Practice 8

8 Risk Management

8 RISK MANAGEMENT

8.1 INTRODUCTION

8.1.1 Purpose

Risk is the degree of exposure to an event that might happen to the detriment or benefit of a program, project, or activity. It is described by a combination of the probability that the risk event will occur and the consequence of the extent of loss or gain from the occurrence.

Risk management is a structured, formal, and disciplined approach, focused on the necessary steps and planning actions to determine and control risks to an acceptable level.

Project risk management is the continuing application of the risk management process throughout the project life cycle. Its purpose is to enhance the probability of project success by increasing the likelihood of improved project performance, thereby decreasing the likelihood of unanticipated cost overruns, schedule delays, and compromises in quality and safety.

Risk is an inherent part of all activities, whether the activity is simple and small, or large and complex. The relative size and/or complexity of an activity may or may not be an indicator of the potential degree of risk associated with that activity.

A key output from the risk analysis effort is the establishment of appropriate contingency/reserves within the project cost estimates and the project schedules at the confidence levels decided upon. A probabilistic approach is essential where a simple algebraic addition of best case underestimates contingency and worst case overestimates contingency.

8.1.2 Scope

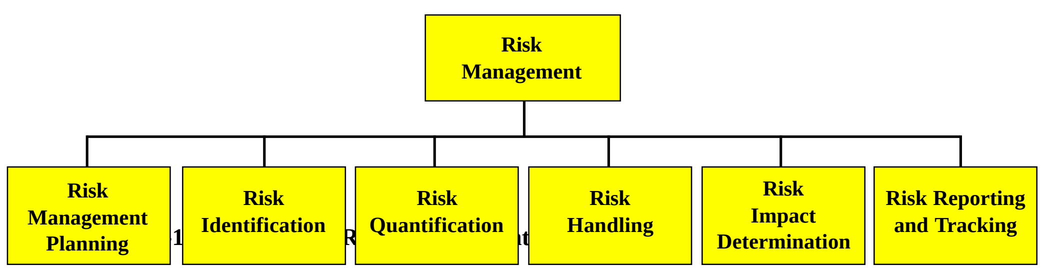
Risk management is the continuing process of planning, identifying, quantifying, responding to, and controlling risks to maximize the potential for the success of an activity. The degree of application of risk management is to be commensurate with a tailored approach, and is a management tool to maximize the results of positive events and minimize the consequences of adverse events.

Risk management is not defined as an Environmental, Safety, or OSHA risk assessment, and consequently, this section does not address the conduct of these specific "safety-type" risk assessments. These independent assessments may, however, provide an input to the risk management process based upon the potential (or likelihood) of events materializing as risks that would increase project cost, cause schedule delays, reduce safety margins, or reduce the quality of the final product.

Risk management can be applied to cost, schedule, technical performance (i.e., risk associated with evolving a new design or approach), programmatic performance (i.e., risk associated with obtaining and using resources that can affect the project), and any other factors important to the management decision process.

Activity success means that the activity is technically feasible, programmatically feasible, and can be completed within an established budget and an established schedule. Conversely, activity failure can result from the failure to meet any of these factors.

Achieving risk reduction is an integral part of setting priorities, sequencing project work, and responding to the most serious risks first. Risk is a dimension of work prioritization and an important (but not the only) consideration in establishing prioritized sequencing of activities and other decision-making processes. The elements of risk management are shown in Figure 8-1.



8.1.3 Different Types of Risk

Numerous types of risk exist. Some examples of risk in different categories are shown in Figure 8-2.

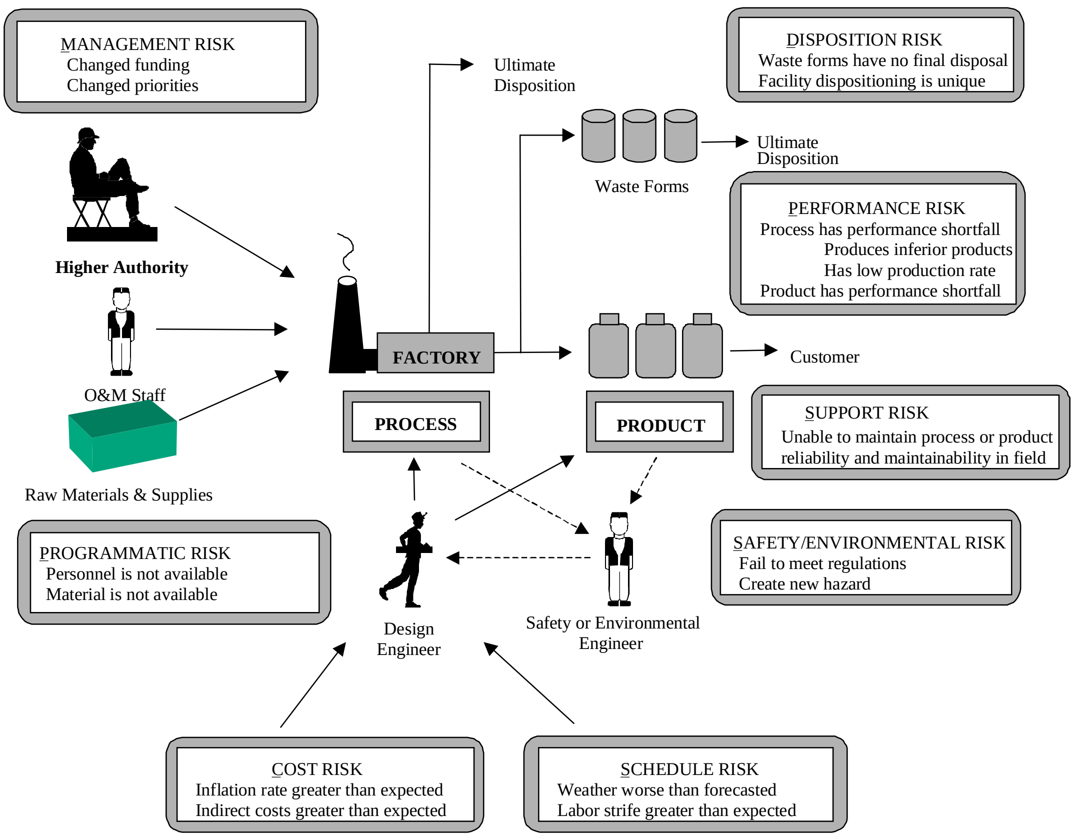


Figure 8-2. Types of Risk

Risks may be grouped or sorted into different categories. The Department of Defense identifies five facets of risk:

- Technical
- Programmatic
- Supportability

- Cost
- Schedule.

The Department of Energy discusses eight facets of risk, but recognizes that safety, environment, disposition, support, and procurement are all technical risks. [3]

- Safety
- Environment
- Disposition
- Support
- Procurement
- Programmatic
- Cost
- Schedule.

The way one chooses to categorize risks is not important as long as the information is used properly. Technical risk is defined as the possible impacts associated with developing a new design or approach either to provide a greater level of performance or to accommodate some new requirements or constraints. Programmatic risk is defined as the possible disruptions caused by decisions, events, or actions that affect project direction, but are outside the manager's control. The combined set of technical and programmatic risks constitutes project risk.

Cost and schedule are unique and treated somewhat differently. They are both types of risk and indicators of project status. This is further complicated because other types of risks will eventually occur in cost and schedule. For example, increasing project scope sometimes resolves performance and design technical problems, thereby increasing cost and/or schedule.

In general, when the risks associated with a project are being evaluated, all aspects of the project should be considered. While there is never a technical risk that does not have a potential impact on cost and/or schedule, the converse is not true. There are a number of cost- and schedule-driven administrative or management factors that do not result from technical issues. While these can also have significant impacts on cost and schedule, they do not need to address technology or design issues.

Any given risk may belong to more than one risk category. For example, a particular piece of equipment may pose a technical challenge and have significant programmatic implications (e.g., not available when needed).

Historically, estimating uncertainties have been included in project cost estimates as “traditional contingency”. It primarily represents uncertainties in the project cost and schedule estimates for the defined work scope that result from:

- Errors and omissions
- Inflation
- Adverse weather
- Pricing variances
- Quantity variances
- Complexity
- Facility access.

For complex projects that involve significant technology development or first-of-a-kind scope/design uncertainties, the traditional contingency models may not be adequate. For these projects, a systematic technical programmatic risk analysis methodology may be used for evaluating needed contingency. This contingency includes the possible impacts from technical and programmatic types of risk. In addition, the actions resulting from risk response/risk handling strategies are included in project baseline scope and cost estimate.

8.1.4 RELATIONSHIP TO SYSTEMS ENGINEERING

The risk management process is a part of the overall systems engineering approach to definition of objectives and evaluation of solutions to problems as shown in Figure 8-3.

The approach consists of four steps that are performed in a logical sequence, supported by three additional process control activities that are performed concurrently with each of the sequential process steps. Risk management is one of the

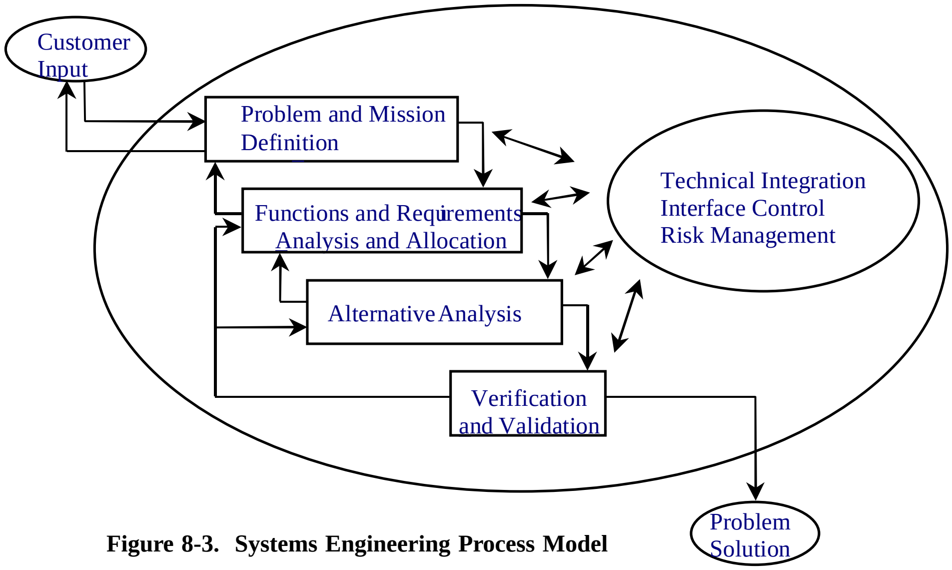


Figure 8-3. Systems Engineering Process Model

process control activities that are performed in each step. The systems engineering approach can be applied to problems and activities at all levels (e.g., project level, system level, component level) and of all types (e.g., physical design, organizational change, problem resolution) where change is needed.

Applications generally involve iterative implementation of the process starting at the top-level mission statement and progressing through increasing levels of detail. Each step of the process is performed before repeating the process for the next level of detail.

For additional information on the systems engineering approach, refer to Practice 13, System/Value Engineering.

8.2 Risk Management Process Steps and Methodology

The following sections provide a detailed description of the six steps in the process and describe at least one approach or methodology. The Risk Management Functional Flow Diagram, which shows the interrelationship among the six major risk management process elements, is shown in Figure 8-4.

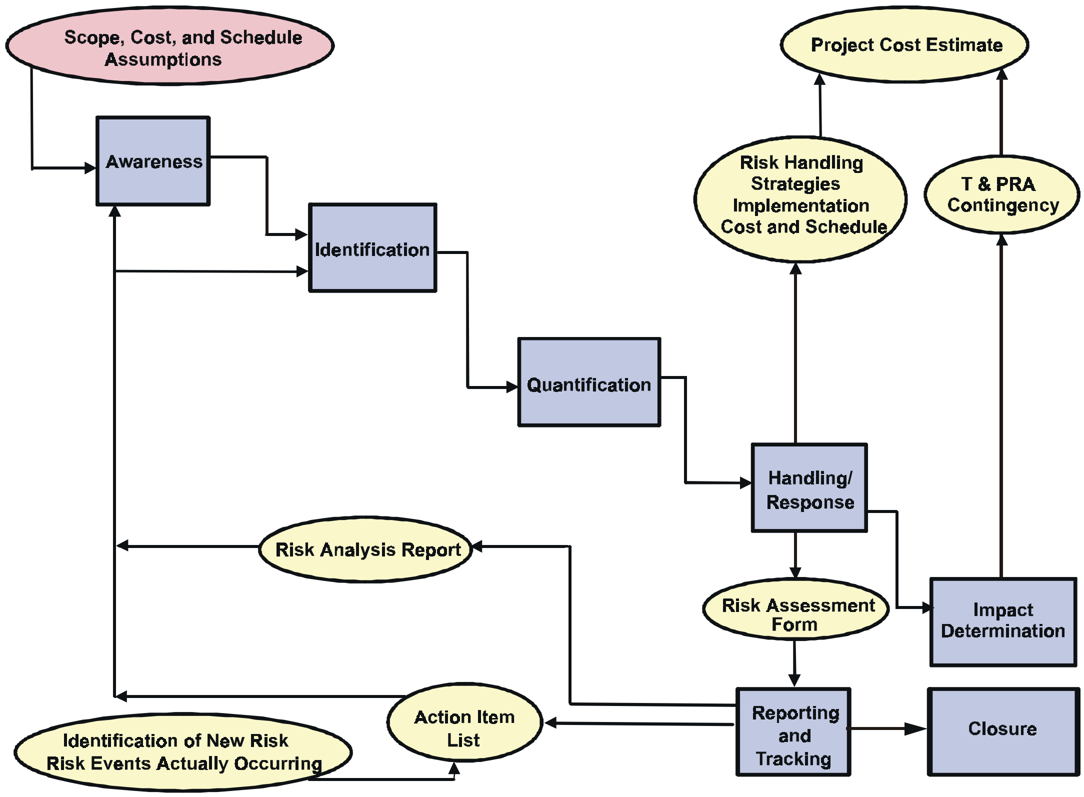


Figure 8-4. Risk Management Functional Flow Diagram

8.2.1 RISK MANAGEMENT PLANNING

Prior to initiation of risk management, an activity is evaluated to determine if there is a potential for risk in the proposed or defined baseline (scope, schedule, and cost). This determination is not always simple to accomplish in that all activities contain risk. In many cases, however, this risk is judged to be low enough that existing limited controls required to manage the scope, schedule, and costs are adequate, and that no special attention is required for any particular potential risk occurrence.

8.2.1.1 Risk Screening

To facilitate the activity evaluation process, the activity manager reviews the activity against a set of criteria designed to lead than through a concise but comprehensive risk screening. An example of a criteria, set in the form of a questionnaire is provided in Table 8-1. In cases where an identified criterion/criterion question does not apply, the *No* response is obvious. For situations where the potential risk is judged to be *Low* (or acceptable), as described above, the basis for that evaluation may not be clear. In such cases, there is merit in documenting the rationale used in making this determination since the information may be valuable in supporting a decision as to whether or not the risk management process should be applied.

In all cases, the activity is first screened for the need to apply project controls as required by project management procedures. This is accomplished by calibrating the activity with respect to such issues as size, organizational interfaces, and political visibility via evaluation of Part B of the checklist. This evaluation, as distinct from the remainder of the risk management process, while indicating a level of project control has no bearing on the remainder of the risk management process.

Once the level of project control is determined, Part A of the checklist is evaluated for the potential for *Yes* technical risks. If all answers are *No* or *Low (acceptable)*, the process is complete and no risk management is required. If any answers are *Yes*, then the risk management process is initiated by moving to the next step (i.e., preparation of a risk management plan).

Table 8-1. Risk Screening Guidelines

Screenings are performed to determine if the project or activity has the potential for risk. Judgement must be exercised in determining whether the screening item results in a potential risk. Categories that pose *No* risk to the project are identified as such. A *Low* risk is marked accordingly and should be justified under separate documentation. A *Yes* response indicates the potential for risk. If any of the questions are answered as *Yes*, a Risk Analysis is required.

Part A: Technical Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
TECHNOLOGY			
1. New technology?			
2. Unknown or unclear technology?			
3. New application of existing technology?			
4. Modernized/advanced technology in existing application?			
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?			
2. Multiple technical agencies?			
3. Interface with operating structures, systems, or components during installation?			
SAFETY			
1. Criticality potential?			
2. Significant exposure/contamination potential?			
3. Any impact to the Facility's Authorization Basis?			
4. Hazardous material involved?			
5. Process hazard potential?			
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?			
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?			
2. Additional releases?			
3. Undefined disposal methods?			
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)			
2. Classified process / information? (DOE Orders require Security Risk Assessment)			
DESIGN			
1. Undefined, incomplete, or unclear functional requirements?			
2. Undefined, incomplete, or unclear design criteria?			
3. Complex design features?			
4. Difficult to perform functional test?			
5. Numerous or unclear assumptions?			
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?			
2. Specialty resources required?			
OTHER (Define below)			
1.			
2.			

Table 8-1. Risk Screening Guidelines (cont.)

Part B: Project Risk Screening Criteria	Potential for Risk? No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?			
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?			
PROCUREMENT			
1. Long-lead items that may affect critical path?			
2. Potential unavailable qualified vendors or contractors?			
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?			
2. Multiple project interface?			
3. Multiple contractor interface?			
4. Significant interface with operational facility?			
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			
OTHER (Define below)			
1.			
2.			

8.2.1.2 Risk Management Plan

If required, a risk management plan should be developed at the onset of a project. This plan is a living document used throughout the life of the project and should therefore be under configuration management. The plan should identify project mission and description, project assumptions, responsibilities for risk management, and a description of the risk management process that will be followed—including the procedures, criteria, tools, and techniques to be used to identify, quantify, respond to, and track project risks. Inherent in the project description should be the identification of issues/exceptions with standardized practices and procedures, such as:

- Unusual heat stress or exposure to cold situations
- New or atypical traffic pattern requirements
- Nonstandard methods for compliance with OSHA
- Deviations from standard construction practices
- Requirements that could alter standard job plans or maintenance activities
- Limited access to medical facilities
- Work involving confined spaces, scaffolding, ladders, etc., where current site practices are lacking.

These issues should be documented to facilitate identification of any risks associated with them, as opposed to identification of tasks that can readily be defined and costed as part of the project scope and baseline. While all applicable industry and site safety, operations, and maintenance documents provide input to facilitate risk identification, subject matter experts are generally the best source of information.

A risk management plan should also identify when, during the project life cycle, the risk analysis (identification, quantification, and response) will be performed and updated. The level of detail in the plan, and the scope, timing, and level of risk analysis should be commensurate with the complexity of the project. Risks that are identified and quantified as low should have minimal follow-on activities. The outline of a typical Risk Management Plan is shown in Table 8-2.

Table 8-2. Risk Management Plan Outline (Typical)

1.0 INTRODUCTION
1.1 Risk Management History for this Activity
1.2 Risk Management Purpose and Scope Summary
1.3 Scope Limitations
2.0 ACTIVITY (e.g., PROJECT, PROGRAM, OR TASK)
2.1 Background
2.2 Assumptions
2.3 Structure for Risk Analysis
2.4 Risk Management Team
2.5 Responsibilities for Risk Management
3.0 RISK MANAGEMENT PROCESS EXECUTION
3.1 Risk Management Planning
3.2 Risk Identification
3.3 Risk Quantification
3.4 Risk Handling
3.5 Risk Impact Determination
3.6 Risk Tracking, Reporting, and Closure
4.0 REFERENCES
5.0 APPENDICES
5.1 Risk Screening Typical Risk Management Data Tracking
5.2 Risk Assessment Form and Instructions
5.3 Guidelines for Conduct of Risk Management Activities
5.4 Typical Risk Management Data Tracking

For most projects, risk management is not a one-time activity or project event; it is a continuing process. Risk analyses will occur several times in the project life cycle. Often a preconceptual risk analysis is conducted to facilitate alternative evaluations, determine the level of project management planning required, and the level of technical information and development activity appropriate to the project. Risk analysis for a project is typically performed and updated during each of the life-cycle phases of the project. Periodic reviews of the risk analysis should be performed to identify new risks and to evaluate changes during the project implementation cycle.

The project manager is responsible for the development of a risk management plan with key team personnel input and buy-in described above. This plan will document the strategies and procedures that will be used to manage project risk. Rather than a separate plan, it may be included as a section in the overall Project Execution Plan.

8.2.1.3 Selection of Assessable Elements

Assessable elements are discrete entities against which an effective risk analysis may be performed and the results evaluated to provide the input needed to make necessary decisions. Dividing an activity, project, or program into smaller more manageable elements enables the identification of risks in a structured manner.

For example, in attempting to evaluate the risk associated with two different alternatives available to baseline a project design, the assessable elements might be “Alternative 1” and “Alternative 2”. Similarly, in evaluating manufacturing a new widget, assessable elements might be the Product “Widget” and the Process “Manufacturing Facility”. If the project involves design, construction, and operation of a facility, the assessable elements can be the various functions or groupings of functions (i.e., systems, subsystems, or functions). It can also be based on the various elements in the Work Breakdown Structure (WBS) for the project. Table 8-3 provides guidance in the selection of appropriate assessable elements for a project. Note that there is no right or wrong selection; some elements are simply more conducive to future activities than others. In situations where multiple risk assessments are conducted for the same project, it is not necessary that the same assessable elements be used each time. In fact, it is most likely that the selection of assessable elements will change throughout the project’s life cycle.

Table 8-3. Guidance For The Selection Of Assessable Elements

► Individual Alternatives—useful for "new mission" or "new facility" activities with multiple potential alternatives, or to assist in down-selecting to the best or better alternatives as a part of an alternative study.
► Product/Process Components—useful when the facility's deliverable is clearly distinct from the facility.
► Distinct Functions or Groupings of Functions (e.g., facility or a system)—useful when the functions have readily identified risks or grouping have been readily defined.
► WBS Allocation—useful when the project is in final design stage.

8.2.2 RISK IDENTIFICATION

Risk identification is an organized approach for determining which events are likely to affect the activity or project, and documenting the characteristics of the events that may happen with a basis as to why this event is considered a risk. Identification relies on the skill, experience, and insight of project personnel and subject matter experts, as well as the project manager. Subcontractor participation in the identification process may be desirable and useful. Risks should be identified that are both internal (under project control) and external (beyond project control).

Once risk areas have been identified, risk identification proceeds by clearly documenting what risks are foreseen in each area. This includes not only the issue or event, but specifically why this concern is an assessable risk to the project.

Whereas risk is generally considered in terms of negative consequences (e.g., harm or loss) in the project context, it is also concerned with opportunities that result in positive outcomes. Therefore, risk identification may be accomplished through cause and effect evaluation that indicates whether an outcome should be avoided or encouraged.

Key sources of input to risk identification include:

- *Activity or Project Descriptions (Scope Statements, etc.).* The nature of the project will have a major effect. For example, a project involving proven technology may have significantly less risk when compared to a project involving new technology, which may require extensive development and thus have a higher risk.

- *Other Activity or Project Planning Documents.* The WBS may provide visibility into new innovations not readily extracted from scope statements, statements of work (SOWs), etc. Cost and/or time estimates may provide greater risks when developed from early or incomplete information. Procurement plans may identify unusual market conditions such as regional sluggishness or lack of multiple suppliers. Finally, the end user and the design agency may develop hazard lists that identify additional sources of risk.
- Historical Information—This information can be extracted from previous project files, personal remembrances, the Estimating Department, and commercial databases. Lessons learned can also provide input.

Methods and tools for initiating identification of risk can vary, depending upon the resources (project documentation, experience with similar projects, lessons learned, knowledgeable personnel, etc) available. Risk identification can be initiated by using risk source checklists (including categories for both technical and programmatic risks), process flow charts, risk/activity templates, interviews with subject matter experts, and team brainstorming. The tools are intended to both stimulate the thought process of the Risk Analysis Team and supplement their knowledge regarding potential risks.

Table 8-4 illustrates a typical checklist of risk categories. In using these checklists, the Risk Analysis Team evaluates each assessable element, one-by-one, against each item in the risk category list, to determine whether anything in the project presents a risk. The process continues until the entire checklist has been considered. While the use of a template is similar to that of a checklist, using a process flowchart helps to bring about a better understanding of each step in a scenario and the interrelationships between steps. This type of evaluation considers each of the steps involved in the process, one at a time, to determine the potential that the step includes any risks. This method is most useful when new or modified process steps are involved.

The results of the risk identification step are clear statements of risk with corresponding bases. The event that creates the risk will be identified, as well as the affect the event could have on the project or activity. This information should be documented in Section A of the Risk Assessment Form shown in Table 8-5. The other parts of this form will be addressed in subsequent sections of this document. Table 8-6 contains line-by-line instructions for completing the risk assessment form.

Table 8-4. Risk Category List

Design	**Technology**
• Undefined, Incomplete, Unclear Functions or Requirements	• New Technology
• Complex Design Features	• Existing Technology Modified
• Numerous or Unclear Assumptions or Bases	• New Application of Existing Technology
• Reliability	• Unknown or Unclear Technology
• Inspectability	**Procurement**
• Maintainability	• Procurement Strategy
• Safety Class	• First-Use Subcontractor/Vendor
• Availability	• Vendor Support
• Errors and Omissions in Design	**Construction Strategy**
Regulatory & Environmental	• Turnover/Start-Up Strategy
• Environmental Impact Statement Req'd. (EIS)	• Direct Hire/Subcontract
• Additional Releases	• Construction/Maintenance Testing
• Undefined Disposal Methods	• Design Change Package Issues
• Permitting	**Testing**
• State Inspections	• Construction
• Order Compliance	• Maintenance
• Regulatory Oversight	• Operability
Resource/Conditions	• Facility Startup
• Material/Equipment Availability	• System Startup (Subcontractor or PE&CD)
• Specialty Resources Required	**Safety**
• Existing Utilities Above and Underground	• Criticality Potential
• Support Services Availability	• Fire Watch
• Geological Conditions	• Exposure Contamination Potential
• Temporary Resources (Power, Lights, Water, etc.)	• Authorization Basis Impact
• Resources not Available	• Hazardous Material Involved
• Construction Complexities	• Emergency Preparedness
- Transportation	• Safeguards & Security
- Critical Lifts	• Confinement Strategies
- Population Density	**Interfaces**
• Escorts	• Multiple Agencies, Contractors
• Personnel Training & Qualifications	• Special Work Control/Work Authorization Procedures
• Tools, Equipment Controls, & Availability	• Operating SSCs Including Testing
• Experience with System/Component (Design,	• Multiple Customers
Operations, Maintenance)	• Co-Occupancy
• Work Force Logistics	• Outage Requirements
• OPC Resources	• Multiple Systems
- Operations Support	• Radiological Conditions (Current and Future)
- Health Physics	- Contamination
- Facility Support	- Radiation
- Facility Maintenance Centralized Maintenance	• Multiple Projects
- Construction Support Post Modifications	• Proximity to Safety Class Systems
• Training	**Management**
• Research and Development Support	• Funding Uncertainties
• Multiple Project/Facility Interface	• Stakeholders Program Strategy Changes
• Facility Work Control Priorities	• Errors and Omissions in Estimates
• Lockout Support	• Fast Track/Critical Need
Safeguards & Security	• Infrastructure Influence
• Catetgory I Nuclear Materials	
• Classified Process/Information	

Table 8-5. Risk Assessment Form

Risk Assessment Form

Risk Identification No.: *00-00002*

KASE # (Optional):

Date:

Assessed Element (Optional):

Risk Title:

Risk Category (Optional):

Risk Type (Optional):

Responsibility (Optional):

A. Statement of Risk: *(State Event and Risk)*

B. Probability: *(State the probability and basis that the risk will come true without credit for RHS)* P= ______

O Very Unlikely(VU) $(P \leq 0.1)$ O Unlikely(U) $(.2 \leq P \leq 0.4)$ O Likely(L) $(.5 \leq P \leq 0.7)$ O Very Likely(VL) $(.8 \leq P \leq 1.0)$

C. Consequence: *(State the consequences and quantify basis if that risk comes true without credit for RHS)* C= ______

Worst Case Cost Impact: ______ Worst Case Schedule Impact: ______

O Negligible(N) $(C \leq 0.1)$ O Marginal(M) $(.2 \leq C \leq 0.4)$ O Significant(S) $(.5 \leq C \leq 0.7)$ O Critical(C) $(.8 \leq C \leq 0.9)$ O Crisis(Cr) $(C > 0.9)$

D. Risk Level: O Low(L) O Moderate(M) O High(H) Probability x Consequence = Risk Factor (optional): ______

E. Risk Handling Strategies:

Risk Handling Approach	Risk Handling Strategy (RHS) Description and Bases	Reduced			Implementation		Tracking# (Optional)
		Prob.	Cons.	Risk	Cost	Schedule	

F. Residual Risk Impact:

	Best	Most Likely	Worst
Cost Consequence:			
Schedule Consequence:			

G. Description of Residual Risk:

H. Schedule to Cost Conversion Factor: $ ______ per unit ______

I. Affected WBS:

J. Additional Comments (optional):

Unclassified ONLY

Table 8-6. Typical Risk Assessment Form Instructions

Line A	Provide a clear statement of the risk.
Line B	Identify the probability of occurrence of the risk in a qualitative or quantitative manner. This line also should indicate the basis for arriving at the probability value
Line C	Identify the consequence of occurrence of the risk in a qualitative or quantitative manner. This line also should indicate the basis for arriving at the consequence value. The (worst case) cost and the schedule impact if the consequence is realized is also identified.
Line D	Identify the risk level and calculate the risk factor (if quantitative).
Line E	Identify the risk handling strategies (both preferred and a backup strategy, if any), and document the impact of the handling strategy on the risk. The new probability and the consequence values are identified for the residual risk. The cost and duration for the implementation of these strategies are also identified.
Line F	Identify the impact of the reduced consequence on the total cost as determined in terms of the best, expected, and worst case cost estimates.
Line G	Provide a description of the residual risk in terms of anticipated work/rework.
Line H	Identify a cost per unit time of delay (i.e., "hotel load cost").
Line I	Identify the WBS element that would be affected by realizing the stated risk. This can be labor and/or equipment items.
Line J	Provide any additional comments that may apply to the risk, in any of the other line entries.

8.2.3 Risk Quantification

Risk quantification involves determining the probability of the occurrence of a risk, assessing the consequences of this risk, and combining the two (probability and consequence) to identify a "risk level." This risk level represents a judgment as to the relative risk to the project as a whole and is categorized as *Low*, *Moderate,* or *High*. Based on the risk level, handling strategies are identified to respond to the risk.

A number of factors complicate this analysis including:

- A single risk event can cause multiple effects on a number of systems (ripple effect).
- Opportunities for one participant may be considered detrimental by another.

- Mathematical techniques can cause false impressions of precision and reliability, i.e., results may only be indicators, not absolute measures.

Risk quantification may be performed *quantitatively* or *qualitatively*, depending upon the project complexity and the preference of the analysis team. The end result is the same in both cases.

Risk level determination can be done using a variety of techniques. This can be done by determining the probability of the risk occurring and its consequence(s). The probability of a risk occurring is usually a number or a grade and has no units (dimensionless). However, consequences are usually measured in specific units such as cost, exposure rates, or casualty rates. In the methods described below, criteria are defined and used to convert the consequence(s) into a unitless number or grade. Later, the impact of risk on a project or activity is defined using units of cost.

Table 8-7 shows typical criteria for defining probabilities and Table 8-8 shows typical criteria for defining consequences. These probability and consequence tables are used with both the qualitative and quantitative methods of risk quantification discussed below. The criteria followed by asterisks in these tables must be calibrated relative to the project. For example, the consequence definitions of *Negligible*, *Marginal*, *Significant*, *Critical*, and *Crisis* may vary considerably from a small to a large project.

Table 8-7. Risk Probabilities (Typical)

Probability of Occurrence		**Criteria**
Qualitative	**Quantitative**	
Very Unlikely	< 0.1	Will not likely occur anytime in the life cycle of the facilities; or the estimated recurrence interval exceeds 10,000 years*; or the probability of occurrence is less than or equal to 10%.
Unlikely	> 0.1 but < 0.4	Will not likely occur in the life cycle of the project or its facilities; or estimated recurrence interval exceeds 1000 years*; or the probability of occurrence is greater than 10% but less than or equal to 40%.
Likely	> 0.4 but < 0.8	Will likely occur sometime during the life cycle of the project or its facilities; or estimated recurrence interval is between 10 to 1000 years*; or the probability of occurrence is greater than 40% but less than 80%.
Very Likely	> 0.8	Will likely occur sometime during the life cycle of the project; or estimated recurrence interval is less than 10 years*; or the probability of occurrence is greater than or equal to 80%.

*Time intervals to be customized per needs specific to the modification being assessed.

Table 8-8. Risk Consequences (Typical)

Consequence of Occurrence		Criteria[1]
Qualitative	**Quantitative**	
Negligible	< 0.1	Minimal or no consequences; unimportant. Some potential transfer of money, but budget estimates not exceeded. Negligible impact on program; slight potential for schedule change; compensated by available schedule float.
Marginal	0.2 to 0.4	Small reduction in modification/project technical performance. Moderate threat to facility mission, environment, or people; may require minor facility redesign or repair, minor environmental remediation, or first aid/minor medical intervention. Cost estimates marginally exceed budget.[2] Minor slip in schedule with some potential adjustment to milestones required.[2]
Significant	0.5 to 0.7	Significant degradation in modification/project technical performance. Significant threat to facility mission, environment, or people; requires some facility redesign or repair, significant environmental remediation, or causes injury requiring medical treatment. Cost estimates significantly exceed budget.[2] Significant slip in schedule with resulting milestones changes that may affect facility mission.[2]
Critical	0.8 to 0.9	Technical goals of modification/project cannot be achieved. Serious threat to facility mission, environment, or people; possibly completing only portions of the mission or requiring major facility redesign or rebuilding, extensive environmental remediation, or intensive medical care for life-threatening injury. Cost estimates seriously exceed budget. Excessive schedule slip unacceptably affecting overall mission of facility/site/DOE objectives, etc..
Crisis	> 0.9	Modification/project cannot be completed. Cost estimates unacceptably exceed budget. Catastrophic threat to facility mission, environment, or people; possibly causing loss of mission, long-term environmental abandonment, and death.[2]

[1] Any one or more of the criteria in the five levels of consequence may apply to a single risk. The consequence level for the risk being evaluated must be based upon the highest level for which a criterion applies.

[2] Actual dollar values and schedule delays to be determined, per the needs/limitations of the modification being assessed.

Special attention must be given to first-of-a-kind risks because they are often associated with project failure. First-of-a-kind risks should receive a critical or crisis consequence estimate unless there is a compelling argument for a lesser consequence value determination.

The output of the risk quantification process is a determination of the probability of occurrence, the consequence of occurrence, and the risk level for each risk. This information is documented in Sections B, C and D of the Risk Assessment Form shown in Table 8-5. The risk quantification method chosen must be able to provide this risk level based upon the judgment exercised in the analysis process and be consistent with the implementing organization's procedures. Numerous methodologies can be employed to quantify risk. Whatever method is used, documentation of the chosen methodology is recommended. Documentation creates a record for future use in the event that a new team performs a later review, revision, or update.

The two methods developed further in this section include:

- Qualitative—based upon the intersection of the qualitative probability and consequence values derived from Tables 8-7 and 8-8, respectively, using the Risk Level Matrix shown in Figure 8-2.
- Quantitative—based upon the product of the quantitative probability and consequence values derived from Tables 8-7 and 8-8, respectively.

8.2.3.1 Qualitative Approach (Risk Level Matrix)

This method begins by assigning qualitative values to event probability and consequence(s) that will then be used to determine a qualitative risk factor. The following steps provide the details of the method. The key features of this method are that it:

- Allows independent assessment of the probability and consequence of a risk
- Provides qualitative definition of basis for the risk and risk level.

The qualitative methodology uses the risk level matrix shown in Figure 8-5.

Steps:

1. Address each risk statement from the risk assessment form individually.
2. Determine the qualitative probability of occurrence value (P) for each risk with appropriate basis and justification. The probability of occurrence is for the duration of all project phases or for the activity being assessed. Table 8-7 provides typical criteria for establishing probability values.
3. Determine the qualitative consequence of occurrence value (C) for each risk with appropriate basis and justification. The consequence of occurrence is for the duration of all project phases or for the activity being assessed. Table 8-8 provides typical criteria for establishing consequence values.

Assign a risk level based upon the intersection of the qualitative P and C values on the 5x4 risk level matrix in Figure 8-5. Depending upon the activity and the ability to differentiate the risk levels, other matrices may be chosen by the risk analysis team.

Probability of Risk Materializing	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	**Low**	**Moderate**	**High**	**High**	**High**
Likely	**Low**	**Moderate**	**High**	**High**	**High**
Unlikely	**Low**	**Low**	**Moderate**	**Moderate**	**High**
Very Unlikely	**Low**	**Low**	**Low**	**Low**	**High**
	Severity of Consequence				

Figure 8-5. Risk Level Matrix

8.2.3.2 Quantitative Approach (Probability x Consequence Equation)

This method begins by assigning quantitative values to event probability and consequence(s) that will then be used to determine a quantitative risk factor. The details of this method are outlined below. The key features of this method are that it:

- Provides qualitative definition of basis for the risk, but quantitative inputs for risk level
- Provides finer grading within the risk levels.

This method is useful for prioritization activities, either among alternatives where numerous risks exist within the individual risk levels, or among risks in determining where to allocate resources.

The quantitative methodology uses the Probability x Consequence Equation

RF = (Px C), where:

RF = Risk Factor
P = Probability of Occurrence
C = Consequence of Occurrence

Steps:

1. Address each risk statement from the risk assessment form individually.

2. Determine the quantitative probability of occurrence (P) for each risk with appropriate basis and justification. The probability of occurrence is for the duration of all project phases or for the activity being assessed. The probability is expressed as a decimal between 0 and 1, where 0 is no probability of occurrence and 1 is 100% probability of occurrence. Table 8-7 provides typical criteria for establishing probability values.

3. Determine the quantitative consequence of occurrence (C) for each risk with appropriate basis and justification. The consequence of occurrence is for the duration of all project phases or for the activity being assessed. The consequence is expressed as a decimal between 0 and 1. Table 8-8 provides typical criteria for establishing consequence values.

4. Using the formula RF = P x C, determine the risk factor for each identified risk.

5. Based on the following values, determine the risk level for each identified risk.

   High Risk - RF is greater than 0.4[1]

   Moderate Risk - RF is greater than 0.1, but less than or equal to 0.4

   Low Risk - RF is less than or equal to 0.1

[1] This threshold ensures that risks with a mid-range (0.6) probability of *Likely* and a high-end (0.7) consequence of *Significant* (and vice-versa) will be classified as *High* risks.

8.2.3.3 Other Risk Quantification Methods

Expected monetary value, expert judgement, simulation, and the use of decision trees are other risk quantification methods that may be used.

Expected monetary value is the product of the risk event probability multiplied by the value of the gain or loss that will be incurred. Schedule impacts and intangibles (i.e., a loss may put the organization out of business) must be considered when using this approach.

Expert judgment is often used in lieu of, or in conjunction with, mathematical techniques. For example, risk events could be described as having a very likely, likely, unlikely, or very unlikely probability of occurrence and a crisis, critical, significant, marginal, or negligible impact or consequence. Based on these descriptions, the risk level matrix shown in Figure 8-5 can be used.

Simulation uses a model of a system process such as the project schedule to simulate a project using Monte Carlo analysis to “perform” the project many times so as to provide a statistical distribution of calculated results. The use of Monte Carlo analysis to estimate the risk cost distribution by statistically combining risk costs is illustrated in Section B.3.5.

A decision tree is a diagram depicting key interactions between decisions and associated change events as understood by the decision-maker. This approach helps the analyst to divide a problem into a series of smaller, simpler, and more manageable events that more accurately represent reality to simplify decision-making.

8.2.4 RISK HANDLING

Risk handling is the identification of the course of action or inaction selected for the purpose of effectively managing a given risk. **All identified risks shall be handled.** Risk-handling methods should be selected after personnel have determined the probable impact on the project, so that handling strategies are selected that identify the optimum set of steps to balance risk with other factors, such as cost and timeliness. Responses to risks generally fall into one of four major categories (reduce or mitigate, accept, avoid, or transfer) shown in Figure 8-6 and are described in greater detail in the subsections that follow.

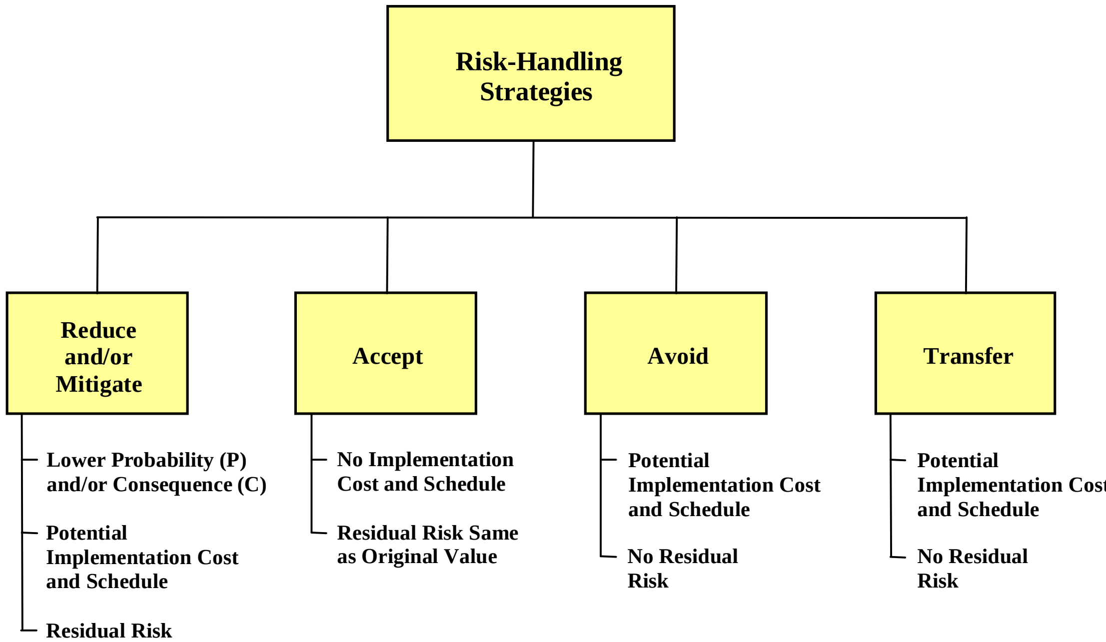


Figure 8-6. Risk Handling Strategies

The selected handling strategy, or strategies, should be documented in Sections E, F, G, and H of the Risk Assessment Form shown in Table 8-5. Costs related to the scope of the selected risk handling strategies are added to the project baseline cost and incorporated in project action items. Thus, risk handling implementation costs are included in the baseline cost.

8.2.4.1 Reduce and/or Mitigate

This strategy identifies specific steps or actions, which will increase the probability that an activity will succeed, or, conversely, reduce the probability of the occurrence of the risk or mitigate the consequence of a risk. The expected outcome of a risk event can be reduced by lessening the probability of occurrence, e.g., by using proven technology to lower the probability that the project will not work, or by reducing the risk outcome by adding specific mitigation actions and any corresponding cost implementation and schedule to the project scope. Using this strategy, the risk remains, but at a reduced level. This reduced level is called the residual risk. This residual risk will be statistically combined later with other residual risks to develop risk contingency.

If the strategy is to reduce and/or mitigate the risk, then the cost and duration to implement that strategy is determined and documented on the risk assessment form. In addition, the probability, the consequence, and the risk factor and level of the residual risk (i.e., risk after reduction and/or mitigation) are then determined. The potential cost and schedule impact of the residual risk is identified using three types of estimates: the best case (or most optimistic), the most likely, and the worst case (or most pessimistic) estimate for establishing the cost distribution probability for Monte Carlo simulations.

8.2.4.2 Accept

Accepting a risk is essentially a “no action” strategy. Selection of this strategy is based upon the decision that it is more cost effective to continue the project as planned with no resources specifically dedicated to addressing the risk. However, the “no action” strategy may be hedged by developing a contingency plan in case the risk event occurs and then tracking the risk to assure that it does not increase during project execution. Low risks are typically accepted.

For a handling strategy of *accept*, the residual risk equals the initial risk because this strategy does not change the risk level. The residual risk will be statistically combined with other residual risks to develop contingency. If the risk is accepted without additional actions, then the cost and duration of implementation is zero, which is documented on the risk assessment form. The potential cost and schedule impact of the risk is identified using three types of estimates: the best case (or most optimistic), the most likely, and the worst case (or most pessimistic) estimate for establishing the cost distribution probability for Monte Carlo simulations.

8.2.4.3 Avoid

This strategy focuses on totally eliminating the specific threat or risk-driving event usually by eliminating the potential that the risk event can occur. This can be accomplished through total structure, system, or component redesign, or by selecting an alternate design approach, that does not include the particular risk. The project will not be able to eliminate all risks, but specific risk events can often be eliminated with this strategy.

If the strategy is to avoid the risk, the cost and duration of implementation of the strategies is determined and documented. Once the strategy is implemented, the risk level for the specific element will be reduced to zero. No residual risk remains with this strategy.

8.2.4.4 Transfer

This strategy is used when a project scope with identified risks can be transferred to another project or entity, especially when this same risk can be more easily handled within the receiving project or entity. A risk can be transferred to an outside organization by purchasing services to obtain technology outside of the project. This in itself is a risky strategy in that the vendor can go out of business or fail to meet the agreed requirements, leaving the project with the same initial problem. In any case, the individual or organization receiving the risk must accept the risk transfer.

If the strategy is to transfer the risk, the cost and duration of implementation of the strategies is determined and documented. Once the strategy is implemented, the risk level for the specific element will be reduced to zero. No residual risk remains with this strategy.

8.2.5 Risk Impact Determination

Risk impact determination is the process of evaluating and quantifying the effect of risk(s) on the project. Risk impacts a project in two different ways:

- Handling strategy implementation, which must be reflected in a revised project baseline
- Residual risk, which must be reflected in project contingency.

The ultimate impact of risk management is to increase the probability of project/activity success by focusing attention on problem areas early and reducing the amount of costly rework in the future. For each and every risk, there is potential cost or schedule impact if the risk occurs. The impacts of these risks on cost and schedule must be addressed in the project estimates.

8.2.5.1 Handing Strategy Implementation

The first impact is the handling strategy implementation, which must be included in the project cost and schedule baseline. If the risk is reduced using a risk reduction or mitigation strategy, there may be a cost and schedule impact associated with the implementation of that strategy as shown in Figure 8-7. The "implementation" cost and schedule impacts of the risk mitigation strategy must be included in the baseline project cost and schedule.

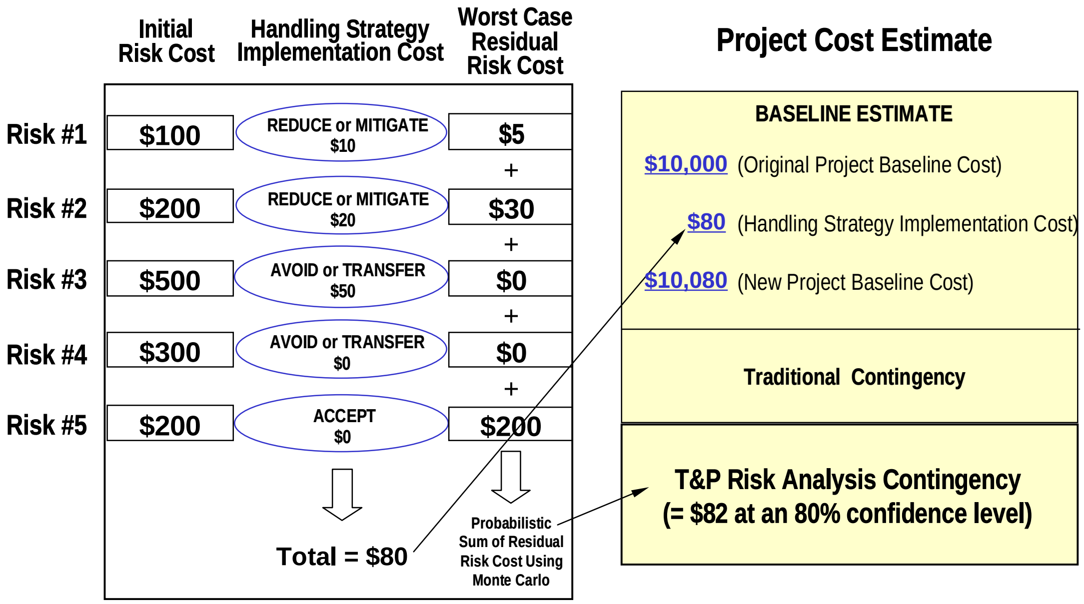


Figure 8-7. Risk Impact Determination Reflected in Project Cost Estimate

8.2.5.2 Residual Risks

Even after risk-handling strategies have been implemented, there may be remaining risk impacts, which are referred to as residual risks. The cost and schedule impacts of residual risks must be included in the contingency calculations. This is accomplished by determining a cost and/or schedule impact probability distribution for each residual risk. These probability distributions are then combined statistically through a Monte Carlo process to produce the contingency estimate. For the example shown in Figure 8-7, the contingency is $82 (at an 80 percent confidence level), significantly less than the $235 algebraic sum of the worst case residual risk costs.

Figure 8-8 illustrates the impact of risk handling on cost in another example. The initial risk cost prior to handling is $48.630 million. The handling implementation cost is $1.989 million, and the residual risk contribution to the project contingency, using the Monte Carlo process at an 80% confidence level, is $7.371 million.

The remainder of this section provides greater detail on the analysis of cost impacts from risks and the use of an approach to determine the risk impact on schedule.

TSF Risk-Based Cost Contingency

Risk Item / Basis	Before Handling: Risk Level	Before Handling: Worst Case Cost ($K)	Handling Strategy	Cost to Implement Handling	After Handling: Risk Level	After Handling: Residual Risk Cost Estimates ($K) Best Case	Most Likely	Worst Case
Redesign to solve problems identified during reviews	Moderate	3,360	Mitigate	75	Low	0	150	500
Do analyses/design 105 per external comments	Moderate	390	Avoid	0	---	N/A	N/A	N/A
Rework design documents during concept evolution	Moderate	5,720	Mitigate	0	Moderate	0	750	2,500
Redesign for add'l equipment for ops/pretreat. interface	Moderate	160	Mitigate	0	Low	0	40	100
Design for cintering equipment	High	500	Mitigate	308	Moderate	0	0	200
Redo design for SNF re-sizing	Moderate	200	Accept	0	Moderate	0	50	200
Redesign; contamination control in process room	Moderate	5,000	Mitigate	361	Moderate	0	300	3,000
Change design basis, due to scale-up impact	Low	50	Accept	0	Low	0	15	50
Redesign, for SC furnace	Low	800	Mitigate	0	Low	0	0	50
Redesign to add gas-trapping system	Low	1,550	Accept	0	Low	0	0	1,550
Rework to add waste streams to design	High	3,000	Mitigate	0	Moderate	0	250	2,300
Rework robotic features design	High	7,440	Mitigate	53	Moderate	0	500	2,000
Redesign for characterization	High	5,000	Mitigate	176	Moderate	0	600	3,000
Redesign to meet requirements of DOE canisters	Moderate	3,000	Reduce	0	Moderate	0	100	3,000
Design for new cables	Moderate	400	Mitigate	0	Low	0	0	50
Redesign for additional MC&A equipment	Moderate	400	Mitigate	0	Low	0	0	50
Redesign, to apply new structural criteria to 105L	Moderate	1,500	Mitigate	300	Low	0	0	700
Redesign, per SGS inputs	Low	500	Accept	0	Low	0	0	500
Redesign for changes, per DOE/NRC interface	Moderate	200	Mitigate	0	Low	0	0	150
Additional utility design features	Moderate	500	Accept	0	Moderate	0	300	500
Delays initiating design, awaiting R&D completion	High	5,360	Mitigate	0	Moderate	0	240	720
Delays, redesigning for classified process control system	Low	60	Avoid	0	---	N/A	N/A	N/A
Add features to meet IAEA	Moderate	500	Mitigate	0	Low	0	0	50
Uncertainty in obtaining contingency funds	Moderate	2,000	Avoid	0	---	N/A	N/A	N/A
Disposal of bundling tubes	Moderate	100	Avoid	75	---	N/A	N/A	N/A
Decontamination of final-product canister	Moderate	500	Avoid	341	---	N/A	N/A	N/A
Storage location for depleted uranium	Moderate	100	Avoid	75	---	N/A	N/A	N/A
Availability of emergency generator and fuel tank	Moderate	40	Avoid	0	---	N/A	N/A	N/A
Redesign for necessary structural supports	Moderate	300	Avoid	225	---	N/A	N/A	N/A
Arithmetic Sums:		**48,630**		**1,989**		**0**	**3,295**	**21,170**

T&PRA Contingency (at 80% Confidence Level) using Monte Carlo simulation = $7.371K

Figure 8-8. Impact of Risk Handling on Project Cost

Cost Analysis Methods

There are a number of methods available for determining the impact of risk on a project. One method is to assign a standard, flat percent contingency to the cost estimate, as determined by the cost estimator and project manager. This method can be termed the *"flat rate contingency"* method and is generally useful for activities where estimating uncertainty is know, based on historical data and experience. This flat rate calculation is applied individually to each function or activity such as engineering or construction instead of applying it to the overall project cost. The sum of the individual components become project risk.

The second contingency estimation method for projects with a number of moderate or high risks is termed the *"Monte Carlo simulation"* method. This is performed by defining the cost of each activity in terms of a cost profile, namely a cost probability distribution. Once the profiles are known, they can be statistically combined using the Monte Carlo simulation method.

The result of the simulation will be a project risk cost profile versus the probability of project success. This method is extensively used in the insurance industry to determine insurance rates based on mortality data. There are software tools such as Crystal Ball®, Risk for Microsoft Project®, or Primavera® Monte Carlo that can be used to do similar modeling. A similar cost impact analysis approach could be used to determine the impact of risk on schedule. This process is summarized below.

Application of the Monte Carlo Method

The Monte Carlo method uses individual cost vs. probability distributions for each of the residual risks to statistically generate the overall cost vs. probability profile. The simulation software also generates a sensitivity chart showing the impact of the various risk-based cost elements on the overall distribution.

As noted above, the process begins with preparation of an input probability distribution for each of the residual risks. In general, for each residual risk there is a range of costs with the best case and worst case estimates. One of the distributions commonly used for cost profiles is the triangular distribution shown in Figure 8-9. Other distributions, such as normal, exponential, or beta, could be used based on the available data and user experience/judgement. Figure 8-10 provides examples of some of these additional distribution functions that are available in Crystal Ball®.

For a triangular distribution, however, one needs only three data points for each residual risk element, namely, the most likely or anticipated cost, the best case cost, and the worst case cost. The most likely value falls between the best and the worst case values, forming the triangular-shaped distribution, which shows that the values near the minimum and the maximum are less likely to occur than those near the most likely value. The various risk elements with their residual cost versus probability profiles are provided as input to the model.

Assume a triangular cost distribution for each residual risk, where:

- L = low or best case estimate
- M= most likely case estimate
- H = high or worst case estimate

Note: Other distributions such as beta, exponential, and logarithmic can also be used for residual risk cost estimates. The use of these other distributions to better fit the expected cost risk probability distributions depends upon the experience of the risk facilitator.

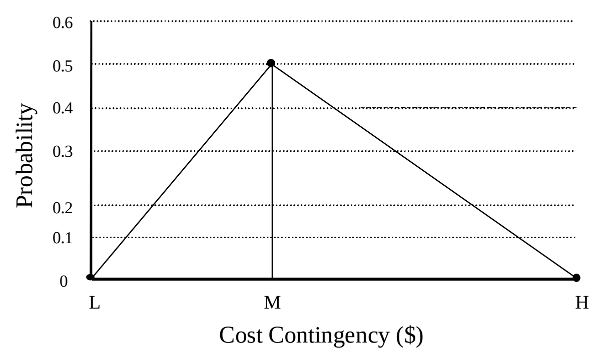


Figure 8-9. Triangular Residual Risk Cost Distribution

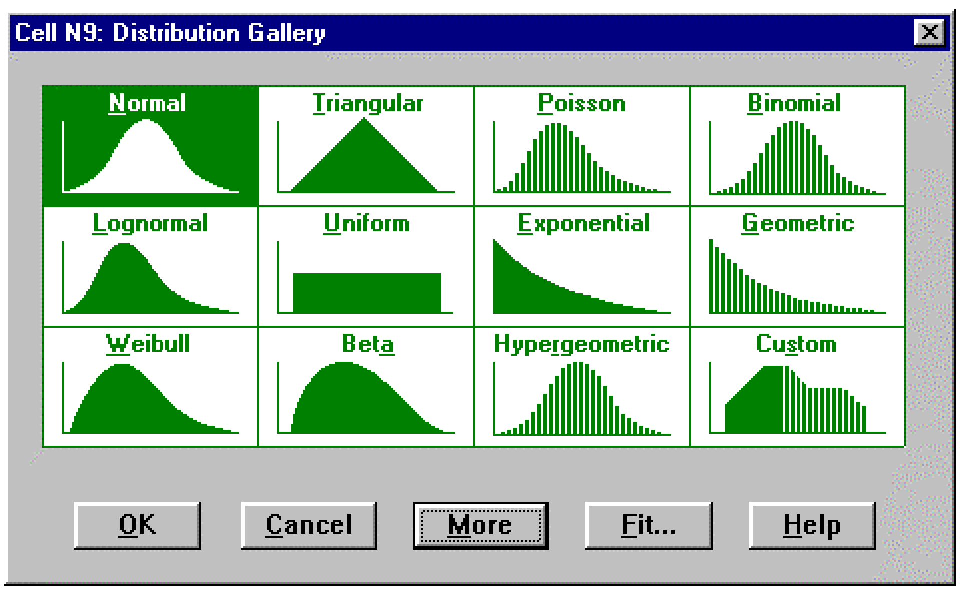


Figure 8-10. Other Available Probability Distributions

Calculation of the Total Residual Risk Cost Contingency Distribution

Once this data is obtained, the individual residual risk costs can be statistically combined as shown in Figure 8-11 using Monte Carlo simulation to obtain the overall project cost vs. probability profile. A total cost distribution is generated using the random sampling methodology or Monte Carlo method. This is usually done using a Monte Carlo software tool available from commercial vendors. Crystal Ball® software was used to generate the total cost distribution in this model (see Figure 8.12).

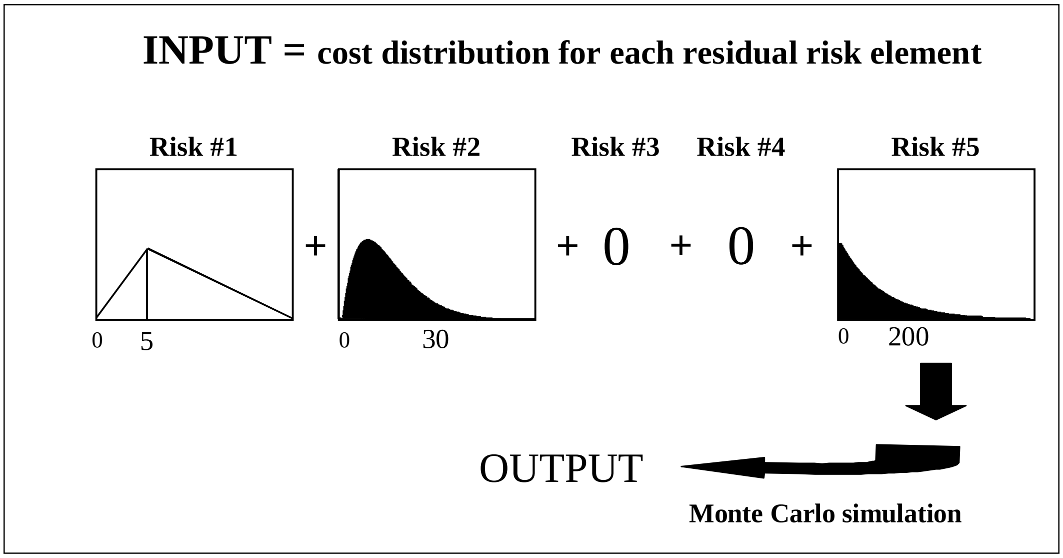


Figure 8-11. Probabilistic Sum of Residual Risk Costs (Monte Carlo simulation)

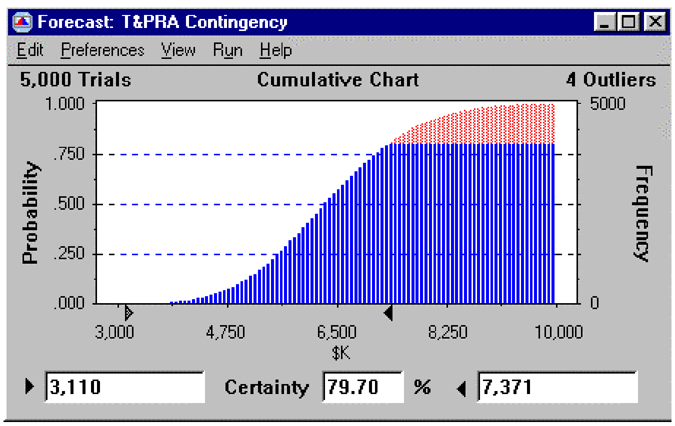


Figure 8-12. T&PRA Contingency Profile

Schedule Contingency

The residual risk impact on schedule has at least three effects, as follows:

1. It potentially delays the completion of the specific task element(s).
2. As a result of the slip, the task element(s) that precede or follow the affected element will also be impacted; this can result in a cost impact.
3. Additional project cost (in the form of such things as overtime differential pay, etc.) may be incurred for delays in schedule completion.

For example, resources may have been staged to perform various project activities. If one activity is delayed, there is a schedule impact. In addition, the resources to perform the follow-on activities will have to be idled or allocated to other tasks or activities which can result in demobilization and remobilization of manpower resources. This results in a cost impact. The term "hotel load" cost is used for the task of "maintaining a core work group in a standby mode" when task element(s) are delayed.

The method to determine the impact on the schedule and establish a schedule contingency is similar to the contingency analysis and uses the Monte Carlo method. The schedule impact is determined for each residual risk element in the form of "best case," "most likely case," and "worst case" estimates. Using project scheduling software such as Primavera® Monte Carlo, the schedule risk profile can be determined. The schedule contingency can be calculated, based on the amount of risk that one is willing to take.

The "hotel load" costs associated with the schedule contingency are also determined for each residual risk element and the "hotel load cost" contingency is calculated using Monte Carlo method. This is termed "cost of schedule contingency" and is added to the cost estimate contingency.

8.2.6 Risk Reporting and Tracking

Risk reporting is the documentation of the risk identification, quantification, handling, and impact determination activities for a project in a risk analysis report. This report normally becomes a reference in the project's overall risk management plan for use in future risk analysis activities.

Risk tracking is the active monitoring of action items developed from risk handling strategies and the identification of a need to evaluate new risks and /or reevaluate changes in previously identified risks. Risk tracking can typically monitor the following types of information:

- Accomplishment of detailed scheduled milestones, specifically as they apply to risk handling elements
- Cost data including both monthly and periodically generated status information
- Research and development studies, engineering studies, and science and technology roadmaps
- Test results, especially for risky program elements
- Technology transition plans (formalizing an agreement between the technology developer and technology user)
- Project action item list

Typical useful management indicators, depending upon the project, can include

- monthly and periodic status reports.
- technical performance measures.
- character and scope of design review action items.

Because the types of information and indicators being monitored are so diverse, appropriate tracking tools will vary widely among projects. A tracking system and tracking tools should be defined that are commensurate with the size and complexity of the project. The selection and definition of a tracking system to be used in a project is normally defined in the project's risk management plan.

Unfavorable trends from risk tracking indicate either that risks were not fully or properly defined, or that handling strategies were not adequate. In such cases, the risk analysis must be re-evaluated.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

NOTE: This Attachment has its own appendices, tables and figures

RISK MANAGEMENT PLAN
for
SPENT NUCLEAR FUEL
TREATMENT AND STORAGE FACILITY (U)

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Prepared by

Systems Engineering	Date
Systems Engineering	Date

Approvals

SFSD Design Authority Manager	Date
SFSD Program Manager	Date
Project Engineering Manager	Date
Project Manager	Date

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

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ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

1.0 INTRODUCTION

The Risk Management Plan (RMP) for the Spent Nuclear Fuel-Treatment and Storage Facility (SNF-TSF) Project S-7703 defines the scope and process for identification, evaluation of impact and management of risks applicable to the project. Risk Management will include assessable risks that could potentially jeopardize the successful completion of the project and will also address risks that potentially jeopardize facility operation and final facility decommissioning as related to or caused by this project.

This plan includes the work that earlier project activities had identified, identifies approaches to handle these issues, and expands risk management to include new risks due to project/design evolution. The risk assessment is based on the entire project scope, both programmatic (nontechnical) and technical project risks.

The objective of this plan is to define the strategy to manage project-related risks throughout the remainder of the project's life cycle, such that there is acceptable, minimal impact on the project's cost and schedule as well as on the conduct of the facility's operational performance.

1.1 PROJECT RISK MANAGEMENT HISTORY

A Risk Assessment Program Plan[1] was issued in November 1997 in preparation for the SNF alternative technology decision analysis. A technology risk assessment[2] was conducted as a first step in the decision analysis to determine if either, or both, of the technologies being considered posed significant risks that would make them unsuitable for further development. The risk assessment concluded that both technologies (Melt and Dilute and Direct Co-Disposal) were acceptable for further development provided that the mitigation strategies recommended by the team for high and moderate risks were followed and tracked through completion by a project team. Risk mitigation plans and risk handling, tracking, and closure were left for a future plan. The decision analysis that followed identified a preference for the Melt and Dilute technology, which is now the basis of the TSF project.

This risk management plan and subsequent risk assessment will be based on up-to-date project cost, schedule, and scope information. The assessment will include consideration of the moderate and high risks identified in the previous risk assessment for the Melt and Dilute technology.

1.2 PURPOSE AND SCOPE SUMMARY

The purpose of this RMP is to assure that the SNF-Treatment and Storage Facility project incorporates appropriate, efficient, and cost-effective measures to mitigate unacceptable project-related risks.

This plan establishes the concept and defines the process for risk management for the project. It describes the roles and responsibilities of project personnel in performing the risk management functions, and defines reporting and tracking requirements for risk-related information.

The product of this risk analysis will be a risk analysis report listing the various risks with their classification, mitigation and handling strategies, impact on cost and schedule, and project action items. A typical summary database is shown in table form in Appendix A.

The risk management process will:

- Identify potential sources of risk and the mechanisms forming these risks
- Assess individual risks and their impact on project and facility performance, cost, and schedule
- Evaluate alternative approaches to mitigate high and moderate risks
- Develop action plans to handle (i.e., avoid, reduce, transfer, or accept) individual risks
- Interface risks with other projects/programs

The risk management process specified in this plan was established during project team meetings with risk assessment personnel. The risk analysis process will follow the requirements of WSRC Manual E 11 and E7 for both technical and nontechnical project risks. Risk assessments will be performed in accordance with the Risk Management Guidance Document WSRC-IM-980003 (Reference 4.2) and the instructions in Appendices B and C of this plan. This will be consistent with DOE Order 430.1 and its associated guides. This RMP will remain valid for the life cycle of the project and will be under project configuration control. RMP revisions will require approval that is identical to the initial approval level.

1.3 SCOPE LIMITATIONS

The scope of this RMP will include risks generally originating from several interfacing project areas such as engineering, construction and startup; and also other external infrastructure activities related to utilities, safeguards and security, and interfacing SRS waste generating, processing, and storage facilities, etc., that

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[1] Risk Assessment Program Plan (U), Transfer and Storage Services for Aluminum-Based Spent Nuclear Fuel, G-ESR-G-00027 Revision 0, November 1997.

[2] Spent Nuclear Fuel Alternative Technology Risk Assessment (U), Y-TRA-G-00001 Rev. 0, July 16, 1998.

are required for the project. However, risks generated by SRS-external sources will be managed on a case-by-case basis at the direction of the Project Manager.

The risk management process will identify, analyze, and handle risks that potentially affect the facility structures, systems, and components affected by the project. It will establish a risk hierarchy that traces each high and moderate risk to the appropriate level of design detail and will report status and closeout of high and moderate risks. As documented in the TSF Systems Engineering Management Plan[3], the TSF project risk policy is that high risks will not be accepted and must be reduced to at least moderate risks through implementation of a risk mitigation strategy. If this is not possible, PE&CD, Spent Fuel Storage Division, and DOE Management will be advised. Moderate risks will be considered on a case by case basis for potential mitigation actions, and low risks will not be mitigated or tracked, but will be retained in the risk assessment report for future reference only and closed out without further handling.

The plan will track, as a potential risk to the project's cost and schedule, the successful mitigation of hazards to the environment, and safety and health of the public or the worker (i.e., "ESH Risks"). However, in accordance with SRS policies (WSRC 1-01 Management Policy 4. 1, "Environmental Protection" and Policy 4.5, "Nuclear Safety") regarding risk management for projects and facilities, this RMP excludes the detailed management and handling of these ESH Risks. Other documents, such as WSRC Manual E7, Conduct of Engineering, specify procedures for assuring that these ESH risk are within SRS limits and meet ALARA requirements.

[3] Systems Engineering Management Plan for SNF Treatment and Storage Facility (U), Y-PMP-L-00001 Rev. 0, September 21, 1998.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

2.0 PROJECT BACKGROUND & RISK MANAGEMENT

2.1 PROJECT BACKGROUND

The Department of Energy (DOE) Environmental Management Program (EM) has the responsibility for the safe, effective, and efficient storage of the current and future inventory of DOE-owned spent nuclear fuel (SNF). This SNF, including the returned foreign research reactor and domestic research reactor SNF, will be prepared for disposal and stored in a road-ready condition awaiting placement in a permanent geologic repository. Per the DOE SNF Programmatic Environmental Impact Statement Record of Decision, SRS is designated to manage the aluminum-clad SNF inventory for the DOE complex, as well as projected receipts for the next 30 to 40 years. The TSF project will perform a major role in the management of this SNF.

Recent evaluations have confirmed the technical feasibility and potential cost savings for the reuse of the 105-L facility for housing the TSF project. The project consists of direct de-inventory of the existing wet basins to repository-ready storage via transfer and treatment provisions installed in the 105-L Reactor Building. Summary features of the project are:

- Continued receipt at L-Area Disassembly Basin of DOE-owned aluminum-clad SNF from domestic and foreign research reactors using existing equipment. Existing cask decontamination equipment in the stack area will also be used.
- Preparation of the SNF for disposal at a national repository using the melt and dilute treatment technology, with new furnaces and associated support equipment, including an off-gas system, installed in the 105-L Process Room. SNF will be transferred to the Process Room from the L-Area Disassembly Basin via the D&E canal using a modified D&E conveyor.
- Load treated SNIF into a canister/transfer cask, and perform scaling and leak testing operations using new transfer cell and canister preparation equipment installed in the existing Crane Maintenance Area.
- Load the transfer cask onto a special transporter in the Stack Area using the existing crane. Transfer the canister of treated SNIF to dry interim storage, consisting of a modular storage system installed outside the 105-L Building.
- Load canisters of treated SNF into transportation casks for transport off the SRS for storage or disposal.

In general, the project will make use of existing structures, systems, or components (SSCs) where possible, and add new SSCs where necessary.

2.2 PROJECT ASSUMPTIONS

This Risk Management Plan will take a broad view of the Treatment and Storage Facility project to address specific risks that require assessment, mitigation, and tracking. Risk assessment will be an ongoing process throughout the project life cycle. This initial assessment will be focused on the establishment of a valid project baseline prior to project validation. In addition, the following assumptions will serve to guide/bound the risk assessment:

a) It is assumed that the particulate type SNF (as identified in Appendix B of the Technical Performance Requirements for Proposed Treatment and Storage Facility for Spent Nuclear Fuel, WSRC-TR-98-00218, Rev. 0, July 28, 1998) can be treated by the melt and dilute process at some time in the future with relatively minor modifications (Reference 4.3). Because of uncertainties in the receipt condition, form, packaging, and the length of time until receipt, the TSF project scope does not include functions specific to particulate material at this time.

b) It is assumed that the transfer shipments between Building 105-L and the Road-Ready Storage area are not required to meet NRC transportation requirements.

c) It is assumed that L-Basin will be available for the life of the TSF for continued receipts, wet storage, conditioning, and characterization of SNF.

d) It is assumed that the L-Area Disassembly Basin will have the capability to receive and unload all SNF shipments to SRS during TSF operations.

e) It is assumed that changes to the Mined Geologic Disposal System Draft Disposability Interface Specification (1300000000-01717-4600-00108, Rev. 0, February 1998) will not cause major changes to the TSF.

f) It is assumed that the Record of Decision for the SRS SNF Management EIS will select the melt and dilute treatment technology.

g) It is assumed that the TSF will not be NRC licensed.

h) It is assumed that the treated SNF to be shipped to the MGDS becomes the responsibility of DOE-RW when the loaded transport cask is on the railcar or trailer. From that point on, DOE-RW is responsible for performing the shipping function and what follows.

i) It is assumed that the loaded road-ready canisters will not require opening for any sort of inspection or repackaging, as part of TSF activities.

2.3 STRUCTURE FOR RISK ANALYSIS

The functional areas/systems listed below are in alignment with the TSF FDD and will be used as the assessable elements for the risk assessment:

0 TSF Program
1 SNF Pretreatment
2 Furnace
3 Off-gas
4 Secondary Waste
5 HVAC
6 Remote Handling
7 Characterization
8 Packaging
9 Controls
10 Material Handling
11 Fire Protection
12 Power (normal and emergency)
13 Safeguards and Security
14 Structures
15 Road-Ready Storage
16 Balance of Plant.*

*Balance of Plant includes Air, Inert Gas, Plant Communications, Radiation Monitoring and Protection, Road and Rail, Service Water, and Storm Sewer.

2.4 PROJECT RISK MANAGEMENT TEAM

The project risk management team will consist of the core project team with additional subject matter experts participating as appropriate in the risk identification and analysis. The core team is comprised of:

- Project Manager
- Project Engineering Manager
- Program Manager
- Design Authority Engineering Manager
- Operations Manager
- SRTC Melt and Dilute Development Task Lead
- Safety (WSMS)
- Systems Engineering Lead.

2.5 RESPONSIBILITIES FOR RISK MANAGEMENT

The Project Manager has overall responsibility for project risk management and the implementation of this risk management plan. The activities required to implement the following responsibilities may be delegated; however, the responsibility remains with the identified function.

<u>Project Manager;</u>

- Is responsible for the development and approval of the Risk Management Plan (RMP)
- Will provide budget for RMP implementation activities
- Will actively participate in the project's conduct of risk management, particularly in remedial actions, such as:
  (a) mitigation of programmatic risks, when the project's scope, budget, or schedule are impacted
  (b) mitigation of interfacing risks when other organizations (outside SRS) are involved
- Or designee will chair the risk assessment meetings
- Will assemble and lead the Project Team in the risk analyses
- Will assure the risk analysis results are documented and risk mitigation plans are brought to closure
- Will schedule periodic reviews of the risk summary report and the status of the associated handling actions, delegate risk coordination to the Systems Engineering Lead.

<u>Project Engineering Manager</u>

- Will actively participate in the project's conduct of risk management, particularly in remedial actions, such as:
  (a) technical risks, when the project's scope, budget, or schedule are impacted
  (b) interfacing risks when interfaces to other SRS organizations are involved
- Will identify the need for technical risk analyses
- Will approve the risk management plan.

Design Authority Engineering Manager

- Will actively participate in the project's risk management activities that relate to design and engineering activities and their interfaces.
- Will approve the risk management plan.

Program Manager

- Will coordinate and integrate the other project activities (such as operations, external issues) with the programmatic risk management activities.
- Will approve the risk management plan.

Systems Engineering Lead

- Is responsible for the maintenance of the RMP
- or designee will schedule risk assessments, propose meeting agenda, and approve meeting minutes
- Will designate a Risk Management Coordinator
- Will prepare and periodically present to the Project Manager and Project Engineering Manager a summary status of risk mitigation activities and status of RMP implementation.

Risk Management Coordinator

- Will facilitate risk assessment meetings
- Will manage the identification, the assessment, and rating of risks
- Will prepare a set of identified risks and risk handling strategies.

Project Team Members

- Will perform risk screening to identify risks
- Will assess and grade identified risks
- Will develop risk mitigation strategies.

3.0 RISK MANAGEMENT PROCESS

3.1 RISK MANAGEMENT ACTIVITIES

The risk management process will follow the requirements of WSRC Manual E11 and E7 for both technical and noNtechnical project risks. Risk assessments will be performed in accordance with the instructions of Appendices B and C of this plan and Risk Management Guidance Document WSRC-IM-980003 (Reference 4.2). Each project element, as identified in Section 2.3, will be assessed. The risk areas suggested by the Risk Screening Form included in Appendix D will be used to initiate identification of risks.

Evaluations of the status and mitigation progress of identified risks, any additional identification of new potential risks, and the closure of acceptable risks will be performed at key points in the project cycle, including:

a) Prior to completion of the TPC Estimate for Validation of the Design Project,
b) Prior to Project Critical Decisions
c) At selected points during detailed design and construction as identified in the Project Team Execution Plan.

Additional risk assessments may be added in support of the procurement and construction schedules, as appropriate. The Project Manager will schedule and initiate risk screening as needed to identify new potential risks.

The project risk management process contains the following major elements:

1) Risk Management Planning
2) Risk Identification
3) Risk Analysis
4) Risk Mitigation
5) Risk Tracking, Reporting, and Closure.

Figure 3-1 depicts these major elements and their sub-activities.

3.1.1 Risk Management Planning

The planning activity will identify the assumptions and the level of risk assessment. The SNF-TSF project risk team will review all the risk elements of the project in detail including both technical and programmatic activities. This is documented in this Risk Management Plan.

3.1.2 Risk Identification

The assessable elements for the project are shown in Section 2.3. This is based on the individual systems and structures that comprise the project with their associated functions. The analysis will consider the risks related to various elements.

3.1.3 Risk Analysis

The risk analysis process will classify the risks into high, moderate, or low based on the charts shown in Appendix B. The criteria or definitions for the probability and the consequences of the risk being realized are also shown in Appendix B.

The analyses will be documented in the Risk Analysis and Identification Form, shown in Table 5-1 of Appendix A.

3.1.4 Risk Mitigation and Handling

The handling of risks is the process that will either ensure that a risk is acceptable to the project or make an unacceptable risk acceptable. This effort will commence after the risk assessments and grading have been completed. The first activity is the establishment of priorities and the level of justifiable effort for the handling of the individual risks.

In general, the following four strategies are acceptable alternative means to mitigate risks. They are:

1. Risk reduction,
2. Risk avoidance,
3. Risk transfer, or
4. Risk acceptance.

Each completed risk analysis will contain a recommended risk-handling process, which will form the basis for the risk-handling plan. The objective of the risk handling plan is a graded approach establishing a risk handling priority and a level of justifiable effort for risk handling, with the basis being the risk level as determined by the frequency of risk occurrence and the severity of risk consequences. Risk priority and the availability of budgets and personnel resources determine the execution sequence of each risk mitigation.

3.1.5 Risk Tracking, Reporting, and Closure

Handling strategies for all high risks will result in a schedule activity. Standard project implementation of these schedule activities will be the primary tool for tracking and reporting the status of all high risks. It will record the progress of risk mitigation by listing up-to-date information on risk status and closure.

- Risk identification
    - -description of risk
    - -source of risk
- Risk assessment data
    - -risk level
- Risk mitigation
    - -risk mitigation strategies
    - -impacted SSC
    - -risk resolution.

Moderate risks will be recorded in the Project Action Item list, either individually or as a distinct collection of multiple risks.

Periodically scheduled meetings will be the platform for identifying and concurring with newly identified risks to be added to the database for risk processing. The meeting frequency, attendance, and conduct will be the responsibility of the Project Manager or designee.

Risk status meetings will be used to review the progress of all top-level risks and any other risks of important concern, and resolve apparent risk-handling problems. The objective of these status meetings is to focus on the progress of high risks and to make efficient use of project and other staff expertise. The conduct of these status meeting will be the responsibility of the Project Manager.

An assessment of the status of applicable identified project risks will be performed by the project team during conduct of subcontracts for project engineering and design (E&D), and the proper management of risks in accordance with this plan will be imposed on E&D subcontractors.

The risk management database will contain relevant data on identified programmatic and technical project risks and will reflect the current status of risks. It will maintain files on risks that have been closed.

The format of the risk-handling strategies will be such that they can interface with other already existing project databases (e.g., schedule activities list) to allow for efficient data generation and transfer.

3.1.6 Risk Analysis Report

The process of risk handling will be documented in a Risk Analysis Report. This report will (a) document the results of completed risk identification activities, (b) contain the detailed risk assessments, and (c) provide the recommended mitigation of individual risks. This report will be initially issued for the preliminary design phase under the Project Engineering Manager's approval and will be periodically updated if new risks are identified or existing risks are deleted.

3.1.7 Trend/BCP

Mitigation actions will be evaluated as potential trends per Project S-7703 guidelines. Changes to the mitigation actions for high risks will require the approval of a Baseline Change Proposal (BCP). Changes to the risk value resulting from the completion of planned actions do not require approval of a BCP.

4.0 REFERENCES

4.1 WSRC Manual E11, Conduct of Project Management and Controls, Procedure 2.62, Revision 1, February 1, 1997, Project Risk Analysis.

4.2 Systems Engineering Methodology Guidance Manual, WSRC-IM-98-00033, Appendix B Risk Management, Revision 0, September 25, 1998.

4.3 Bases for Functional Performance Requirements for a Spent Nuclear Fuel Treatment and Storage Facility, WSRC-TR-98-00228, July 1998.

4.4 WSRC Manual E7, Conduct of Engineering and Technical Support, Procedure 2.16, Revision 0, July 1, 1995, Technical Risk Analysis.

5.0 APPENDICES

5.1 Appendix A - Typical Risk Management Data for SNF Treatment and Storage Facility Project

5.2 Appendix B - Instructions for Template for Individual Risk Assessments for SNF-Treatment and Storage Facility

5.3 Appendix C - Guidelines for Conduct of Risk Management Activities for SNF-Treatment Storage Facility Project

5.4 Appendix D - Risk Screening Form

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

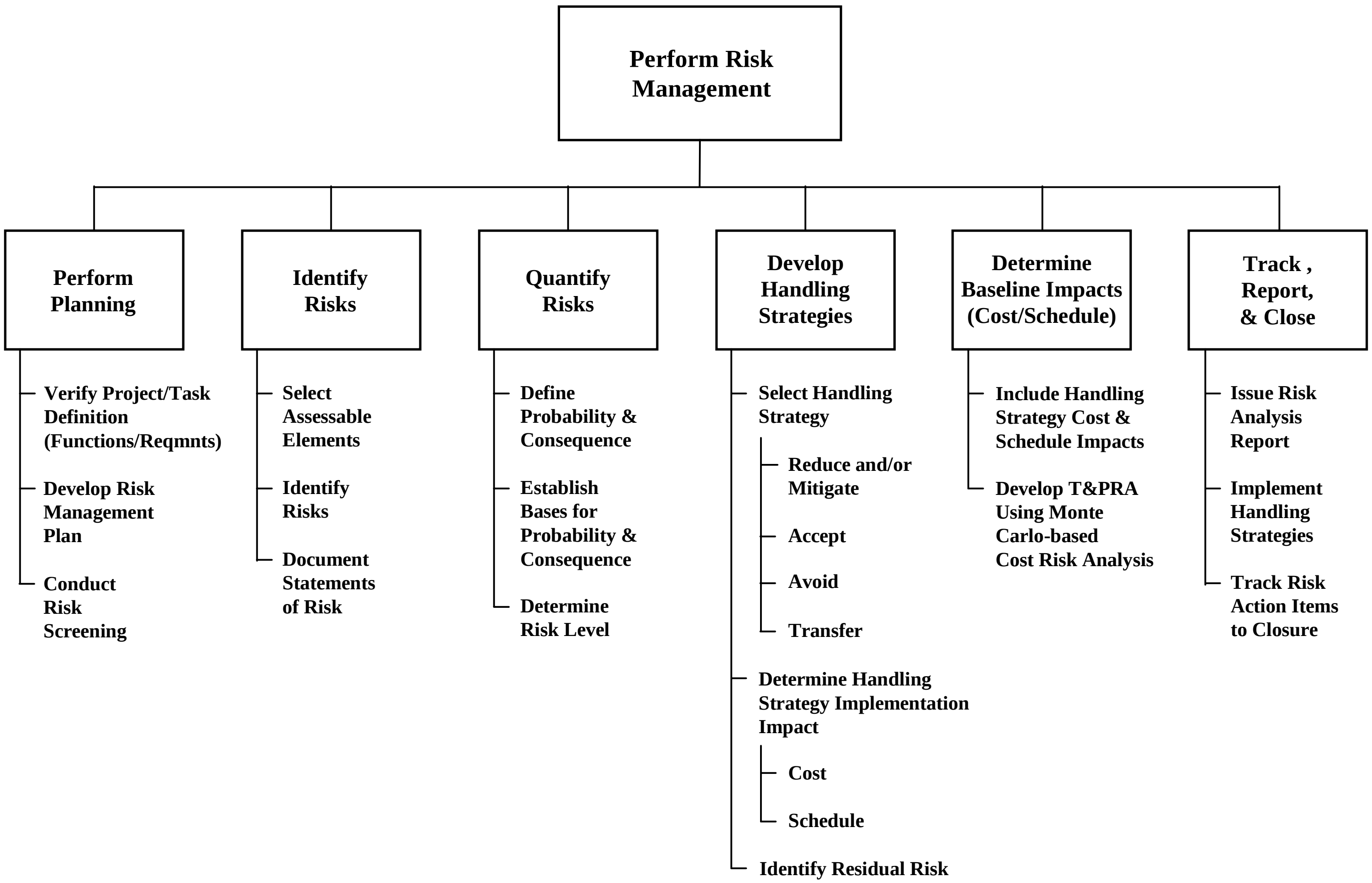


Figure 3-1 Function Tree for Risk Management Process

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

5.1 Appendix A - Typical Risk Management Data for SNF-Treatment and Storage Facility Project

RISK NUMBER	RISK LEVEL	RISK IDENTIFICATION (What is it?)	RESPONSIBILITIES (Who handles the risk?)	RISK HANDLING/TRACKING (How is it mitigated/resolved?)	RISK CLOSURE (What solves it, what is remaining on risk?)
Numbering consistent with the schedule activities numbering system, with cross reference to risk assessment number	High	Description of hazard Source of risk (project-internal/external) Impacted/interfacing equipment	Who (organization/individual) Schedule (any critical restraints?)	Risk handling document No. Risk resolution/mitigation	Risk closure document & date
Numbering consistent with the project action item list numbering system, with cross reference to risk assessment number	Moderate	General description of issue or action item caused by risk(s) Impacted equipment	Who (organization/individual) Schedule (any critical restraints?)	Risk handling document No., if applicable Risk resolution/mitigation	Risk closure date
Risk assessment number	Low	Listing of all low risks (without further mitigation)	NA	NA	NA

5.2 Appendix B

Instructions for Template for Individual Risk Assessments for SNF-Treatment and Storage Facility

Purpose

Table 5-1 is a template to be used for the SNF-Treatment and Storage Facility risk assessments. It is similar to the form that has been used for previous risk assessments. It contains the risk assessment parameters for each risk and, when completed, provides the necessary information for any further handling of the risk.

Guidance for Completion of the Template

Date: This date is the date of the specific risk assessment of the project/project element. This date will be specified with the assessment and will change only when the assessment of the individual risk changes.

Risk Number: This is a sequential number assigned to a risk after it was determined that a potential risk requires further assessment. Each risk will maintain its assigned number.

Location Description: The specific area/building in which the risk is located shall be specified here. (See listing of applicable buildings for proper identification or use "Project/Programmatic" for project-level risks).

Statement of Risk: A brief and precise statement of why the risk is important. The statement shall be formulated to clearly indicate a risk by stating "What we are concerned about." The statement should be limited to two lines of text to allow meaningful entry into the risk management database.

Probability: The probability that the identified risk will materialize shall be judged and scored under the following guidelines:

Probability of Occurrence	Criteria
0, 0.1 (Very Unlikely)	Will not likely occur anytime in the life cycle of the project; or estimated occurrence interval > 10,000 years.
0.2, 0.3, 0.4 (Unlikely)	Will not likely occur in the life cycle of the project; or 10,000 years > estimated occurrence interval > 100 years.
0.5, 0.6, 0.7 (Likely)	Will likely occur sometime during the life cycle of the project; or 100 years > estimated occurrence interval > 10 years.
0.8, 0.9, >0.9 (Very Likely)	Will likely occur sometime during the life cycle of the project; or Estimated occurrence interval < 10 years.

Consequences: The severity of the consequences, should the risk occur, shall be described, judged, and scored under the following guidelines:

Consequence of Occurrence	Criteria
≤ 0.3 (Negligible)	Small, acceptable, reduction in project technical performance. Minor threat to facility mission, environment, or people; possibly requires minor facility operations or maintenance changes without redesign, routine cleanup, or first aid. Cost estimates (TPC) increase by up to $500K. Minor slip in schedule, measurable in weeks, with some potential adjustment in milestones required.
0.4, 0.5 (Marginal)	Some reduction in project technical performance. Moderate threat to facility mission, environment or people; possibly requires minor facility redesign or repair; moderate environmental remediation or causes minor injury requiring medical intervention. Cost estimates (TPC) increase by >$500K and up to $2.5M. Moderate slip in schedule, between 1 and 6 months, and adjustment to milestones.
0.6, 0.7 (Significant)	Significant degradation in project technical performance. Significant threat to facility mission, environment, or people; requires some facility redesign or repair; significant environmental remediation or causes injury requiring medical treatment. Cost estimates (TPC) increase by >$2.5M and up to $12.5M. Significant slip in development schedule, between 6 and 12 months, and modification to milestones or affect on facility mission.
0.8, 0.9 (Critical)	Technical goals of project cannot be achieved. Serious threat to facility mission, environment, or people; possibly completing only portions of the mission; or requiring major facility redesign or rebuilding; extensive environmental remediation or intensive medical care for life-threatening injury. Cost estimates (TPC) increase by >$12.5M and up to $ 25M. Excessive schedule slip, exceeding 1 year, affecting overall mission of the facility or site.
> 0.9 (Crisis)	Project cannot be completed. Catastrophic threat to facility mission, environment, or people; possibly causing loss of mission; long-term environmental abandonment and death. Cost estimates (TPC) increase by >$25M. Excessive schedule slip unacceptably, affecting overall mission of facility/site/DOE objectives, etc.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Risk Level: The level of each risk is a function of the probability of the risk to materialize, times the severity of the consequence when the risk occurs (i.e., Risk Factor = Probability x Consequence). Table 5-1 depicts a relationship that will allow the determination of each risk level, once the probability and consequence of a particular risk are known.

The risk levels are identified in the Risk Analysis Report, including risks that are outside project control, that reflect risks which will be managed through interface control with DOE and other organizations, and by the Project Change Control system. These risks have no risk level assigned and are identified by "O/C" in the Risk Analysis Report.

Table 5-1 Risk Level Determination

Risk Factor	Risk Level
Less than. 0.1	Low
Between 0.1 and 0.5, inclusive	Moderate
Greater than 0.5	High

Consideration of First-of-a-Kind Risks

Most innovative projects carry an additional risk potential for failure when they are based on –"First-of-a-Kind" (FOAK) technology or FOAK structures, systems, or components. The project may or may not contain FOAK risks, and the risk analyses will be used to determine any FOAK risks. Although certain processes are not FOAK by themselves, they may very well become FOAKs when considered working together. e.g., robotics in highly radioactive environments. Other FOAK candidates are processes/components with large scale factors, i.e., existing and proven equipment that has been scaled up by a factor of, say, more than five.

Identified FOAK risks will generally be assigned a frequency range/numerical value in the "Very Likely" area and a consequence severity consistent with "Critical" or "Crisis" unless lesser ratings can be substantiated.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Table 5-1 Template for Project Risk Assessments

Risk Assessment Form

Risk Identification No.: *00-00001*

Assessed Element:

Risk Title:

KASE #:

Risk Category (Optional):

Risk Type:

Date:

Responsibility:

A. Statement of Risk: *(State Event and Risk)*

B. Probability: *(State the probability and basis that the risk will come true without credit for RHS)* P= ______

O Very Unlikely(VU) (P ≤ 0.1) O Unlikely(U) (.2 ≤ P ≤ 0.4) O Likely(L) (.5 ≤ P ≤ 0.7) O Very Likely(VL) (.8 ≤ P ≤ 1.0)

C. Consequence: *(State the consequences and quantify basis if that risk comes true without credit for RHS)* C= ______

Worst Case Cost Impact: ______ Worst Case Schedule Impact: ______

O Negligible(N) (C ≤ 0.1) O Marginal(M) (.2 ≤ C ≤ 0.4) O Significant(S) (.5 ≤ C ≤ 0.7) O Critical(C) (.8 ≤ C ≤ 0.9) O Crisis(Cr) (C > 0.9)

D. Risk Level: O Low(L) O Moderate(M) O High(H) Probability x Consequence = Risk Factor (optional): ______

E. Risk Handling Strategies:

Risk Handling Approach	Risk Handling Strategy (RHS) Description and Bases	Reduced			Implementation		Tracking# (Optional)
		Prob.	Cons.	Risk	Cost	Schedule	

F. Residual Risk Impact: Cost Consequence: ______ ______ ______

Schedule Consequence: ______ ______ ______

Best Most Likely Worst

G. Description of Residual Risk:

H. Schedule to Cost Conversion Factor: $ ______ per unit ______

I. Affected WBS:

J. Additional Comments (optional):

Unclassified ONLY

5.3 Appendix C - Guidelines for Conduct of Risk Management Activities for SNF-Treatment and Storage Facility Project

Section 3.1 describes the risk management activities for the project. Section 2.3 lists the elements to be assessed for the project.

(a) Planning of Risk Management:

As specified by this document.

(b) Identification of Risks:

Potential risks are identified by project team members from various disciplines in meeting sessions initiated by the Project Manager, with subject matter experts participating at the Project Manager's request. The basis for the identified risks will be established, and each risk will receive a judgmental rating (high, moderate, low) at that time.

(c) Risk Analyses:

The identified risks will be analyzed by project subject matter experts for the parameters listed in Table 5-1 (Template). The analyses will be performed under the guidance of Manual El1, Procedure 2.62, for technical and programmatic project risks. Project risk assessments will use Risk Level Table 5-2 for assigning the applicable risk level of "High," "Moderate," or "Low." Additional instructions are provided in Appendix B.

(d) Handling of Risks:

Risk Handling is identification of a strategy for ensuring that risks are acceptable to the project. In general, the following four strategies are acceptable alternative means to handle risks: (1) risk mitigation, (2) risk avoidance, (3) risk transfer, or (4) risk acceptance.

For the SNF-Treatment and Storage Facility, only high risks and moderate risks will be considered for mitigation. Low Risks will be recorded and retained in the risk analysis report. Mitigation activities will be evaluated as possible "Trends" per project guidelines. Changes to the mitigation actions for high-level risks, once incorporated into the project, require an approved BCP.

Risk mitigation is the process that will make an unacceptable risk acceptable. This effort will commence after the risk analysis and grading processes are completed. The first activity is the establishment of priorities and the level of justifiable effort for the handling of the individual risks.

To (1): Mitigate the Risk:

Each completed risk analysis will contain mitigation strategies that recommend risk handling that will form the base for a risk-handling plan. The objective of the risk-handling plan is a graded approach by the establishment of a risk handling priority and the level of justifiable effort for risk handling, with the basis being the risk level. Risk priority and the availability of budgets and personnel resources determine the execution sequence of each risk.

A risk can be reduced in its frequency of occurrence or its severity of consequences by engineering studies of alternative technologies or design concepts. However, before an alternative can be chosen, a careful review of the potential for new risks associated with this alternative has to be conducted as part of the risk mitigation effort. Sometimes, new risks can appear in interfaces with related structures, systems, or components.

Each completed risk analysis will contain a recommended course of action prepared by the risk-handling analyst and can form the base for the risk-handling plan. The objective of the risk-handling plan is a graded approach by the establishment of a risk-handling priority and the level of justifiable effort for risk handling, with the basis being the risk grade (risk probability and severity of risk consequences). Risk priority and the availability of budgets and personnel resources determine the execution sequence of each risk mitigation.

To (2) Avoid the Risk:

Risk avoidance requires a clear understanding of the root cause of the risk. Again, changes in technology or design concepts will result in risk reduction or risk avoidance, when the root cause is clearly apparent. The risk-handling plan will specify any risk avoidance efforts.

To (3) Transfer the Risk:

Risk transfer is an action taken when an identified risk can be assigned to another party. Occasionally this strategy is acceptable when a project scope with identified risks can be transferred to another project, especially when this same risk can be more easily handled within the receiving project. Rarely, but on occasion, a risk can be transferred to an outside organization, such as a vendor. This in itself is a risky strategy in that the vendor can go out of business or fail to meet the agreed requirements, leaving the project with the same initial problem. In any case, the individual or organization receiving the risk must accept employment of risk transfer.

To (4) Accept the Risk:

In most cases, risk mitigation is associated with additional cost and schedule impacts, which can force the decision to accept the risk. Additionally, risk mitigation can lead to a partial risk acceptance. In these cases, the project (or the operating facility) can become prepared for the potential for the risk to occur by identifying typical risk trigger points that can be used to activate pre-prepared risk-handling contingencies. The identification of trigger points and the preparation of risk-handling contingencies will be developed as part of the individual risk-handling plan.

(e) Risk Tracking, Reporting, and Closure:

The project schedule activities will be the primary tool for tracking and reporting the status of all high risks. Moderate risks will be entered into the Project Action Item List. The schedule activity database is a permanent document that will contain all relevant data on every identified programmatic and technical high project risk, and will reflect the current status of each risk. It will permanently retain essential records on risks that have been closed. The database will be a controlled document under the supervision of the Project Manager.

Appendix A is an example of a typical format developed with objectives of having the capabilities to enter data, and to search, query, sort, and display any necessary risk information to a level of detail commensurate with the level of risk. In addition, the schedule activities should communicate with other project databases, such as project and task scheduling and commitment tracking databases as applicable to the project.

Other risk management activities for risk tracking and reporting include periodically scheduled meetings as the platform to concur on newly identified risks to be added to the risk database for risk processing. Risk status meetings will be used to review the progress of all top-level risks and any other risks of important concern, and resolve apparent risk-handling problems. Particular attention will be directed to risks that affect facility mission or DOE commitments.

The schedule activities and Project Action Item List will be used to document closed-out risks.

5.4 Appendix D - Risk Screening Form

TECHNICAL CATEGORIES

Design

- Undefined, Incomplete, Unclear Functions or Requirements
- Complex Design Features
- Numerous or Unclear Assumptions or Modification Bases
- Reliability
- Inspectability
- Maintainability
- Safety Class
- Availability
- Errors and Omissions in Design

Regulatory & Environmental

- Environmental Impact Statement Required. (EIS)
- Additional Releases
- Undefined Disposal Methods
- Permitting
- State Inspections
- Order Compliance
- Regulatory Oversight

Technology

- New Technology
- Existing Technology (Modified or New Application)
- Unknown or Unclear Technology

Testing

- Construction
- CTO/Maintenance
- Operability
- Startup (Facility)
- Startup (Subcontract or PE&CD)

Safety

- Criticality Potential
- Fire Watch
- Exposure Contamination Potential
- Authorization Basis Impact
- Hazardous Material Involved
- Emergency Preparedness
- Safeguards & Security
- Confinement Strategies

Interfaces

- Multiple Agencies, Contractors
- Special Work Control Work Authorization Procedures
- Operating SSCs Including Testing
- Multiple Customers
- Co-occupancy
  - Outage Requirements
- Multiple Systems
- Radiological Conditions (Current and Future)
  - Contamination
  - Radiation
- Multiple Projects
- Proximity to Safety Class Systems

PROGRAMMATIC CATEGORIES

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

<u>Programmatic</u>
- Funding uncertainties
  - Stakeholders (CAB, customers, etc)
  - Program Strategies Change
- Fast track/critical need
  - Infrastructure influence
- Schedule deferrals
- Schedule acceleration
- Management acceptance of identified risk w/o mitigation

<u>Procurement</u>
- Procurement Strategy
- First-use Subcontractor/Vendor
- Vendor Support

<u>Construction Strategy</u>
- Turn-over/Start-up Strategy
- Direct Hire/Subcontract
- Construction/Maintenance Testing
- Design Change Package Issues

<u>Resource/Conditions</u>
- Material/Equipment Availability
- Specialty Resources Required
- Existing Utilities Above and Underground
- Support Services Availability
- Geological Conditions
- Temporary Resources (Power, Lights, Water, etc.)
- Resources Not Available
- Construction Complexities
  - Transportation
  - Critical Lifts
  - Population Density
- Escorts
- Personnel Training & Qualifications
- Tools, Equipment Controls & Availability
- Experience with system/component (design, operations, maintenance)
- Work Force Logistics
- OPC Resources
  - Operations Support
  - HP Support
  - Maintenance, Construction, Plant Maintenance
  - Construction Post-Modifications
  - CSWE Support
  - TNX Support
  - Multiple Project/Facility Interface
  - Facility Work Control (Priorities vs. Projects)
  - Lockout Support

Work Conditions Resulting in Unusual Applications of General Site Safety Standards
These topics are part of SRS's standard safety practices and job planning.
- Personnel Injury
  - Heat Stress
  - Exposure to Cold
  - Industrial Hazards
  - Process Hazards
  - Use/Creation of Carcinogens
  - Confined Space Work

  - Air Quality
  - Work Elevation Hazards
- Personnel Protection
  - Access to Medical Supplies/Facilities/Personnel
  - Availability of Protective Equipment
- Vehicular
  - Traffic Patterns
  - Traffic Control
  - Pedestrian Areas
  - Unusual Vehicles
- Explosion Potential
- Ergonomics
  - Work Outside Field of Vision
  - Access Reach
- Weather/Climate Conditions

Other

- Schedule
- Cost
- Errors and Omissions in Estimates
- Project Scope Change
- Security
- Housekeeping

ATTACHMENT II – SAMPLE RISK ASSESSMENT FORM

Risk Assessment Form

Risk Identification No.: *PJT-KASE35-00001*

Assessed Element (Optional): 15 233-H Process

Risk Title: Modification of TCAP Technology

KASE # (Optional): 35

Risk Category (Optional): Technology: Existing Technology : Modified

Risk Type (Optional): PJT-Project Programmatic

Date: 11/13/98

Responsibility (Optional): Design Engineering

A. Statement of Risk: *(State Event and Risk)*
TCAP technology will be modified and may not meet expected performance requirements. Rework/redesign may be required to address such things as heating/cooling method, scale-up, etc..

B. Probability: *(State the probability and basis that the risk will come true without credit for RHS)* P= 0.90
Numerous changes to existing technology in heating/cooling method. Limited technical expertise in the areas analytical model, PDK aging, start-up control and heat transfer.

○ Very Unlikely(VU) (P ≤ 0.1) ○ Unlikely(U) (.2 ≤ P ≤ 0.4) ○ Likely(L) (.5 ≤ P ≤ 0.7) ● Very Likely(VL) (.8 ≤ P ≤ 1.0)

C. Consequence: *(State the consequences and quantify basis if that risk comes true without credit for RHS)* C= 0.70
Significant performance impact, with associated deviation documentation and operations impact, and/or significant design modifications/rework to improve performance. (Cost and schedule impacts are for the project only.)

Worst Case Cost Impact: $1,000,000 Worst Case Schedule Impact: 6 Mo(s)

○ Negligible(N) (C ≤ 0.1) ○ Marginal(M) (.2 ≤ C ≤ 0.4) ● Significant(S) (.5 ≤ C ≤ 0.7) ○ Critical(C) (.8 ≤ C ≤ 0.9) ○ Crisis(Cr) (C > 0.9)

D. Risk Level: ○ Low(L) ○ Moderate(M) ● High(H) Probability x Consequence = Risk Factor (optional): 0.63

E. Risk Handling Strategies:

Risk Handling Approach	Risk Handling Strategy (RHS) Description and Bases	Reduced Prob.	Reduced Cons.	Reduced Risk	Implementation Cost	Implementation Schedule	Tracking# (Optional)
Reduce and Mitigate	Continue component development work, allowing early identification of design issues.	0.4 U	0.4 M	0.16 M	$300K	0	

F. Residual Risk Impact:

	Best	Most Likely	Worst
Cost Consequence:	0	$200K	$500K
Schedule Consequence:	0 Mo(s)	1 Mo(s)	4 Mo(s)

G. Description of Residual Risk: Design perturbations to preclude performance degradation.

H. Schedule to Cost Conversion Factor: $ 200K per unit Mo(s)

I. Affected WBS: TCAP system; engineering labor

J. Additional Comments (optional):
Implementation cost represents EAC cost increase to include addressing change to heating/cooling method, analytical model, packaging, start-up control, scale-up, inside insulation, and heat transfer.

Unclassified ONLY

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

Attached is the residual risk-based cost contingency calculated for the Spent Nuclear Fuels Treatment and Storage Facility (TSF) Project example used throughout this Appendix. This calculation was performed to support a preconceptual design-only estimate. This information is provided in two sections. Section A is a summary of the results, representing the total estimated T&PRA contingency for the project. This section identifies a total residual risk-based contingency of $7.37 million at the 80% confidence level and would be used by the Cost Estimating organization to prepare the final Cost Estimate Report. Section B provides the details feeding into Section A.

Section A includes:

- A listing of the raw data input, as derived from the risk assessment results and subsequent decisions on incorporation of handling strategies – see Figure III-1.
- Listings of all risks documented in the example risk assessment, identifying those avoided by the project's handling strategies, those included in this risk-based contingency estimate, and those funded in the base cost estimate for this example project. Since the cost estimate for this example project as a design-only scope is not yet complete, no risks were eliminated due to their being covered by the existing cost estimate – see Figure III-1.

Section B includes:

- A sensitivity chart that identifies the relative importance of each assumption (i.e. - risk cost probability distribution) in the creation of a forecast (T&PRA contingency) – see Figure III-2.
- A forecast (T&PRA contingency) based upon the probabilistic sum of the assumptions using Monte Carlo simulation – see Figure III-3.
- Assumptions (risk cost probability distributions) assigned to each of the individual risks – see Figure III-4.

Although the inputs provided to this document would be screened to ensure that they did not duplicate entries into the standard project cost estimate, users are advised that screening does not validate the inputs. Furthermore, since the project cost estimate is not yet complete, no technical risks were eliminated in this example. It is left to Project Management and Cost Estimating to ensure that risks included in this analysis are not included in the traditional cost estimate elements and/or variables.

Both the input values and results of this contingency are subjective estimates of the likelihood and cost associated with realizing potential risks. This example is not intended to predict that any one of these individual risks will occur, or that the contingency cost identified will be required beyond the subjective estimate identified. Further, there are a number of very low-probability risks, with extremely high consequences, should these risks materialize. The contingency calculated here is based on the low-probability event. Covering these risks' high consequences is considered to be beyond the ability of the project.

In support of the information provided here, the risk report generated for this project would document and discuss all risks identified by the risk assessment and the handling strategy planned for each risk.

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

Legend for Figure III-1:
Risk Item/Basis – A brief description of the individual risk.
Before Handling, Risk Level – The level of risk determined during the risk assessment prior to the implementation of any handling strategy. The Risk Level will either be *High*, *Moderate*, or *Low*.
Before Handling, Worst Case Cost – An estimated value of the highest cost expected to occur should the residual risk materialize and without the benefit of any handling strategy implementation. This estimate is generally based on the risk assessment team's experience and judgement.
Handling Strategy **–** The type of handling strategy selected by the assessment team for the risk. The Handling Strategy will either be *Reduce, Mitigate*, *Avoid*, *Accept*, or *Transfer*.
Cost to Implement Handling – An estimate of the cost for implementing the selected handling strategy. This implementation cost is added to the baseline cost of the project or activity.
After Handling, Risk Level – The level of risk determined during the risk assessment after the implementation of any handling strategy (i.e., residual risk). The Risk Level will either be *High*, *Moderate,* or *Low.*
After Handling, Residual Risk Cost, Best Case – An estimate of the lowest cost that will be incurred by the project in "recovering from" the residual risk, should the residual risk occur. This value is generally based upon the risk assessment team's experience and judgement but is normally zero.
After Handling, Residual Risk Cost, Most Likely – An estimate of the most probable cost that will be incurred by the project in "recovering from" the residual risk, should the residual risk occur. This value is generally based upon the risk assessment team's experience and judgement.
After Handling, Residual Risk Cost, Worst Case– An estimate of the highest cost that will be incurred by the project in "recovering from" the residual risk, should the residual risk occur. This value is generally based upon the risk assessment team's experience and judgement.
T&PRA Contingency – An estimated value of the amount of contingency that is recommended to adequately protect the project against the identified risks following the implementation of handling strategies.

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

SECTION A – SUMMARY OF RISK-BASED CONTINGENCY COSTS

A	C	D	F	G	H	I	M	N	O
2	**TSF Risk-Based Cost Contingency**								
3		**Before Handling**				**After Handling**			
4							**Residual Risk Cost Estimates ($K)**		
5	**Risk Item / Basis**	**Risk Level**	**Worst Case Cost ($K)**	**Handling Strategy**	**Cost to Implement Handling**	**Risk Level**	**Best Case**	**Most Likely**	**Worst Case**
6	Redesign to solve problems identified during reviews	Moderate	3,360	Mitigate	75	Low	0	150	500
7	Do analyses/design 105 per external comments	Moderate	390	Avoid	0	---	N/A	N/A	N/A
8	Rework design documents during concept evolution	Moderate	5,720	Mitigate	0	Moderate	0	750	2,500
9	Redesign for add'l equipment for ops/pretreat. interface	Moderate	160	Mitigate	0	Low	0	40	100
10	Design for cintering equipment	High	500	Mitigate	308	Moderate	0	0	200
11	Redo design for SNF resizing	Moderate	200	Accept	0	Moderate	0	50	200
12	Redesign; contamination control in process room	Moderate	5,000	Mitigate	361	Moderate	0	300	3,000
13	Change design basis, due to scale-up impact	Low	50	Accept	0	Low	0	15	50
14	Redesign, for SC furnace	Low	800	Mitigate	0	Low	0	0	50
15	Redesign to add gas-trapping system	Low	1,550	Accept	0	Low	0	0	1,550
16	Rework to add waste streams to design	High	3,000	Mitigate	0	Moderate	0	250	2,300
17	Rework robotic features design	High	7,440	Mitigate	53	Moderate	0	500	2,000
18	Redesign for characterization	High	5,000	Mitigate	176	Moderate	0	600	3,000
19	Redesign to meet requirements of DOE canisters	Moderate	3,000	Reduce	0	Moderate	0	100	3,000
20	Design for new cables	Moderate	400	Mitigate	0	Low	0	0	50
21	Redesign for additional MC&A equipment	Moderate	400	Mitigate	0	Low	0	0	50
22	Redesign, to apply new structural criteria to 105L	Moderate	1,500	Mitigate	300	Low	0	0	700
23	Redesign, per SGS inputs	Low	500	Accept	0	Low	0	0	500
24	Redesign for changes, per DOE/NRC interface	Moderate	200	Mitigate	0	Low	0	0	150
25	Additional utility design features	Moderate	500	Accept	0	Moderate	0	300	500
26	Delays initiating design, awaiting R&D completion	High	5,360	Mitigate	0	Moderate	0	240	720
27	Delays, redesigning for classified process control system	Low	60	Avoid	0	---	N/A	N/A	N/A
28	Add features to meet IAEA	Moderate	500	Mitigate	0	Low	0	0	50
29	Uncertainty in obtaining contingency funds	Moderate	2,000	Avoid	0	---	N/A	N/A	N/A
30	Disposal of bundling tubes	Moderate	100	Avoid	75	---	N/A	N/A	N/A
31	Decontamination of final-product canister	Moderate	500	Avoid	341	---	N/A	N/A	N/A
32	Storage location for depleted uranium	Moderate	100	Avoid	75	---	N/A	N/A	N/A
33	Availability of emergency generator and fuel tank	Moderate	40	Avoid	0	---	N/A	N/A	N/A
34	Redesign for necessary structural supports	Moderate	300	Avoid	225	---	N/A	N/A	N/A
35	**Arithmetic Sums:**		**48,630**		**1,989**		**0**	**3,295**	**21,170**

T&PRA Contingency (at 80% Confidence Level) using Monte Carlo Simulation = $7.371K

Figure III-1. Impact of Risk Handling on Project Cost for TSF Example

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

SECTION B – ASSUMPTION DISTRIBUTIONS AND CRYSTAL BALL® OUTPUT

Crystal Ball Report
Simulation started on 6/7/00 at 12:52:00
Simulation stopped on 6/7/00 at 12:53:50

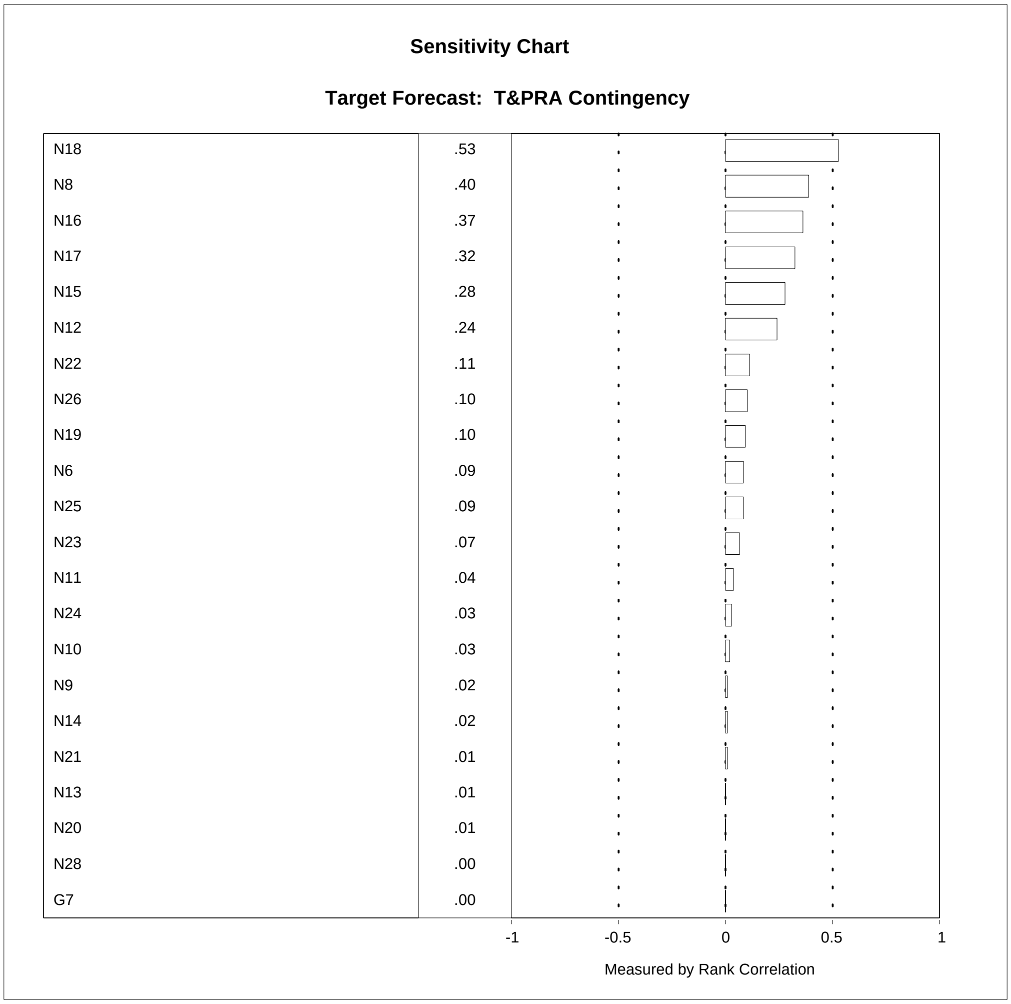


Figure III-2. Crystal Ball® Sensitivity Chart for TSF Example

Forecast: T&PRA Contingency **Cell: N35**

Summary:

Certainty Level is 99.90%
Certainty Range is from 3,110 to 10,000 $K
Display Range is from 3,000 to 10,000 $K
Entire Range is from 3,110 to 10,612 $K
After 5,000 Trials, the Std. Error of the Mean is 16

Percentiles:

Percentile	$K
0%	3,110
10%	4,975
20%	5,437
30%	5,754
40%	6,068
50%	6,351
60%	6,647
70%	6,985
80%	7,371
90%	7,896
100%	10,612

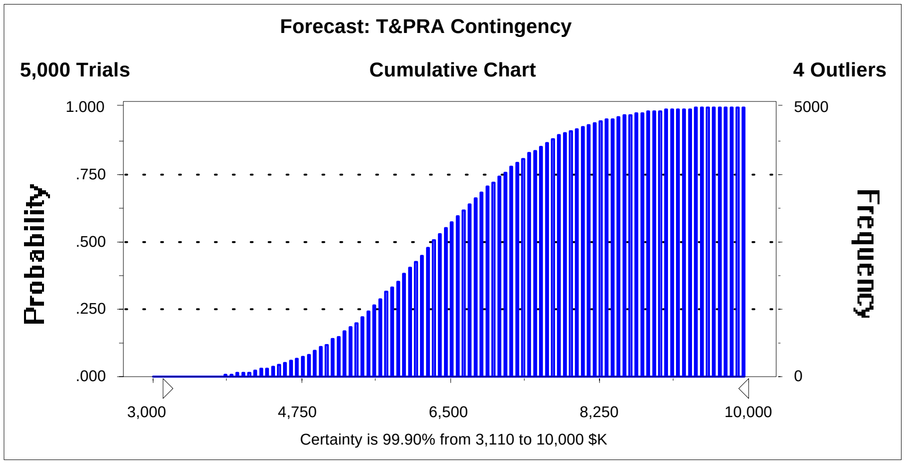


Figure III-3. Crystal Ball® T&PRA Contingency Forecast for TSF Example[4]

[4] The "Cell" designation in Figure III-3 refers to that specific cell in the spreadsheet shown in Figure III-1. This notation also applies to the Assumptions shown in Figure III-4.

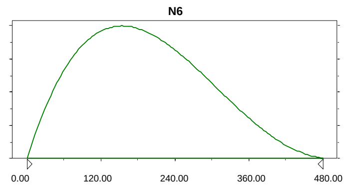
Assumptions

Assumption: N6 **Cell: N6**

Beta distribution with parameters:

Alpha	2.00
Beta	3.25
Scale	500.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 190.12

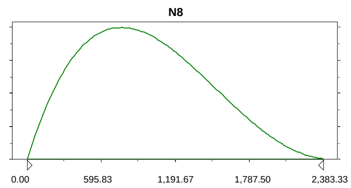


Assumption: N8 **Cell: N8**

Beta distribution with parameters:

Alpha	2.00
Beta	3.30
Scale	2,500.00

Selected range is from 0.00 to 2,465.52
Mean value in simulation was 941.07

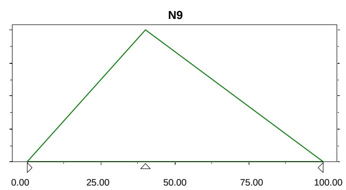


Assumption: N9 **Cell: N9**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	40.00
Maximum	100.00

Selected range is from 0.00 to 100.00
Mean value in simulation was 46.50



Assumption: N10 **Cell: N10**

Beta distribution with parameters:

Alpha	1.00
Beta	4.00
Scale	300.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 59.92

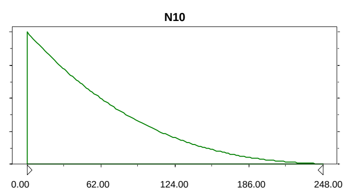


Figure III-4. Crystal Ball® Assumptions for TSF Example

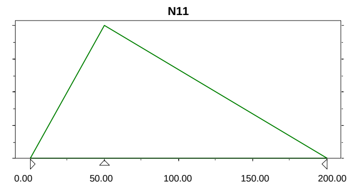
Assumptions (cont.)

Assumption: N11 **Cell: N11**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	50.00
Maximum	200.00

Selected range is from 0.00 to 200.00
Mean value in simulation was 82.71

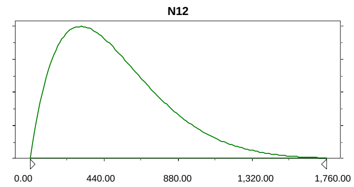


Assumption: N12 **Cell: N12**

Beta distribution with parameters:

Alpha	2.00
Beta	10.00
Scale	3,000.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 507.63

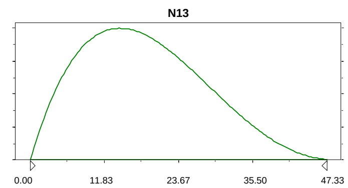


Assumption: N13 **Cell: N13**

Beta distribution with parameters:

Alpha	2.00
Beta	3.50
Scale	50.00

Selected range is from 0.00 to 48.97
Mean value in simulation was 18.27



Assumption: N14 **Cell: N14**

Beta distribution with parameters:

Alpha	1.00
Beta	260.00
Scale	50.00

Selected range is from 0.00 to 60.48
Mean value in simulation was 0.19

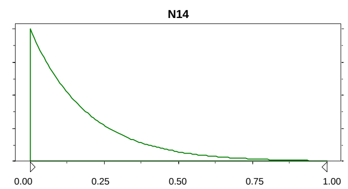


Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

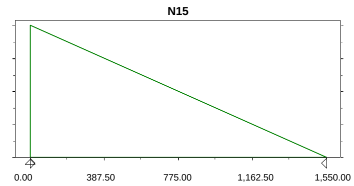
Assumptions (cont.)

Assumption: N15 **Cell: N15**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	0.00
Maximum	1,550.00

Selected range is from 0.00 to 1,550.00
Mean value in simulation was 519.03

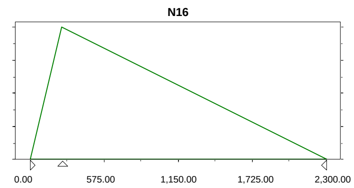


Assumption: N16 **Cell: N16**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	250.00
Maximum	2,300.00

Selected range is from 0.00 to 2,300.00
Mean value in simulation was 841.45

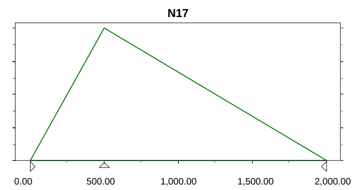


Assumption: N17 **Cell: N17**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	500.00
Maximum	2,000.00

Selected range is from 0.00 to 2,000.00
Mean value in simulation was 840.17



Assumption: N18 **Cell: N18**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	600.00
Maximum	3,000.00

Selected range is from 0.00 to 3,000.00
Mean value in simulation was 1,206.46

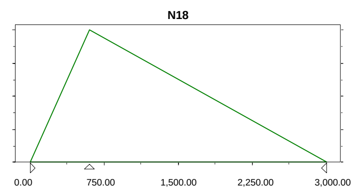


Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

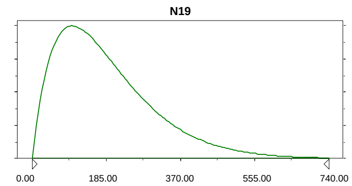
Assumptions (cont.)

Assumption: N19 **Cell: N19**

Beta distribution with parameters:

Alpha	2.00
Beta	30.00
Scale	3,000.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 188.46

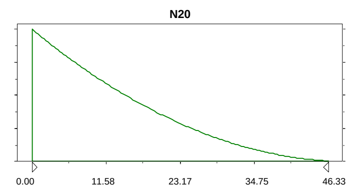


Assumption: N20 **Cell: N20**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	50.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 12.18

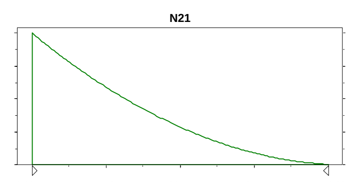


Assumption: N21 **Cell: N21**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	50.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 12.67



Assumption: N22 **Cell: N22**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	700.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 173.03

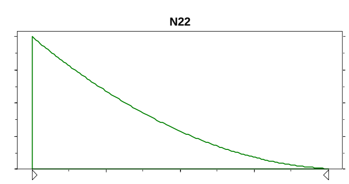


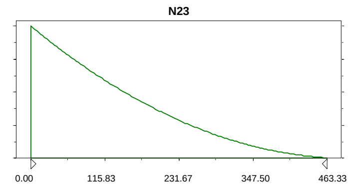
Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

Assumptions (cont.)

Assumption: N23 **Cell: N23**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	500.00

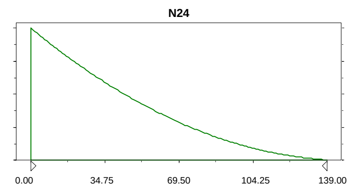


Selected range is from 0.00 to +Infinity
Mean value in simulation was 124.00

Assumption: N24 **Cell: N24**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	150.00

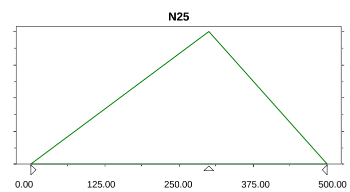


Selected range is from 0.00 to +Infinity
Mean value in simulation was 36.88

Assumption: N25 **Cell: N25**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	300.00
Maximum	500.00

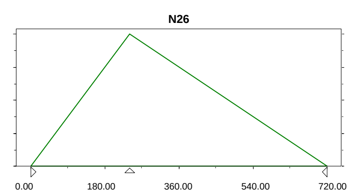


Selected range is from 0.00 to 500.00
Mean value in simulation was 268.49

Assumption: N26 **Cell: N26**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	240.00
Maximum	720.00



Selected range is from 0.00 to 720.00
Mean value in simulation was 322.70

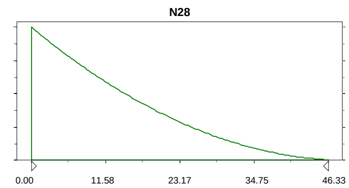
Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

Assumptions (cont.)

Assumption: N28 **Cell: N28**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	50.00



Selected range is from 0.00 to +Infinity
Mean value in simulation was 12.49

End of Assumptions

Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

ATTACHMENT IV – COMBINING TRADITIONAL AND T&PRA CONTINGENCIES

Once the cost impact of residual risks has been identified, this cost – referred to as the T&PRA contingency – may be combined with the traditional contingency and included in the project cost estimate.[5] There are various methods for accomplishing this, the simplest being algebraic addition of the T&PRA contingency estimate and the traditional contingency estimate. A more accurate reflection of this combined value can be established through probabilistic addition of the traditional and T&PRA contingencies.

The most thorough treatment of risk impact is to incorporate the cost associated with each risk directly into the cost of an identified project "item," along with the traditional contingency. For example, assume the estimated cost for procurement and installation of 100 feet of pipe is $1,000. Traditional contingency variables of quantity, unit cost, labor rates, etc. identify a distributed cost of between 90% and 125% of this value, or $900 to $1,250. Project risks, such as unexpected radiological conditions encountered in the construction area, unanticipated underground interferences, lack of integrity of the existing system, etc., identify an addition to the cost distribution of -$0/+$400. This results in a new distributed cost for the cost of the installed piping of between 90% and 165% of the estimated cost of $1000. The primary shortcomings of this method are:

- This cannot be applied unless the WBS levels have been identified in the estimate
- Many risks are identified that do not have a one-to-one alignment with a single, specific project element/WBS entry.

An alternative method for combining traditional and T&PRA contingency is to statistically combined the final distributed project cost estimate, as generated by Project Controls, with the final, distributed T&PRA contingency calculation of all risks identified for the project. If the Project Controls cost estimate is not provided as a distribution function model, an appropriate model is generated to reflect the data. This process is illustrated by the following example.

Suppose that the output generated by a project cost estimate yields the data in Table IV-1 on the following page:

[5] For a more thorough discussion on project contingency, refer to Project Management and Control Methods, WSRC-IM-95-00020, Guide 1.4, Project Contingency.[9]

ATTACHMENT IV – COMBINING TRADITIONAL AND T&PRA CONTINGENCIES

Table IV-1. Output of a Standard Project Cost Estimate

Estimated Project Cost ($50,741K)	
Probability of Overrun (%)	Contingency (%)
84	8.63
80	9.08
70	11.09
60	13.02
50	14.81
40	16.73
30	18.61
20	21.90
16	22.64

Multiplying the estimated project cost by each of the contingency percentage values results in the following confidence level versus expenditure data:[6]

Table IV-2. Project Confidence Level vs. Contingency

Confidence Level (%)	Contingency	
	(%)	($K)
0	5.30	2,689
10	7.20	3,653
16	8.63	4,379
20	9.08	4,607
30	11.09	5,627
40	13.02	6,606
50	14.81	7,515
60	16.73	8,489
70	18.61	9,443
80	21.90	11,112
84	22.64	11,488
90	24.00	12,178
100	26.00	13,193

> i.e., if the project is allocated a contingency of $4,379K to increase the estimated project cost to $55,120K, there is a 16% level of confidence that the project is underfunded.

Using the TSF example provided in Attachment III, this data is input into the Crystal Ball® spreadsheet as a probability distribution, and is then statistically summed with the individual T&PRA residual risk distributions using the Monte Carlo simulation. The result of this statistical summation is shown in Figure IV-1 on the following page.

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[6] Contingency values for confidence levels below 16% and above 84% were produced by extrapolating existing data.

ATTACHMENT IV – COMBINING TRADITIONAL AND T&PRA CONTINGENCIES

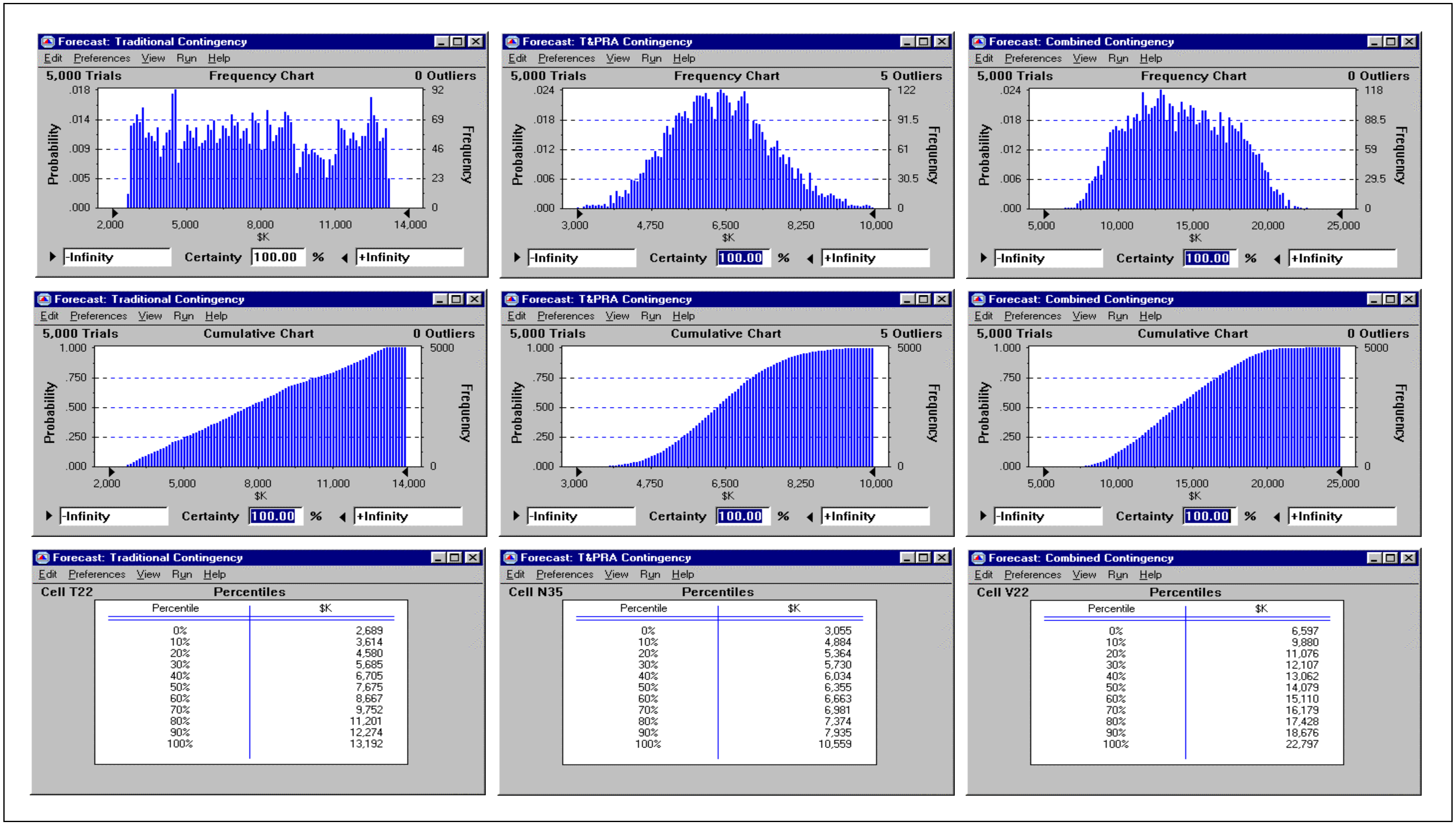

Figure IV-1. Traditional, T&PRA, and Combined Contingencies