

Project Risk Management Using the Project Risk FMEA

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Abstract: Identifying and mitigating project risks are crucial steps in managing successful projects. This article proposes the extension of the Failure Mode and Effects Analysis (FMEA) format to quantify and analyze project risks. The new technique is labeled the project risk FMEA (RFMEA). The RFMEA is a modification of the well-known process, product, and service FMEA technique. In order to use the FMEA format for projects, the detection value of the standard FMEA is modified slightly for use in the project environment. The new approach is illustrated in a case study from the electronics industry. By adding the detection value to the risk quantification process, another measure beyond the typical risk score is made available to the project team. The benefits of the RFMEA include an increased focus on the most imminent risks, prioritizing risk contingency planning, improved team participation in the risk management process, and development of improved risk controls.

Keywords: Risk Management, Risk Matrix, Risk Analysis, Project Management

EMJ Focus Areas: Program & Project Management

Today, effectively managing risk is an essential element of successful project management. Proper risk management can assist the project manager to mitigate against both known and unanticipated risks on projects of all kinds. Failure to perform effective risk management can cause projects to exceed budget, fall behind schedule, miss critical performance targets, or exhibit any combination of these troubles.

In 1999 the Standish Group reported that only 26% of software projects were successful. In other studies across

numerous types of development projects, Adams reported similar numbers, where only about one-fourth of all projects entering development become a market success (2004). Datta and Mukerjee (2001) stated that “successful project completion depends to a great extent on the early identification of immediate risks.” Jiang et al. (2002), using factor analysis, confirmed their hypothesis that risks adversely impact project success for software development.

Certainly there are a number of factors that determine whether a project will be a success, but it seems likely that failing to perform adequate risk management will increase the possibility of failure. The old axiom, “failing to plan is planning to fail,” appears to apply to risks. Having an effective method to plan for and manage project risks that is easy for the project team to understand, use, and apply is critical. As projects increase in complexity and size, taking a multidisciplinary approach to project management requires giving proper attention to risk management. This article proposes a simple risk management tool that has been shown to be beneficial to managing project risks and improving project success.

The FMEA as a Project Risk Management Tool

Risk analysis techniques include expert interviews, expected monetary value, and response matrices, along with more advanced risk techniques such as the Monte-Carlo method. Pritchard (2001) and Raz and Michael (1999) provide comprehensive information about and references to risk analysis techniques for various applications and requirements. One risk management technique multiplies probability of the risk occurring with the expected impact of the risk. This leads to an evaluation for each risk. In this work, the method of using the risk probability multiplied by the risk impact value is expanded by also multiplying a detection value for each risk.

Multiplying three values of likelihood of occurrence (or probability), severity (or impact), and detection is the familiar

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format of the failure mode and effects analysis (FMEA) used for process, design, and service planning. The FMEA technique dates back to the United States military procedure MIL-P-1629 (1949). Bongiorno (2001) provides an overview of a design FMEA (DFMEA), as well as the basic mechanics of the FMEA technique. Currently, the technique is an integral part of ISO-9000 and QS-9000 quality certification levels. It is used within the comprehensive framework of product and process development with such tools as FTA, APQP, QFD, DOE, SPC, 8-D, and the like (FMEAC.COM, 2003). The FMEA method is a natural addition to the project risk management process due to its ease of use, familiar format, and comprehensive structure.

In the method of applying the FMEA format to project risks, it is defined here as the project risk FMEA or RFMEA. The RFMEA technique is not just another way of analyzing project risks but helps focus the risk contingency planning required early in the project on critical risks. Pritchard (2000) first identified the FMEA technique as an advanced format capable of capturing project risks. The use of the FMEA technique is developed here with terminology, along with a detailed methodology. In addition, the method of using the RFMEA with simple graphical analysis techniques is introduced for risk priority planning. First, the most common risk terminology in the literature is reviewed with the reader. Second, definitions for using the RFMEA are provided. The method of creating the RFMEA is then explained. The benefits of the RFMEA are discussed to help the engineering manager, project manager, and team members realize the importance of this method. A case study of the RFMEA in use is shown as an example for the reader. The conclusion highlights the importance of such a method to the engineering management community.

Risk Terminology

While the literature on risk management is plentiful, the definitions and meanings of a few key similar terms within the field are inconsistent. A *Guide to the Project Management Body of Knowledge PMBOK® Guide* (PMI, 2000) defines the risk management process as being comprised of six steps: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control. A *project risk* is defined as “an uncertain event or condition that, if it occurs, has a positive or negative effect on a project’s objectives” (PMI, 2000). Authors have used various terms for depicting the probability attribute of a risk event such as, “probability,” “likelihood,” “probability of occurrence,” and “occurrence frequency.” Scales used for these probability ratings range from low, medium, and high, 1 to 10, 0 to 1.0, or some other nonlinear or linear scale. Although these terms and scales are all correct, inconsistent use and terminology creates confusion.

The discrepancies do not stop with the probability value. A second attribute typically associated with a risk event is what is called the “impact,” “severity,” “consequence,” or the “amount at stake.” Even the *PMBOK® Guide* (2000) mixes the words impact and consequences in the discussion on tools and techniques for qualitative risk analysis under section 11.3.2.1. The impact attribute is defined as “the effect on project objectives if the risk event occurs” (PMI, 2000).

To add to the confusion, the meaning of the combined probability and impact value varies. Depending on the authors’ preference for naming these two risk attributes, the combination

has been called the expected value (Lukas, 2002; PMI Risksig Lexicon, 2003; Pritchard, 2000), risk score (PMI, 2000), risk severity (Graves, 2000), P-I score (Hillson, 2000), risk exposure (Githens, 2002), or risk event status (Wideman, 1992). Royer (2000) identifies an “intersecting matrix” for the probability and severity factors. Price (1998) defines risk as the probability times multiple consequences using a probabilistic fault tree approach. Datta and Mukerjee (2001) developed a nine-segment matrix for immediate project risk analysis based on weighted probability. Pyra and Trask (2002) describe a quantitative priority ranking based on a table of probability and impact. Other models, as discussed by Kerzner (2002, p. 707), use a mathematical function that defines the risk factor as the multiplication of a number of probability and consequence factors (Equation 1).

$$\text{Risk Factor} = Pf + Cf - Pf \times Cf \quad (1)$$

where:

Pf represents the probability of failure due to degree of maturity and complexity.

Cf represents the consequence of failure due to technical factors, cost, and schedule.

It is apparent that there are many ways to capture the effect of project risks. The method an organization chooses depends on the situation. For consistency and communication, the terminology used should align with the *PMBOK® Guide* (PMI, 2000). The RFMEA method described here aligns with the standard terminology and has been applied to numerous types of projects in a high technology environment.

Project Risk FMEA (RFMEA) Definitions

In order to lend some standard naming to the RFMEA, the definitions adopted for this work are used in such a way as to align closely with the *PMBOK® Guide* (PMI, 2000). The definition of a risk is as cited earlier. The *PMBOK® Guide* (2000) further defines the risk probability as the likelihood that a risk will occur. For the RFMEA the term *likelihood* is used for this risk attribute because a true probability scale is not possible across all risks, as they are not all dependent. The second attribute is labeled the *impact*. Finally, the multiplication of the likelihood value and the impact value for a specified risk is defined here as the *risk score*.

Failure mode and effects analysis (FMEA) has long been used as a planning tool during the development of processes, products, and services. In developing the FMEA, the team identifies failure modes and actions that can reduce or eliminate the potential failure from occurring. Input is solicited from a broad group of experts across design, test, quality, product line, marketing, manufacturing, and the customer to ensure that potential failure modes are identified. The FMEA is then used during deployment of the product or service for troubleshooting and corrective action.

The standard FMEA process evaluates failure modes for occurrence, severity, and detection (Chrysler Corp., Ford Motor Co., and General Motors Corp., 1995). The multiplication of these values leads to what is known as the risk priority number (RPN) (Equation 2).

$$\text{RPN} = \text{Occurrence} * \text{Severity} * \text{Detection} \quad (2)$$

In using the RFMEA approach, there are a few required modifications to the standard FMEA format. The project RFMEA

Exhibit 1. Simplified Standard FMEA and RFMEA Forms

Typical FMEA Columns	Failure ID	Failure Mode	Occurrence	Severity		Detection	RPN
Typical RFMEA Columns	Risk ID	Risk Event	Likelihood	Impact	Risk Score	Detection	RPN

is a tool to identify, quantify, and remove or reduce risks in a project environment versus with the product’s technical aspects as identified in the FMEA. The RFMEA is used in conjunction with the developed FMEAs for product design, process development, and service deployment. Samples of the standard FMEA and the RFMEA forms are given in Exhibit 1. First, the “failure mode” column is replaced with the “risk event.” Second, the “occurrence” is termed “likelihood.” Third, the “severity” is termed the “impact.” The likelihood, impact, and detection values are assigned by the project team based on standard tables, not unlike those provided for a standard FMEA; however, the impact attribute definitions are modified for the project environment (Graves, 2000). Exhibits 2, 3, and 4 provide guidelines for assigning the likelihood, impact, and detection values for each risk within the RFMEA. For an actual project, the percentages for cost and time in Exhibit 3 must be converted to time and dollar values based on the particular project. This allows the project team to grasp the magnitude of the risk in terms of time and dollars instead of the generic percentage values provided as guidelines. The risk score is the multiplication of the likelihood and the impact. The RPN value is the multiplication of the likelihood, impact, and detection values.

Exhibit 2. Likelihood Value Guidelines

9 or 10	Very likely to occur
7 or 8	Will probably occur
5 or 6	Equal chance of occurring or not
3 or 4	Probably will not occur
1 or 2	Very unlikely

The largest deviation from the standard FMEA is the definition used for detection attribute. In the standard FMEA, the highest detection value means that the organization has no detection capability available for the fault, whereas a low detection number in the standard FMEA means that the organization has a way to detect the fault before it ships from the operation almost 100% of the time.

For the RFMEA, detection techniques or methods are defined as, “the ability to detect the risk event with enough time to plan for a contingency and act upon the risk.” If the team cannot be reasonably assured that the risk can be detected because it is, in a sense, sneaky or has subtle symptoms, the detection number must be assigned as a 10 at initial planning. If the risk is, as Pritchard (2000) noted, “like a freight train that can be heard for miles,” then the detection value will be smaller because the team has adequate time to plan a workaround or mitigate the risk once the symptoms are identified. The detection value helps to further rank risks in order to deal with those that require attention

Exhibit 3. Impact Value Guidelines

9 or 10	<p>Schedule—Major milestone impact and > 20% impact to critical path.</p> <p>Cost—Total project cost increase > 20%.</p> <p>Technical—The effect on the scope renders end item unusable.</p>
7 or 8	<p>Schedule—Major milestone impact and 10% – 20% impact to critical path.</p> <p>Cost—Total project cost increase of 10% – 20%.</p> <p>Technical—The effect on the scope changes the output of the project and it may not be usable to client.</p>
5 or 6	<p>Schedule—Impact of 5% – 10% impact to critical path.</p> <p>Cost—Total project cost increase of 5% – 10%.</p> <p>Technical—The effect on the scope changes the output of the project and it will require client approval.</p>
3 or 4	<p>Schedule—Impact of < 5% impact to critical path.</p> <p>Cost—Total project cost increase of < 5%.</p> <p>Technical—The effect on the scope is minor but requires an approved scope change internally and maybe with the client.</p>
1 or 2	<p>Schedule—Impact insignificant.</p> <p>Cost—Project cost increase insignificant.</p> <p>Technical—Changes are not noticeable.</p>

immediately. Certainly the detection assignment is subjective, but no more so than the assignment of the likelihood and impact values for the common risk matrix method. Thus, the detection value is a measure of being able to foresee the specific risk event. Those risks with high detection values may need additional controls or monitors for early warning. The goal is to detect the risk with as much advanced notice as possible. The value is in the process of properly discussing the risks and being better prepared in advance of the risk event.

Since risk management is concerned about positive as well as negative events, the matrix can be used in the same fashion to take advantage of opportunities. Again, the detection value is high if the team would *not* have time to create a plan to take advantage of the opportunity. The remainder of the RFMEA method is then the same as for negative risks.

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Exhibit 4. The Detection Value Guidelines

Detection Definition is “the ability of detection technique or method(s) to detect the risk event with enough time to plan for a contingency and act upon the risk.”

9 or 10	There is no detection method available or known that will provide an alert with enough time to plan for a contingency.
7 or 8	Detection method is unproven or unreliable; or effectiveness of detection method is unknown to detect in time.
5 or 6	Detection method has medium effectiveness.
3 or 4	Detection method has moderately high effectiveness.
1 or 2	Detection method is highly effective and it is almost certain that the risk will be detected with adequate time.

Method

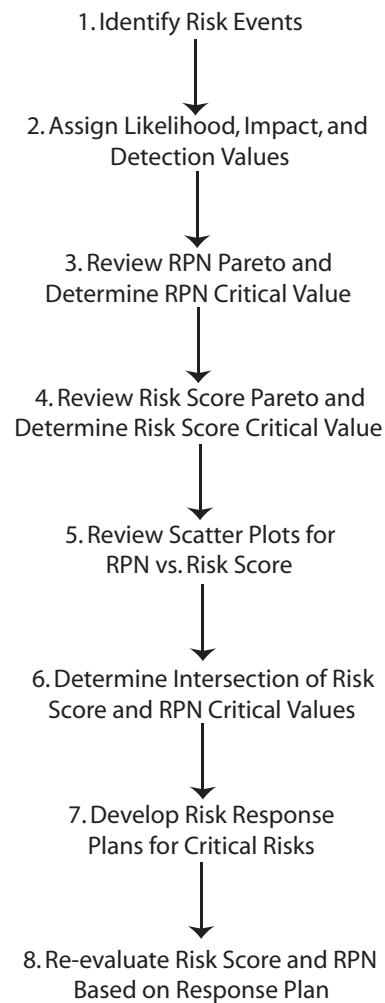
RFMEA Format and Method. The RFMEA is developed along the same lines as a typical FMEA. Customized columns can be added to the simple RFMEA form of Exhibit 1 to document the needs of a specific project and the organization. A list of additional sample fields that can be included in the RFMEA are shown in Exhibit 5.

The RFMEA is introduced during a team planning meeting utilizing the template form modified as needed for the specific project. Modifications may include adding project details, adjusting the percentages of Exhibit 3, applying specific time and dollar impact values, and adding additional columns as noted in Exhibit 5. The RFMEA procedure is outlined in Exhibit 6. Step one is for the team to brainstorm risk events. The team is coached that each risk event must be identified in the form of, “If x happens, then y will occur,” where x is the risk event and y is the impact of the event happening. The impact might be serious time delay,

Exhibit 5. Other Typical RFMEA Fields

- Risk Categories (i.e., Cost, Time, or Performance / Technical)
- Functional Area
- Project Phase
- Task Name or WBS #
- Response Strategy (avoidance, transference, mitigation, acceptance)
- Response Plan
- Revised RPN Factors

Exhibit 6. Steps in the RFMEA Process



an increase in costs, or both. A given risk might have multiple impacts, and in those cases, a risk ID is given for each impact identified. While the impact and subsequent contingency plans for a particular risk are likely to be different, the likelihood value and the detection value for the event will typically be the same.

Second, the values entered for likelihood, impact, and detection are assigned by team vote. The team discusses the scores and agrees on a value that may require additional data from experts or a review of past RFMEA’s. By having experienced professionals from various backgrounds contributing to the RFMEA, the quality of the analysis is greatly increased. The scoring procedure is replicated for the impact and detection factors.

Once the values for the three factors are entered, both the risk score and the RPN values are calculated. The third step is to review the RPN Pareto to determine the critical RPN value. As Bongiorno (2001) points out for the typical FMEA, a standard RPN threshold value across all projects is also not used or recommended in the RFMEA. A certain RPN value on one project may be deemed moderate, whereas on another project it may be a crucial risk to manage. As each project is unique, so are the risks and the corresponding RPN values. Thus, the analysis of the Pareto is a critical step to determine the value to use.

Fourth, a similar Pareto is generated for the risk scores, and a critical value is determined for this measure. There is no scientific rule for the selection of the critical values. In some cases, the choice is obvious, and in other cases the distribution is smooth

and continuous, making the selection more difficult. The point to keep in mind, and to address with the project team, is that this is simply a starting point. The critical values simply provide guidance for prioritizing risk response planning.

After the critical values are known for both the RPN and the risk score, step five is to create a scatter diagram for RPNs versus risk scores. There is no expectation that the data plotted should fit any pattern.

The objective of step six is to find the intersection of the two critical values to define the initial set of risks that require a response plan be generated early on. The risk events that have both a risk score and an RPN above the critical values are given priority for initial risk response planning.

There are risks that may have a high-risk score, but because it is anticipated that the risk could be detected early enough, they are given a low detection value and subsequently a low RPN. The team must evaluate whether these risks, even if they can be detected, are significant enough to indicate generation of a response plan early. If those risks happen, will the project continue? Even being able to detect the risk with enough time to develop a risk response plan is not very valuable if the impact is so severe that it renders the project a failure. Thus the risk score and the RPN value must both be evaluated, as each number serves a distinct yet related purpose.

After identifying the critical risks, in step seven the team must consider risk response strategies such as avoidance, transference, mitigation, and acceptance and document response plans accordingly. Following the response planning, the final step is to recalculate the risk score and RPN values based on the actions of the anticipated response plan. As Jiang and Klein (2001) point out, care must be given with respect to the response plan based on the category into which the risk falls. Depending on the organization's strategy and tolerance, analysis of risks across cost, schedule, and technical categories must occur (Pritchard, 2001). If the recalculated RPN number does not fall below the critical value, the team must revise the response plan, improve detection methods, or have an approved override to accept the risk. In extreme cases the risk may be unavoidable and the project may be stopped if the impact is deemed too severe to continue.

A full contingency plan is not always the first step. Adding methods to detect the risk is a second option. This serves to reduce the RPN and may make the risk less critical for early response planning. At times, adding detection capability is cheaper than completing a contingency plan early on. In effect, the detection of the risk is made easier and may serve to postpone contingency planning until a later date. There is little one can do to mitigate all project risks.; however, it is typically more expensive for a risk to occur than to detect an oncoming risk and evoke a contingency plan.

Benefits of the RFMEA. There have been tangible and intangible benefits realized from the RFMEA method. In terms of tangible benefits, time spent doing up-front risk contingency planning is reduced. West (2002) describes an approach for using a matrix to capture the event, the probability, the impact, and the risk score where he notes, "the team will be considering every risk identified at this point so the list may be long." With the RFMEA the project team does not address every risk in the early stages, thanks to the detection values being included in the RPN. This provides an additional measure to prepare the timing of the risk response.

The idea of postponing the risk response development is not new. Nagarajan (2002) asserts that the project risk response can be postponed to a later date because, "as some risk parameters become clearer the project manager is better positioned to handle the risk at a later time." The RFMEA gives the team a better method for determining which risk planning can be postponed. By having more time to focus on the most critical risks, the risk response plans are improved.

The detection value provides another benefit over just using the risk score by aiding the discovery of new detection methods for risk symptoms. By adding the thought process around detection, team members produce innovative ideas for identifying symptoms of the risk, and in some cases, for adding new and novel detection methods.

There are also the intangible benefits derived from the lower frustration of the team. Most technical project team members have a bias for action that does not usually include risk planning. The value of planning cannot be disputed, but there are those who would like to eliminate it as much as possible; however, there is some validity to the complaints against the requirement to create a contingency plan for all identified risks. If the team can detect a known risk with enough time to plan the contingency at a later date, then this reduces the early planning time and thus team frustration. This is especially true in a complicated and changing project environment, where you can hardly plan to a detailed scope, let alone identify and then plan for all risks you may encounter. Given that most people like to accentuate the positive, dwelling on negative risks is usually unpopular. Royer (2000) identifies the sociological nature of labeling someone who thinks about risks as a "negative thinker." Thus, spending time on risks that everyone agrees are the most important, rather than all risks at once, lowers the frustration of the team.

Enhanced organizational learning is another benefit from the RFMEA. Walewski, Gibson, and Vines (2002) point out that documenting the risk elements and determinations is critical for lessons to be learned. By capturing the major risks of the technology projects in a comprehensive fashion, future project teams can use and build on this past experience.

So is the RFMEA just another form? Yes and no. It is a form that has serious implications for the success of the project. As Love (2002) points out, a form for risks helps the project manager show visible verification of people's concerns and ideas; issues are logged and documented; it promotes teamwork, as everyone is involved in the process; it is used as a communications tool; progress is monitored on the form; it becomes a way to be proactive and not reactive; and it is a central location to document resolutions. The RFMEA form is there to capture the results of a very complicated and critical management process. The value comes from the team and their expert knowledge of using the method to ultimately improve the results of the project.

Case Study Example of the RFMEA Process. The RFMEA has been used during projects for the development of integrated circuits for product, process, and package development initiatives. Depending on the complexity of the product under development, the projects range on the order of 40 days to 500 days. The planning phase, including risk management planning, is very aggressive, with the RFMEA being just one of the planning processes in the phase-gate methodology. This case illustrates the use of the RFMEA for a development effort of about one year.

Prior to implementing the RFMEA, the risk management process was based on using a brainstormed list of risks within each project phase. Each risk was assessed for its impact and a response plan was generated to avoid the risk or take advantage of an identified opportunity. The process was not effective for risk response planning as there was no scoring method for risk prioritization. This made it very difficult to focus on high-level risks. Based on using the sole impact attribute, each functional group lobbied that the risks in their area were either the most important or not an issue. The process was time consuming and frustrating for team members.

The RFMEA technique was introduced as a way to systematically capture risk events, score them, and then respond to those that posed the most threat to the project. Exhibit 7 is a small part of the RFMEA for two risk events within this case. While shown in two sections, the columns actually extend across a single sheet. The actual RFMEA for this project included a total of 45 identified risks.

Once the risks were identified, the team added known symptoms for the risk and assigned the likelihood, impact, and detection values. Pareto charts of the risk score and the RPN values were generated by risk ID. Exhibits 8 and 9 are the Pareto's using a partial list of risks from the matrix for illustration purposes. Since each of the risks within the actual project are not being examined here, the main thing to notice on these two exhibits is the distribution of the values and that the risk IDs that have high risk scores do not necessarily have high RPN scores.

The first revelation was that the initial critical risks one would address based on the two measures were different. The team began to realize that by addressing risks simply based on the risk score alone, they might be addressing risks that could be easily detected and dealt with much later or in a different manner; however, they might not have been addressing risks that could be complete surprises, given the lower priority based on a risk score alone. Using its assessment of the Pareto charts, the team then chose the critical values for both the risk score and the RPN. For

Exhibit 7. Sample RFMEA Form with Example

Risk ID (or WBS #)	Risk Event (If., then ...)	Symptom	Likelihood	Impact	Risk Score	Detection	RPN
G	If hardware is not valid then need to redesign and reorder with delay of 12 weeks and cost of over \$100k.	During final test.	4	9	36	7	252
K	If prototype material is built wrong then delay to validation by min of 50 days and cost of rebuild of \$30k.	During fabrication by scrap reports.	5	7	35	9	315

Risk Response Plan (or work package #)	Revised Likelihood	Revised Impact	Revised Risk Score	Revised Detection	Revised RPN
G	2	3	6	3	18
K	5	4	20	4	80

Exhibit 8. Pareto of Risk Score Values

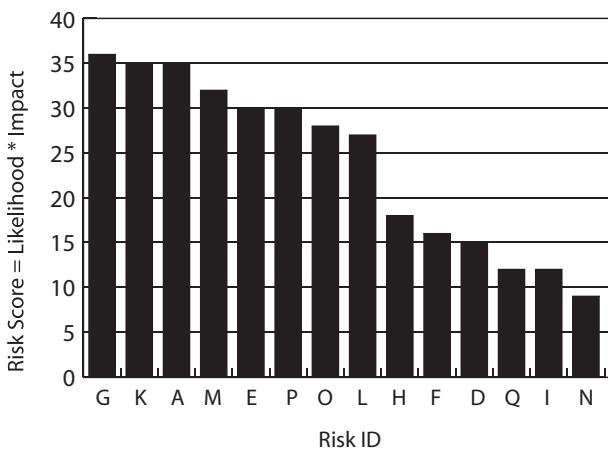


Exhibit 9. Pareto of RPN Values

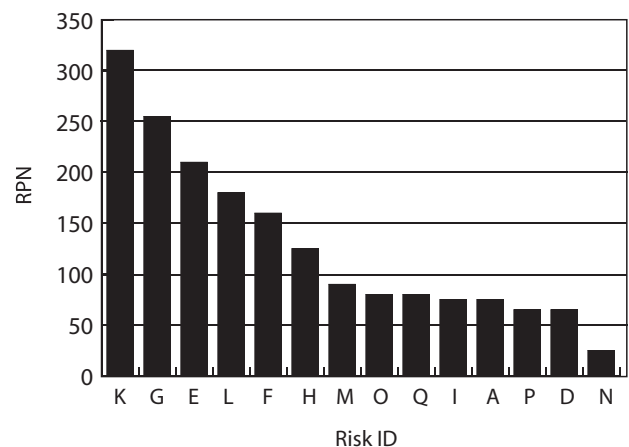
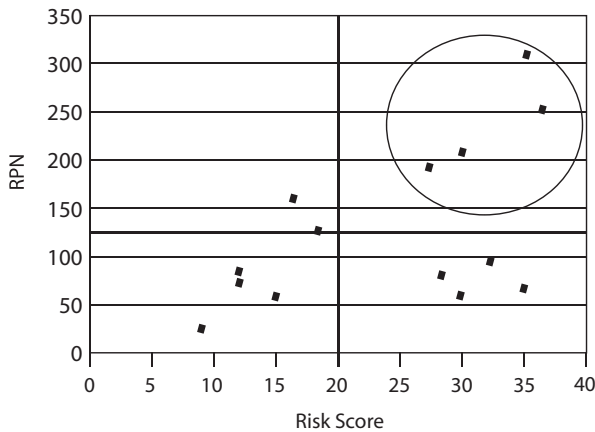


Exhibit 10. RPN vs. Risk Score

the data in this case, the risk score critical value was chosen as 20 and the RPN critical value was 125.

Following assignment of the critical values, the scatter plot of the RPNs versus risk scores was reviewed after adding lines to show the critical values. The scatter plot in Exhibit 10 shows that there were four critical risks that required early risk response planning (shown in the upper right quadrant within the circle).

The team was then charged with addressing the critical risks, then re-evaluating the risk score and RPN based on the development of a contingency plan. If the team had immediately addressed all the risks that were above the critical risk score of 20 (in this simplified example) there would be eight risks requiring contingency plans. This is double the risk identified by the RFMEA method.

For the evaluation of the full project RFMEA, of the total 45 risks identified, there were 20 above the risk score critical value. Creating adequate risk plans for 20 risks is a challenge; planning for all 45 risks is nearly impossible, given the typical project environment.

In this illustration, both risks 'G' and 'K' of Exhibit 7 required that a response plan be generated and revised RPN values calculated. As an example, the contingency plan for risk 'G' was to build generic test hardware that could be more easily modified than custom hardware. This reduced the impact to less than a week of re-work. In terms of the value of the detection number for this risk, originally it was at seven, but the team came up with a novel way of using generic boards to be able to prove out the hardware earlier and the detection value was reduced to three. The added cost of first using generic hardware was less than accepting the impact of the original risk, which could have cost even more had time to market been considered. The other attribute values might also be revised, contributing to a further reduction in the RPN. These types of results were similar for many of the other risks within the RFMEA.

Case Lessons and Extensions. Assessing the impact of mitigating risks is not easy to do since there is no easy way of exactly telling the impact of the risk had the team not addressed it with a contingency plan. In this specific case, out of the total 45 risks identified, the team addressed 9 critical risks during the early planning phase. It was apparent from the sighs of relief

that the team was grateful for the reduced number of risks requiring contingency plans over the previous all-risk method. The time spent in the risk planning meetings was reduced by over 30%. Even more significant was the result that the risk contingency plans were significantly improved based on past experience.

One of the major benefits of adding the detection value came about in determining new detection methods that were coupled to risk contingency plans. Once the team members were able to see that increased detection was required to mitigate the risk, they were willing to devise methods and monitor the risk events. As in the example, for risk 'K' in Exhibit 7, the prototype material was scrapped twice, but given new detection methods and using contingency planning, the time lost was minimized. The team had started back-up material and the manufacturing representative moved the backup material through the line a few steps back from the initial lot. As critical steps were completed, more material was released. This may not seem like a novel idea, but in the past, monitoring and managing such activity was not seen as valuable. Once the need for early detection was apparent, however, the buy-in to perform the added monitoring and added cost was easy to obtain.

The team was energized throughout the RFMEA process and the value of the risk management plans were greatly improved. The lead design engineer even commented following the risk management meeting that it was "fun" and "we should have more meetings like that." The team as a whole had very positive comments about the process.

The RFMEA matrix was used and updated throughout the project, approved at phase reviews, and during the project post mortem. At the close of the project, the RFMEA was archived with the project documents. It was also added to the risk database to identify possible risks during future project planning and to review the results and learnings of past contingency plans.

The RFMEA has since been used on a number of subsequent projects that have been short in duration and projects lasting well over a year. It has been applied to facility closings, facility expansions, business process development, process transfers, as well as multiple new product development projects. The development teams have become accustomed to the new method and relate to quantifying risks better than the previous risk assessments. The risk management process training is part of a comprehensive project manager development program in place in the organization (Carbone and Gholston, 2004).

Conclusions

The RFMEA is an advanced risk tool that is simple and intuitive. It is based on the well-known FMEA technique, modified for project risk management. With some minor modifications to a standard FMEA format, the RFMEA method provides increased value to the risk management process. The RFMEA expands the concept of a simple risk score, based solely on likelihood and impact, by adding the detection attribute to a risk event. By adding the detection value, improved risk prioritization is possible. The RFMEA is based on evaluating both the risk score and the RPN value to find the critical risks that require immediate risk response planning. If properly utilized, the RFMEA can greatly reduce risks on a project, create team ownership in risk planning, and act as a resource for future projects in terms of knowledge management and lessons learned.

The risk management process in an organization must become part of the culture. Value must be placed on identifying the shortcomings of an idea or plan. This simple RFMEA method of classifying and prioritizing risks helps the organization mature its risk management process. People are more engaged in the process of identifying, analyzing, and mitigating risks.

Organizations should apply risk management processes and tools as they apply to their specific projects. The RFMEA method described here is provided as an example, but users must be aware of using such a tool in their applications, because the identification of a risk and its impact can have dire effects on the end product. The risk management knowledge area is crucial to the project management process, and organizations must make a concerted effort to ensure the tools they are using are providing them with the required level of insight and value.

The engineering manager can use this method and format as a simple and concise way to capture project and program risks. The ability to reuse the data and anything learned from the RFMEA enhances organizational learning. The project manager and engineering manager can use this information to improve project success by focusing on key risks by using the simple risk management RFMEA process.

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