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Design For Reliability
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CHAPTER 13

Evaluating Product Risks

13.1 Introduction

This chapter addresses the issues of technical risk management and can be used as guidance for all technical areas. Risk management applies to all new product development. Common technical risk areas include performance, producibility, production, scheduling, resources, and so forth. Risk varies depending on whether customer requirements match technology performance capability predictions, if field experience is available on analogous assemblies, if the technology is revolutionary or evolutionary, if the application is new, if the intended use environment is harsh and different from previous field experience, and so forth. Risks are often assessed in categories. A technology management risk matrix is often used in industry (see Figure 13.1).

As Figure 13.1 shows, revolutionary technologies carry a higher risk. For example, when the first airplanes were developed in the early 1900s, flying these early machines often resulted in injury or death. Now that flying is a mature technology, the risks of flying are very low. Evolutionary changes to the aircraft having similar applications today carry low risks since the technology is mature.

Figure 13.1
The management technology matrix

	Evolutionary	Revolutionary
Same Application	Category I (Low Risk)	Category III (High Risk)
New Application	Category II (Moderate Risk)	Category IV (Very High Risk)

Placement within the matrix determines the degree and aggressiveness of the management program.

13.2 Goals of a Risk Program

The goal of a risk management program is to make correct decisions at key points in the program. Technology risk management is essential to the success of any development program. Risk issues and their consequences concern everyone involved with a program's success. The larger and the more undeveloped a technical program, the more important it is to manage risks. In the case of a reasonably large and/or complex program, many technical details can impact the system. This chapter is designed to help mitigate risks. To help in

Table 13.1
Applicable sections of this reliability manual

Applicable Chapters of This Reliability Manual	Category I Low Risk	Category II Moderate Risk	Category III High Risk	Category IV Very High Risk
1. Reliability Science/ Design for Reliability			√	√
2. Understanding Customer Requirements	√	√	√	√
3. Design Assessment Reliability Testing			√	√
4. Design Maturity Testing	√	√	√	√
5. Screening and Monitoring			√	√
6. Process Reliability			√	√
11. Reliability Predictive Modeling		√	√	√
12. Failure Modes and Effects Analysis		√	√	√

the use of this chapter, rank your technology according to the categories in Figure 13.1. Refer to the applicable chapters of this manual for associated reliability items in Table 13.1 that match your technology rankings.

Table 13.1 indicates applicable chapters to aid in mitigating your risk. Even low-risk issues can become costly. Therefore, if you have a low-risk product, you may still wish to refer to the details below. The benefits of full risk management are shown in Figure 13.2.

Figure 13.2
Benefits of risk management

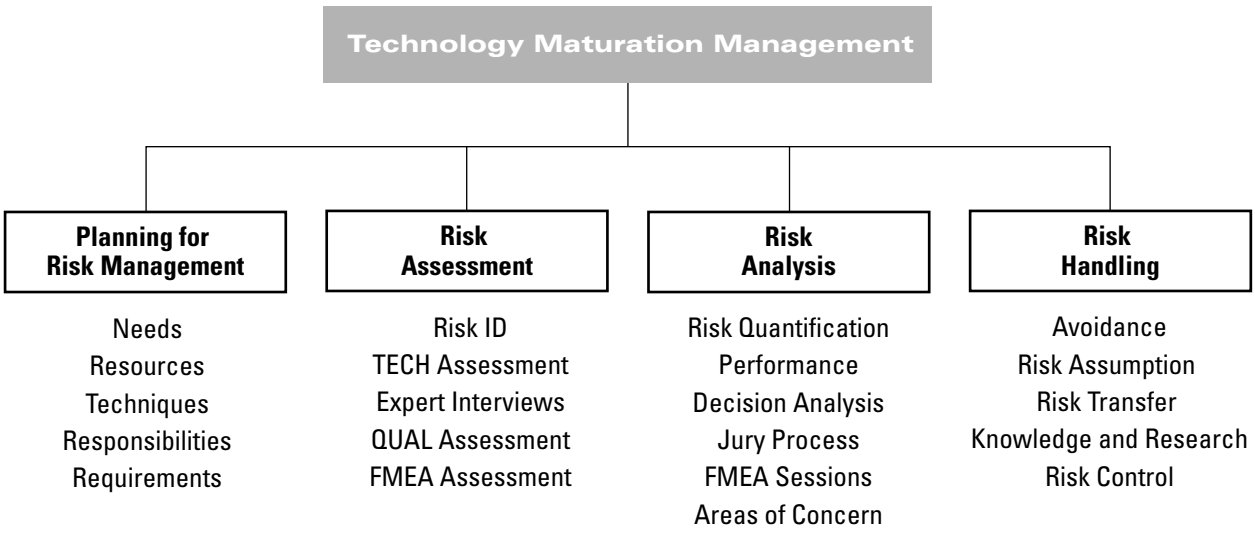
- ✓ Expose high-risk areas and critical parameters early in the program.
- ✓ Help direct resources by providing insight into potential consequences to allow for informed program decision-making.
- ✓ Identify and track actions to minimize risk and ensure resolution of key issues.
- ✓ Provide information to help Program Managers select an appropriate subsystem/component.
- ✓ Identify areas of risk that are potentially most harmful.
- ✓ Minimize liability risk.

Since component and subsystem risks are magnified at the system level, it is important that program management becomes aware of issues early in the program. All potential risk areas require identification and risk handling. Management can then direct resources to prioritized risk areas and conserve valuable time and expenses. These benefits are best realized when technical risk issues can be properly identified, assessed, quantified, and finally handled both at the system and the subsystem level.

13.3 Managing Risks for Your Program

The risk management process can be set up so it is reasonably formal, systematic, and applied in a disciplined manner. Figure 13.3 shows the classical systematic approach to risk management. A systematic approach will ensure that each element of risk planning, risk assessment, risk analysis, and risk handling is managed. Each element is described in this chapter. The easiest way to qualitatively manage a product's risk is to review the elements in Figure 13.3 and appropriately identify, in your Work Breakdown Structure (WBS), key events that are *potential risk factors*. Every program is different, and unfortunately, no magic approach can guarantee that risks are minimized. *Remember, the goal of a risk management program is to make correct decisions at key points in the program.* Decision management is risk management, and decisions should be

Figure 13.3
Technology maturation management

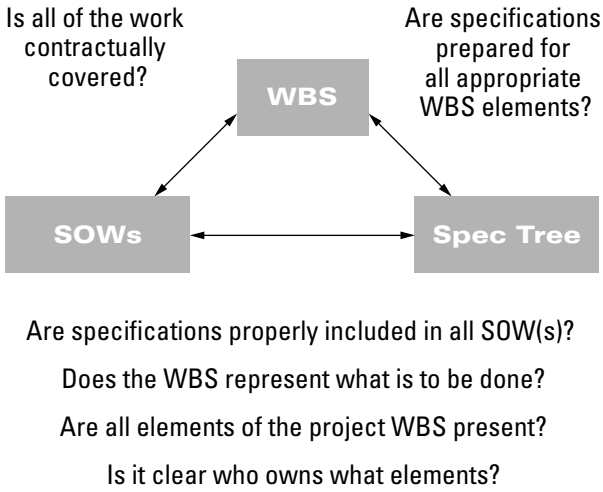


based on information. The probability of making a correct decision is higher when correct information is obtained and made available in a timely manner. Following simple risk-management guidelines can save a program dollars. Follow the guidelines provided in each element to ensure that you are able to make the correct decision in a timely manner.

FMEA – A Reliability Method for Evaluating Product Risk

Although risk, as described here, applies to all facets of a project, a good example of how risk is managed in reliability is in FMEA. FMEAs can be viewed as one type of risk management (see Chapter 12). In an FMEA, all phases of risk management shown in Figure 13.3 are performed, including risk management planning, assessment, analysis, and handling. The progression provided in Figure 13.5 is followed in a team-oriented FMEA, where a brainstorming session is held to perform the evaluation, identify failure-mode issues, and quantify risks in terms of Severity, Occurrence, Detectability, and an RPN number. Finally, design controls and recommended actions are detailed to help mitigate and handle risks.

Figure 13.4
Work breakdown structure



13.4 Four Steps to Risk Management

Figure 13.3 illustrates the elements of the risk-management process. Working through these elements in steps can perform risk management. Figure 13.5 shows the process. Starting with risk planning (Step 1), a brainstorming session should be held to overview the WBS or the project's overview. The purpose of the session is to identify concerns with such areas as meeting a project's needs, its resources, schedule, performance, reliability, and so forth.

All the areas of concern should be formally categorized into risk assessment (Step 2). This helps to organize and plan appropriately while identifying departmental responsibilities. At this point, each department can further detail the risks involved in its area and offer feedback into the program plan. The decision process can start. Decisions should be based on information. This is the point of risk management when decisions are made on program needs, gaps, and further information and testing that must be performed to more fully understand risks and make intelligent decisions.

Risk should be quantified when possible. This is part of the risk analysis noted in Step 3. Key to the program's success is the ability of the technology to meet or exceed customer performance expectations. Performance targets are often well defined in customer specifications. If the technology is revolutionary and part of a new application, expert opinion should be used when data are not available.

Estimates should be made as early as possible in the program as to whether the unit can meet performance, reliability, and other requirements. If the unit has only a 90% chance of meeting an important requirement and this jeopardizes the whole program, the Program Manager should be aware of the risks. For example, if the program is worth $10 million, the financial risk is 90% of this, or $9 million.

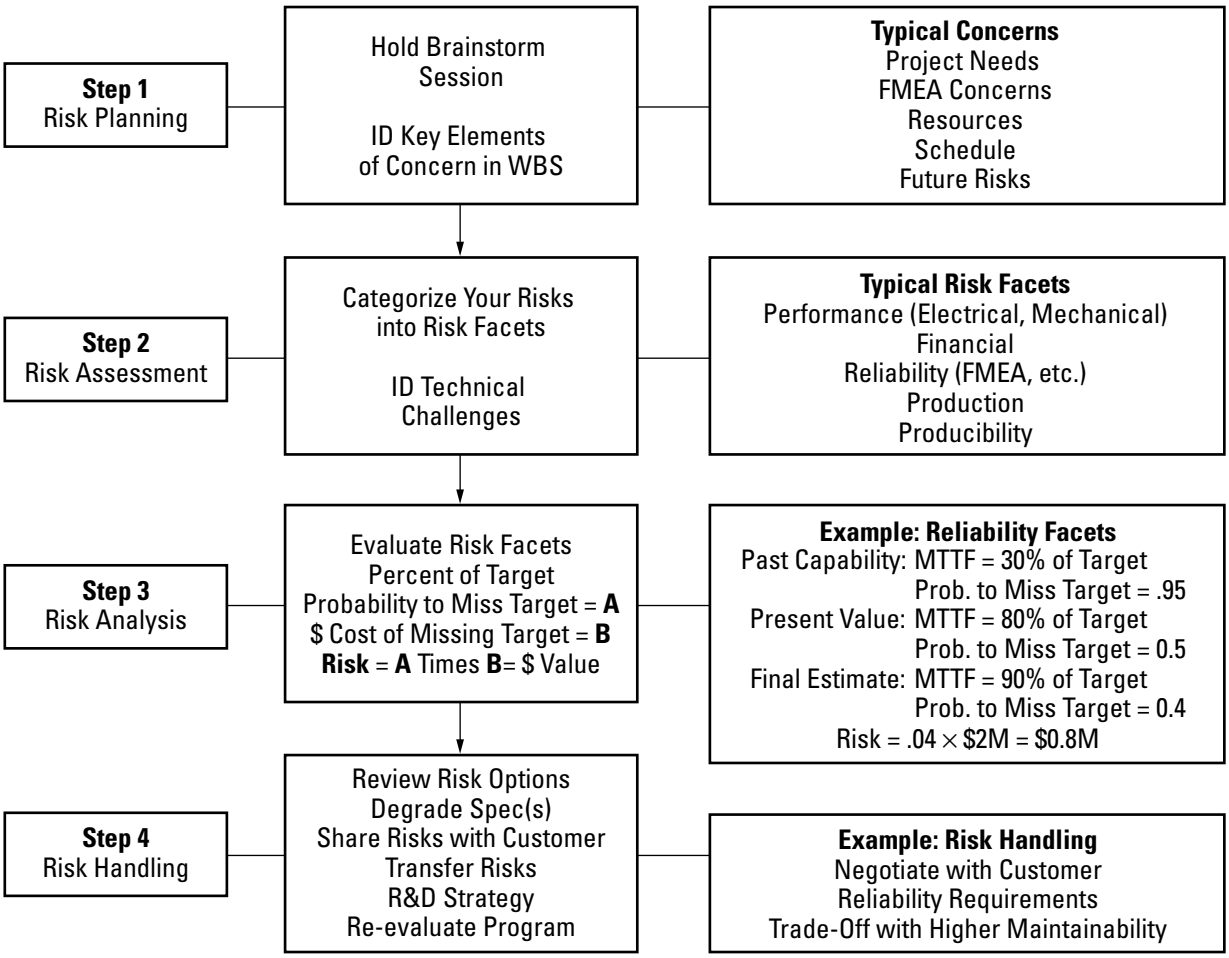


Figure 13.5
Four steps in risk management

At this point, risk handling is required (Step 4). Management needs to assess the options, such as sharing the risk with the program's customer by negotiating specifications, contractual agreements, trading off for tighter specification in other areas, and so forth. A watchlist is also required in risk handling. This list serves to identify scheduling problems, assess previously identified risks, update performance capabilities, and so forth. This chapter further details these steps in the risk-management process.

13.5 Guidelines for Risk Planning (Step 1)

This first step in a technology maturation program plan should include a risk-management plan. To plan for risk management, the five major areas identified in Figure 13.3 (under its block) need to be addressed. These are described in compact notation in Table 13.2.

Areas of Concern	Description	Guidelines
Needs	Coordinating program needs	Needs include personnel, appropriate teams, and suppliers. Eliminate and minimize the effects of undesirable occurrences.
Resources	Identifying resource problems	Establish time, money, and/or engineering reserves to cover risks that cannot be avoided.
Techniques	Systematic approach	Providing a formal and systematic risk-management approach is integral to the program's success and key to decision-making.
Responsibilities	Assigning and ensuring responsibilities	Document all risk for accountability so that appropriate engineering staff closely watches identified risk areas.
Requirements	Identifying future risk needs	Ensure important items undergo complete risk assessment, analysis, and handling as part of risk management.

Table 13.2
Guidelines for risk management

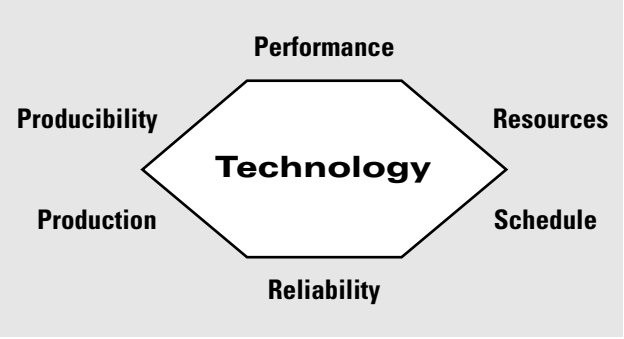
Using the program's WBS/customer specification, work through the table to identify the areas of concern. For each area, if necessary, schedule a separate brainstorming session with area experts to both help plan and start to perform risk assessment.

13.6 Guidelines for Risk Assessment (Step 2)

The second step in technology risk management is to assess risk (see Table 13.3). Risk needs should be identified and categorized into appropriate risk facets first so that responsibilities can be assigned to further clarify the risk category.

Common risk facets such as performance, reliability, and resources are shown in Figure 13.6. Each risk has associated challenges and tasks related to reducing and eliminating the risk. This assessment is initially qualitative and should be evaluated and identified as soon as possible.

Figure 13.6
Technology risk facets



After a gross survey of the challenges, the assessment needs to be refined. This should include expert opinions from experienced individuals. The decision process goes from being qualitative to quantitative, to make assessments more accurate regarding problems. At this point, risk analysis should be performed.

Areas of Concern	Description	Guidelines
Risk Identification/ Facets	ID technology risk and categorize into appropriate risk facets (Figure 13.6)	Identify risk and understand its relationship to the technology. Establish an organized approach to categorizing risk into appropriate facets.
Technology Assessment	Identify technical challenges that may fail	Provide an assessment of risk associated with evolving a new design, which is expected to provide greater performance and reliability.
Expert Interview	Obtain expert opinion	Gather qualitative information regarding their technology and baseline and/or analogous systems.
Qualitative Assessment	A process to qualitatively evaluate your risk	A consistent method for qualitative evaluation of risk and the likelihood of risk occurrence. Usually this is done with expert opinion after some brainstorming. Risk is then documented. If quantitative assessment is to be added, this should be planned (see the next section).

Table 13.3 *Guidelines for risk assessment*

13.7 Guidelines for Risk Analysis (Step 3)

There are a number of mathematical methods in performing risk and decision analysis. Any reasonable analysis is better than no analysis. This is true for several reasons, mainly because an analysis brings more information to the decision process. Usually information leads to some sort of relative comparison or analysis. Absolute assessment can be avoided, and decisions can be based on historical baseline information.

One process of risk analysis is shown in Table 13.4. All of the steps in the table need to be performed.

The first goal in the analysis is to establish a parameter assessment (see Figure 13.7). The key parameters of concern are categorized in Table 13.4 with target and specification values. The present values are listed next. Expert opinion is sought, after which a mature estimate is made. In establishing an expert opinion, one must be realistic and understand whether the targets need to be reached with evolutionary or revolutionary technical advancement.

Figure 13.7 *Performance parameter assessment*

	Subsystem: Transmitter			
Parameter	**Target**	**Present Value**	**Mature Estimate**	**Prob. to Miss Target**
Unit Cost	$225	$335	$240	10%
Power Rating	2 Watts	1.8 Watts	2 Watts	0%
Reliability	500,000 Hrs	200,000 Hrs	250,000 Hrs	60%
Schedule	1 Year	1.4 Years	11 Years	5%

Areas of Concern	Description	Guidelines
Risk Quantification	ID technology risks and categorize risks	This can be as simple as a ranking system or as complex as a full risk analysis. Mathematically, risk is the probability of Occurrence times the Severity of consequence (usually dollar value). Often requires analyzing expert opinion and quantifying data into probability distributions.
Performance	ID technical challenges associated with obtaining performance	Provide an assessment of risk associated with evolving a new design, which is expected to provide a greater level of performance and reliability. Establish target performance values, present values, and mature estimates.
Decision Analysis	Obtain expert opinion. Perform path analysis	This is the process of interviewing subject-area experts to gather qualitative information regarding their technology and baseline and/or analogous systems. Then a decision path should be established.
Jury Process	A process for quantifying each risk	This is a consistent method for qualitative evaluation of risk and the likelihood of risk occurrence. Expert-opinion jury process can rank probability of Occurrence and Severity cost to help quantify risk dollars.

Table 13.4
Guidelines for risk analysis

Figures 13.8 and 13.9 provide guidelines for reviewing the area of risk that is actually involved. In the case of revolutionary technological advancement, it is most likely necessary to form a jury and fully judge the realities involved. Along with this mature estimate, the experts need to establish a probability of success or failure. Once this probability is established, a risk value can be obtained. This value is defined mathematically as the probability of failure times severity costs (see Figure 13.8).

In many cases, the cost of failure is the program value. In some cases, it can be higher, such as losing your customer or future programs. Once you are aware of your risk cost, you will be in an excellent position to start the risk-handling process and/or make decisions.

The most common analytic method for analyzing a decision is through decision path analysis. This is illustrated in Figure 13.10. The process is similar to evaluating risk. Each path has associated with it a failure probability and a cost. The total risk can be combined for each major path leg, and decisions can be based on the lowest risk path. Other factors may be difficult to work out, such as the risk of being too conservative. This can cause loss of future business as well. When evaluating a high-risk program, the best path is to try to advance your technology without losing your customer and a program's potential future. This can mean that there is often a need for risk handling at the highest management levels.

Figure 13.8
Quantifying risk into dollars

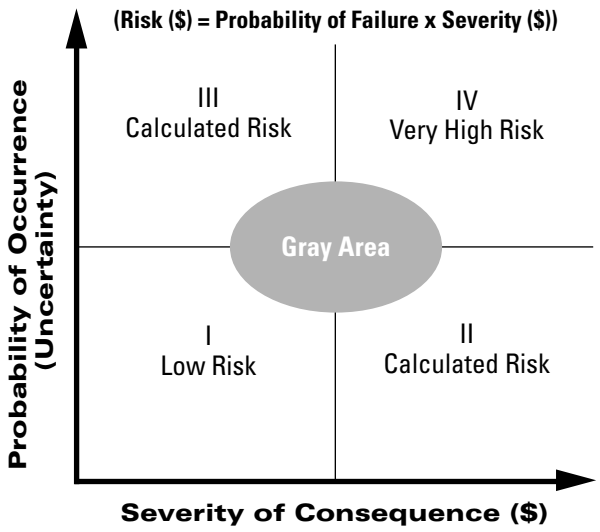
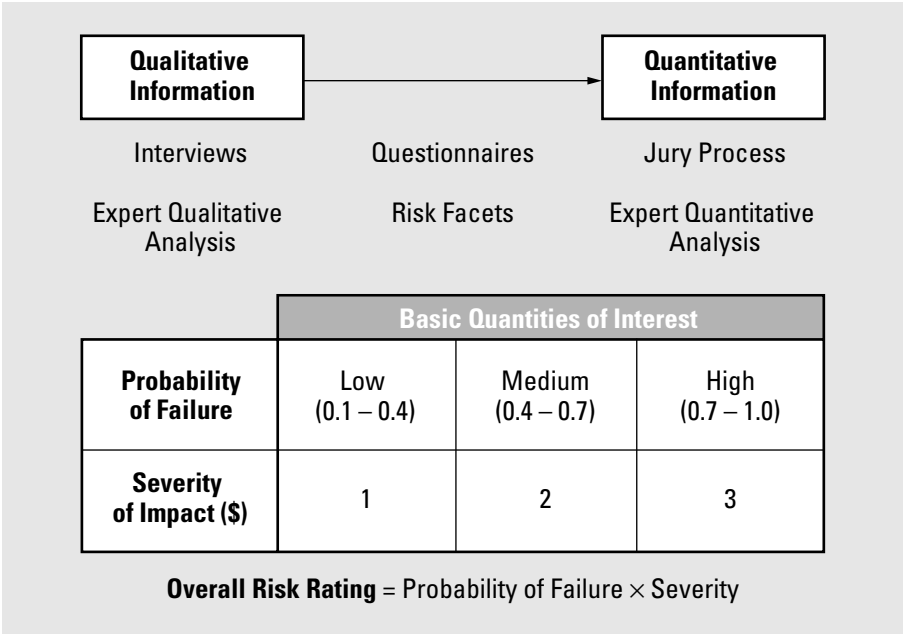


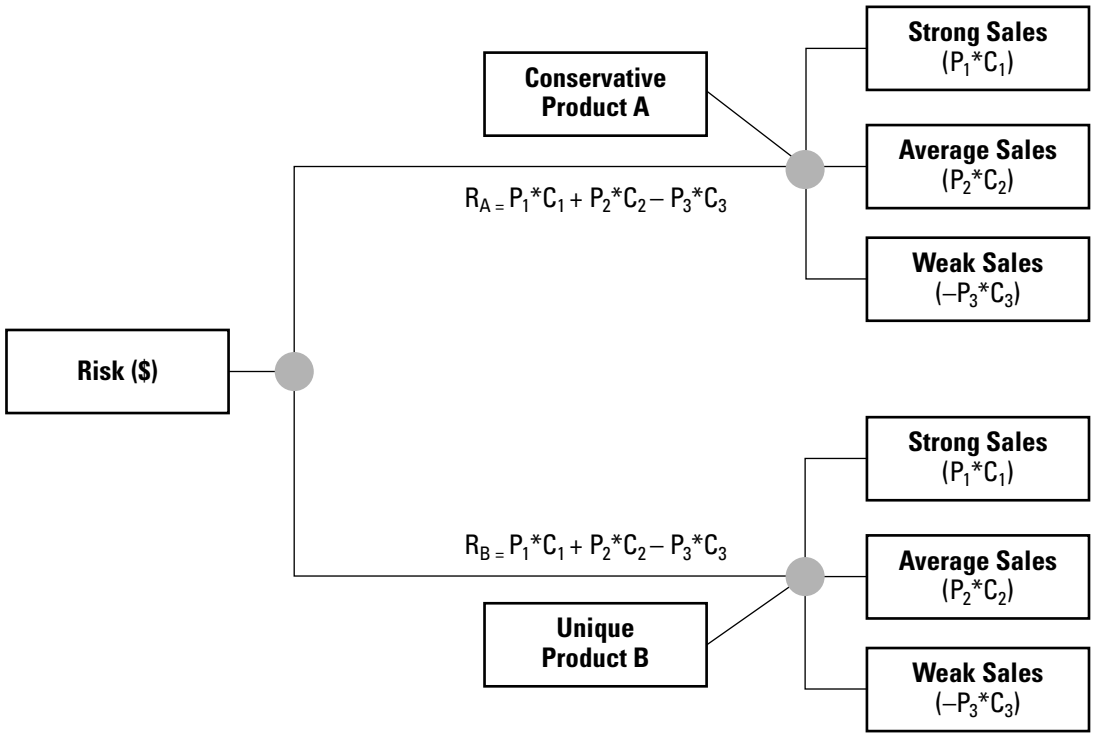
Figure 13.9
Quantifying risk judgment



	Basic Quantities of Interest		
Probability of Failure	Low (0.1 – 0.4)	Medium (0.4 – 0.7)	High (0.7 – 1.0)
Severity of Impact ($)	1	2	3

Overall Risk Rating = Probability of Failure × Severity

Figure 13.10
Decision path analysis



13.8 Guidelines for Risk Handling (Step 4)

With the information provided in the analysis, intelligent risk handling can be pursued. There are a number of ways to handle risk issues; each choice depends on the situation. Risk handling includes the major areas shown in compact notation of Table 13.5. These include risk avoidance, risk assumption, risk transfer, and risk control. In all cases, you should know your options. A watchlist should be developed that lists the program's risks, facets (areas of impact), and the handling actions.

This list may be expanded further for each item and the department that is handling the actions. At this point in your risk management, you should be in a reasonable position to manage potential problems without jeopardizing the impact they have on your customer.

Figure 13.11
Risk handling

- **Watchlist is an output of risk analysis areas of concern and risk priorities**
  - ✓ Make recommendations concerning risk avoidance, risk assumption, risk transfer, and risk control
- **Watchlist example:**

Event/Item	Area of Impact (Risk Facet)	Handling Action
Part A – low MTBF	Reliability	Use alternate part or implement corrective action; negotiate requirement
Loss of supplier	Production Cost	Seek second source
Long lead items delayed	Schedule	ID early in program; buy a place in line

Table 13.5
Guidelines for risk handling

Method	Description	Guidelines
Risk Avoidance	Avoiding unnecessary risks	Selecting the lowest risk choice using risk analysis.
Risk Assumption	Understanding and accepting known risks	Accepting risk at a specified safety level. For example, assume that the specification limit will be exceeded and negotiate with your customer.
Risk Transfer	Sharing risks	Sharing risk with contractors/customers through warranties, etc.
Knowledge & Research	Understanding technical risk issues	Understanding technical risk and reducing risk through skills and ingenuity.
Risk Control	Controlling risk through management	Continual monitoring and documenting progress on key milestones and corrective actions from the watchlists, enabling risk decisions to be optimally made in a timely manner.