging Risk and Uncertainties for Effective Project Management*. IGI Global; 1 edition

Avlijas G., 2018 . Examining the Value of Monte Carlo Simulation for Project Time Management. Management. *Journal of Sustainable Business and Management Solutions in Emerging Economies*. 10.7595/management.fon.2018.0004

Edwards, W., Miles, R. F., von Winterfeldt, D. 2007. *Advances in Decision Analysis. From Foundations to Applications*. New York: Cambridge University Press.

Hillson, D. 2012. Practical Risk Management: The ATOM Methodology (2nd ed.). Berrett-Koehler Publishers. ISBN 978-1567263664.

Hillson, D. 2009. Managing Risk in Projects (Fundamentals of Project Management),. Routledge. ISBN 978-0566088674.

Intaver Institute, 2018. Agile Project Management and Quantitative Analysis. Available at http://intaver.com/blog-project-management-project-risk-analysis/agileprojectmanagement/. Accessed March 1, 2020.

Kashyap, H. 2016. Risk Analysis and Estimation of Schedule Using Monte Carlo Simulation. *International Journal Of Engineering And Computer Science*. 10.18535/ijecs/v5i9.42

Salkeld, D. 2016. Project Risk Analysis: Techniques for Forecasting Funding Requirements, Costs and Timescales. Surrey, England: Gower Pub Co; 1st edition.

Sherer, Susan & Alter, Steven. 2004. Information Systems Risks and Risk Factors: Are They Mostly About Information Systems?. Communications of the AIS. 14. 10.17705/1CAIS.01402.

Virine, L. 2013. Integrated Qualitative and Quantitative Risk Analysis of Project Portfolios. In *Proceedings of Enterprise Risk Management Symposium*. April 22–23, 2013, Chicago, IL

Virine, L., Trumper, M. 2013. *Projectthink: Why Good Managers Make Poor Project Choices*. Routledge; 1 edition (April 15, 2016)

Virine, L., Trumper, M. 2017. *Project Risk Analysis Made Ridiculously Simple*. WSPC

Virine, L., Trumper, M. 2019. *Project Decisions: The Art and Science*. Management Concepts. Berrett-Koehler Publishers; 2 edition

Vose, D. 2008. Risk Analysis: A Quantitative Guide (3rd ed.). Great Britain: Wiley. ISBN 978-0-470-51284-5.

Vanhoucke, M. 2016. Integrated Project Management Sourcebook: *A Technical Guide to Project Scheduling, Risk and Control*. Switzerland, Springer; 1st ed. 2016 edition

Wanner, R. 2013. Project Risk Management: The Most Important Methods and Tools for Successful Projects. CreateSpace: Independent Publishing Platform.

Williams, T. "Why Monte Carlo simulations of project networks can mislead". *Project Management Journal*, Vol 35. Issue 3, (2004): 53-61

Zondervan-Zwijnenburg, Mariëlle et al. 2017. “Application and Evaluation of an Expert Judgment Elicitation Procedure for Correlations.” Frontiers in psychology vol. 8 90. 31 Jan. 2017, doi:10.3389/fpsyg.2017.00090