



A Contemporary Review of Risk Management in Software Development

K.Adalarasan¹, Dr.R..Balu²

Ph.D Research Scholar, Bharathidasan University, Tiruchirappalli, Tamil Nadu, India¹

Assistant Professor, Department of Computer Science, Sudharasan College of Arts and Science, Pudukkottai
Tiruchirappalli, Tamil Nadu, India²

ABSTRACT: Risks are potential problems that may affect successful completion of a software project. Risk management is basically an approach in which we explore to identify, analyse, plan and mitigate/avoid the risks that can affect software project success. Risk management is an important part of project management which leads to the success of a project if handled efficiently. This documentation provides a basic concepts, terminology, tools and techniques of Software Risk management.

KEYWORDS: Risk Management, Risk Management Tools and Techniques, Process of Monitor and Control Risks, Qualitative and Quantitative Risk Analysis.

I. INTRODUCTION

The purpose of risk management is to identify potential problems before they occur so that risk handling activities may be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives. Risk management is a continuous, forward looking process that is an important part of business and technical management processes. Risk management should address issues that could endanger achievement of critical objectives. A continuous risk management approach is applied to effectively anticipate and mitigate the risks that have critical impact on the project.

A. GOAL OF RISK MANAGEMENT:

To increase the probability and impact of positive events and decrease the probability and impact of negative events in the project. A risk is the possibility of an event or condition that would have a negative impact on a project. Risk management is the process of identifying, mitigating, and controlling the known risks in order to increase the probability of meeting your project objectives.

B. DEFINITION OF RISK:

Risk is an expectation of loss, a potential problem that may or may not occur in the future. It is generally caused due to lack of information, control or time. The probability of occurrence for uncertain events and its potential loss is risk. A risk is an uncertain event or condition that, if it occurs, has an effect on at least one objective (scope, schedule, cost, quality) of primary software development parameters. A risk may have one or more causes, and one or more impacts. Known risks are those that we can identify, analyze, and manage. Unknown risks cannot be managed. Proactively; therefore we must perhaps handle them with contingency plans. A risk that has occurred is an issue.

C. PERCEPTION RISK MANAGEMENT:

Risk Management is the process of identifying, analysing and responding to risk factors throughout the life of a project and in the best interests of its objectives. Proper risk management implies control of possible future events and is proactive rather than reactive. The purpose of risk management is to identify potential problems before they occur so that risk-handling activities may be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives. An effective risk management strategy allows identifying the project's



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strengths, weaknesses, opportunities and threats. An uncertainty must be addressed proactively and consistently to improve the changes of project success

II. GENERAL CATEGORIES OF RISK

- a) Schedule Risk- Schedule not realistic, only "best case".
- b) Technical, quality, or performance risks – such as reliance on unproven or complex technology, unrealistic performance goals, changes to the technology used or to industry standards during the project.
- c) Requirement Risk - Requirements are poorly defined, and further definition expands the scope of the project.
- d) Customer Risk - Customer review/decision cycles for plans, prototypes, and specifications are slower than expected.
- e) Project management risks – Such as poor allocation of time and resources, inadequate quality of the project plan, poor use of project management disciplines
- f) Organizational risks – such as cost, time, and scope objectives that are internally inconsistent, lack of prioritization of projects, inadequacy or interruption of funding, and resource conflicts with other projects.
- g) External risks – such as shifting legal or regulatory environment, labor issues, subcontractors and suppliers, country risk and weather.

General Sources of Risk

- a) External, but unpredictable (Regulatory, Natural hazards, side effects)
- b) External predictable, but uncertain (Market risks, Operational, Currency changes, etc)
- c) Internal, non-technical (Schedule, Cost, Cash flow, etc).
- d) Technical (Technology changes, Design, Complexity)
- e) Legal (Licenses, Patent risks, Contractual, etc).

III. THE PROCESS OF RISKS MANAGEMENT

Risk management process focuses on identifying and assessing the risks to the project and managing those risks to minimize the impact on the project. There are no risk-free projects because, infinite number of events that can have a negative effect on the project. Risk management is not about eliminating risk but about identifying, assessing, and managing risk.

There are five major steps combined to deliver an effective risk management process.

Step 1: Identify the Risk. Recognize and describe risks that might affect successful implementation of the systems.

Step 2: Analyze the risk. Once risks are identified, determine the likelihood and consequence of each risk.

Step 3: Evaluate or Rank the Risk. Evaluate or rank the risk by determining the risk magnitude, which is the combination of likelihood and consequence. You make decisions about whether the risk is acceptable or whether it is serious enough to warrant treatment.

Step 4: Treat the Risk. This is also referred to as Risk Response Planning. During this step assess highest ranked risks and set out a plan to treat or modify these risks to achieve acceptable risk levels.

Step 5: Monitor and Review the risk. This is the step used to monitor, track and review risks.

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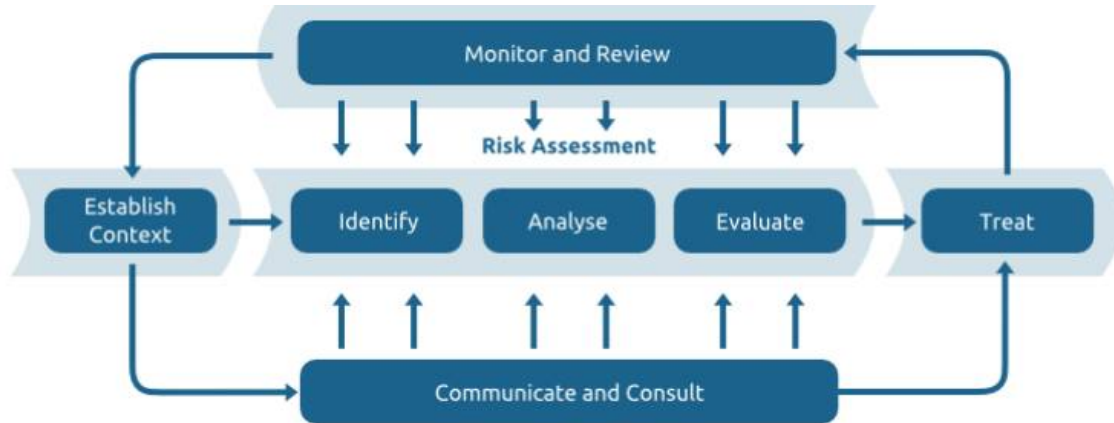


Figure 1: Iterative Risk Management Process

A. PROCESS OF PLAN RISK MANAGEMENT

Plan Risk Management is the process of defining how to conduct risk management activities for a project. The key benefit of this process is it ensures that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization. The risk management plan is vital to communicate with and obtain agreement and support from all stakeholders to ensure the risk management process is supported and performed effectively over the project life cycle.

Inputs	Tools & Techniques	Outputs
<ol style="list-style-type: none"> 1. Project Management Plans 2. Project Charter 3. Stakeholders register 4. Environmental Factors 5. Organizational process assets 	<ol style="list-style-type: none"> 1. Analytical techniques 2. Expert judgment 3. Meetings 	<ol style="list-style-type: none"> 1. Risk Management Plan

Table 1: Risk Management Plan –Input, Tools & Output

A.1 INPUTS OF PLAN RISK MANAGEMENT:

- a) Project scope statement, provides information on the project and deliverables and helps establish the significance of the risk management effort
- b) Cost management plan, defines how risk budgets, contingencies, and management reserves will be reported and accessed
- c) Schedule management plan, defines how schedule contingencies will be reported and assessed.
- d) Communications management plan, defines interactions and who can provide information on risks and responses
- e) Enterprise environmental factors, including risk attitudes and tolerances
- f) Organizational process assets, including risk categories, common definitions, risk statement formats, stand templates, roles and responsibilities, authority levels, lessons learned, and stakeholder register

A.2 THE TOOLS AND TECHNIQUES OF PLAN RISK MANAGEMENT

Planning meetings and analysis, held to develop the risk management plan should include: Project management, project team leaders, key stakeholders, risk managers and others as needed. Develop high level plans covering. Basic plans for conducting the risk management- Risk cost elements, schedule activities, risk responsibilities, etc. Templates for risk



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categories, levels of risk, and probability by type of risk, impact by type of objectives, probability and impact matrix tailored to the project.

- a) Strategic risk scoring Sheets.
- b) Stakeholder risk profile, Analysis may be performed to grade and qualify the project stakeholder appetite and tolerance.
- c) Expert Judgment, To ensure that a comprehensive risk management plan is developed expert advice should be taken from groups or individuals with specialized knowledge on the subject area.

A.3 THE OUTPUTS OF PLAN RISK MANAGEMENT

Risk management plan, including:

1. Methodology
2. Roles and responsibilities
3. Budgeting for risk management resources
4. Timing of risk management activities
5. Risk categories
6. Definition of risk probability and impact
7. Probability and impact matrix, to assist in prioritizing
8. Revised stakeholder tolerances
9. Reporting formats for risk management process outputs
10. Tracking. Documents how risk activities will be reported, monitored, and audited for the project.

B. IDENTIFY RISKS PROCESS

Risk Identification process determines which risks may affect the project and documenting their characteristics. It is an iterative process as risk can be identified at any levels in the project. Irrespective of risks having positive or negative consequences, all risks events and their consequences should be identified.

Inputs	Tools & Techniques	Outputs
<ol style="list-style-type: none"> 1. Risk Management Plan 2. Cost management Plan 3. Schedule Management Plan 4. Quality management Plan 5. Human resource management Plan 6. Scope baseline 7. Activity Cost estimates 8. Activity Duration estimates 9. Stakeholder register 10. Project documents 11. Procurement documents 12. Enterprise environment factors 13. Organizational process Assets 	<ol style="list-style-type: none"> 1. Documentation reviews 2. Information gathering techniques 3. Checklist analysis 4. Assumptions analysis 5. Diagramming analysis 6. SWOT analysis 7. Expert judgment 	<ol style="list-style-type: none"> 1. Risk Register

Table 2: Risk Identification –Input, Tools & Output

B.1 THE INPUTS OF IDENTIFY RISKS

1. Risk management plan, including roles and responsibilities, budget and schedule provisions, and categories of risks
2. Activity cost estimates, to view range of results
3. Activity duration estimates, also with ranges



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4. Scope baseline, including assumptions and the WBS
5. Stakeholder register, useful to identify who can provide inputs
6. Cost management plan, provides approach to cost management
7. Schedule management plan, for its schedule management approach
8. Quality management plan, for its impact on risk
9. Project documents, including the assumption log, work performance reports, earned value reports, network diagrams, baseline, and others
10. Enterprise environmental factors, including published information, academic studies, benchmarking, industry studies, and risk attitudes
11. Organization process assets, including project files with actual data, organizational and project process controls, risk statement templates, and lessons learned

B.2 THE TOOLS AND TECHNIQUES OF IDENTIFY RISKS:

Documentation reviews: a structured review of project documentation, including plans, assumptions, previous project files, contracts, etc. This is generally the initial step taken by the project team in identifying possible risks. The quality of the documents under review is itself an indication of project risk. Information gathering techniques, including: brainstorming, the Delphi technique, interviewing, and root cause analysis. Goal is to respond to the cause of the risk, so we must determine the cause. Checklist analysis: using checklists developed based on historical information. This can be quick and simple, but might act as a thinking box, so think outside the checklist. Assumptions Analysis: Exploring the validity of assumptions, and consequences if the assumptions are false. Diagramming techniques: Cause and effect diagrams, system or process flow charts, and influence diagrams. These techniques were covered earlier.

- ❖ SWOT analysis: strengths, weaknesses, opportunities, and threats.
- ❖ Expert judgment: possibility from risk management departments within the organization.

B.3 THE OUTPUTS OF IDENTIFY RISKS:

Risk register: The results of Identify Risks are typically contained in a document called a risk register. It ultimately contains the outcomes of the other risk management processes as they are conducted. The register is often in the form of a spreadsheet, with columns containing details

- List of identified risks, with root causes.
- List of potential responses.

C. THE PROCESS OF PERFORM QUALITATIVE RISK ANALYSIS:

Prioritizing the identified risks for further action by addressing and combining these probabilities of occurrence and impact. Assess the priority of identified risks using their probability of occurring, the impact on project objectives, and factors such as time frame for response and risk tolerance of the project on constraints of cost, schedule, scope, and quality. A rapid and cost-effective means of establishing priorities for Risk Response Planning that also lays the foundation for Quantitative Risk Analysis.

Inputs		Tools & Techniques		Outputs
1.	Risk Management Plan	1.	Risk probability and impact assessment	1. Project document updates
2.	Scope baselines	2.	Probability and impact matrix	
3.	Risk Register	3.	Risk data quality assessment	
4.	Enterprise environmental factors	4.	Risk categorization	
5.	Organizational process assets	5.	Risk urgency assessment	
		6.	Expert judgment	

Table 3: Risk Management Qualitative Analysis –Input, Tools & Output



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C.1 THE INPUTS FOR THE PROCESS OF QUALITATIVE RISK ANALYSIS:

- Risk register, which has the identified risks.
- Risk management plan, particularly roles and responsibilities, budgets, schedules, risk categories, definitions of probability and impact, probability and impact matrix and risk tolerances.
- Project scope statement to determine whether this is a normal project for us, or a new type.
- Organizational process assets, including information on prior similar projects, risk specialty studies, and risk databases available from industry or proprietary sources.

C. 2. THE TOOLS AND TECHNIQUES FOR QUALITATIVE RISK ANALYSIS:

Risk probability and impact assessment, which investigates the likelihood that each specific risk will occur and the potential effects on a project objective such as time, cost, scope, or quality, including both negative effects for threats and positive effects for opportunities. Assessed in meetings, interviews, or facilitated discussions. Explanatory detail, including assumptions for the levels assigned, is recorded. Ratings are according to the levels defined in the risk management plan. Probability and impact matrix. Risk probability is the likelihood that a risk will occur. Risk impact is the effect on project objectives if the risk event occurs. Using a combination of probability and impact scales, the probability and impact matrix assigns risk ratings to individual risk events. These ratings are typically qualitative in nature. Risk data quality assessment, a technique used to evaluate the degree to which the data about the risk is actually useful in making risk management decisions.

- The extent to which the source of the information understands the risk.
- The accuracy, quality, reliability, and integrity of data regarding the risk.

Risk categorization by source, area of impact, or other category. Grouping by common root causes can lead to effective risk responses. Risk urgency assessment, to determine how near-term the risk is to determine how soon we must deal with it. Expert judgment, to assess probability and impact. Expert judgment can be secured using facilitated workshops.

The Scales of Probability and Impact:

- Probability scale – 0.0 to 1.0 (0% to 100%), or a more qualitative scale such as "very unlikely" to "almost certain".
- Impact scale – reflects the severity of the risk's effects on the project objectives and it determines overall rating for each risk.
- The risk probability scale - 1. Very low, 2. Low, 3. Medium, 4. High, 5. virtually certain.
- The risk impact scale - 1. Very little impact on critical factors of project (time, cost, etc.), 2. Minor, 3. Moderate (workaround solution apparent), 4. Moderate (no apparent workaround solution), 5. Severe (missions critical degradation).

C. 3 THE OUTPUTS OF THE PROCESS – PERFORM QUALITATIVE RISK ANALYSIS

Risks register updates, with:

- Relative ranking or priority list of project risks.
- Risks grouped by categories to reveal common root causes.
- Causes of risk or project area requiring particular attention.
- List of risk requiring response in the near-term (urgent risks).
- List of risks for additional analysis and response.
- Watch-lists of low priority risks.
- Trends in qualitative analysis results, as risk analysis is repeated on the project, a trend may appear making risk response or additional analysis more or less important.

D. THE PROCESS OF QUANTITATIVE RISK ANALYSIS

The process numerically analyses the effect of identified risk events on overall project objectives. It is performed on risks that have been prioritized by the Qualitative Risk Analysis process as potentially and substantially impacting the project's completing demands. Perform quantitative risk analysis may not be required on all projects, dependent on available time and budget. It should be performed again after Plan Risk Responses and during Monitor and Control Risks to determine if project risk has been satisfactorily addressed.



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Inputs	Tools & Techniques	Outputs
1. Risk management plan 2. Cost management plan 3. Schedule management plan 4. Risk register 5. Enterprise environment factors 6. Organizational process assets	1. Data gathering and representation techniques 2. Quantitative risk analysis and modeling techniques 3. Expert judgment	1. Project document updates

Table 4: Risk Management Quantitative Analysis –Input, Tools & Output

D.1 THE INPUTS OF THE PROCESS FOR QUANTITATIVE RISK ANALYSIS:

1. Risk register
2. Risk management plan
3. Cost management plan, which details with cost
4. Schedule management plan, which deals with project schedule
5. Organization process assets, including information on prior similar completed projects, studies of similar project by risk specialists, and risk databases available from industry of proprietary sources.

D.2 THE TOOLS AND TECHNIQUES OF QUANTITATIVE RISK ANALYSIS:

- a) Data gathering and representation techniques, including:
- b) interviewing, including three point estimating to obtain ranges of values
- c) Probability distributions, such as beta distributions and triangular distributions of probability
- d) Quantitative risk analysis and modelling techniques, including:
- e) Sensitivity analysis to determine which risks have the most impact
- f) Expected monetary value analysis, which determines a value by multiplying each outcome by its probability and adding the results together. This is commonly used in decision tree analysis.
- g) Modeling and simulation, using a model which translates the specified uncertainties into their potential impact on objectives, iterative simulations are performed using Monte Carlo technique, which is run many times using input values for project variables chosen at random from the probability distributions of the variables. Results will be probability distribution of results.
- h) Expert Judgment used to identify potential cost and schedule impacts, to evaluate probability and define inputs to analysis tools. Expert judgment is also used in interpreting the results.

D. 3 THE OUTPUTS OF QUANTITATIVE RISK ANALYSIS:

Risks register updates, including:

- a) Probabilistic analysis of the project, showing results with associated confidence levels.
- b) Probability of achieving the cost and time objectives
- c) Prioritized list of quantified risks
- d) Trends in quantitative risk analysis results, which may lead to conclusions affecting the planned responses.

E. THE PROCESS OF PLAN RISK RESPONSES

Plan Risk Responses is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives. Risk responses must be appropriate, cost effective, and realistic. Includes identification and assignment of one or more persons (the "risk response owner") to take responsibility for each agreed-to and funded risk response. Project management plan is updated and necessary to implement responses.



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Inputs	Tools & Techniques	Outputs
1. Risk management plan 2. Risk register	1. Strategies for negative risk or threats 2. Strategies for positive risks or opportunities 3. Contingent response strategy 4. Expert judgment	1. Project management plan updates 2. Project document updates 3. Risk register updates

Table 5: Risk Management Response Plan –Input, Tools & Output

E.1 THE INPUT OF PLAN RISK RESPONSES

- Risk register, with all information developed so far.
- Risk management plan, including roles and responsibilities, definitions, etc.

E.2 THE TOOLS AND TECHNIQUES OF PLAN RISK RESPONSES

- Strategies for negative risks or threats (Avoid, Transfer, Mitigate, Accept).
- Strategies for positive risks or opportunities (Exploit Share, Enhance, and accept).
- Contingent response strategies. Some responses are designed for use only if certain events occur. Involves defining actions to be executed under certain predefined conditions, if it is believed there will be sufficient warning to implement the plan. Events that trigger the contingency responses should be defined and tracked.
- Expert judgment related to the actions to be taken.

E.3 THE OUTPUTS OF PLAN RISK RESPONSES

- Risk register updates.
- Risk-related contract decisions, such as insurance, services, etc.
- Project management plan updates, including updates to the schedule management plan, cost management plan, quality management plan, procurement management plan, human resource management plan, the WBS, and the schedule and cost baselines.
- Project document updates, including the assumption log and technical documentation.

Additional components of the risk register can now be included after Plan Risk Responses:

- Identified risks, their descriptions, the area(s) of the project (e.g. WBS element) affected, their causes, and how they may affect project objectives.
- Risk owners and their assigned responsibilities.
- Outputs from the qualitative and quantitative risk analysis.
- Agreed upon response strategies.
- Specific actions to implement the chosen response strategy.
- Triggers, symptoms and warning signs of risks' occurrence.
- Budget and schedule activities required to implement the chosen responses
- Contingency plans and triggers.
- Fallback plans.
- Residual risks expected to be remaining after the strategy is implemented.
- Secondary risks that arise due the response.
- Contingency reserves calculated based on quantitative analysis and organization's risk thresholds.

F. THE PROCESS OF MONITOR AND CONTROL RISKS

- The Process of monitor and control risks as follows.
- Implementing risk response plans



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- c) Identifying, analyzing, and planning for newly arising risks
- d) Keeping track of the identified risks and those on the watch list
- e) Monitoring residual risks
- f) Evaluating the effectiveness of the risk management process
- g) This process applies techniques such as variance and trend analysis, requiring the use of performance information. Other purposes include determining if:
 - h) Project assumptions are still valid
 - i) Analysis shows a risk has changed or can be retired (closed)
 - j) Risk management policies and procedures are being followed
 - k) Contingency reserves should be adjusted
 - l) Can involved:
 - m) Choosing alternative strategies
 - n) Implement contingency plans
 - o) Taking corrective actions
 - p) Modifying the project management plan
 - q) Risk response owners report periodically on the effectiveness of the plan, unanticipated effects, and any mid course corrections needed to handle the risk appropriately.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Risk register 3. Work performance data 4. Work performance reports	1. Risk reassessment 2. Risk audits 3. Variance and trend analysis 4. Technical performance measurement 5. Reserve analysis 6. Status meetings	1. Work performance information 2. Change requests 3. Project management plan updates 4. Project document updates 5. Organizational process assets updates

Table 6: Risk Management Monitoring and Control –Input, Tools & Output

A.1 THE INPUT OF MONITOR AND CONTROL RISKS:

- a) Risk register, listing risks and other information
- b) Project management plan, including the risk management plan
- c) Work performance information, including deliverable status, schedule progress, and costs incurred
- d) Performance reports, including variance analysis, earned value data, and forecasting results.

A.2 THE TOOLS AND TECHNIQUES OF MONITOR AND CONTROL RISKS:

- a) Risk reassessment, including identifying new risks and closing risks
- b) Risk audits, which examine and document the effectiveness of risk management processes
- c) Variance and trend analysis, comparing planned and actual
- d) Technical performance measurement, which monitors specific, quantifiable measures of technical performance appropriate to the application area of the project.
- e) Reserve analysis based on risks that have or have not occurred, to determine if reserves should be adjusted.
- f) Status meetings, which should include project risk management as an agenda item to keep some attention focused on risks.

A.3 THE OUTPUT OF THE PROCESS – MONITOR AND CONTROL RISKS

- a) Risk register updates, including outcomes of reassessments, audits, and risk reviews, along with 6
- b) Organizational process assets updates, to capture project risk information for future use as well as lessons learned.
- c) Change requests to implement contingency plans, or to recommend corrective or preventive actions.



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- d) Project management plan updates, revised and reissued to reflect approved changes
- e) Project document updates, including the same documents that may be updated in Plan Risk Response process.

IV. CONCLUSION

Risk Identification in the project is critical in order to manage and complete the project successfully. The earlier the risk can be identified, the earlier the plan can be made to mitigate the effects of the potential risks. There are a lot of tools and techniques or method available to identify the project risks. The method suggested in this article will complement the existing risk identification method to get a more comprehensive risk list for Risk Management Planning. Identifying the risk is an iterative process, and the entire project team should be involved from the beginning of the project. Comprehensive and good risk identification will produce a good project results.

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