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Development of a Generic Risk Matrix to Manage Project Risks

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ABSTRACT

A generic risk matrix is presented for use identifying and assessing project risks quickly and cost effectively. It assists project managers with few resources to perform project risk analysis. The generic risk matrix (GRM) contains a broad set of risks that are categorized and ranked according to their potential impact and probability of occurrence. The matrix assists PMs in quickly identifying risks and can serve as a basis for contingency planning to minimize cost and schedule overruns. It is suitable for a wide variety of projects and can be modified for specific types of projects using historical data or expert opinion. An R&D project case study is included to demonstrate how the GRM is applied for a specific project.

***Keywords*:** Risk Management, Project Management, Risk Matrix, Contingency Planning.

1. INTRODUCTION

Risk identification, assessment, management, and communication are phases of risk analysis. Risk management (RM) is an important aspect for improving project performance and successfully completing projects on schedule and within cost. Since every project is unique in terms of risk, assessing risks in terms of probability and impact is challenging and time consuming. A project manager (PM) could find similar projects and analyzes the occurrence of risks associated with his or her project Henselwood et al, (2006). When risks are identified early, a risk matrix can be used by a project manager to develop a risk control and contingency plan. A risk matrix is used to rank risks and is considered a semi-quantitative approach to risk assessment Dyke et al, (2002).

The goal of this study is to develop a generic risk matrix (GRM). The matrix is used to identify and assess project risks quickly in a cost effective manner. The GRM will assist PMs who have not typically done risk analysis due to a lack of resources, a lack of emphasis on contingency planning, or an uncertainty about how to approach project risk analysis. The generic risk matrix (GRM) contains a broad set of risks that are categorized and ranked according to their potential impact and their general probability of occurrence. The generic risk matrix is suitable for a wide variety of projects. It can be modified for specific types of projects if the project manager has historical data or input from subject matter experts to customize the matrix. The matrix assists PMs in quickly identifying risks and directs that focus of contingency planning to minimize cost and schedule overruns. The risk matrix was created by considering the impact and probability of various risks

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within numerous industrial and government organizations based on inputs from 13 project managers. An R&D project case study is included to demonstrate how the generic risk matrix can be modified and applied for a specific project.

During literature survey, it was found that categorization of risks is often according to the project area like construction or governmental projects. No consistent set of risks was found, developing general risk categorizations was challenging. A survey was performed to identify which risks should be included in generic risk matrix and which could impact projects. An online survey was used to gain the opinion of respondents from a variety of organizations and fields. Potential risks came from a literature review, a preliminary project risk survey, and subject matter expert opinions. Once these materials were compiled the potential generic risk categories were incorporated into the final survey. After the risk categories are formed, the assessment of risks based on impact and probability for each risk is done. Then the generic risk matrix is formed, with the various risks and their prioritization.

2. RELATED WORK

Wang et al (2000) define risk as generally arising because of uncertainty. Another definition of risk defined by Cooper et al (2005) is “It is exposure to the impacts of uncertainty.” Lansdowne (1999) define risk as “The possibility that a program’s requirements cannot be met by available technology or by suitable engineering procedures or processes.” Hillson et al (2004) define risk as “An uncertainty that if it occurs could affect one or more project objectives.” Risk is different from uncertainty. Risk arises when uncertainty has the potential to affect objectives and can be defined as “Any uncertain event or set of circumstances that, should it occur, would have an effect on one or more objectives” Simon et al., (2004). There are uncertainties that do not significantly affect objectives and which therefore are not classified as risks. Risks can occur at any stage of the project and so risk identification and analysis is important in project management for successfully completing the project on cost, within budget, and on schedule.

2.1. Risk Identification Techniques

The goal of risk identification is to identify risks before they become problems. Chapman and Ward (2003) conclude that risk identification is both important and difficult. They recommend risk identification techniques including brainstorming, interviewing with individual and groups, and using checklists. Lyons et al (2003) also concludes that brainstorming is the most common risk identification technique. A risk identification process should be comprehensive so as many risks as possible, can be captured. Risks that are not identified cannot be assessed. If unidentified risk occurs during some stage of the project, they can hinder the overall success of the project. Risk identification can be done by using information from historic data, empirical data, or the opinions of experts such as project stakeholders. Risk identification can be done using various techniques including brainstorming, checklists, Delphi technique, interviewing, scenario analysis, work breakdown structure analysis, surveys, and questionnaires to collect information from similar projects. In some special scenarios, event tree analysis and/or fault tree analysis can be used for project risk identification (Cooper, 2005).

Brainstorming is an interactive team based approach where risks are identified based on the experience and knowledge of the team. Participants are asked to list all of the potential project risks that can, no matter how unlikely they are to occur. This technique is done as a group because as one person identifies a risk it will often trigger another person to identify additional related risks. This technique is useful for the initial identification of wide range of risks. (McInnis, 2001)

Similar to brainstorming, the Delphi technique gains information from experts about the likelihood of risks occurring. However, the technique eliminates bias and prevents any one expert from having undue influence on the others, which can occur with brainstorming. Group meetings can suffer from "leader following" or collective thinking tendencies and result in resistance to stated opinions. The Delphi technique is based on the Hegelian Principle of achieving oneness of mind through a three-step process of thesis, antithesis, and synthesis. This technique is an iterative process, where experts express their opinions anonymously, which are complied, and the entire group reviews the results and responds until a consensus is achieved. In this approach participants tend to accept ownership of the results and develop a consensus. The drawback is that this technique can be labor intensive and time consuming (Shen et.al., 2008).

Another meeting based risk assessment technique is interviewing. In this approach, face-to-face meetings with project participants, stakeholders, subject-matter experts, and/or individuals with similar project experience are used to gain information about risks occurring during past projects or potentially occurring in the new project. This approach is more structured than the brainstorming. It is faster than the Delphi technique; however, it can be affected by groupthink. (Chapman & Ward, 2003)

A checklist analysis includes a listing of potential risks that is typically developed over time from historical information or lessons learned (Chapman and Ward, 2003 and Cross, 2001). The Risk Breakdown Structure (RBS) can also be used as a checklist for project risk analysis. Hillson (2002) used an RBS framework similar to a work breakdown structure to identify risks. A risk identification breakdown structure with several levels in hierarchical order for specific projects are discussed in Trummala et al (1999), Chapman (2001) and Miller et al (2001). Abdou et al (2005) identified various risk factors and events, which could occur in health care projects. Checklists are not comprehensive and other techniques may be used to complete the lists of risks. They are generally useful for routine projects and can be a hindrance to non-standard or unique projects because the items in the pre-developed checklists may not apply to these new projects.

Diagramming techniques, such as system flow charts, cause-and-effect diagrams, and influence diagrams have been commonly used to identify risks in production operations. Cause and effect diagrams or fish bone diagrams are used to find the causes of risk or errors. Flow charts show the interrelationship between processes or elements in a system. Influence diagrams show influences between input and output variables. According to the *PMBOK Guide* (2008), they show risks or decisions, uncertainties or impact and their influence on each other. This technique however, calls for resources and expertise in risk management. It can be very time consuming and requires considerable effort to be completed.

Surveys can also be used to determine which risks can impact various projects (Cooper, et.al, 2005). List of questions are developed and data is collected in a survey format to identify potential risks in a project. One drawback to this technique is that surveys are not always completed or answered in the anticipated way. They are subjective in nature so gathering the required information is sometime cumbersome and elusive. The questions should be focused and the answers should be given according to the asked questions for this technique to be successful. It is critical that the individuals completing the surveys understand the scope of the particular project. For projects dealing with new technology or research efforts, this can be particularly difficult.

2.2. Risk Assessment Techniques

While the tools and techniques used for risk identification are designed to help a project manager gather information which can impact a project's objectives, scope, and budget; risk assessment provides an insight concerning how likely something is to go wrong (likelihood) and what the associated impact will be (Wang et al, 2000). There are many different terms used to describe risk impact. Some studies have used categories such as "*catastrophic*", "*critical*", "*marginal*", and "*negligible*" (Standard Practice for System Safety, 2000) or "*critical*", "*serious*", "*moderate*", "*minor*", and "*negligible*" (Lansdowne, 1999) or "*catastrophic", "major", "moderate", "minor",* and "*insignificant*" (Cooper et al, 2005). Likewise, for defining the extent of probability, some authors have used "*frequent*", "*probable*", "*occasional",* and "*remote*" (Rosenburg et al., 1999) or "*very likely*", "*probable'*, and "*improbable*" (Department of Defense, 2000) or "*almost certain", "likely", "possible"," unlikely", "rare"* (Cooper et al, 2005).

Ranking the risks based on product of likelihood (P) and consequence (c) gives a risk factor (RF) (Cooper, 2005). This can be stated mathematically as RF = P * C, where P and C are not restricted between zero and one. The significant disadvantage in this method is that high consequences and low probabilities may result in a low risk factor. Even though the risk has a low value due to the low probability, the PM may still want to manage the risk due to its high consequence. An example of this logic is the home owner who buys flood insurance even though the probability of a flood is very, very low. Another recommend method of calculating a risk factor is RF = P + C - (P*C) where the values of P and C are restricted between zero and one. This is based on the probability calculation for disjunctive events: prob (A or B) = prob(A) + prob(B) - prob(A) * prob(B). There are a variety of other risk assessment techniques that provide unique risk calculations including scenario analysis, risk assessment matrices, failure modes and effects analysis, fault tree analysis, and event tree analysis.

Scenario analysis is commonly used technique for analyzing risks. Each risk event is analyzed for it potential undesirable outcome. The magnitude or severity of the event's impact, chances of the event occurring, and the time when that event can occur during the project's life is determined. The values can be qualitative or quantitative. Quantitative analysis is generally not done because real data availability is limited. (Gray et al, 2005).

The risk assessment matrix method allows for categorization of different risk types. Risks can be classified into different types including internal and external project risks, (Cleland et al, 2010) risks caused by natural and human risks (Bowen et al, 1999). Wideman (1992) used classifications including external unpredictable, external predictable, internal non-technical, technical, and legal risks. Previous researchers have developed risk categories for specific project types, such as underground rail projects (Ghosh et al., 2004) and public health care projects (Abdou et al., 2005). Previous studies have chosen categories according to the project's type (Nielsen, 2006). Table 1 summarizes some studies done on risk identification in project management.

Failure mode and effects analysis (FMEA) is another risk analysis technique. It is used to evaluate a system or design for possible ways in which failures can occur. Failure can be defined as a problem, concern, error, or challenge (Stamatis, 2003). Failure mode is defined as physical description of the manner in which a system component fails. The potential failure causes can then be defined. As an example, a failure could be loss of power to a motor the cause of this failure could include a short circuit, disconnect power cord, or loss of electricity. The effect of failure is then determined. For example this could be stopping the motor. Due to the complex of systems today, FMEA is performed by a team with widely ranging expertise. For each failure three values are established probability of occurrence, severity of the failure, and how the failure would be detected. A risk priority number (RPN) is generated which is the product of occurrence, severity, and detection. High RPN failures are addressed first, if the failures have same RPN, high severity as compared to detection is chosen. The impacts of these failures are investigated and a bottom-up approach to

Table 1 Previous Studies Categorizing Risks in Specific Projects

Author	Risk Categories
Stamatis, 2003	Competition, Safety, Market Pressure, Management Emphasis, Development of Technical Risk, Public Liability, Customer Requirements, Warranty, Legal, Statutory Requirements
Ghosh et al., 2004	Financial and Economic Risk, Contractual and Legal Risk, Subcontractors related Risk, Operational Risk, Safety and Social Risk, Design Risk, Force Majeure Risk, Physical Risk, Delay Risk
Abdou et al., 2005	Financial and Economic Risk, Design Risk, Operational and Managerial Risk, Political Risk
Nielsen, 2006	Delivery/ Operational Risk, Technology Risk, Financial Risk, Procurement Risk, Political Risk, Environmental Risk, Social Risk, Economic Risk
Condamin, 2006	Financial Risks: Banking Risk, Liquidity Risk, Foreign Exchange Risk, Interest Rate Risk, Investment Risk; Non-Financial Risks: Health Risk, Military Risk, Weather Risk
Thomset, 2004	Business Risk, Production System Risk, Benefits System Risk, Personal Risk
Henselwood et al, 2006	Geographic Risk, Societal Risk
Hall et al, 2002	Management Risk, External Risk, Technology Risk

examine their impact is used. This is proactive approach commonly used before a design or process is implemented (Lansdowne, 1999, Nielsen, 2006 and PMBOK®, 2008). The disadvantage of FMEA is that it is time consuming, complex, and may not include failures caused by a combination of events. The FMEA risk priority number is subjective. The standards for rating severity, occurrence, and detection vary from organization to organization. FMEA is effective for systems with component that can potentially fail. It is not well suited for projects where failures are not connected with specific component failures and the uniqueness of each project makes it difficult to determine the impact of failures.

Fault Tree Analysis (FTA) was developed by Bell Labs in 1961. The FTA diagram graphically shows the various combinations of conditions that may result in a failure. Fault trees are constructed using logical connections including “AND” gates and “OR” gates. FTA may include a quantitative evaluation of the probabilities of various faults or failure events leading eventually to calculation of probability at the top event, the system failure (Wang et al, 2000). The main advantages of FTA is that it helps in visualizing the analysis, considering combinations of failures, and determining occurrence probability for complex failures. The FTA risk assessment can be either done qualitatively or quantitatively. The main disadvantage is that the failure trees can become very large and complicated especially for complex and large systems. Event tree analysis is similar to FTA. The ETA describes the possible range and sequence of outcomes that may arise from an initiating event. Event trees are a forward logic technique, which attempts to see all possible outcomes of an initiating event (Rausand, 2003). An advantage of ETA is that multiple failures can be studied. The main disadvantage of ETA is that initiating events are studied as independent events and the technique does not work well with parallel sequences. It would be difficult to use ETA for project management since it is often challenging to foresee the impact of various potential events due to the complexity and uniqueness of most projects.

3. GENERIC RISK MATRIX APPROACH

The goal of this paper is to construct a high-level risk identification and assessment tool broad enough for use with a wide variety of project types. The proposed GRM risk assessment approach uses a risk identification tool based on an industrial survey. The survey results were used to develop risk categories that populate the rows of the GRM. Risk probability and impact attributes are included as columns on the GRM for the user to enter data based on their specific project. The GRM allows a PM to make quick risk identification similar to completing a checklist. The risk assessment for the identified risks can be based on the generic impact and probability values or can be specific for the project with weights and data collected from project stakeholders.

3.1. GRM Risk Categories

From an extensive review of the literature, including the papers listed in Table 1, nine categories were identified. Respective risks determined for each category. The categories and associated risks are as follows.

(1) **Technological and Operational Risk** is sub-divided into operational, engineering, and performance risk. Operational risk includes lack of communication and coordination in the project, labor productivity and improper project planning. Engineering risk includes inadequate engineering designs, incomplete project scope, inadequate specifications, and differences between actual values and engineering assumptions. Performance risk includes technology limits and quality.

(2) **Financial and Economic Risk** is sub-divided into credit default, budget constraint/ scope creep, foreign exchange, inflation and interest rate, insurance, and funding risk. It includes credit fraud, changes in inflation or interest rates, and changes in the price of raw materials. For international projects, changes in exchange rates can cause budget pressures leading to cost overruns and/or decreases in the project performance or scope.

(3) **Procurement and Contractual Risk** is sub-divided into raw material procurement and subcontractor procurement risk. Raw material procurement risk is the delay due to market competition. Contractual risk involves issues or concerns associated with procurement through contractor.

(4) **Political Risk** is sub-divided into political instability and customer requirement risk. Political risk can be due to revisions in policies and rules, slow approvals, instable governments, or other bureaucratic hurdles. The political environment can impact projects during the implementation phase. Customer requirement risks can be caused by changes to customer technical or aesthetic requirements, which often lead to scope creep.

(5) **Environmental Risk** is sub-divided into weather and pollution risk. Risks to the project due to weather conditions such as rain, snow, or reduced sunlight are considered weather risks. Pollution risk is considered when the project affects the environment by generating pollution and vice versa. Generating pollution can result in delays and fines. Working in a polluted environment may affect the project's performance or cause additional effort to successful complete the project.

(6) **Social Risk** is sub-divided into cultural relationship and society impact risk. Society impact risk occurs when a project has an effect on society. An example of social risk is the construction of a dam that could disturb the ecological balance of the region. Cultural relationship risk is often associated with global projects. In these situations misunderstanding the needs and sensitivities of the customer can impact the scope and operation of the projects.

(7) **Regulatory and Legal Risk** is risk sub-divided into litigation and non-compliance with codes and laws. Rules and regulations vary by country and industry sector. Changing

regulations can impact a projects' budget and/or schedule. The risk of litigation is great if rules are not properly followed.

(8) **Safety Risk** includes security risk. Security risk can be caused by many factors, such as acts of God, fire, theft, terrorism, and war. For example, floods or fire can drastically impact construction projects but they can influence any type of project if deliveries are impacted.

(9) **Delay Risk** is sub-divided into project delay and third party delay risk. Project delay risk can be caused by plan approval delays or other constraints. Third party delay risk is caused by delays by sub-contractors, suppliers, or vendors.

3.2. GRM Probability and Impact Assessments

Once the generic risk categories were developed, it was necessary to create a risk assessment classification scheme to complete the GRM. The interpretation of probability and risk impact is not consistent throughout various industries. To address these inconsistencies, a simplified risk matrix approach was chosen. Figure 1 shows the levels of probability and impact that were selected. Both impact and probability use the values of "low", "medium" and "high". Using only three values limits the amount of information for the PM to work with. This simplifies the process of completing the matrix for a specific project but also reduces the detail in the results. Given the limited information available to a PM concerning probabilities, this is a reasonable level of detail for an initial risk assessment.

	Probability		
Impact	Low	Medium	High
Low	LI-LP	LI-MP	LI-HP
Medium	MI-LP	MI-MP	MI-HP
High	HI-LP	HI-MP	HI-HP

Figure 1 Simplified Risk Matrix

For the development of the GRM in this study, each risk was divided into LI-LP (low impact & low probability), LI-MP (low impact & medium probability), LI-HP (low impact & high probability), and similarly MI-LP, MI-MP, MI-HP, HI-LP, HI-MP and HI-HP. These nine different combinations, as shown in Figure 1, were defined in the form of "economic function" definitions (Condamin, 2006) for this work. Such definitions facilitate the ease of use of the GRM. It defines the implications of impact-probability combinations on the project planning and budgeting. In this way, a PM can take a particular course of action depending on what level the risks fall into. The LI-LP implies little practical significance to the project's performance and these factors can be addressed if and when they occur. They do not justify additional planning or monitoring. LI-MP might require some judgment or budget provisions. The LI-HP implies that contingency budgeting should be performed. The MI-LP and MI-MP indicate that the impact of the risk could be considerable and contingency planning at the minimum should be done. HP risks will often need allocated amounts in the budget, since the chances of the risk occurring are maximum. HI-LP and HI-MP imply that if the event occurs external funding may be necessary or insurance should be purchased. If the risk affects resources the PM should consider identifying potential additional resources and possibly even reserving them. MI-HP and HI-HP implies that the PM should plan for the risk event to occur. This might include budgeting additional funds or additional slack time to associated tasks to either avoid or minimize the impact of the event.

In order to rank the risk elements a weighting scheme was applied to the nine simplified risk matrix categories. The impact and probability attributes were given a weight of 1, 2 and 3 corresponding to "low", "medium" and "high" values. The impact and probability values are then multiplied to get a combination weight. For example, LI-LP combination will generate factors (1 and 1) that are multiplied together giving a combined risk value of 1. Similarly LI-HP and HI-LP resulted in a risk value of 3 and HI-HP results in a risk value of 9. The risk matrix with weights is shown in Figure 2. However, one caveat to this approach is that weighing impact and probability attributes in this manner may not be detailed enough or can be misleading. Using this balanced approach, MI-HP and HI-MP are both given the same value of six. These two combinations may not be of equal concern for some projects. The weights can be adjusted by the PM for projects that warrant it.

		Probability		
	Impact	Low	Medium	High
Weights		1	2	3
1	Low	LI-LP (1)	LI-MP (2)	LI-HP (3)
2	Medium	MI-LP (2)	MI-MP (4)	MI-HP (6)
3	High	HI-LP (3)	HI-MP (6)	HI-HP (9)

Figure 2 Impact –Risk Combinations with Weights

3.3. GRM Survey

A survey was designed to find the frequency of use of risk management techniques in project management and to rank various business risks. The survey consisted of 55 questions for PMs. The A section of the survey contained demographic questions about the respondent's employer and PM experiences. The second section contained impact and probability assessments of each of the identified risks. The available choices for the risk impact questions were *critical, serious, moderate, minimal, negligible* and *not applicable*. The probability options given to the respondents were *0-20%, 20-40%, 40-60%, 60-80%, 80-100%* and *not applicable*. The response data was converted into the simplified impact-probability matrix as follows –

Critical & Serious – High Impact

Moderate – Medium Impact

Minimal & Negligible – Low Impact

60-80% & 80-100% - High Probability

40-60% - Medium Probability

0-20% & 20-40% - Low Probability

3.4. Survey Results

All of the survey participants were in technical and/or managerial positions in their organization with extensive project management experience. A total of 13 useable responses were used in the analysis. Many respondents were involved with construction projects; however other types of projects including R&D and military programs were represented in the survey. Respondents were currently working on an average of two to three projects. The average project size was $100,000 to $1,000,000 (See Figure 3). The majority did use some kind of risk management techniques; however a significant portion, nearly 28% of respondents, had seldom or never used risk management techniques in their organizations (See Figure 4). The survey asked respondents about the type of risk matrix being used for risk management in the question "Is the risk matrix approach company or project based?" Of the organizations doing risk management, the majority used a company-wide risk matrix, while few used project-specific ones. This may be due to the number of ongoing projects as an organizational-based generic risk matrix would be more likely for those doing numerous projects or it could be due to a lack of available generic matrices. Some comments from those using a risk matrix highlighted their usefulness including: "It minimizes the risk exposure and keeps the project on schedule. The schedule is for convenience, planning and costs" and "It is a good way to ID tasks"

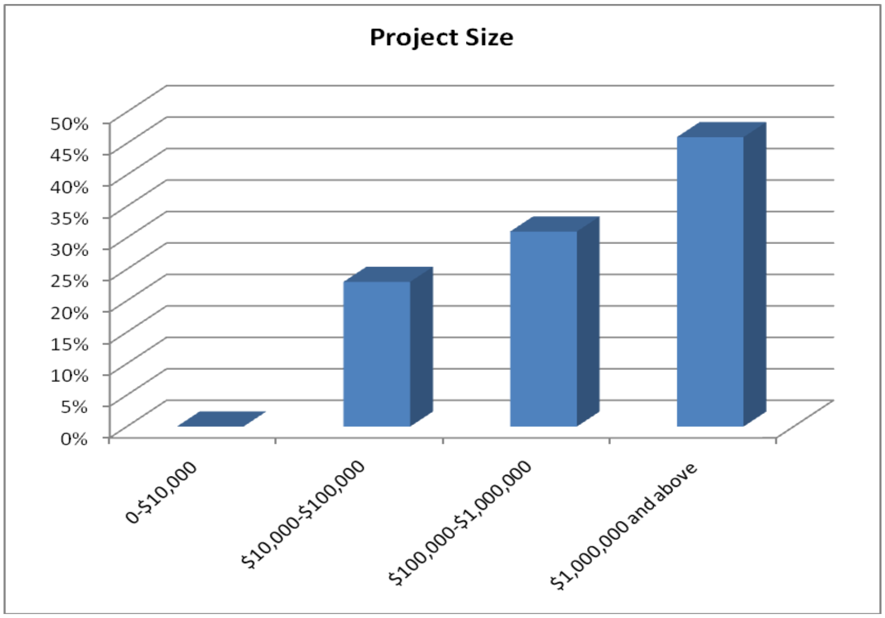

Figure 3 Project Size

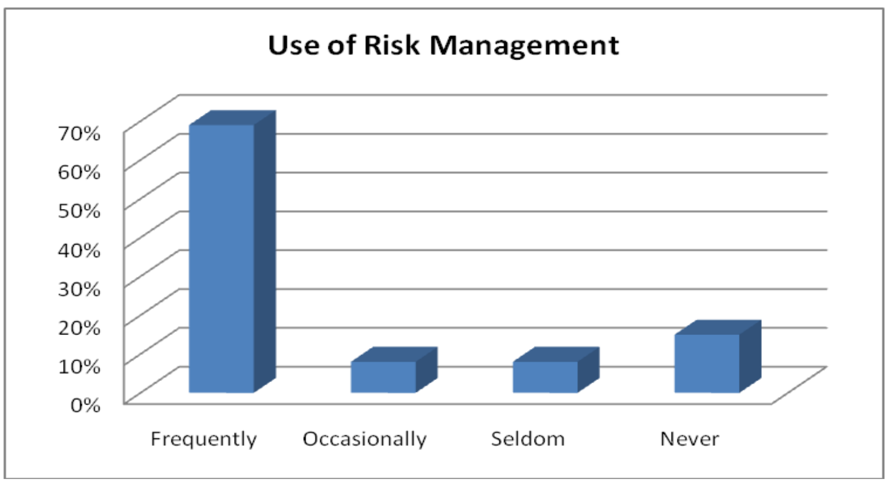

Figure 4 Use of Risk Management

Risk Ranking

To prioritize the risks the survey responses were converted to risk ranking parameters. The analysis is based on 13 responses to the survey. The individual responses to impact and probability of each risk is combined and classified in one of the nine types, namely LI-LP, LI-MP, LI-HP, MI-LP, MI-

MP, MI-HP, HI-LP, HI-MP and HI-HP. The responses for each of the nine types were totaled and converted into a percentage value. For example, in Table 2, one response falls under LI-LP, giving it a value of 7.69% (1/13*100). These percentage values were then multiplied by the associated weights (as per Figure 2) and summed together row-wise. The resultant total weighted value is used in ranking the risks. The column showing N/A or not applicable is the percentage of respondents finding that specific risk not applicable to their projects. It has a weight of zero and does not influence the total weighted values.

Table 2 Risks Ranked

		LI-LP	LI-MP	LI-HP	MI-LP	MI-MP	MI-HP	HI-LP	HI-MP	HI-HP	N/A	Weighted Importance	Rankings from most to least importance
	Weight -->	1	2	3	2	4	6	3	6	9	0		
	Types of Risk												
1	**Technological and Operational risk**												
	Operational risk	7.69	0.00	0.00	0.00	0.00	59.17	30.77	30.77	15.38	7.69	778.11	1
	Engineering risk	7.69	0.00	0.00	7.69	0.00	0.00	30.77	30.77	15.38	7.69	438.46	5
	Performance risk	7.69	0.00	0.00	7.69	15.38	0.00	7.69	46.15	0.00	15.38	384.62	7
2	**Financial and Economic risk**												
	Credit risk/ Default risk	30.77	0.00	0.00	23.08	0.00	0.00	7.69	7.69	7.69	23.08	215.38	14
	Budget Constraint/ Scope creep risk	0.00	0.00	0.00	15.38	15.38	7.69	7.69	23.08	15.38	15.38	438.46	5
	Foreign Exchange risk	38.46	0.00	0.00	0.00	0.00	0.00	15.38	0.00	0.00	46.15	84.62	17
	Inflation and Interest rate risk	53.85	0.00	0.00	23.08	0.00	0.00	0.00	0.00	7.69	15.38	169.23	15
	Insurance risk	30.77	0.00	0.00	23.08	0.00	0.00	15.38	15.38	0.00	15.38	215.38	14
	Funding risk	15.38	0.00	0.00	7.69	15.38	0.00	30.77	15.38	7.69	7.69	346.15	8
3	**Procurement and contractual risk**												
	Raw material procurement risk	15.38	0.00	0.00	23.08	7.69	7.69	0.00	23.08	7.69	15.38	346.15	8
	Subcontractor procurement risk	7.69	7.69	0.00	15.38	0.00	0.00	23.08	23.08	15.38	7.69	400.00	6
4	**Political risk**												
	Political instability risk	38.46	0.00	0.00	7.69	0.00	0.00	7.69	23.08	7.69	15.38	284.62	10
	customer requirement risk	15.38	0.00	0.00	0.00	7.69	7.69	7.69	30.77	23.08	7.69	507.69	2
5	**Environmental risk**												
	Weather risk	15.38	0.00	7.69	7.69	0.00	7.69	0.00	46.15	7.69	7.69	446.15	4
	Pollution/ environmental risk	23.08	0.00	0.00	23.08	7.69	0.00	0.00	23.08	7.69	15.38	307.69	9
6	**Social risk**												
	Cultural relationship risk	38.46	7.69	0.00	0.00	0.00	7.69	0.00	7.69	7.69	30.77	215.38	14
	Society impact risk	30.77	0.00	0.00	15.38	15.38	0.00	0.00	0.00	0.00	38.46	123.08	16
7	**Regulatory and legal risk**												
	Litigation risk	7.69	0.00	0.00	30.77	0.00	0.00	23.08	23.08	0.00	15.38	276.92	11
	Non-complaince of codes and laws risk	30.77	0.00	0.00	15.38	0.00	0.00	23.08	23.08	0.00	7.69	269.23	12
8	**Safety risk**												
	Security risk	30.77	0.00	0.00	0.00	0.00	0.00	53.85	7.69	0.00	7.69	238.46	13
9	**Delay risk**												
	Project delay risk	0.00	0.00	0.00	0.00	23.08	7.69	7.69	53.85	0.00	7.69	484.62	3
	Third party delay risk	0.00	0.00	0.00	15.38	15.38	7.69	7.69	46.15	0.00	7.69	438.46	5

Consider another example, in Table 2, credit/default risk has values of 30.77, 0, 0, 23.08, 0, 0, 7.69, 7.69, 7.69, and 23.08 for the impact-probability combinations respectively. These values are multiplied by respective weights of 1, 2, 3, 2, 4, 6, 3, 6 and 9. Summing the resultant values will result in a value of 215.38. This value is used to rank the risks. Thus, credit risk gets a rank of 14 as shown in Table 2. Risks having identical weighted values are given the same rank. Operational Risk and Customer Requirement risk are the top two most important risks that a PM should consider in risk management of projects in general.

Table 3 Risks Rated for Probability and Impact

		Probability			Impact			Probability			Impact			Rankings from most to Least important
		Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	
	Types of Risk													
1	**Technological and Operational risk**													
	Operational risk	38.46	30.77	74.56	7.69	59.17	76.92			X			X	1
	Engineering risk	46.15	30.77	15.38	7.69	7.69	76.92	X					X	5
	Performance risk	23.08	61.54	0.00	7.69	23.08	53.85		X				X	7
2	**Financial and Economic risk**													
	Credit risk/ Default risk	61.54	7.69	7.69	30.77	23.08	23.08	X			X			14
	Budget Constraint/ Scope creep risk	23.08	38.46	23.08	0.00	38.46	46.15		X				X	5
	Foreign Exchange risk	53.85	0.00	0.00	38.46	0.00	15.38	X			X			17
	Inflation and Interest rate risk	76.92	0.00	7.69	53.85	23.08	7.69	X			X			15
	Insurance risk	69.23	15.38	0.00	30.77	23.08	30.77	X					X	14
	Funding risk	53.85	30.77	7.69	15.38	23.08	53.85	X					X	8
3	**Procurement and contractual risk**													
	Raw material procurement risk	38.46	30.77	15.38	15.38	38.46	30.77	X				X		8
	Subcontractor procurement risk	46.15	30.77	15.38	15.38	15.38	61.54	X					X	6
4	**Political risk**													
	Political instability risk	53.85	23.08	7.69	38.46	7.69	38.46	X					X	10
	customer requirement risk	23.08	38.46	30.77	15.38	15.38	61.54		X				X	2
5	**Environmental risk**													
	Weather risk	23.08	46.15	23.08	23.08	15.38	53.85		X				X	4
	Pollution/ environmental risk	46.15	30.77	7.69	23.08	30.77	30.77	X					X	9
6	**Social risk**													
	Cultural relationship risk	38.46	15.38	15.38	46.15	7.69	15.38	X			X			14
	Society impact risk	46.15	15.38	0.00	30.77	30.77	0.00	X				X		16
7	**Regulatory and legal risk**													
	Litigation risk	61.54	23.08	0.00	7.69	30.77	46.15	X					X	11
	Non-compliance of codes and laws risk	69.23	23.08	0.00	30.77	15.38	46.15	X					X	12
8	**Safety risk**													
	Security risk	84.62	7.69	0.00	30.77	0.00	61.54	X					X	13
9	**Delay risk**													
	Project delay risk	7.69	76.92	7.69	0.00	30.77	61.54		X				X	3
	Third party delay risk	23.08	61.54	7.69	0.00	38.46	53.85		X				X	5

The results of Table 2 are used as a baseline to rank the risks with the Generic Risk Matrix. The weighted importance values provide a quick assessment of impact and probability of each risk. The impact and probability ratings were used to determine generic impact and probability values for the GRM. The low, medium and high impact survey responses were summed and the results are shown in Table 3. The same was done for the probability responses. For example, Operational Risk in the first row has 7.69% for LI-LP, 0% for LI-MP and 0% for LI-HP which is summed up for impact attribute to generate a value of 7.69% for low impact. Similarly, for low probability of Operational

Table 4 Generic Risk Matrix

		Generic							Specific						
		Probability			Impact			Generic	Probability			Impact			Specific
		Low	Medium	High	Low	Medium	High	Rankings	Low	Medium	High	Low	Medium	High	Rankings
	Types of Risk														
1	**Technological and Operational risk**														
	Operational risk			X			X	1							
	Engineering risk	X					X	5							
	Performance risk		X				X	7							
2	**Financial and Economic risk**														
	Credit risk/ Default risk	X			X			14							
	Budget Constraint/ Scope creep risk		X				X	5							
	Foreign Exchange risk	X			X			17							
	Inflation and Interest rate risk	X			X			15							
	Insurance risk	X					X	14							
	Funding risk	X					X	8							
3	**Procurement and contractual risk**														
	Raw material procurement risk	X				X		8							
	Subcontractor procurement risk	X					X	6							
4	**Political risk**														
	Political instability risk	X					X	10							
	customer requirement risk		X				X	2							
5	**Environmental risk**														
	Weather risk		X				X	4							
	Pollution/ environmental risk	X						9							
6	**Social risk**														
	Cultural relationship risk	X			X			14							
	Society impact risk	X				X		16							
7	**Regulatory and legal risk**														
	Litigation risk	X					X	11							
	Non-compliance of codes and laws risk	X					X	12							
8	**Safety risk**														
	Security risk	X					X	13							
9	**Delay risk**														
	Project delay risk		X				X	3							
	Third party delay risk		X				X	5							

Risk, the values of 7.60% for LI-LP, 0% for MI-LP and 30.77% for HI-LP are summed to get 38.46%. The aggregate of impact and probability values for each risk has been marked an “X”. A conservative approach has been used, when identical values were found, the maximum of the two was considered. For example, the values for Insurance Risk under impact are 30.77% for low as well as high impact. Here, the risk has been marked as high impact. This table allows for a quick assessment just by looking at the concerned columns. The risk ranks have been retained from the previous calculations in Table 2.

The probability and impact columns, marked with an “X” in Table 3, are the basis of the GRM. They provide a quick overview that a PM can use to identify risks when managing a project. These results are particularly useful when a PM has little insight into the project and potential challenges that may arise during the life of the project. However, PMs and others in the organization often have some insight into the potential problems the project can face. Blank columns were added to the GRM to allow the PM to use knowledge and judgment about a specific project to customize the risk matrix. The PM can rate the risks for impacts and probabilities for any or all of the risks listed. Thus the generic rankings shown in the GRM in Table 4 gives the PM a baseline value to work from. The PM can then customize it to suit a specific project. This same methodology could be used to generate a matrix for a specific project type or even to generate a company-wide matrix for a particular industry.

4. CASE STUDY

To illustrate the practicality of the generic risk matrix, it was applied to a project with a two-year span and a one million dollars budget. This was a research and development (R&D) project for the Department of Defense (DoD). This case was chosen to illustrate that the generic matrix could be applied to an R&D project. The risk ranking developed in this paper was based on respondents from a variety of industries. We suspected that some potential risk factors, the Foreign Exchange risk for example, might not apply to a DoD R&D project.

A blank risk matrix without generic rankings was given to three PMs with significant experience on military research projects. The blank matrix listed all the generic potential risks. The PMs were asked to rate the impact and probability of each risk for the two year, one million dollar project. The PMs did not know specifics of the case study project, but based their responses on their prior experiences with government research projects. The results were compiled and the specific ranked risks averaged as shown in Table 5.

These rankings come purely from each PM’s perspective. There is some variability in the values due to their subjective nature, but there is general agreement on many values. Budget constraint/scope creep was ranked 1, 2, and 4 for an average values of 2.3 is the highest priority risk for this type of research project. As expected some risks such as political and environmental have low priority since they do not typically apply to R&D projects. A construction project, however, would typically rate these to be significant concerns. Many of the risks did have ranking approximately similar to the results for the generic risk matrix shown in Table 2. The generic matrix provides the R&D PM with a good set of categorized risks for contingency planning. Seeking input from PMs with related experience provides further refinement. The PM will still need to consider the various risks based on the project’s parameters and project to-date, but the GRM has given the PM much needed structure for the risk analysis process.

5. CONCLUSIONS AND DISCUSSION

Twenty three percent of the PMs surveyed are not using risk management frequently. This could be due to a lack of a easy to use process for risk assessment. The generic risk matrix developed in this paper provides a quick approach to guide project managers in contingency planning. This matrix identifies risks and prioritizes them with minimal resources required of the PM. In the GRM approach, the use of nine different risk areas can be a first step to standardization of risk identification process in an organization. This reduces the subjectivity in defining risks and more importantly can aid discussions about risks across projects. The GRM approach attempts to reduce the subjectivity and remain simple to use by limiting values to either low, medium, or high.

Table 5 Case Study Results

	Types of Risk	Rankings from most to least important (1-22) Respondent-1	Rankings from most to least important (1-22) Respondent-2	Rankings from most to least important (1-22) Respondent-3	Rankings Average	Avearge Rankings from most to least important (1-22)
1	**Technological & Operational risk**					
	Operational risk	1	6	12	6.333	5
	Engineering risk	2	13	6	7.000	6
	Performance risk	3	14	5	7.333	7
2	**Financial & Economic risk**					
	Credit risk / Default risk	10	7	20	12.333	10
	Budget constraint/ Scope creep risk	4	1	2	2.333	1
	Foreign exchange risk	11	15	22	16.000	17
	Inflation & interest rate risk	12	16	13	13.667	12
	Insurance risk	13	17	19	16.333	18
	Funding risk	14	18	14	15.333	15
3	**Procurement & Contractual risk**					
	Raw material procurement risk	5	2	4	3.667	2
	Subcontractor procurement risk	7	3	3	4.333	4
4	**Political risk**					
	Political instability risk	15	19	21	18.333	21
	Customer requirement risk	16	20	15	17.000	20
5	**Environmental risk**					
	Weather risk	17	21	11	16.333	19
	Pollution / environmental risk	18	22	16	18.667	22
6	**Social risk**					
	Cultural relationship risk	19	8	18	15.000	14
	Society impact risk	20	9	17	15.333	16
7	**Regulatory & Legal risk**					
	Litigation risk	21	10	8	13.000	11
	Non-compliance of codes and laws risk	22	11	9	14.000	13
8	**Safety risk**					
	Security risk	8	12	7	9.000	9
9	**Delay risk**					
	Project delay risk	6	4	1	3.667	3
	Third party delay risk	9	5	10	8.000	8

A project manager can use the GRM as is for a quick start on risk planning or can call on personal experience or the expertise of other PMs in the organization and customize the matrix. The contingency planning can be as basic or as elaborate as warranted. It is critical that project managers consider the wide variety of things that can go wrong on a project; the GRM gives the PM a tool to do this. As with project management in general, planning and monitoring the project for a variety of risk factors is key to having a successful project.

In order to take this research further, there could be a few opportunities to consider other risk factors in the analysis. PMBOK 4th edition mentions the inclusion of 'positive risks' in the project planning stage. Positive risks are opportunities which can be capitalized on, resulting in a favorable outcome. These risks have a probability of a positive outcome and are usually initiated by the project manager. Such risks can be considered in future for conducting this analysis. Positive risks can be ranked according to perception of its importance among respondents and project managers.

Such risks might be industry specific, but the survey results might prove ability of managers to consider such risks as well as how much importance would they give in comparison to other project risks.

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