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A REVIEW OF THE TOOLS AND TECHNIQUES FOR SOFTWARE RISK ANALYSIS

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Abstract

Today's software development process is fraught with difficulties and dangers. For a long time, technologies have been utilized in software development. They are used in performance analysis, verification and testing debugging, and application development. Linkers, for example, are very simple and lightweight software tools, whereas computer-assisted software engineering (CASE) integrated development platforms and tools are very large and complex (IDEs). Some facets of software development, such as risk analysis, are carried out throughout the project, from inception to completion. To manage risks, we must first comprehend the scope and objectives of software development and then employ efficient risk management tools and techniques. The purpose of this term paper is to demonstrate sophisticated tools and techniques for software risk analysis.

Keywords: Software development, Software risks, Risk analysis, Risk management, Risk management tools, Risk assessment, Software engineering tools.

I. INTRODUCTION

Numerous risks must be carefully managed when developing high-quality software. Despite new technology, innovative methods, and tools, the development process is still fraught with danger. According to the research conducted by McKinsey & Company in collaboration with the University of Oxford on average, large software-related IT projects (with a budget>$15 million in 2010 dollars) run 66% over budget and 33% over time [1], while delivering 17% less value than predicted, according to the article by Michael Bloch, Sven Blumberg, and Jürgen

Laartz in October 2012 [2]. As a result, managing particular IT risks associated with our software projects is required to ensure project success: risk identification and storage in a shared data storage, risk assessment, using tools and techniques, selecting appropriate mitigation action, and tracking that mitigated risks are lower than they were. All software development companies, including Amazon, Microsoft, Oracle, and IBM, have recognized the importance of project risk management. The science of risk management was developed in the 1600s during the Renaissance, an era of scientific breakthroughs, however, since 1990, a significant number of methods and techniques have been developed to resolve the requirement for more effective risk management [2]. In this paper, we investigated and compared different risk analysis tools and techniques in the context of software engineering.

II. PROBLEM STATEMENT

It is an undeniable fact that any process of Project Risk Management (PRM), irrespective of the number of process steps involved, details, or level of activities, necessitates the use of tools and techniques. Adopting a process necessitates an investment. Depending on the size of the organization, nature, and sector of operations, the magnitude of investment can be very significant in some cases. While there are several well-established tools and techniques used in large organizations for managing project risks [3], there is limited research literature on the tools and techniques employed in project risk management in organizations [4].

III. CONSIDERATIONS

When software checklists are available, the value of software tools increases. Because not all identified risks should be treated the same way, some tools have predefined risk categories. Some of the identified risks are likely to occur, while others if realized, would have a greater impact. The types of risks considered influence risk analysis and management. [5]

A. *Technical risks*

Language issues, project size, project functionality, platforms, methods, quality, reliability, and timeliness issues are all risks associated with software product performance. Even if there are no scope changes in the middle of the project, unforeseen technical complications can turn the project upside down. Project managers may be very familiar with the technologies being used in the project, but when they integrate them with another component, the result is a complete disaster.

B. *Financial risks*

Capital, return on investment constraints, cash flow and budgetary issues are among the risks. These risks are related to the cost of the software product during development, including final delivery, and include the following issues: budget, nonrecurring costs, budget, fixed costs, recurring costs, variable costs, realism and profit/loss margin.

C. *Personnel risks*

Staffing gaps, experience and training issues, ethical and moral issues, staff conflicts, and productivity issues are all risks. Other resource risks include insufficient or late delivery of equipment and supplies, insufficient tools, insufficient facilities, distributed locations, insufficient computer resources, and slow response times.

D. *Schedule and scope risks*

These risks are associated with the software product's development schedule and scope. Changes in scope are common in IT projects and, to some extent, logical.

IV. ANALYSIS OF SOFTWARE RISK MANAGEMENT

To minimize negative deviations and maximize positive results during project development, risk identification and risk assessment should be completed as early as possible. Assessing software risks entails determining the consequences of potential hazards. The automated tool may provide a predefined set of criteria for risk assessment, assisting experts in conducting an evaluation.

Several strategies for software risk management have been since suggested and implemented in the context of software engineering. Notwithstanding the several research studies and experiences accepted for publication about risk management, the tech sector, in general, does not appear to follow a model to analyze and control risks through product development [6]. There are two main approaches to software project management: traditional and risk-oriented [7]. The traditional approach is reactive, dealing with both systemic problems common to all software projects and project-specific problems as they emerge. However, the latter approach is proactive in that it aims to recognize and manage the unique qualities of a particular project before they have an impact on the project.

Risk analysis and management are typically based on information gathered from traditional knowledge, roughly comparable well-known instances, good judgement, the results of experiments or tests, and the review of unintentional exposure. The automated tools' first goal is to gather historical data to create a database. Once the database is created, it will process the data and extract some useful information to assist the manager in analyzing risks and making decisions. Today's tools can automatically save all project results in a centralized repository that all users can access. Changes and requirements can be edited, specified, and prioritized. Tasks are deduced from prerequisites that can be followed throughout the life cycle. This means that data collection and analysis must be key considerations when selecting a system. Today, we have a wide range of technologies at our disposal, and we can use the software as needed. Numerous software people preferred computer tools that require little to no setup. They want to avoid the hassles of installation, implementation, training, and maintenance. Nowadays, value is defined by connectivity rather than functionality. The user appears to be shifting away from process-centric and client-server architecture and toward decentralized functions and data-centric software with real-time interconnection.

Continuing to support guidance, benchmarks, and risk methodologies will indeed assist users in solving the following practical issues in the system life cycle on a scientific basis: Analysis of enterprise quality management systems, corroboration of quantitative requirements specification to hardware, software, clients, personnel, and technologies; requirements analysis, assessment of project engineering decision making, investigating issues concerning possible threats to the operation of the system, including information security and terrorist protection; evaluating system operation quality, substantiation of recommendations for rational system use and operation [8]

Risk evaluations may differ from one assessor to the next in contexts where evaluations are conducted but not standardized. Whether or not an effective response is taken is determined by the assessor, which means that similar issues may be treated differently. A single system ought to be used to gather and manage risk management-related practices to prevent inconsistent risk assessments. The system should ensure that corporate risk tolerance threshold values are used and followed for all risk-related activities throughout the entire IT project.

The Project Management Institute's (PMI) PMBOK is a project management guide and an internationally recognized standard providing the underlying principles of project management as they pertain to a broad spectrum of projects such as construction, software, engineering, automotive, and so on [9]. Risk management consists of the following processes:

- Risk Management Planning
- Risk Identification
- Qualitative Risk Analysis
- Quantitative Risk Analysis
- Risk Response Planning
- Risk Monitoring and Control

Risk Management Planning

- deliverable is the Risk Management Plan

Risk Identification

Risk categories:

- technical
- project management
- organizational
- external

Qualitative Risk Analysis

- define probability and consequences
- data gathering
- impact by objective
- assumptions testing
- data precision ranking

Quantitative Risk Analysis

- individual and project risk
- probability distributions
- sensitivity and decision tree analysis
- simulation methods

Risk Response Planning

Responses should be:

- appropriate
- cost-effective
- timely, realistic
- agreed (funded)

Risk Monitoring and Control

- ongoing, continuous action
- risks monitored
- new risks identified
- effectiveness of risk management evaluated

V. AVAILABLE TOOLS AND TECHNIQUES

To deliver high-quality software solutions to the market promptly while within budget, it is essential to identify computer-based tools with highly accurate probability to assist managers in making decisions. Data analysis and data mining can be used to supplement software risk analysis and management. Project managers can use automated tools to help them plan and set up projects, assign resources to tasks, track progress, manage budgets, requirements, changes, and risks, and analyze workloads. To offer more effective risk management methods, intelligent and adaptive risk management software tools are required.

A sampling of the enterprise applications often used to support the risk analysis and management process is listed in Table 1 below. Table 1 shows that there is also limited software that can offer complete support for a fully comprehensive and integrated risk management system. As a result, it is possible to assert that the literature is extremely rich in conceptual frameworks for overcoming the casualness of risk management initiatives. Risk management paradigms, on the other hand, exist as methodologies as opposed to systems that can fully support the RM process. Already existing risk management support tools are typically based on quantitative risk assessment and analysis, with the remaining phases carried out outside of the software.

Table 1: Some of the commercial RM software [10]

Tool	Developer	Where it can be used	Which analysis techniques are used	Which RM activities are supported
Risk Radar	Software Program Managers Network	Risk identification and prioritisation	Risk rating	Risk identification and monitoring
@Risk	Palisade Europe	Project cost/schedule risk estimation	Monte Carlo Simulation	Risk analysis
ACE/RI$K	ACEIT	Cost/schedule risk analysis and technical risk assessment	Latin Hypercube sampling	Risk analysis
CRIMS	Expert choice	Comparison of alternatives according to preset criteria	Analytical Hierarchy Process	Risk analysis
Decision Pro	Vanguard Software	Setting up a project model for scenario building	Monte Carlo Simulation, Decision Tree	Risk analysis
Crystal Ball	Decisioneering	Probabilistic modelling of project variables, estimation of cost, time etc.	Monte Carlo Simulation, sensitivity testing	Risk analysis
iDecide	Decisive tools	Construction of project models, risk assessment	Monte Carlo Simulation, influence diagramming	Risk analysis
Monte Carlo	Primavera	Modelling project variables with probability distributions, integrated with various planning software	Monte Carlo simulation	Risk analysis
Precision Tree	Palisade Europe	Decision analysis	Decision tree analysis, influence diagrams	Risk analysis
Predict!Risk Analyser	Risk Decisions	Modelling project variables with probability distributions, integrated with various planning software	Monte Carlo simulation	Risk analysis
Risk+	Project Gear	Integrated with MS Project Planner, modelling of project variables with probability functions, risk Gantt charts	Monte Carlo simulation	Risk analysis
Risk Tools	Carma	Risk modelling where qualitative data exists, scenario analysis	Fuzzy sets, neuronets	Risk analysis

SCRAM	SCRAM Software	Stochastic risk analysis and generation of PERT and Gantt charts	Monte Carlo simulation	Risk analysis
OpenPlan Professional	Welcom Software Technology	Project Management Information Systems	Monte Carlo simulation	Risk analysis and monitoring
REMIS	HVR Consulting Services	Structured support for all risk management phases, integrated with other support tools (e.g., @Risk), construction of WBS, risk register, mitigation plans	Monte Carlo simulation	Risk identification, analysis, response and monitoring
Ris3 RisGen	Line International	Risk identification, construction of risk registers, modelling project variables and preparing mitigation plans	Monte Carlo simulation	Risk identification, analysis, response and monitor

VI. CRITICISMS AND PITFALLS

The following are some flaws in the way risks are handled, as well as inferences drawn in risk management support tools [11]:

1. **Simplistic risk assessment techniques:** Neither of the risk analysis techniques can fully quantify the risk impacts on project success on their own. The most widely used risk rating technique, for example, predicated on the multiplication of likelihood with impact, is an overly simplistic approach because it is based on the assumption that "risk factors are independent." There are normally significant associations among risks because they are influenced by similar underlying sources, such as political risk and economic risk influenced by general macroeconomic forces. As a result, a hierarchical structure is required to ensure risk evaluation at each level, where how one risk factor at the upper-level impacts another at the lower level becomes a critical issue that cannot be easily solved using the traditional rating technique. Furthermore, when assigning ratings (typically by using the Likert scale), there could be substantial differences in the values assigned by different decision-makers due to a commonly overlooked subject known as "controllability." Some people may believe that the probability of risk factors occurrence is low if they are controllable, assuming that appropriate measures will be taken to alleviate them, whereas others believe that the probability of occurrence is the same regardless of response. It is extremely difficult to ensure that the overall score is accomplished by making the same presumptions about potential solutions, capabilities, and project success criteria, taking probability and impact into account independently, and having the same risk attitude. Similarly, Monte Carlo simulation can produce incorrect results if comparisons between parameters are not or are incorrectly defined, and it does not reflect the true risk level because some qualitative risk factors cannot be included in the analysis. Furthermore, there is no simple method for defining the distribution function of probabilities of variables influenced by various risk sources. It should be clear which risks are taken into account when allocating probability distributions to data points so that some risk factors are not over or underestimated.

It is well known that poor risk analysis increases the risk of a project. Furthermore, risk analysis cannot be considered apart from the risk response phase and the contract strategy. The risk management process's overall success is determined by the assumptions made during the risk analysis stage.

2. **Inadequate risk definition:** A review of the literature reveals that various researchers have proposed numerous risk checklists and risk breakdown structures. The main disadvantage of some of these lists is "inconsistency." The term risk can refer to the cause, consequence, or likelihood of occurrence of a negative event. When sources and consequences are mixed, there is a major inconsistency and incorrect risk model formulation. A cost overrun, for example, should be considered on a different platform than sources such as inflation, technical risk, or changes in project scope. Thus, before creating risk checklists, identify the cause-and-effect relationships as well as when they are expected to occur. It is extremely difficult to create a systematic risk checklist applicable to all kinds of project settings; nevertheless, the innovation of experience-based databases for instance PERIL (Project Experience Risk Information Library) [9] could very well aid in the development of generic risk libraries applicable to various projects, which is an underrepresented topic in the project management literature.

3. **Lack of integration:** Many researchers argue that the main issue with risk management support tools is an absence of integration. Integration of:
    - Structured information with unstructured information,
    - Hard systems with soft/human issues,
    - Short-term project objectives with long-term strategic objectives,
    - Risk management tasks with project management,
    - RM operations in one organisation with those performed by other project stakeholders,
    - All RM tasks (identification, analysis, response, monitoring) with each other,

    is required for success.

    The traditional linear approach (step-by-step procedure performed at a specific stage of a project, instead of cyclic and continuous techniques adopted throughout the entire project life cycle) and fragmentary activities (e.g., separated risk quantification and response strategy determination) may not meet the industry's risk management requirements. Furthermore, risk models that focus solely on a single performance criterion (cost, time, safety, etc.) may not accurately reflect the total level of risk of the project.

4. **The ambiguity of risk management expectations:** The literature is replete with risk models designed to assist decision-makers in determining the contingency significance that takes into account the project's risk level. Building risk models based on a quantitative risk assessment, which represents a static methodology, is required for better contingency planning; however, building more accurate cost/time plans is only one of many potential benefits that can be realized by implementing a dynamic RM process. Professionals use RM tools for a variety of reasons, including improved quantification of project risks and improved prediction of future outcomes; however, this provides a very limited scope. The goal of risk management should be better response planning through the development of what-if scenarios,

effective monitoring of risks and project success to revise plans, better risk communication among project participants, the development of corporate memory to introduce experience-based solutions for how risks can be avoided, and finally, learning from risks. More research on these issues, demonstrating the potential benefits of RM philosophy, as well as mathematical models built for better estimation and forecasting, are thus required. The importance of RM, which includes opportunity management, as a value-added activity in project management, should be emphasized more strongly.

VII. FUTURE WORKS

In light of the foregoing discussions, scientists should create a risk management support tool that can identify the correlation between sources of risk, implications, responses, and project success prerequisites, as well as integrate all risk management tasks [12]. Figure 1 depicts a simplified illustration of a proposed technique for modelling relationships. The following modules make up the proposed RM software:

Module 1: Defines Risk Breakdown Structure (RBS), Work Breakdown Structure (WBS), Project Organization Structure (POS), and Activities (schedule)
Module 2: Defines the interdependence of risks, project objectives, activities, strategies/responses and ownership.
Module 3: Development of a project performance model (integration of objectives like time, cost and quality)
Module 4: Scenario creation by changing the values of predefined variables (objectives, responses, ownership, constraints and risk of scenarios) and simulation of project performance under various scenarios.
Module 5: Building a corporate risk/response memory

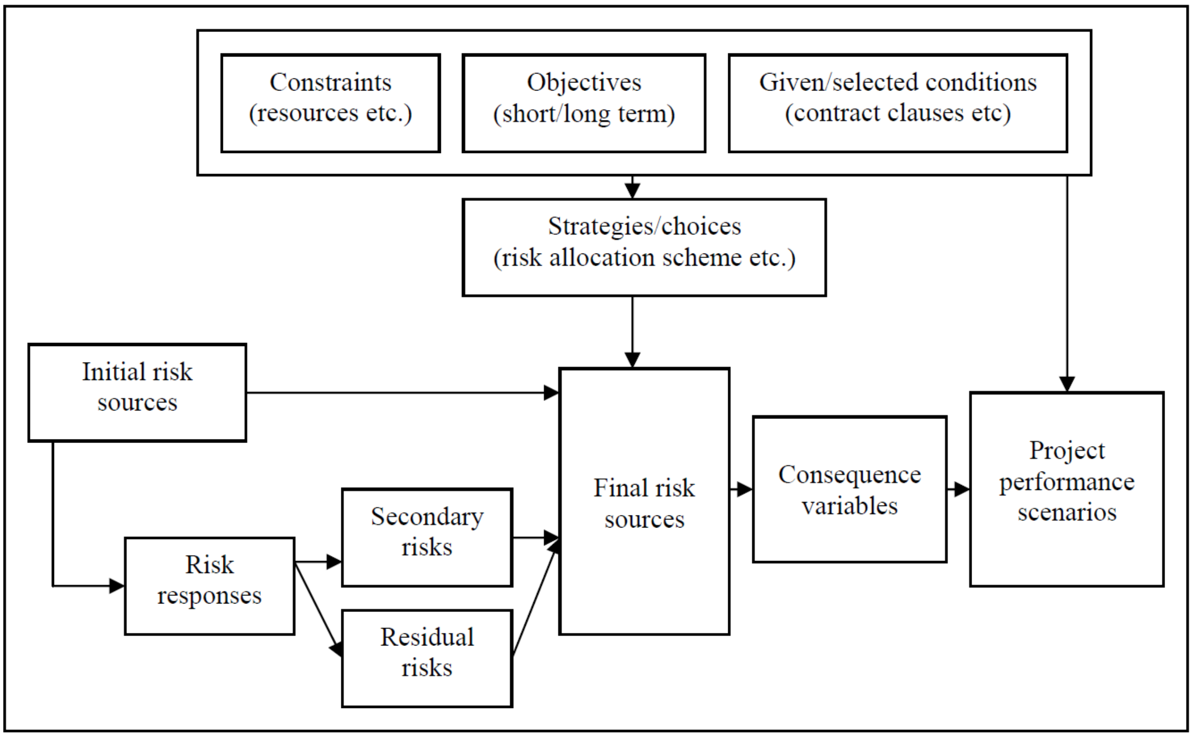

Figure 1: Representation of relationships between risk sources, consequences, strategies and performance [6]

The main goal of these modules is to ensure that the project performance model is built by using a built-in risk breakdown structure (RBS) and that the relationships between risk, response, and performance are established by referring to cases in the corporate memory. After preparing an initial plan, the project performance model will be employed to monitor project success such that the original plans can be modified. The risk-response performance relationships lessons learned will indeed be preserved in the corporate risk memory to achieve better decision-making in future projects. This tool is currently in the prototype stage, and interviews with construction professionals are being conducted to modify the basic architecture based on their requirements and recommendations. The prototype model's dependability will indeed be trialled on a real construction project.

VIII. CONCLUSION

The plan we had set was to research widely accepted management tools and techniques used in software development, and we made every effort to carry it out by studying a large number of journals and research papers. By conducting a comparative analysis, we hoped to identify improved risk management tools and techniques. Due to their various traits and operating procedures, our comparative analysis concludes that no single tool or technique, on its own, is perfect for managing risks in software development. As a result, we believe that our comparative analysis will assist and provide basic ideas to institutions in the shortlisting of risk management techniques based on their developments.

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