NOT MEASUREMENT SENSITIVE

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Risk Management Guide

[This Guide describes suggested non-mandatory approaches for meeting requirements. Guides arenot requirements documents and are not to be construed as requirements in any audit or appraisalfor compliance with the parent Policy, Order, Notice, or Manual.]

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Office of Project Management

FOREWORD

This Department of Energy (DOE) Guide is for use by all DOE elements. This Guide intends to provide non-mandatory risk management approaches for implementing the requirements of DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, dated 11-29-2010. DOE programs may adopt other acceptable risk management approaches/methods as determined appropriate for the type of project and program maturity by the line management for the specific program. This Guide does not impose, but may cite, requirements. Guides neither substitute for requirements nor replace technical standards that implement requirements. Program-specific guidance takes precedence over this guide. Send citations of errors, omissions, ambiguities, and contradictions found in this guide to PMpolicy@hq.doe.gov.

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1.0 PURPOSE

The purpose of this guide is to describe effective risk management processes. The continuous and iterative process includes updating project risk documents and the risk management plan and emphasizes implementation communication of the risks and actions taken. The guidelines may be tailored according to program guidance and the needs of projects. DOE programs may adopt other acceptable risk management approaches/methods as determined appropriate for the type of project and program maturity by the line management for the specific program. A program (e.g., Office of Science) that has a methodology to adequately govern risk management may continue to use its own specific methodology.

This guide provides a suggested framework for identifying and managing key technical, schedule, and cost risks and how it integrates with the development and consistent use of government contingency and contractor management reserve. DOE Order 413.3B (the Order) states that risk management is an essential element of every project.

Risk management for this purpose is the handling of risks through specific methods and techniques within the bounds of project management. The definition of risk for this guide is a factor, element, constraint, or course of action that introduces an uncertainty of outcome that could impact project objectives. The risks to be handled should be comprised of threats and opportunities. Threats are risks with negative consequences, and opportunities are risks with positive benefits.

The suggested risk management process set forth in this guidance demonstrates a continuous and iterative process. This framework meets the requirements of the Order to be forward looking, structured, and informative. The issue of the establishment of technical design marginsto address the uncertainties or unknowns associated with the design is addressed in greater detail in the DOE Guides[1]; however, the risk and its uncertainty arising from designs are addressed by this Guide as are the necessities of increased technical oversight requirements.

Further, this risk management process has been developed to meet the overall monitoring and reporting requirements, and to allow one to continue to monitor those technical uncertainties.

2.0 SCOPE

This guide may be used by all Department of Energy (DOE) offices and the National Nuclear Security Administration (NNSA), their respective field operations, operations' contractors, and subcontractors as specified in their respective contracts.

This guide suggests processes for the initiation, planning, execution, monitoring, and close-outof the risk management throughout the life cycle of the project. As such, the concepts and practices in this guide may be tailored based upon:

- The project complexity.

[1] For example: DOE G 413.3-1, *Managing Design and Construction Using Systems Engineering*, for use with DOE O 413.3, current version.

- The size and duration of the project.
- The initial overall risk determination of the project.
- The organizational risk procedures.
- The available personnel and their skills levels for performing risk management.
- The available relevant data and its validation.

The final determination for risk management tailoring should be with the Integrated Project Team (IPT) or the Contractor Project Manager (CPM) as described in the project risk management plan. Tailoring of the risk management process generally includes selection of what risks to actively manage based on risk level, determination whether to perform a quantitative analysis, types of analysis to be performed, communication plan requirements, andtypes and frequency of reporting and monitoring.

This guidance and advice should be intended to meet, but should not be limited to, the following objectives:

- Identify the risk management processes.
- Identify the steps necessary to facilitate the implementation of those processes.
- Provide life-cycle risk management guidance.
- Provide risk management documentation guidance.
- Provide risk management monitoring and reporting guidance.

This guide should not be intended to replace assessment processes developed for nuclear safety, climate change, and environmental, safety, health, and quality (ESH&Q). It should also not be intended to replace assessment processes developed for safeguards and security. This guidance also recognizes the benefit and necessity of early consideration and integration of climate change, safety, and security related project risk into the project risk management process.

3.0 RISK MANAGEMENT ORGANIZATIONAL BREAKDOWN STRUCTURE, CONCEPT, AND RESPONSIBILITIES

3.1 Risk Management Organizational Breakdown Structure

Using the organizational breakdown structure (OBS) in the Project Execution Plan (PEP) or Project Management Plan (PMP), the risk management team should be identified along with roles and responsibilities of the team members. Whenever the PEP or PMP is updated, the risk management plan should also be updated, if changes have been made to the OBS.

The organizational breakdown structure should serve three purposes in risk management. These purposes, as well as illustrations for each purpose, are shown as follows:

- Highlights the chain of authority, communication structure, and management framework with which risk management and the decision processes will occur.
    - Assists with identifying organizational risks and/or external risks.
    - Assists with identifying where certain risk management ownership and decision processes reside.
    - Reduces time for critical risk communication.
    - Allows for documentation of risk communication chain.
- Provides a means to map risks organizationally to determine where the greatest number of risks resides and/or the highest-rated risks reside.
    - Can provide a format for the development of a Risk Breakdown Structure (see Attachment 1, Risk Breakdown Structure).
    - Provides a means of identifying risk owners.

The risk management organizational structure assists in integrating risk management into the procedures and processes of the organization. It also assists in developing the responsibility assignment matrix for key risk management roles and responsibilities in a structured and formal manner and facilitates the communication process suggested in this guide. It provides a means to link the risk breakdown structure with the organization for risk management to determine where the risks reside and who is responsible for them.

3.2 Risk Management Organizational Concept

Programs and projects are of varied types and of differing complexity. The risks may span multiple levels of organizational management, crosscut multiple organizations, and/or crosscut different sites within the complex. For risk management to be effective, it should be an integral part of the organization's corporate enterprises-governance (e.g., standards, procedures, directives, policies, and other management documentation).

In order to implement the risk management principles[2] and processes successfully, an organizational process perspective should be considered within which the risk management processes could operate. The processes and procedures, along with applicable tools to be used for performing risk management functions should be carefully considered, established, and well defined when implemented. The risk management processes described later in this guide should be carefully tailored to involve and meet the needs of the organization's internal planning, assessment, project controls, risk monitoring, reporting, and decision-making processes at the different levels of risk management.

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[2] OMB M-07-24, Memorandum for the Heads of Executive Departments and Agencies, Updated Principles for Risk Analysis, September 19, 2007. (Text cited only for the universal risk management principles and not the context they are presented within the memo.)

A clearly defined integrated risk management framework should consider the structure and interactions of the management organization(s) and management levels. These should be charted or mapped out and institutionalized (process-wise) in order to help:

- Align the organization(s) to accomplish the mission, in concert with the established requirements, policies, strategic plans, roles and responsibilities aligned via clearly defined and well-understood processes and procedures. This alignment should be done in order to meet the goals and objectives of the Department at all levels of the organization(s) supported by risk management-based decision making knowledge.

- Increase the interaction and communication between upper management and functional contributors, and to better understand all types of project risks, such as: political, economic, social, and technological, policy, program, project, financial, resource-based, climate change and extreme weather, health and safety, safeguards and security, and operational. Without this interaction, identification of risks and the communication and handling of risks cannot be adequately accomplished or be well understood.

- Apply a consistent integrated systematic risk management process approach at all levels of risk management to support decision-making and encourage better understanding and application of the risk management process. For example, the same risk can exist in different organizational levels such as the contractor, the site DOE Offices, and Program Headquarters (HQ) Offices. This risk may be shared by all the organizations and may be managed by all utilizing different perspectives. This risk can also be within the same site and crosscut and affect other capital, cleanup, information technology, or operating projects, etc.

- Build a culture that fosters risk management related learning, innovation, due diligence, responsible leadership, management participation and involvement, lessons learned, continuous improvement, and successive knowledge transfer.

- The risk management framework should be completely integrated into the procedures and processes of the organization. The risk management processes and procedures should be supported by management through self-assessments, lessons learned, and a continuous improvement environment.

3.3 Risk Management Organizational Responsibilities

The key roles, roles which have a significant impact upon the risk management of the project, and responsibilities are the highest level of project risk authority and responsibility. A complete responsibility assignment matrix for risk management roles and responsibilities should be included in the risk management plan.

3.3.1 Federal Project Director

As per DOE O 413.3B, the Federal Project Director (FPD) is responsible for leading the IPT. Throughout the project life cycle, the FPD should:

- Apply a continuous, iterative risk management process.

- Document and manage risks.
- Develop, maintain, and provide required risk documentation, and report to appropriate project and program management personnel. This includes providing configuration management for this documentation.
- Ensure a tailored approach to risk management.
- Ensure that the sponsoring program office continues to be informed of the status of project risks with potentially large cost and schedule impacts as soon as they are recognized.
- Formally accept or reject any risks that are proposed to be transferred from the contractor to the federal government (DOE or NNSA).
- Oversee acceptance and closure of risks owned by the FPD.
- Oversee the roles and responsibilities of each IPT member with respect to risk management.
- Coordinate with the project's Contracting Officer early in the acquisition process and throughout the project for contract-related risks.
- Serve as the focal point of communication between the contractor and DOE-HQ for all risk-related issues.
- Develop an environment in which lessons learned are encouraged from project experience and risk management, and develop new lessons learned as appropriate.

3.3.2 Integrated Project Team

Throughout the project life cycle, the IPT, in support of the FPD, should:[3]

- Apply the continuous risk management process.
- Document and manage the risk management process contained within the risk management plan and the risk management communication plan (see Section 5.3, Risk Management Communication Plan).
- Provide documentation and management of risks throughout the project life cycle via the project risk register (see Section 4.3.5, Risk Register, and Attachment 1, Risk Breakdown Structure).

[3] Additional information on the IPT roles and responsibilities is provided in DOE Guide 413.3-18, *IntegratedProject Team Guide*, current version.

- Develop and provide the project risk status report (see Attachment 2, Risk Status Report) to management.

3.3.3 Contractor Project Manager

The CPM manages risks under the Contract Budget Base (see Attachment 11, Figure A-1) independently subject to the requirements set in the procurement contract. The risk management responsibilities of the CPM, unless otherwise directed by the contract terms and conditions as they bound the project life cycle, should be to: (see Section 7 and Attachments 11-14 for a discussion on contractor's risks and their management under the Contract Budget Base)

- Apply a continuous, iterative risk management process for all contractor risks.
- Document and manage contractor risks and transfer to the Government, with FPD concurrence, risks that are not the contractor's responsibility.
- Develop, maintain, and provide required risk documentation (using configuration management) and reporting to appropriate project and program management personnel. This includes providing configuration management for this documentation.
- Ensure the project's Contracting Officer continues to be informed of the change control process and that the supporting documentation is generated for managing risks within the Contract Budget Base.
- Coordinate with the FPD in the development of a tailored approach to overall project risk management.
- Coordinate with the FPD in the process of recognition, acceptance and closure of key project risks.

3.3.4 DOE/National Nuclear Security Administration Headquarters

Headquarters program office personnel should:

- Provide guidance on the risk management process.
- Provide support to site office programs in the evaluation, analysis, assessment, and reporting of risk.
- Provide support to site office programs for training and education in risk management.
- Facilitate information sharing on risk management best practices, trends, and publications.
- Interface with the FPD and IPT for risk.

4.0 RISK MANAGEMENT PROCESS WITHIN THE PROJECT LIFE CYCLE

4.1 Project Phase Integration

This risk management guide is integrated with DOE O 413.3B, but it also suggests process steps beyond those stated in DOE O 413.3B in some specific instances, such as the Risk Register. The risk management process is a continuous, iterative process that is performed as early in the project life cycle as possible.

Wherever possible, the project phases in DOE O 413.3B should be aligned with the risk management process to allow an integrated view (Figure 1). Figure 1 provides a view of the steps of the risk management process against the Critical Decision Phases of a project. While this view presents a static view of risk management, it is not meant to infer that the process is static. Instead, it is meant to demonstrate when one should initiate certain process steps for the first time.

The risk management plan should be included in or referenced in the preliminary project execution plan during CD-1 (see Section 5.2, Risk Management Plan).

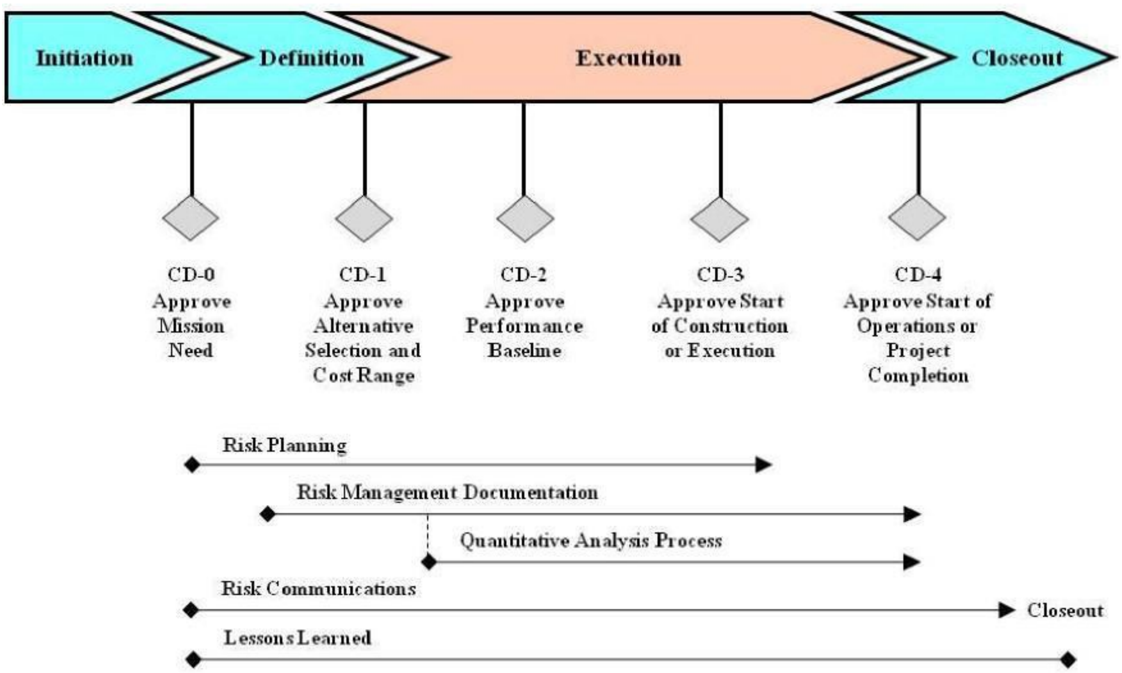


Figure 1. Critical Decision Phases with Continuous and Iterative Risk Management

While the process flow appears linear, the process itself is iterative and not necessarily consecutive. The risk planning step, for example, is continuous throughout the project life cycle,as is the need for risk communication and documentation. The pattern that is represented by the linear process diagram (Figure 2) demonstrates that certain steps generally precede others; however, as the project proceeds, the review processes do not necessarily progress in the same manner.

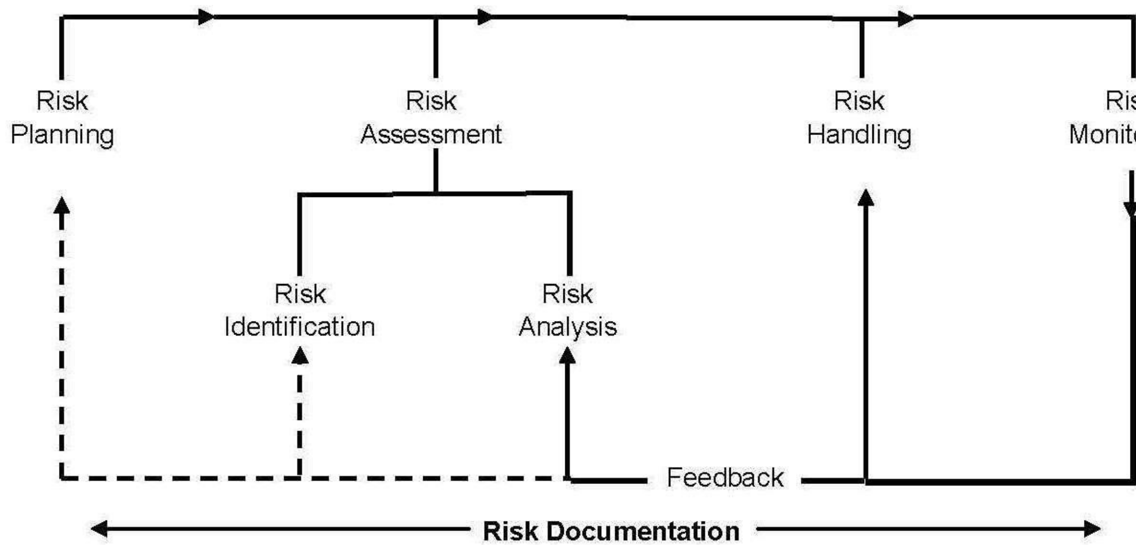


Figure 2. Risk Management Process.
Linear Representationof the Continuous and Iterative Process

4.2 Risk Planning

The risk planning process should begin as early in the project life cycle as possible. Planning sets the stage and tone for risk management and involves many critical initial decisions that should be documented and organized for interactive strategy development.

Risk planning is conducted by the IPT[4] (if assembled by this time) and a FPD or an assigned lead federal employee if the FPD is not yet assigned. Risk planning should establish methods to manage risks, including metrics and other mechanisms or determining and documenting modifications to those metrics and mechanisms. A communication structure should be developed to determine whether a formal risk management communication plan should be written and executed as part of the tailoring decisions to be made in regard to the project (see Section 5.3, Risk Management Communication Plan, and Section 6.0, Tailoring of Risk Management). Input to the risk planning process includes the project objectives, assumptions, mission need statement, customer/stakeholder expectations, and site office risk management policies and practices.

The team should also establish what resources, both human and material, would be required for successful risk management on the project. Further, an initial reporting structure and documentation format should also be established for the project.

Overall objectives for risk planning should:

- Establish the overall risk nature of the project including recognizing the relative importance of the project o the office with the DOE or the NNSA (to include its priority ranking within the organization).

[4] For a discussion and guidance on the types of skill sets (which include Subject Matter Experts in Risk Management) that should be represented on an IPT see DOE G 413.3-18, *Integrated Project Teams Guide*, current version.

- Establish the overall experience and project knowledge desired of the IPT.
- Establish the technical background and risk knowledge desired of the IPT.

An initial responsibility assignment matrix with roles and responsibilities for various risk management tasks should be developed (see Attachment 3, Risk Responsibility Assignment Matrix). Through this Responsibility Assignment Matrix, gaps in expertise should be identified and plans to acquire that expertise should be developed.

The result of the risk planning process is the Risk Management Plan (see Section 5.2, Risk Management Plan). The Risk Management Plan (RMP) ties together all the components of risk management – i.e., risk identification, analysis, and mitigation – into a functional whole. The plan is an integral part of the project plan that informs all members of the project team and stakeholders how risk will be managed, and who will manage them throughout the life of the project. It should be part of the initial project approval package. A companion to the RMP is a Risk Register which is updated continuously and used as a day-to-day guide by the project team.

4.3 Risk Assessment

Risk assessment includes the overall processes of risk identification and analysis. The risk assessment process identifies, analyzes, and quantifies potential program and project risks in terms of probability and consequences. Risk analysis is a technical and systematic process that is designed to examine risks, identify assumptions regarding those risks, identify potential causes for those risks, and determine any relationships to other identified risks, as well as statingthe overall risk factor in terms of the probability and consequence, if the risk should occur. Risk identification and analysis are performed sequentially with identification being the first step (see Attachment 5, Risk Register).

4.3.1 Risk Identification

As with each step in the risk management process, risk identification should be done continuously throughout the project life cycle. As projects change - particularly in terms of budget, schedule, or scope - or when a mandatory review or update is required, the risk identification process should be iterated, at least in part. Post CD-1, the Risk Register should be evaluated at least quarterly.

To begin risk identification, break the project elements into a risk breakdown structure that is the hierarchical structuring of risks. The risk breakdown structure is a structured and organized method to present the project risks and to allow for an understanding of those risks in one or more hierarchical manners to demonstrate the most likely source of the risk. The risk breakdown structure provides an organized list of risks that represents a coherent portrayal of project risk and lends itself to a broader risk analysis. The upper levels of the structure can be set to project, technical, external, and internal risks; the second tier can be set to cost, schedule, and scope. Each tier can be broken down further as it makes sense for the project and lends itself to the next step of risk analysis. To be useful, the risk breakdown structure should have at least three tiers.

Such a breakdown is just one methodology, as the type of project or project organization may dictate the best risk breakdown structure to apply. Templates for project types may be found in the literature for software projects, construction projects, and others; however, these templates should be modified based upon the specifics of the project being undertaken. The reason for this statement is that the taxonomy to be used is often project specific and scope dependent (see Attachment 1, Risk Breakdown Structure).

Whenever using the Risk Breakdown Structure, it is important to remember to consider the use of a category called “other." This category will promote further brainstorming during the process and provide another opportunity for risk identification.

The risk breakdown structure can be used to inform the following:

- Updates of the risk management plan.
- Work breakdown structure.
- Cost estimates.
- Key planning assumptions.
- Preliminary schedules.
- Acquisition strategy documents.
- Technology Readiness Assessment (TRA) information.
- Project Definition Rating Index (PDRI) analyses.
- EM Project Critical Decision Assessment Tool (CDAT) analyses.
- Safety-in Design considerations per DOE-STD-1189-2016.
- Safety analysis assumptions.
- Environmental considerations such as seismic, climate change and extreme weather (e.g., wind and flooding).
- Safeguards and security analysis assumptions.
- Requirements documents or databases.
- Subject matter expert interviews.
- Stakeholder input.
- Designs or specifications.
- Historical records.

- Lessons learned.
- Any legislative language pertaining to the project.
- Other similar projects.
- Pertinent published materials.

Various techniques that can be used to elicit risks include brainstorming, interviews. and diagram techniques. Regardless of the technique, the result should not be limiting and should involve the greatest number of knowledgeable participants that can be accommodated within their constraints. In addition, the participants need to address risks that affect the project but are outside of the project ability to control. Examples include:

- Closure of Waste Isolation Pilot Plant.
- National repository not ready.
- Congressional funding reductions.
- DOE funding reductions.
- Re-programming.
- Stakeholder changes.
- Site mission changes.
- Regulatory and Statutory changes.
- DOE directives.

Once the process of initial risk identification is completed, the IPT should follow up with the self-assessment process noted in Section 4.7.2.2, Self-Assessment, using the Risk Identification Checklist in Attachment 8.

As the team identifies risks, it is important that they are aware of biases that may influence the information. Typical biases the facilitator of the risk identification should be aware of include the following:

- Status quo—strong bias toward risks already identified.
- Confirming evidence bias—information that supports existing points of view are championed while avoiding information that contradicts.
- Anchoring—disproportionate weight is given to the first information provided.

- Sunk cost—tend to make choices in a way that justify past choices, unwillingness to change direction.

When identifying a risk, it should be stated clearly in terms of both the risk event and the consequences to the project. The format for the risk identified should generally be cause / risk / effect.

One may choose to record cause, risk, and effect in separate fields to facilitate grouping of risks into categories based on commonality of these attributes.

This format should be employed whether the risk is a threat to the project or an opportunity, which is a risk with a benefit. Documentation should be done in affirmative terms - as if the risk will occur - to enable the IPT to draft a definitive risk handling strategy. The information should be captured in a risk register to facilitate tracking and reporting (see Attachment 1, Risk Breakdown Structure).

Examples of risks captured in the affirmative are:

- Discovery of classified material in landfill delays removal of transuranic material and impacts schedule resulting in higher than expected project costs.

- Delay in signing a cooperative research and development agreement impacts availability of specialized research personnel in statistical analysis of nano-scale stress data of carbon-based metals, delaying project by one year resulting in higher than expected project costs.

- Seismic site analysis area is expanded due to adjacent construction site seismic reports, resulting in new drilling and reporting that delays site preparation by six months resulting in higher than expected project costs.

- Project complexity and size limits the number of contractor proposals competing for the work, project costs are based on a limited number of proposals for work, resulting in higher than expected project costs.

Risks should be linked to activities or Work Breakdown Structure as much as possible. The linkage is important, especially if the risk owner is different as the risk owners may need to coordinate their efforts on the risk handling strategies.

The IPT should capture both opportunities and threats. Opportunities are often shared between and among projects. It should be noted that opportunities for one participant could be detrimental to another; therefore, they should be worked cooperatively. Examples of opportunities include:

- Available human resources with flexible scheduling can be shared to the advantage of two or more projects.

- A crane is available at another site at a lower cost than purchasing a new or a used one.

- Additional bench scale testing shows that the process flowsheet can be simplified.

In addition to identifying a risk in terms of the causal event and consequence, the pertinent assumptions regarding that risk should be captured in the risk register to aid in future reporting of the risk. These assumptions might include items such as, but not limited to, interfaces amongand between sites, projects, agencies, and other entities; dependencies on human resources, equipment, facilities, or other; and historically known items that may impact the project either positively or negatively. The assumptions should be kept current and should be validated through various methods including documentation and subject matter experts.

4.3.2 Assignment of the Risk Owner

Before assigning a qualitative assessment to the dimensions of a risk (probability and consequence), a risk owner should be identified. The risk owner is the team member responsible for managing a specific risk from risk identification to risk closeout and should ensure that effective handling responses or strategies are developed and implemented, and should file appropriate reports on the risk in a timely fashion. The risk owner should also validate the qualitative and quantitative assessments assigned to their risk. Finally, the risk owner should ensure that risk assumptions are captured in the risk register for future reference and assessment of the risk and to assist possible risk transfer in the future.

Any action taken in regard to a risk should be validated with the risk owner before closure onthat action can be taken.

4.3.3 Assignment of Probability and Consequence

Risk analysis has two dimensions—probability and consequence. Probability is the likelihood of an event occurring, expressed as a qualitative and/or quantitative metric. Consequence is the outcome of an event. The outcome of an event may include cost and/or schedule impacts. The initial assessments should assume that no risk handling strategy has been developed (see Section 4.3.6.1, Qualitative Risk Analysis and Section 4.3.6.3, Project Learning Analysis). After the risk mitigation approach is identified and a decision made to implement the mitigation, the mitigation cost becomes part of the line-item cost and not the contingency. Only the remaining residual risk should be included in the risk register and contingency analysis. During the qualitative analysis, the probability and consequence scales can be categorical. However, it is often useful to assign quantitative metrics to the qualitative categories to help ensure consistent assignment of probabilities and consequences across a project (see Attachment 4, Probability Scale/Schedule Consequence Criteria). This approach works well for probability and consequence.

4.3.4 Assignment of Risk Trigger Metrics

A risk trigger metric is an event, occurrence or sequence of events that indicates that a risk may be about to occur, or the pre-step for the risk indicating that the risk will be initiated. The risk trigger metric is assigned to the risk at the time the risk is identified and entered into the risk register. The trigger metric is then assigned a date that would allow both the risk owner and the FPD to monitor the trigger. The purpose of monitoring the trigger is to allow adequate preparation for the initiation of the risk handling strategy and to verify that there is adequate cost and schedule to implement the risk handling strategy.

4.3.5 Risk Register

The risk register is the information repository for each identified risk. It provides a common, uniform format to present the identified risks. The level of risk detail may vary depending upon the complexity of the project and the overall risk level presented by the project as determined initially at the initiation phase of the project.

The fields stated here are those that should appear in the risk register, whether the risks presented are a threat or an opportunity. Other fields that are suggested to be considered are contained in Attachment 5, Risk Register, and are suggested to be included as they allow a much better view of the full field of options available:

- Project title and code (denotes how the project is captured in the tracking system used by the site office and/or contractor).
- Unique risk identifier (determined by the individual site).
- Risk statement (consider separate sub-fields to capture cause/risk/effect format to facilitate automated search capabilities on common causes of risks).
- Risk category (project, technical, internal, external, and any sub-category that may be deemed unique to the project such as safety or environment).
- Risk owner.
- Risk assumptions.
- Probability of risk occurrence and basis.
- Consequence of risk occurrence and basis.
- Risk cause/effect.
- Trigger event.
- Handling strategy (type and step-wise approach with metrics, who has the action, planned dates, and actual completion dates). Include the probability of success for the risk handling strategy and consider probabilistic branching to account for the handling strategy failing.
- Success metric for overall handling strategy.
- Residual risks.
- Secondary risks.
- Status (open/closed) and basis.

The risk register may also include back-up strategies for primary risks, risk handling strategies for residual and secondary risks, the dates of upcoming or previous risk reviews, and a comment section for historical documentation, lessons learned, and subject matter experts' input.

4.3.6 Risk Analysis

Risk analysis should begin as early in the project life cycle as possible. The simplest analysis is a cost and benefit review, a type of qualitative review. The qualitative approach involves listing the presumed overall range of costs over the presumed range of costs for projected benefits. The result would be a high-level overall assessment of the risks on the project (see Attachment 6, Cost/Benefit Analysis, for an alternative quantitative approach that can be used when enough information is available).

After CD-1 approval, two forms of risk analysis may be performed: Qualitative and quantitative. These analyses serve as the foundation for continuing dialog about future risk realizations and the need for the application of the contingency and management reserve, which are subjects addressed in other DOE G 413.3-series guides that handle cost and contingency calculations.

4.3.6.1 Qualitative Risk Analysis

The purpose of qualitative risk analysis is to provide a comprehensive understanding of known risks for prioritization on the project. Qualitative risk assessment calls for several risk characteristics to be estimated:

- Assumptions.
- Risk probability.
- Risk consequence.
- Trigger metrics or conditions.
- Affected project elements.
- Others, as appropriate.

These items should be captured in the risk register. The initial qualitative assessment is done without considering any mitigation of the risk, that is, prior to the implementation of a handling strategy.

Qualitative analysis, or assessment as it is sometimes referred, is the attempt to adequately characterize risk in words to enable the development of an appropriate risk handling strategy. Additionally, qualitative analysis assigns a risk rating to each risk, which allows for a risk grouping process to occur. This grouping of risks may identify patterns of risk on the project. The patterns are indicative of the areas of risk exposure on the project. The qualitative analysis may be the foundation for initiating the quantitative risk analysis, if required.

4.3.6.1.1 Qualitative Matrices Analysis

One of the tools used to assign risk ratings is a qualitative risk analysis matrix, also referred toas a probability impact diagram or matrix (see Figure 3, Qualitative Risk Analysis Matrix).

Risk ratings are also often referred to as risk impact scores. The matrix shown in Figure 3 is an example of the tool and could be modified by site and contractor, or any other category as required.

The matrix combines the probability and consequence of a risk to identify a risk rating for each individual risk. Each of these risk ratings represents a judgment as to the relative risk to the project and categorizes at a minimum, each risk as low, moderate, or high. Based on these risk ratings, key risks, risk handling strategies, and risk communication strategies can be identified.

As with a threat, an opportunity should also be assessed using a risk assessment framework (see Attachment 7 for an example of an opportunity matrix). Risk ratings should be assigned via a matrix to the risk, threat, or opportunity, based upon the risk classification. Typical risk classifications are low, moderate, or high. Another option could be to use numerical values for ratings. The numerical value could be tailored to the project or standardized for a program.

Risks that have a determinative impact upon project cost or schedule will generally rate towards the higher end of the qualitative scale. However, a risk's qualitative risk rating, does not necessarily correlate with its determinative impact. Therefore, one should exercise caution with the lowest rated risks in the qualitative analysis.

Care should be taken when comparing project risk scores of different projects as the project risk scores are a result of a subjective process and are prepared by different project teams.

Qualitative risk analysis could also be performed on residual risks and secondary risks, but only after the handling strategy has been determined for the primary risk. Again, the risk owner should validate and accept the risk rating.

As the information is gathered and finalized, the data should be analyzed for bias and perception errors. While the data will not be systematically used for a quantitative analysis, it should still be analyzed and perceptions scrutinized.

Following the completion of the qualitative analysis, one should do a review of Section 4.3.6.3, Project Learning Analysis.

Figure 3. Qualitative Risk Analysis Matrix.
Note: Matrix is suggested only, as each site may have a site-specific matrix.

Probability \ Consequence	Negligible	Marginal	Significant	Critical	Crisis
Cost	Minimal or no consequence. No impact to Project cost.	Small increase in meeting objectives. Marginally increases costs.	Significant degradation in meeting objectives significantly increases cost; fee is at risk.	Goals and objectives are not achievable. Additional funding may be required; loss of fee and/or fines and penalties imposed.	Project stopped. Funding withdrawal; withdrawal of scope, or severe contractor cost performance issues.
Schedule	Minimal or no consequence. No impact to Project schedule.	Small increase in meeting objectives. Marginally impacts schedule.	Significant degradation in meeting objectives, significantly impacts schedule.	Goals and objectives are not achievable. Additional time may need to be allocated. Missed incentivized and/or regulatory milestones.	Project stopped. Withdrawal of scope or severe contractor schedule performance issues.
Very High >90%	Low	Moderate	High	High	High
High 75% to 90%	Low	Moderate	Moderate	High	High
Moderate 26% to 74%	Low	Low	Moderate	Moderate	High
Low 10% to 25%	Low	Low	Low	Moderate	Moderate
Very Low <10%	Low	Low	Low	Low	Moderate

4.3.6.1.2 Other Qualitative Techniques

One qualitative technique that may be used is to search on the risk register for common causes of risks. By looking for risks with common causes, one can attempt to find opportunities within the handling responses or strategies as well as commonalities in monitoring triggers, risk owners, or other shared items. Further, it may be that changes can be made to the scope to avoid the risks that were not apparent when viewing the risks individually.

Another qualitative technique for analyzing risks is to use a network diagram. Using a network diagram to show what tasks bear the high and moderate risks and where they exist in regard to the critical path can be a powerful tool in analyzing how much contingency should be set aside for the risk to ensure that the critical path is not impacted or the risk to the critical path is within a manageable range for the FPD. The diagram is used to determine the impact to successor tasks, especially those that either impact the critical path directly or will have an impact upon a critical input to the critical path.

The risk breakdown structure methodology provides the option of demonstrating patterns of risk placement or risk groupings. For instance, rather than specifying the risk, the risk is captured as a mark on the grid and grouped together, then cut across with another matrix technique such as the work breakdown structure or the cost breakdown structure. (See reference – Hillson, D. A. (2007), ‒Understanding risk exposure using multiple hierarchies, published as part of 2007 PMI Global Congress EMEA Proceedings – Budapest).

The risk is mapped to the work breakdown structure element that would be impacted if it occurred. The pattern that emerges allows one to either use the assigned expected value score or to count the number of risks associated with the element. This method allows attention to be focused on specific areas of risks.

Again, a review of Section 4.3.6.3, Project Learning Analysis, should be done.

4.3.6.2 Quantitative Risk Analysis

Quantitative risk analysis should be used to estimate the impact of risks on project cost and schedule. Quantitative risk analysis is a numerical or more objective analysis of the probability and consequence of individual risks that also addresses the extent of the overall project risk through the use of a model. The purpose of the quantitative risk analysis is to provide budget and completion date estimates of the effect of the risks on the project using statistical modeling techniques such as Monte Carlo, Quasi-Monte Carlo, sensitivity simulations, and other stochastic methodologies, depending upon the project data. The simulation produces a Probability Distribution Function (PDF) for a range of possible project outcomes and a Cumulative Distribution Function (CDF) that represents the likelihood that a given probability the project cost or duration will be at or below a given value (see Attachment 12, Cost and Schedule Contingency Development Process, Figure A-3). Quantitative risk analysis could provide a view of which risks or groups of risks should receive more focused attention. It allows a numerical evaluation of risk on the project at a point in time. The simulations could also assist in projecting the future cost and schedule of the project, if no other actions are taken, as well as allow for projections to be run based on options the project could implement. Quantitative analysis could also provide a method to determine the level of cost contingency, management reserve, schedule contingency, and schedule reserve, when combined with cost uncertainty calculations, that is required to complete the project within the level of confidence required by the DOE or NNSA program office.

In general, quantitative analysis is an attempt to determine how much combined risk the project contains and where and when that risk exists to enable the project team to focus the project resources appropriately. Quantitative risk analysis has in the past been reserved for multi-year, large, and/or complex projects or projects where the program or executive management desires a more informed decision as to the amount of risk that exists on the project. Some DOE offices allow for tailoring with respect to quantitative risk analysis. The reason for this type of tailoring is that quantitative analysis allows for the use of different scenarios and alternatives to the base case. However, for overall low risk projects, as determined by the qualitative analysis, it may be determined that quantitative analysis is not warranted.

Quantitative analysis, when done, could be restricted to only those risks that are ranked higher than low as the overall risk ranking from the qualitative analysis process. When this is done, the magnitude of the underestimation should be addressed. The critical path for the project and the approved budget serve as the primary basis for the risk model and for the project analysis.

It is important to model both risk threats and opportunities. It is suggested that the two types of risk are modeled separately to allow for separate analysis given the different project impacts that the two forms may have.

4.3.6.2.1 Quantifying Probabilities and Impacts for Quantitative Risk Analysis

A complete and well executed qualitative analysis is essential to a quantitative analysis. It will serve as the base for developing the data for input into a simulation model for quantitative analysis.

For each risk, a percent or percentage distribution is assigned to the probability (how likely it is the risk will occur), a dollar value or dollar value distribution is assigned to the cost impact, and a schedule duration impact or duration distribution is assigned to the affected activity in the schedule. Depending upon the software modeling program being used, the percent may need to be within a specified range. A variety of probability distribution shapes are available for modeling cost and schedule risk, including triangular, lognormal, beta, uniform, normal distributions, etc. Definitions and a more thorough discussion of the various distribution shapes, and their applicability, are available in Chapter 12 of the GAO Cost Assessment and Estimating Guide, March 2020.

In general, the basic concept is implemented as: $EV = \sum PRi \times CIRi$ (or SIRi)

Where: EV = Expected Value of cost impact (or duration impact) of all risks PRi = Probability distribution function of a risk occurring CIRi = Cost Impact distribution function of a risk occurrence SIR i = Schedule Impact distribution function of a risk occurrence.

[Note: ∑ is not the summation of individual expected values for each risk, but represents a stochastic process (e.g., Monte Carlo simulation) using the collective probabilities and cost/schedule impacts for all identified risk events.]

Inputs for the calculation include, but are not limited to:

- Risk Register.
- Historical records (especially where similar risks were handled).
  - Actual costs.
  - Time impact.
- Subject matter experts.
  - Delphi techniques.
  - Interviewing staff, crafts, retirees, and others familiar with similar work efforts at the site or other sites.
- Technical records such as safety analysis documents including the risk and opportunity assessment, quality assessments, safeguards and security analyses, and environmental assessments.

As information is gathered and finalized, it should be reviewed for bias and perception errors. These findings should be captured in the analysis that accompanies the Monte Carlo simulations. Consideration should also be given to the success of the identified risk handling strategy and how the potential failure of the handling strategy will be reflected in the risk impact modeling strategy. The preferred method for analyzing this risk could be to explicitly include the probability of mitigation success in the quantitative analysis (See Section 4.3.5, Risk Register).

Another item that should be considered in this analysis is a review of any project constraints that may impact the cost and schedule ranges assigned to the risks. Examples of project constraints include the bounding assumptions identified in the risk management plan or risk analysis, which might limit the impact of certain risks. If some of the bounding assumptions are unrealistic and introduce risks to the project, then these risks should be included in the risk analysis. While some of the constraints may be hard to measure, they should still be captured, for significant risks, in the text of the analysis so that the risks are considered as they make decisions regarding the future handling of the risks and any contingency requests or management reserve applications.

The inputs into a Monte Carlo simulation process are normally continuous probability distributions; however discrete probability distributions can also be used, where the need for distinct values can be described. The most common methodology is to use a cost and schedule range, expressed as the optimistic view, the most likely view, and the pessimistic view of the impacts. However, if no central tendency exists for a distribution, a two-point estimate could also be used.

For schedule impact evaluation, the logic-linked project schedule should be utilized as input to allow the random sampling process to be tied to the critical path analysis. The project schedule should contain sufficient logic linkage between the activities to clearly identify critical path and near-critical path activities. The Monte Carlo simulation process simulates the full system and its variables (risks) by random sampling the variables many times from its probability distribution. Each time it develops a modified duration for each risk-related task or activity and determines the project length based on the re-analyzed critical path. The results of the independent system realizations are assembled into probability distributions of possible outcomes. As a result, the outputs are not single values, but probability distributions. A similar process can be executed for cost using the project cost estimate or a detailed cost loaded schedule. Both threats and opportunities should be analyzed.

While the use of the Monte Carlo simulation is one of the standards of the DOE/NNSA, it does not mean that other forms of quantitative analysis are discouraged. Other forms of quantitative analysis may be used. Suggested other forms of quantitative analysis that may be considered are decision trees, influence diagrams, system dynamics models, neural networks (see Attachment 15, Glossary, for definitions), and others.

4.3.6.2.2 Integrated Schedule and Cost Risk

Integrating schedule and cost risk, also known as joint cost and schedule confidence level (JCL) analysis, generates a representation of the likelihood a project will complete its scope and achieve its key performance parameters on time and within budget. Conduct this analysis with risks, prioritized by likelihood of realization and impact, appearing in the risk management plan and a fully burdened resource-loaded integrated master schedule with uncertainties associated with activities. The process uses software tools that examine the schedule and cost implications of the hypothetical realization of risks or manifestations of uncertainty to generate an integrated probability distribution. The Association for the Advancement of Cost Engineering International (AACE International)[5] Recommended Practice (RP) 57R-09, Integrated Cost and Schedule Risk Analysis Using Risk Drivers and Monte Carlo Simulation of a CPM Model, provides a method for simultaneously considering schedule and cost risks. The AACE RP 113R-20, Integrated Cost and Schedule Risk Analysis and Contingency Determination Using Combined Parametric and Expected Value provides techniques to deal with baselines using combined methods of cost estimating. Implement JCL on major systems projects in preparation for CD-2 and thereafter.

4.3.6.2.3 Additional Points of Analysis That Should be Included

The purpose of providing the additional analysis is two-fold. First, simulation graphs should be supported with assumptions and data input (cost and schedule ranges, and probability distributions) captured for each risk, and sensitivity analysis conducted to provide the necessary information to enable an increased understanding of a project's risk exposure. Second, it

[5] Reference https://web.aacei.org/resources/publications/recommended-practices to see recommended practices(Cost for these documents should be factored into other direct costs).

provides decision-makers with a basis to engage the project team in discussions relevant to project risks.

4.3.6.2.3.1 Planning Assumption Validation Analysis

Analyses accompanying Monte Carlo simulation data, including graphs, should include the review of assumptions that serve as the basis for planning the budget and schedule of the project from which risks arose. Since assumptions have a basis in fact, but are not facts themselves, they should ensure they are still operable and as accurate as possible.

4.3.6.2.3.2 Cost and Schedule Quantification Range Assumption Data – GatheringProcess and Validation Analysis

As the costs and schedule ranges are captured for each risk for input into the Monte Carlo simulation runs, the assumptions that formed the basis for those ranges should be captured. The risks that are input may include low risks. The reasons for capturing those assumptions are to form an historic database for future projects, an historic database for the current project, a reference to substantiate how the projected federal contingency or the contractor management reserve/contingency was derived, and as a basis to determine the possible range of error that may exist in the data upon which the Monte Carlo data is based.

4.3.6.2.3.3 Alternative Run (Sensitivity) Analyses

A project may choose to execute further Monte Carlo simulations beyond the overall schedule and cost runs. These may include targeted runs pertaining to specific risks or key risks and their effects on various planned activities or the overall project. Further groupings of risks may be chosen and the affects simulated against the schedule and cost of the project. Chapter 11 of the GAO Cost Estimating and Assessment Guide provides a more thorough discussion of the benefits of sensitivity analysis, including the steps for performing sensitivity analysis.

In choosing to make these runs, it is important to identify the correlation factors (interdependencies and relationships between risks), especially when those have become more apparent when the runs are done after the project has been in the execution phase for several months or years. The constraints of how various risks or similar risks will impact a project will demonstrate characteristics that can be identified and captured as assumptions. While risks are independently identified in most cases, they operate within the confines of the project and have interdependencies, relationships, both positive and negative, as well as dependencies to other projects within the same program area. In other words, there are defined relationships that should be explored. These relationships can give rise to other latent risks or risks that have remained undiscovered to date until these systematic relationships are reviewed. Chapter 12 of the GAO Cost Estimating and Assessment Guide offers a relevant discussion of correlation and interdependencies.

4.3.6.3 Project Learning Analysis

A section of the Monte Carlo simulation written analysis should focus on the incorporation of project learning, or, in other words, lessons learned. If the project is new, this section may be the transference of learning from other projects. If the analysis is an update of the Monte Carlo simulation analysis, it should include learning from prior periods. This analysis should include insight into how risks have thus far presented themselves, how accurate the assumptions and estimations have been, how those assumptions may or may not impact the simulation results, and any other observations that the team finds are relevant to the projections. If the analysis represents lessons learned that are applicable to other DOE entities, the learning should be distributed by submitting lessons learned.

In the quantitative analysis, one should discuss whether bias and perception errors could have influenced the data. Such errors in regard to the incorporation of information from lessons learned can arise from both an overly optimistic or pessimistic view of project status. This view can result in a misunderstanding of the applicability of the lesson to the project in question, caused by the bias of the project team to the lesson presented or by a variety of sensitivities to the data. The results of reviewing the data and questioning of whether any bias or misperception could have occurred should appear in the written analysis that accompanies the data. This analysis is often best provided by independent subject matter experts.

In regard to the impact on the simulation results, the analysis should focus on the calculation of the contingency values. The usefulness of this analysis is in the follow-on risk discussions that occur during the monthly reviews of risks wherein the impacts of risks are reviewed along with the various assumptions as lessons learned are applied. By bringing the learning together with the analysis, the FPD and CPM are potentially better prepared for how risks will react on the project or how handling strategies will potentially mitigate the identified risks.

This process of applying lessons learned is also recommended for projects, which perform only qualitative analysis.

4.3.6.4 Error and Variance Analysis

Depending upon the size of the project and data bank being entered for any given simulation, it may be necessary to subjectively estimate extreme values to "bound" the magnitude of possible outcomes. If this case situation arises, it could introduce random errors into the simulation, which could potentially impact the results. If this occurs, it should be disclosed and any error or bias should be discussed, as well as any methodology—triangle distribution, for example-used to reduce such an impact (see Attachment 15, Glossary, for definition of triangle distribution).

Risk attitude, the explicitly stated or unstated position that the organization holds towards risk, is one factor that can influence how risk is handled and how values are assigned and should be included in the analysis. For example, it influences how one views the ranges of the values and whether future values are considered and how, when considered, they are bounded. This line of reasoning should be a subject of group discussion in the analysis in an effort to mitigate biases or estimating errors.

Given that most risk impacts are estimates, some error is expected, and the introduction of some range of error should be discussed. Even though the values generated by the Monte Carlo simulation may be carried to several decimal points, it is important to remember that these numerical values are indicators, not absolute values.

One suitable methodology for analysis purposes is variance analysis. Generally, variance analysis is a tool that is used once the project has been under way for a period of time and has some data from which the project manager and subject matter experts can use for determining the expected values that are used to calculate the variance analysis.

Quantitative and qualitative analyses serve as the foundation for continuing dialog about future risk realizations and the need for the application of the contingency and management reserve. The written analysis that is derived from the quantitative and qualitative analyses should address how policy has impacted the outcome of the data; the evaluation of the reliability, software relevant issues, other variances which may have been introduced, how a pattern has been applied, what it is and what choices were made to remain consistent in the application thereof and the impact. The benefits of this approach, relative to other potential approaches, should be addressed.

4.3.6.5 Contingency Adequacy Evaluation

Numerous tools exist to analyze the adequacy of the contingency valuation that has resulted from the qualitative and/or quantitative analysis of the risks. Various cost estimating guidance documents have been compiled by industry and are available in texts and journals, such as AACE International[6], and are updated on a regular basis. These references provide percent ranges of the base that a contingency should represent to be considered adequate. Further, the contingency value should be commensurate with the maturity and type of the project, project size, and risks, including technical and technology uncertainties. It should be cautioned that the recommended contingency levels in these documents do not provide a basis for the recommended confidence levels (70 – 90 percent) in this Guide for the derivation of contingency and management reserveby quantitative risk analysis.

If a quantitative risk analysis will not be conducted, estimates for cost contingency and schedule contingency should be provided. As a general rule, the project should use various inputs to determine those values. Those inputs may be, but should not be limited to:

- Historical records.
  - Actual costs.
  - Time impact.
- Subject matter experts.
  - Delphi techniques.
  - Interviewing staff, crafts, retirees, and others familiar with similar work efforts at the site or other sites.

[6] Reference https://web.aacei.org/resources/publications/recommended-practices to see recommended practices(Cost for these documents should be factored into other direct costs).

- Technical records such as safety analysis documents including the risk and opportunity assessment, quality assessments, and environmental assessments.

- Climate change and extreme weather trends utilizing downscaled projection data.

A parametric estimating model, through mathematical cost relationships, logically and predictably correlates the physical or functional characteristics of a project with its cost. When used in risk analyses, some parametric models relate cost growth to risk drivers such as the level of project scope development and the technology readiness level.

AACE RP 42R-08[7], Risk Analysis and Contingency Determination Using Parametric Estimating, offers an approach to estimating contingency, but not MR, based on cost data from similar completed projects. Another AACE RP, 44R-08, Risk Analysis and Contingency Determination Using Expected Value, provides a basis for generating inputs to the methodologyappearing in AACE RP 42R-08. Use the spreadsheet calculator included in AACE RP 43R-08, Risk Analysis and Contingency Determination Using Parametric Estimating – Example Models as Applied for the Process Industries, to make calculations more efficient and transparent. The calculator collects cost and project definition level information. The contingency estimates produced following this methodology best support cost estimate ranges generated prior to CD-0 and CD-1.

As the information is gathered and finalized, the data should be analyzed for bias and perception errors. While the data will not be systematically used for a quantitative analysis, it should still be analyzed and perceptions scrutinized.

Note: It is suggested that the project's initial estimated total cost and schedule contingency should exceed the amount estimated to account for the known risks, in order to plan for the potential cost of handling unknown or unpredictable risks that may manifest themselves during the project life cycle.

4.4 Risk Handling

Risk handling covers a number of risk strategies, including acceptance, avoidance, mitigation, and transfer. When weighing these approaches, the following should be taken into account:

- The feasibility of the risk handling strategy.

- The expected effectiveness of the risk handling strategy based upon the tools used.

- The results of a cost/benefit analysis, i.e., how do the costs of the handling strategy compare to the benefits derived from not realizing the risk event?

- The impacts of the strategy on other technical portions of the project. Any other analysis deemed relevant to the decision process.

[7] Reference https://web.aacei.org/resources/publications/recommended-practices to see recommended practices(Cost for these documents should be factored into other direct costs).

- The risk handling strategies should be compatible with the appropriate DOE or NNSA office's risk management policy and the appropriate risk management plan.

Many parameters of the project can change over time that can impact the risk handling strategies (e.g., scope of the project, available resources, internal and external environments, technical advancements, et al.). Thus, risk handling should be an iterative process. One or more of these items can change a step in a risk handling strategy, or even the complete strategy, which then changes the cost and/or the schedule for implementation of the risk handling strategy.

Risk handling strategies should consider the probability and consequence of the risk and, if deemed necessary by the risk owner, should allow for a back-up risk handling strategy that is documented in the risk register. If back-up risk handling strategies are documented in the risk register, they should be documented at the same level of detail as the primary risk handling strategy. Documentation at the same level as the primary strategy will ease implementation if the primary risk handling strategy is deemed unsuitable or inadequate. Further, the cost and necessary schedule for the back-up risk handling strategy should be calculated and noted in the risk register.

The cost for the risk handling strategy for the primary risk should typically be included in the baseline as direct project costs if the handling action will be performed (see further discussion in the following paragraph). The process includes identifying the scope, cost, and schedule associated with implementing the risk handling strategy, and assigning a unique work breakdown structure number and activity to the strategy so that it can be tracked and monitored.The project team should develop the risk handling implementation plans with the appropriate level of detail. The project activities should include the detailed work plans (for whichever phase the project is then in) with the associated budget and schedule identified in the project Work Breakdown Structure (WBS). At the appropriate time in the project life (Critical Decision 2), the handling actions become part of the project baseline.

Some project teams make the mistake of thinking that all handling costs should be part of the project contingency. If the handling actions will be performed, then DO NOT include the costs of these handling actions in the risk contingency [or contractor Management Reserve (MR)].

These are known, identified project work activities and need to be planned accordingly, and included as part of the direct project costs.

However, if the handling action will not occur until some event that may or may not occur, e.g., a risk trigger event, then it is appropriate to assign those costs to project contingency (contractor MR). If the triggering event occurs, then the project would process a change using the project change control system, to take cost/schedule from contingency (or MR) and assign it to the project handling activities. This latter approach is more the exception than the rule.

There may be occasions when a primary risk is not added to the baseline until a change control action occurs, such as when it is predicted during a monthly project review or a review of lessons learned.

Risk handling strategies should be regularly reviewed throughout the project life cycle for their affordability, achievability, effectiveness, and resource availability as described in the reporting requirements of the risk management plan.

If questions arise about a risk or its handling strategy's potential impacts on the technical goals and objectives of the project, a more comprehensive analysis should be conducted.

Major/Key risks should be analyzed to examine the inter-relationships between other risks, as well as other projects. This could lead to common risk handling strategies. The specific method of analysis may include:

- Pictorial modeling.
- Fish-bone diagramming.
- String diagramming.
- What if analysis systems modeling.
- Time-specific sequencing simulation modeling.

4.4.1 Acceptance

Acceptance as a risk handling strategy should be a deliberate decision and documented in the risk register. Acceptance of the risk does not mean that the risk is ignored. The risk should be included in the cost and schedule contingency impact analysis.

Examples of risks that might be accepted include:

- There will be fewer bidders on a design-build request-for-proposal than desired, but there will still be some competition.
- Funding for the next fiscal year is delayed due to Continuing Resolution.

4.4.2 Avoidance / Exploit

Avoidance, as a risk handling strategy, is done by planning the project activities in such a way as to eliminate the potential threat. Avoidance should be considered the most desirable risk handling strategy. However, avoidance should be analyzed for its cost/benefit to the project within the current funded boundaries of the project. The cost/benefit analysis should also take into consideration the impact on the overall project and the available funding for handling the other identified risks. The decision processes used to determine whether or not to pursue the avoidance risk handling strategy for risks on the project should be documented.

Avoidance strategies often involve a change in requirements, specifications, or practices to eliminate the risk. Avoidance can also be the rejection of an approach to doing a piece of scope, as the risk involved in the approach cannot be reduced to an acceptable level. In general, to exercise this approach, another approach that meets the cost/benefit approach should be available. Examples of risks that might be avoided include:

- The design specifies using an untested material of construction in this application.
- The design specifies a non-conventional/untested glove-box in a nuclear facility.

The term exploit is used for positive benefit risks. To exploit an opportunity is to attempt to ensure that it occurs. As in the avoidance of the negative consequence risk, the thrust of the handling strategy is to ensure that uncertainty is removed and the opportunity definitely happens. In addition to avoidance, exploitation should be analyzed for its cost/benefit to the project.

Examples of exploitation strategies include:

- Remove the uncertainty of whether or not human resources will be available for an action at a certain time, one may extend the contract and have the resources available and working on other efforts at the site. Thus, it is ensured that the resources will be available for the project.
- Pursue a new process configuration that eliminates the requirement for Building A in the project scope.

4.4.3 Mitigation/Enhance

Mitigation is a risk handling strategy that is taken to reduce the likelihood of occurrence and/or impact of an identified negative risk or threat. Enhancement is a risk handling strategy used to increase the likelihood of occurrence and/or benefit of an identified positive risk or opportunity. The goal of a mitigation risk handling strategy is to reduce the risk to an acceptable level.

In regard to the introduction of technologies or technologies needing further development, the technology development plan should be linked directly with the risk handling strategy for risks associated with technology development or availability. Deployment or implementation of a technology may introduce risk that requires specific risk handling strategies.

The risk's mitigation strategy should be developed as a step-wise plan that can be included in the project baseline. The mitigation plan should be analyzed to ensure that it is feasible and that resources are available. An example of a step-wise risk mitigation strategy for a primary risk might be as follows:

- Establish weekly requirements and interface meetings for design teams (set date).
- Establish a separate design review for the interfaces for where technology interfaces occur (set date).
- Establish a separate design review for any rework that should occur for technology interfaces (set date).
- Establish separate contractor and DOE walk-down of facility once technologies are on-site to determine that visual interfaces concur with designs (set date).

- Establish walk-down of facility with technical staff to ensure quality, design, safety, and other necessary requirements for staff concurrence with all interface design features as physically installed (set date).

The term enhance is used for positive benefit risks. The necessity of identifying the triggerevent is highlighted by attempting to enhance the opportunity by reinforcing the conditions identified in the trigger event. An example of an enhancement strategy is:

- Restructure the project scope/contracts to make the project more attractive to potential bidders, thus increasing the pool size of responsive bidders.

Mitigation and enhancement, as risk handling strategy decisions, should also be based on the results of a cost/benefit analysis. The rule for mitigation is not to spend more on the handling than what the risk event would cost if it occurs. Likewise, it makes little sense to spend more on the enhancement costs than the cost savings realized from the opportunity.

4.4.4 Transfer/Share

The risk handling strategy of transferring risk operates differently within the DOE or NNSA than within private industry. In private industry, transferring risk often involves the purchase of insurance or bonds as the transference of the risk. The risk is passed to the insurance company that accepted the risk for a fee. For non-M&O type contracts, the actual risk is transferred between the FPD and the CPM via the contract or from one project to another, or to a program office. Risk transference indicates a transfer of ownership, and therefore written acceptance of the risk should be obtained before transfer is complete. An example of a risk that might be transferred from DOE to a contractor is:

- Contractor assumes material cost escalation up to 10% above current prices.

Examples of risks that might be transferred from the contractor to DOE include:

- DOE is responsible for material cost escalation exceeding 10% of current prices.

- Site utilities are available for tie-in to the project.

When risk has been transferred, the transfer of the risk should be reviewed to ensure it did not create other risks and that it does not impact the project mission and objectives. Therefore, as was done for the acceptance strategy, an analysis review should be conducted to fully understand inter-relationships.

The term share is associated with risks that present positive consequences. For instance, a risk could be shared between the FPD and the contractor, between and among various projects, or a combination thereof. In general, the risk benefits should extend to the parties that shared the risk. If a risk is shared it should be split such that each "owner" is responsible for the appropriate portion of the risk. An example of a shared risk might be:

- Incentivized contracts that allow for sharing of any cost savings derived from implementation of contractor value engineering suggestions. Note: The appropriate portion of the opportunity should be assigned to each party affected so there is a clear owner and benefit.

4.5 Residual Risk

Residual risk (post-mitigated risk) is the risk that remains after the risk handling strategy (accept, avoid, mitigate, or transfer) has been performed to the original primary risk to which they had been assigned in the risk register. A residual risk may end up being the same risk as the original risk (pre-mitigated risk) if the risk handling strategy does not reduce or mitigate the risk or the risk is one that recurs. The fact that residual risk remains does not mean that the risk handling was not effective, only that it did not completely avoid a risk remaining. It is up to the risk owner to decide whether the residual risk will be moved to a primary risk position.

This remaining or residual risk should be qualitatively analyzed. Through this process a decision should be made as to when the risk planning process should stop. Those residual risks for which no risk strategies are planned are accepted and should be clearly communicated to the team and management.

Once it has been determined that the residual risk will remain after the implementation of the primary risk's risk handling strategy, the primary risk should be closed. The residual risk should be moved to a primary position on the risk register. The purpose of this suggested move is to provide focus attention to this risk through the risk register. Once moved to the primary risk position, the risk handling strategy for the risk should be reviewed and updated, if necessary. If a back-up strategy was also logged into the risk register at the time the residual risk was captured, it should be reviewed for applicability also and determined if it is the better risk handling strategy or if the two risk strategies should be merged, blended, or completely redrafted. All steps that were conducted with primary risks in regard to the baseline will need to be accomplished with the new primary risk, if necessary, in regard to the baseline. In other words, a review of the baseline should be done for change in cost and schedule contingency to be made at the discretion of the FPD and/or CPM in consultation with the IPT.

4.6 Risk Monitoring

Risk monitoring involves the systematic, continuous tracking and evaluation of the effectiveness and appropriateness of the risk handling strategy, techniques, and actions established within the risk management plan. Monitoring is performed for individual risks per the risk metrics and overall project risk status. The risk monitoring process should provide both qualitative and quantitative information to decision-makers regarding the progress of the risks and risk handling actions being tracked and evaluated.

Risk monitoring may also provide information that can assist in identifying new risks or changes in the assumptions for risks captured previously on the risk register. These results should be used to initiate another risk identification process.

4.6.1 Risk Monitoring Process Considerations

The Risk Monitoring process should be tailored to the project and be described in the risk management plan. The risk monitoring process should be more than a risk tracking documentation process and should include the following items:

- Ensure that the risk owner is current and performing his or her role and responsibilities.
- Ensure that risk identification is current with the parameters of the project. Ensure that risks, including accepted and low risks, have not changed since first identified.
- Ensure that avoidance strategies are implemented according to schedule, and that metric indicators are showing that the risk is not presenting itself.
- Ensure that risk handling strategies are being implemented and executed to meet or exceed metrics for success.
- Review any back-up plans for applicability and determine if any other plans need to be put into place based upon performance of the current handling strategies.
- Review the cost and schedule contingency calculations for the current handling strategies that are being implemented and those that will be implemented in the near future based upon recent project performance for projected accuracy. That is, compare current risk handling performance with the corresponding risk handling plans in the risk register (before the implementation) to measure current performance. Make adjustments to those risks handling actions that will be implemented in the near future based on recent performance for projected accuracy.
- Review any necessary risk management communication that may be necessary for any current or near-term risks for executive management, customers, stakeholders, or others and review such communication against the risk management communication plan.
- Ensure the recognition of the benefits and necessity of early consideration and integration of safety and security-related project risk into the project risk management process.
- Ensure that the risk register and other risk-related forms are up-to-date.
- Conduct integrated metrics management and reporting (see Attachment 6, Cost/Benefit Analysis).

4.6.2 Risk Monitoring Methods

The following are not the only methods available and do not exclude the use of other methods acceptable to the Program Office.

4.6.2.1 Risk Owner Monitoring

The risk owner has a significant role in risk monitoring. As part of the risk monitoring process, the risk owner should update information in the risk register through an agreed upon process as stated in the risk management plan. Any changes that a risk owner makes to the risk register should be discussed at the risk meetings to ensure that changes in the conditions of one risk do not impact another risk or create another potential risk. It may be necessary to conduct an analysis study depending upon the extent of the impact of the change to the risk register.

4.6.2.2 Self-Assessment

At various junctures during the project, there might be a need to assess the risk management processes that have been implemented. In such a case, the respective manager may wish to use a review document designed for the particular project or a generic checklist (see Attachment 8, Risk Identification Checklist, and Attachment 9, Risk Monitoring Checklist).

4.6.2.3 Integrated Risk Monitoring

Integrated risk monitoring occurs when risk management metric monitoring is integrated with other standard project metrics such as earned value or safety metrics. The determination as to the root cause of any negative or positive impact upon a metric should include a determination as to whether it involved a risk including whether it involved the positive benefit risk known as an opportunity. The output of the reporting process can be the input to the risk management process for further risk identification, analysis of consequence and impact ratings, and the analysis of the handling strategy as planned or as being implemented.

If the project is subject to DOE-STD-1189-2016 for integration of safety into design, the key risks should be tracked and reported per the requirements of the standard and in relationship to the maturity of the project and technical studies that are ongoing. The DOE-STD-1189-2016 provides for the development of risk and opportunities assessments relative to safety in design issues and decisions. Given the potentially significant costs associated with safety decisions, the integration of safety into the design process needs to also include a strong link between the development of Safety-in-Design and identification of project technical and programmatic risks. With anticipated risks, early identification of possible opportunities to address potential risks allows the project to define appropriate cost range estimates. Comprehensive risk identification, coupled with an appropriately conservative safety design posture, affords the project the opportunity to execute within the range estimate with a higher degree of reliability. The project's risks and opportunities assessments are intended to be inputs to its Risk Management Plan and to be managed accordingly.

4.6.2.3.1 Safety Metrics

Safety metrics should be used to measure the effectiveness of the safety program, and various administrative, personnel protection, and engineering methodologies being used to achieve worker and public safety. Various metrics are used in the program offices. Among those metrics are the measures of the occurrence of certain events including electrical safety events, industrial events, radiological events, and near miss events, etc. For the purposes of risk management, the performance assessment that is done in regard to safety should involve a review of events to determine whether or not the event involved a risk, an event that could have been predicted and thus could have been avoided.

If such a risk is determined to have been part of the safety event, lessons learned should be conducted in accordance with the applicable safety order. All related projects should undergo a review for an exact risk or similar risk and the application of the lessons learned.

If the project is subject to DOE-STD-1189-2016, the key risks should be tracked and reported per the requirements of the standard and in relationship to the maturity of the project and technical studies that are ongoing.

Nothing in this section eliminates the risk assessment metrics for safety that may exist in other safety management orders or guides.

4.6.2.3.2 Quality Metrics

Quality metrics should be used to measure quality assurance and quality control processes. Project activities and processes should have a set of metrics. If a metric is not met, an analysis of this shortcoming should be done to determine the reason. If the reason for the non- achievement of the metric is a realized risk, an analysis of the risk should be initiated to determine whether the risk was identified, and, if not, why it was not identified. Additionally, a reflective analysis process may be needed to determine if the risk was hidden or latent due to other risks or perhaps other project factors. Lessons learned should be gathered and applied to the project and other similar projects.

If the risk was identified, the analysis should determine if the risk operated as predicted per the assumptions surrounding the risk, or the handling strategy or response was inadequate, or the residual risk was greater than anticipated, or the accepted risk was greater than what was anticipated. Again, a full analysis should be done and shared with the project participants and other similar projects. If the risk only allowed for partial achievement of the metric, then the handling strategy should be reviewed, especially if the risk is one that could recur or is one that is found on other projects.

Nothing in this section eliminates the risk assessment metrics for qualitative assurance that may exist in other quality management regulations, directives, and orders.

4.6.2.3.3 Safeguards and Security Metrics

Safeguards and security metrics should be used to measure the implementation of the safeguards and security requirements for a given project. These compliance and performance assessment metrics as defined in DOE G 413.3-3, *Safeguards and Security for Program and Project Management*, current version, could be established and integrated early in the project planning. Using these metrics on a monthly basis to highlight either the avoidance of an identified risk or the mitigation of a risk in this area of project integration will form a basis for continuous and iterative risk feedback. Further, if a risk in the area of safeguards and security is realized that was not previously captured on the risk register, it should be reviewed and analyzed. This reflective analysis process may be needed to determine if the risk was hidden or latent due to other risks or perhaps other project factors. Lessons learned should be gathered and applied to the project and other similar projects.

Nothing in this section eliminates the risk assessment metrics for safeguards and security that may exist in other safeguards and securities orders or guides.

4.6.3 Risk Reporting

Although reporting (see Attachment 10, Management Reserve or Contingency Use Report, and Attachment 9, Risk Monitoring Checklist, for suggested format) can be either formal or informal, this guide will focus on suggested formal risk reporting, but acknowledges that informal risk reporting occurs in the field through casual conversations and interactions. While there are thresholds for reporting requirements stated in this guide, each project might vary based upon tailoring and risk communication requirements that will be stated in the risk management plan and the risk management communication plan. In addition, the FPD is encouraged to work with the appropriate DOE program office (i.e., EM, SC, NNSA, etc.) to establish the specific reporting requirements for the individual project.

4.7 Risk Feedback

Risk feedback is a continuous and iterative activity throughout the risk management process. Participants in the risk management process should provide feedback throughout the project. This feedback process begins with the initial identification of the overall risk of the project at the mission need phase of the project, CD-0, to the project close out, CD-4, and the capture of the final lessons learned (see Section 4.3.6.3, Project Learning Analysis). This process should begin as early as possible in the project and should be a thorough risk and requirements feedback process.

The process of providing feedback can be done either in a formal or informal manner—either in a written or oral format. However, it is recommended that wherever possible, feedback should be provided in a formal, written format to ensure that it is captured, and that it is recorded and received by the appropriate project official, whether it is the risk owner or the FPD and/or the CPM.

The risk management plan may prescribe the method for certain types of risk feedback and presentation. The types of risk feedback that the risk management plan should prescribe, but are not limited to, include reporting, official responses to reports, and maintenance of the risk register.

5.0 RISK DOCUMENTATION AND COMMUNICATION

5.1 Project Execution Plan

The risk management plan should be included in or referenced in the project execution plan.

5.2 Baseline Management

Changes to the baseline due to risks not identified will generally result in the filing of a change control document. When a baseline update has occurred, a full review of the risks should be done to ensure that the baseline change has not resulted in other risks that may occur in the future due to the change either in schedule, budget, or scope. Those risk handlingstrategies not part of the project baseline will have cost and schedule impacts, if implementedat a later date.

If the project has had scope changes or other impacts that have resulted in changes to the project's risk profile, the risk identification process should be re-initiated and the risk register resubmitted either in hard copy or electronically during the reporting period when the changes are noted.

5.3 Phase Integration

Risk management and its processes should be tailored to the specific project phase. For example, risk management should be started on a project when it has the greatest impact, which means, generally, at the development of the mission need statement. The degree to which it can be started will depend upon each project and the knowledge possessed at the time.

It is recommended to ensure that risks are represented, and risk handling actions are suitable for the phase of the project. In other words, the response should satisfy a cost/benefit analysis for the phase or timing of the implementation of strategy whether it is early in the project or late, and that the schedule to implement can be done within the project without impacting other milestones or critical activities.

5.4 Acquisition Strategy

The FPD should enlist the assistance of the Contracting Officer early in the initial developmentof the Acquisition Strategy in order to identify the risks to the procurement of the project resulting from key project decisions. When developing the acquisition strategy documentation, the FPD and the Contracting Officer should direct attention to risk identification, consistent with FAR 34, in the following areas as input to the acquisition decisions:

- Cost - as it relates to the facility, technology, or system to achieve the project's mission objective(s).

- Design and Engineering - as it relates to the facility, technology, or system to achieve the design and/or engineering objectives.

- Functional - as it relates to the facility, technology, or system to perform or meet project requirements.

- Integration - as it relates to the integration of any hardware or software for various systems for the facility, technology, or system and the demonstration of this integration to meet project requirements.

- Procurement Vehicles/Process - as it relates to the procurement decision process, contract requirements, available competition, market conditions, and other constraints.

- Regulatory - as it relates to the physical site, environmental conditions and process needs, facility requirements, and any other project specific regulatory requirements.

Other risk categories may need to be reviewed within the acquisition strategy and planning activity and, as they are captured; they should be tracked in the risk breakdown structure under the appropriate category and in the risk register.

5.5 Risk Management Plan

The risk management plan is the governing document for the risk management process on a project. The risk management plan includes by reference the risk register, risk analysis, and other risk data and risk database information that is updated more frequently (but is not reissued whenever such data is changed or updated). Results from the risk analyses (MR, contingency, confidence level) are recommended for inclusion in monthly progress reports if the analyses are updated more frequently than annually.

Note: Tailoring the risk management plan is based upon criteria such as the size, complexity, budget, risk level, resources, technical maturity level, and other considerations deemed relevant. The risk management plan should include the following sections:

I. Introduction (may be contained in project execution plan)

   a. Project summary

   b. Responsibility Assignment Matrix (see Attachment 3, Risk Responsibility Assignment Matrix)

   c. Key definitions

   d. Key requirements documents and regulatory drivers

   e. Assumptions and constraints

II. Risk and opportunity management process

   a. Risk planning

   b. Risk assessment

   c. Risk identification

   d. Risk analysis

   e. Risk and opportunity handling

   f. Risk monitoring

   g. Risk feedback

III. Risk documentation and communication

IV. Conclusion

5.6 Risk Management Communication Plan

Communication is identified in DOE O 413.3, current version, as a key principle to project success. To ensure project success the risk management plan should address how information related to risk, and risk status is communicated to the project team and stakeholders. This communication information could be addressed in either the project execution plan or a communication plan or could be included in the risk management plan. A separate risk management communication plan could also be developed as part of the tailoring decisions. The risk management communication plan should also specifically address the integration points with the DOE enterprise-wide lessons learned systems.

It is recommended that the risk management communication plan should contain the following sections:

I. Background and purpose

  a. Responsible office and key individuals

  b. Necessary oversight and signatory responsibilities

II. Project overview

III. Target objectives

  a. Development of standard, and as needed, communication formats and messagesfor identified risk stakeholders

  b. Development of communication flow diagrams

IV. Strategy

  a. Statement of overall strategy elements

  b. Assumptions and uncertainties

  c. Process for validating and verifying assumptions and uncertainties

V. Key target stakeholders

  a. Identification process

  b. Known stakeholders

VI. Identified communication channels for each target stakeholder grouping

  a. Process for identifying key points of contact

    (1) Primary point-of-contact

    (2) Back-up point-of-contact

b. Process for identifying key points of contact for emergency communications

VII. Key messages

a. Site communication requirements

(1) Goals and objectives

(2) Processes

b. When certain communications may be issued

c. Definition of various modes of communication

d. Situational requirements

e. Definition of special circumstances

f. Definition of special approval channels

g. Communication development

(1) Who should be involved in construction of communications

(2) Who should review

h. Standard messages

i. Key interfaces

j. Communication distribution and feedback

VIII. Roles and responsibilities

a. Identify all parties

b. Responsibility assignment matrix

IX. Overview metrics for responsible persons

X. Message approval process

XI. Revisions and updates

6.0 TAILORING OF RISK MANAGEMENT

Programs may adopt other acceptable methods/approaches as deemed appropriate. The process could be tailored based upon the complexity, size, and duration of the project; initial overall risk determination; organizational risk procedures; available personnel and their skill levels for performing risk management; and available relevant data and its validation.

7.0 APPLICATION OF CONTINGENCY AND MANAGEMENT RESERVE FOR NON-M&O CONTRACTS

7.1 Explanation of the Terms

This section provides clarification guidance for the definition, derivation and consistent application of the terms government contingency and contractor management reserve (MR) in risk management for DOE capital asset projects. This clarification guidance is in accordance with the requirements of DOE Order 413.3B and the Federal Acquisition Regulations (FAR). This clarification guidance is also consistent with Acquisition Letter 2009-01, "Management Reserve and Contingency," dated October 6, 2008 from the DOE Office of Procurement and Assistance Management. Contingency management should be an integral part of the DOE capital asset project risk management process, providing project managers with the tools to respond to project risks and uncertainties that are inherent in all DOE projects. With appropriate management and funding of projects, coupled with well-administered Federal and contractor Risk Management Plans and Change Control processes, project baselines should be well suited to deal with anticipated project risks. The government cost estimate should include contingency for all risks that will impact the project during the development of performance baselines.

When the government issues a solicitation for work to be performed, the terms of the contract establish which work scope risks are borne by the contractor. The offeror and/or contractor is expected to account for the contractor's risks when proposing quantities, costs and schedules in their response to the RFP. As a part of the execution of the work, certain of these risks will be realized, certain risks will be mitigated, and additional risks within the contractor's responsibility could emerge.

The terms "contingency" and "MR" are often used interchangeably in Project Management and Contract Management activities during the execution of the work scope creating confusion about its proper accountability. Using these terms interchangeably should be discouraged. And,while MR is a form of contingency, its application is the responsibility of the contractor.

Contingency derivation and management is the responsibility of the project team. It is advisable that all parties understand the differences and manage each funding source accordingly.

7.2 Contracting Approach for Non-M&O Contracts

"Contingency" and "management reserve", as defined in DOE O 413.3B, are not synonymous with those provided in the FAR. In fact, the term "management reserve" is not used in the FAR, and is not considered a discrete element of cost. Within the FAR, the term "contingency" refers to contractor contingency and not Government contingency, as defined by DOE O 413.3B. If MR is not recognized as a discrete element of cost such as labor, overhead, materials, etc., how then is it factored into a contractor's cost proposal and negotiated into the contract? The answer is that the FAR does allow for contractors to price in contingencies that meet specific conditions, i.e., "those that may arise from presently known and existing conditions, the effects of which are foreseeable within reasonable limits of accuracy", such as escalation for out-year prices, anticipated costs of rejects and defective work, etc. In fact, FAR 31.205-7 states that "contingencies of this category are to be included in the estimates of future costs so as to provide the best estimate of performance cost." As a general matter, in a cost proposal, contractor contingency should be tied to specific work scope and be proposed as standard cost elements recognized by the FAR. What this implies is that the contract price is not allowed to explicitly call out a separate budget for management reserve, since reserves for uncertainties within the scope of the contract are expected to be included within the contractor price. Management reserve is carved out after the contract value has been negotiated.

While DOE Acquisition Letter 2009-01 provides an extensive discussion of pricing of contractor reserves, a source of confusion has been the interpretation of certain guidance stated in AL 2009-01 with respect to the DOE O 413.3B project management model. Specifically, AL 2009-01 states ―Contracting officers shall not include in the contract price any amount (for management reserve, contingency, etc.) to cover prospective requests for equitable adjustments, changes, or risks that might or might not occur during performance." Equitable adjustments, changes to the contract pursuant to the Government Changes Clause (FAR 52.243-1, 2, 3, 4, 5, or 6), and other unknown risks do not satisfy the requirement that contractor contingencies that are priced into a contract must be those that arise from presently known and existing conditions, the effects of which are foreseeable within reasonable limits of accuracy. Changes to the contract, equitable adjustments, and other unknown risks simply cannot be reasonably priced. Changes of this nature are generally handled through the "Changes" clause after contract award as long as the change is within the general scope of the contract.

FAR 31.205-7 also requires that contingencies, "the effect of which cannot be measured so precisely as to provide equitable results to the contractor and to the Government; e.g., results of pending litigation", are to be excluded from cost estimates and should be disclosed separately (including the basis upon which the contingency is computed) to facilitate the negotiation of appropriate contractual coverage. The expectation is that the contractor's proposal includes a clear statement of assumptions and risks that are part of the contractor's proposal to perform the work listed in the solicitation that may have either a positive or negative effect on the Government's proposal evaluation.

7.2.1 Contract Considerations for Non-M&O Contracts

The discussion thus far is primarily focused on cost reimbursement contract types. However, additional discussion on the relationship between risk and contract type is warranted, especially with respect to firm fixed price contracts. Firm fixed price contracts are frequently utilized for capital asset projects throughout the Government. The issue of risk assumes a different complexion in a fixed price environment because the cost risk is wholly borne by the contractor, the contractor is generally not required to provide cost data to the Government, and they are not required to provide visibility into the formulation and use of their MR. Projects that can be priced on a firm fixed price basis will tend to be well-defined and characterized in terms of work scope. Cost overruns are absorbed by the contractor, not the Government.

Under a cost reimbursement contract, the tools, processes, and systems that are required to award and administer the contract reflect efforts to mitigate cost and performance risk that in a cost reimbursement environment are primarily borne by the Government.

An additional consideration with respect to managing risk on a capital asset project is whether it will be performed by the prime contractor, a first tier subcontractor, or a lower tiered subcontractor. FPDs and Contracting Officer's Representatives (CORs) should always be mindful that the Government only has privity of contract with the prime contractor, and not with subcontractors, therefore, the Government's desire to manage a project should carefully account for the role of the prime contractor in directing subcontractors and managing risk for the work scope that has been subcontracted.

7.3 Project Management Approach for Non-M&O Contracts

DOE O 413.3B prescribes a project management model that supports effective contract management. To comply with DOE O 413.3B, the contractor will establish a Performance Measurement Baseline (PMB) for the contractor's scope of work and a Management Reserve (MR) for managing contractor risks. The cost element of the PMB is the total time-phased budget plan of the work breakdown structure (WBS) elements with the contractor's estimate of the planned cost and schedule to accomplish each WBS element. It depicts the schedule for expenditure of the resources allocated to accomplish contract scope and schedule objectives and is formed by the budgets assigned to control accounts and summary-level planning packages, if any, plus any undistributed budget. The PMB cost plus the MR equals the contract cost (or Contract Budget Base). The contract cost plus the contract fee equals the contract price. The contract price is the total estimated cost for the contract (see Figures 4 and 5, and Figure A-1 in Attachment 11).

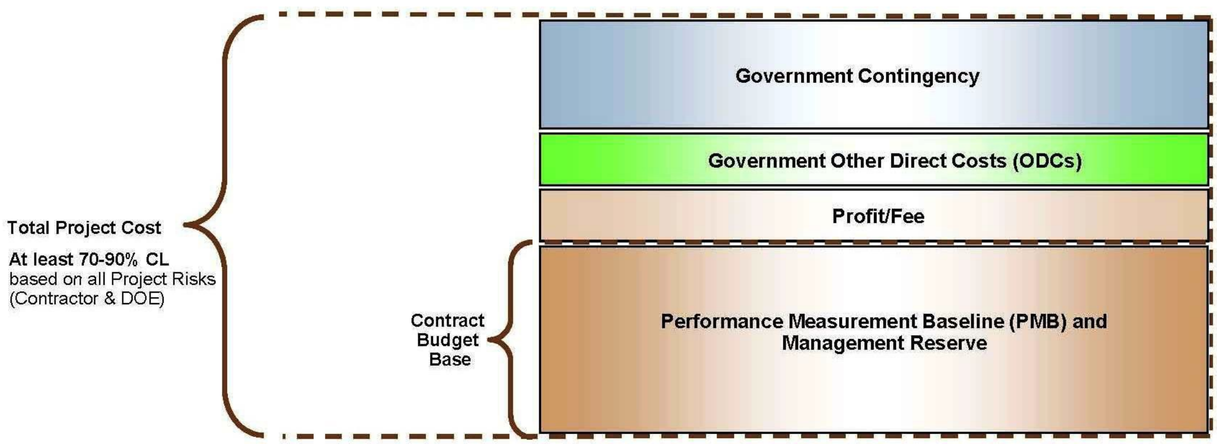


Figure 4. Total Project Cost Breakdown Note: CL = Recommended Confidence Level

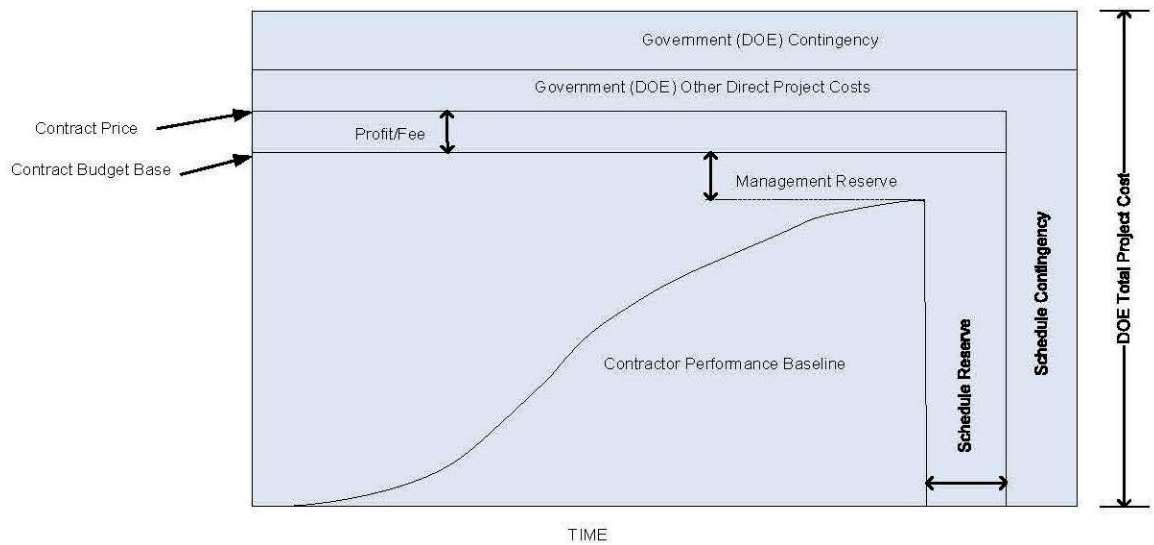


Figure 5. DOE and Contractor Performance Baseline

A performance baseline (PB) as established in DOE O 413.3B is established after sufficient design has been accomplished to provide sufficient certainty the scope of work can be completed within cost and schedule. The FPD defines a cost, schedule, performance, and scope baseline. The Government will define a scope of work to be accomplished by the contractor in a solicitation and determine the risks to be assigned to the contractor. As outlined above, the offeror and/or the contractor's proposal in response to the solicitation will propose a technical approach and incorporate the necessary quantities, cost, and schedule to accomplish the work and handle the risks to accomplish its proposed approach. And then, after the contract is awarded, the contractor will prepare a PMB and MR.

The FPD also assigns certain risks to the Government, such as government furnished services and items (GFS/I), significant revisions to regulatory requirements, etc. Through analysis of these risks, the FPD establishes needed contingency. This contingency is often referred to as DOE contingency to provide clarity from "contingency" referred to in DOE Acquisition Letter 2009-01. And the "contingency" in DOE Acquisition Letter 2009-01, is MR in DOE Order 413.3 guidance.

Risks for all capital asset projects should be analyzed using a range of 70-90% confidence level upon baselining at CD-2 and reflected in funded contingency, budgetary requests, and funding profiles. Projects should contact their sponsoring program office for additional program and project-specific guidance on the confidence level to be used for analysis. If a project has a performance baseline change, the FPD should consider reanalyzing the risks at a higher confidence level and then reflecting this in budgetary requests and funding profiles. DOE does not provide confidence level guidance for the determination of MR by the contractor. Consistent with DOE O 413.3B, the contractor is expected to complete the full contracted scope of work.

The work for a Federal Project can have multiple contracts for the execution of the work. Also, a single contract can execute work for multiple Federal Projects. In establishing the PB when contracts are in-place, the PB will comprise the contractor's price (PMB plus MR plus fee) plus contingency and any Government other direct costs (see Figures 4 and 5 above). The confidence in the PB will be reflected in budgetary requests, and funding profiles.

The amount of MR should correlate with the quantification of the uncertainties and risks identified by the contractor in their Risk Management Plan. During execution, the contractor inherently challenges each of their cost account managers, as well as managers responsible for executing the work (i.e., cleanup, demolition, design, procurement, construction) to accomplish the PMB within the cost and schedule for each work element. The MR provides the contractor with a mechanism to fund a risk should it be realized.

MR should be maintained separately from the PMB and is utilized through the contractor's change control process. MR is established after contract award by the contractor. MR should be risk based, and quantitatively derived and justified. Thus, the MR is a project management tool which allows the contractor to manage risks and uncertainties. Through the risk planning and assessment process, the contractor forecasts the realization and/or mitigation of risks and the utilization of MR. MR should not be managed by the government nor deducted from the total estimated contract price, since the underlying costs were supported through the contractor's proposed scope, cost, and schedule to execute the work and evaluated by the Government.

When a pre or post award integrated baseline review (IBR) is required in accordance with FAR Subpart 34.2 and 52.234, the contractor should demonstrate the ability of the PMB to successfully execute the project and attain cost objectives. This demonstration can best be achieved by identifying the threats and opportunities that the contractor has priced in its bid proposal and the approach to be used in managing the associated budget for those threats and opportunities.

During project execution, the contractor evaluates the attainment of the PMB utilizing their Earned Value Management System (EVMS). The contractor's change control process deals with proposed scope, cost, and schedule changes by the cost account managers, as well as the work execution managers. For potential changes within the contractor's responsibility, sometimes called trends, the contractor will address the change as a potential variance to the work element. This permits the condition to be highlighted and potentially mitigated.

However, if the condition cannot be mitigated, the contractor will typically process the change and utilize MR for the change. Typical uses of MR include funding recovery from the impacts of realized risk events, implementing and executing opportunities to accelerate remaining work in the PMB to increase confidence in schedule commitments. MR is <u>not</u> used to resolve past variances (positive or negative), unless to correct errors, routine accounting adjustments, or to improve baseline integrity and accuracy of performance measurement data. Use of MR should follow EVMS rules per EIA-748D.

DOE authorization should not be required for the contractor to use MR. However, DOE requires contractors subject to compliance with EIA 748D, Earned Value Management System (EVMS), to report the use of MR as part of the monthly reporting of performance against the established PMB (the EVMS is not required to be used for firm fixed-price contracts - DOE O 413.3B). MR should be monitored and evaluated as part of the ongoing project control and oversight functions. The use of MR for scope, cost and schedule mitigation should be planned, reported, and managed over the project duration to ensure successful project completion.

7.4 Project and Contract Changes for Non-M&O Contracts

Changes can occur on two levels: changes within the contractor scope and changes outside the contract scope. Changes within the contract scope are accomplished through the contractor's change control process. The FPD should be cognizant of this process and the contractor's monthly status report should provide a status of executed and pending changes, as well as the status of MR utilization.

If the contractor believes a change has occurred and the change is outside the contract scope, the contractor should immediately notify the Contracting Officer (CO) and the FPD in writing in accordance with the applicable Changes clause prescribed by the FAR and included in the contract. If the FPD and CO concur, the FPD/CO may determine the impacted work is not necessary, and the CO will formally notify the contractor of this decision. If the FPD/CO determine the work is necessary, and in conjunction with the Federal Budget Officer (FBO) that funds are available (typically through the use of contingency, i.e., DOE contingency), the CO will follow the established change control process that leads to issuing a modification to the contract. If the CO, through consultation with the FPD, determine that some of the work is necessary to be executed (to preclude a stop work condition), while the contractor is preparing their proposal, the CO may authorize a unilateral change order modification that clearly establishes a "not-to-exceed" estimate, a definitization schedule, and the revised language for the specific change in the contract scope. Pursuant to the modification, the contractor will prepare a proposal for that specific "changed" scope of work, correlating what has changed from the current contract. The contractor will also determine if the amount of fee is affected. It is critical the contractor shows the correlation of the scope, cost, and schedule change to the contract, not the PMB. The contractor's proposal will factor-in risks, just as the contractor's response to the RFP considered risks. The proposal does not show the change to the PMB. The PMB will be adjusted after the modification is finalized, just as the PMB and MR were established after the contract was awarded. When the contractor's proposal is received by the Government, the FPD/CO/FBO will evaluate the proposal and determine if the modification has merit. If so, the FPD/CO/FBO will determine if contingency (i.e. DOE contingency) should be used to support the modification. If the level of the scope, cost, and schedule change is within the authority of the FPD for the Project Baseline and contingency utilization, and of the CO to perform the contract change, the modification is executed. If the change is above either the FPD or CO approval authority, the change is forwarded to DOE Headquarters for approval by the Acquisition Executive and/or the Head of Contracting Authority (HCA). If approval is received, the modification is executed.

Then, the PMB is revised accordingly.

7.5 Derivation of MR and DOE Contingency (Example)

This section illustrates an example of procedural guidelines for deriving both contractor MR and DOE Contingency for a hypothetical DOE project. Other valid methods exist. This is a fictitious project, but the steps are extracted and summarized from actual DOE projects as well as various resource documents, including this guide. The project illustrated here is conventional construction of a new office and laboratory building (non-nuclear), with a base cost estimate (no contingency or MR) of $150 million. The shaded areas represent the new information required at each step of the risk management process.

A.Contractor's Management Reserve

Remember that MR is controlled by the contractor, after contract award, for risk and uncertainty within the contracted scope of work. Budget for contractor risks and uncertainties is part of (embedded within) the contractor's bid price. A method for reviewing contractor MR is described below. DOE can follow this method when it develops the government estimate for the project, as a means to initially evaluate contractor proposals and later during project execution to assess the robustness of the contractor's stated MR and management plan. Note that MR is an estimate of the potential amount of additional budget the contractor may need to execute the contractor's scope of work and is a combination of the costs derived from 1) risk events, and 2) cost estimating uncertainty. Steps 1-4 below may be used to derive the MR contribution from risk events. Step 5 may be used to derive the MR contribution from cost estimating uncertainty.

1. Risk Identification.

- The contractor team identifies the bounding (enabling) assumptions for the project, based on the contract scope of work.

  Examples:

  - Site utilities will be available in sufficient quantities.
  - The construction site is free from any contamination that will require remediation prior to construction.

- The contractor then identifies the risks (threats and opportunities) associated with its contracted scope of work and assigns a risk owner to each risk. The two risk lists may resemble the following (only a few threats and opportunities are listed to exemplify the process):

Threats

ID	Threat	Owner
T-001	Labor unavailability due to competing projects will delay project completion and increase project costs.	John Smith-Constr. Mgr.
T-002	Construction subcontractor bids come in significantly higher than estimate which will increase project costs.	Mary Jones – Contracts Mgr.
T-003	Material prices rise higher than budgeted will increase project costs.	Joe Adams – Procurement Mgr.

T-004	Stakeholder objections delay building permit and will delay project completion and increase project costs.	Ann Johnson – Project Mgr.

Opportunities

ID	Opportunity	Owner
O-001	Shorten the construction schedule by adding shifts which will reduce the project completion date and reduce project costs.	John Smith-Constr. Mgr.
O-002	Obtain material discounts using prompt payment provisions in procurement contracts and reduce project costs.	Joe Adams – Procurement Mgr.

2. Risk Assessment – Qualitative Analysis

- Identify risk triggers and interdependencies.
- Assign probabilities and consequences to each threat and opportunity based on threshold guideline tables developed by the contractor.
- Assign an overall risk rating to each threat and opportunity using a risk matrix based on the probabilities and consequences.

Threats

ID	Threat	Trigger Event	Affected WBS Elements	Probability	Consequence	Overall Risk Rating
T-001	Labor unavailability due to competing projects.	?	?	Low	Significant	Low
T-002	Construction subcontractor bids come in significantly higher than estimate.	?	?	High	Critical	High
T-003	Material prices rise higher than budgeted.	?	?	Moderate	Significant	Moderate

T-004	Stakeholder objections delay building permit.	?	?	Very Low	Marginal	Low

? = additional information to be filled in by contractor

Opportunities

ID	Opportunity	Trigger Event	Affected WBS Elements	Probability	Consequence	Overall Risk Rating
O-001	Shorten the construction schedule by adding shifts.	?	?	High	Significant	Moderate
O-002	Obtain material discounts using prompt payment provisions in procurement contracts.	?	?	Moderate	Significant	Moderate

? = additional information to be filled in by contractor

3. Risk Handling

- Decide on a risk handling strategy for each threat and opportunity, based on the overall risk rating and professional judgment. Appropriate strategies for threats are Accept, Avoid, Transfer, or Mitigate. Appropriate strategies for opportunities are Accept, Exploit, Share, and Enhance. The process includes the following steps:
  - Identify a handling strategy for each risk.
  - Develop an implementation (mitigation) plan for the strategy, as appropriate.
  - Plan the implementation activities into the baseline project scope.
  - Develop cost and schedule estimates for the planned activities and include in project baseline.
  - Document probability of mitigation success.
  - Identify residual risks and secondary risks, if applicable.
  - Document strategy and handling plan (briefly) on Risk Assessment Form.

Threats

ID	Threat	Handling Strategy	Mitigation Strategy	Probability of Mitigation Success	Residual or Secondary Risk
T-001	Labor unavailability due to competing projects.	Accept	None	-	Same as primary
T-002	Construction subcontractor bids come in significantly higher than estimate.	Mitigate	Advertise nationwide. Have pre-bid meeting with bidders.	50%	Construction contractor bids come in slightly higher than estimate.
T-003	Material prices rise higher than budgeted.	Transfer	DOE accepts material price escalation over 10% above contractor budget.	50%	Material prices rise up to 10% higher than original budget.
T-004	Stakeholder objections delay building permit.	Accept	None	-	Same as primary

Opportunities

ID	Opportunity	Handling Strategy	Enhancement Strategy	Probability of Enhancement Success
O-001	Shorten the construction schedule by adding shifts.	Enhance	Re-plan the project to use multiple shifts for work on or near the critical path.	75%
O-002	Obtain material discounts using prompt payment provisions in procurement contracts.	Enhance	Contact suppliers and fabricators early in project to ensure discounts are made available and included in procurement contracts.	50%

4. Risk Assessment – Quantitative Analysis

- Estimate the cost and schedule impacts for each primary or residual risk, reported as best case, most likely, and worst case.

Threats

ID	Threat	Cost Impacts, $000s			Schedule Impacts, weeks			Probability
		Best Case	Most Likely	Worst Case	Best Case	Most Likely	Worst Case	
T-001	Labor unavailability due to competing projects.	1,000	2,000	4,000	4	8	16	10-25%
T-002	Construction subcontractor bids come in slightly higher than estimate.	0	5,000	20,000	0	0	0	75-90%
T-003	Material prices rise higher than budgeted.	500	1,500	3,000	0	0	0	26-74%
T-004	Stakeholder objections delay building permit.	1,000	2,500	4,000	4	10	16	<10%

Opportunities

ID	Opportunity	Cost Impacts, $000s			Schedule Impacts, weeks			Probability
		Best Case	Most Likely	Worst Case	Best Case	Most Likely	Worst Case	
O-001	Shorten the construction schedule by adding shifts.	3,500*	2,000*	750*	16	10	4	75-90%

O-002	Obtain material discounts using prompt payment provisions in procurement contracts.	3,000	1,500	0	0	0	0	26-74%

*These cost impacts represent the net savings of a shorter schedule (with lower hotel loads, etc.) offset by higher costs resulting from added labor costs (shift differential) and craft productivity impacts.

- Input the cost impact ranges for both threats and opportunities into the Monte Carlo analysis tool, along with the probability of occurrence, to estimate the cost contingency associated with contractor risks.

- Analyze the results from the Monte Carlo (distribution curves) to determine the cost contingency at the desired confidence level. For example, assume the results for all risks and opportunities (not just the ones shown above) show the following:

    - Contribution to MR for Cost Risks - $23.77 million at 80% confidence level.

- Input the schedule impact ranges for both threats and opportunities into the Monte Carlo analysis tool, along with the probability of occurrence, to estimate the schedule contingency associated with contractor risks that affect the Critical Path.

- Analyze the results from the Monte Carlo (distribution curves) to determine the schedule reserve at the desired confidence level. For this example, assume the results for all risks and opportunities (not just the ones shown above) show the following:

    - Schedule reserve – 5 months at 80% confidence level.

- Calculate the cost impact due to schedule contingency using the hotel load. For this example, assume hotel load is $250,000 per month.

    - Contribution to MR from schedule risks – 5 months x $250,000/month = $1.25 million.

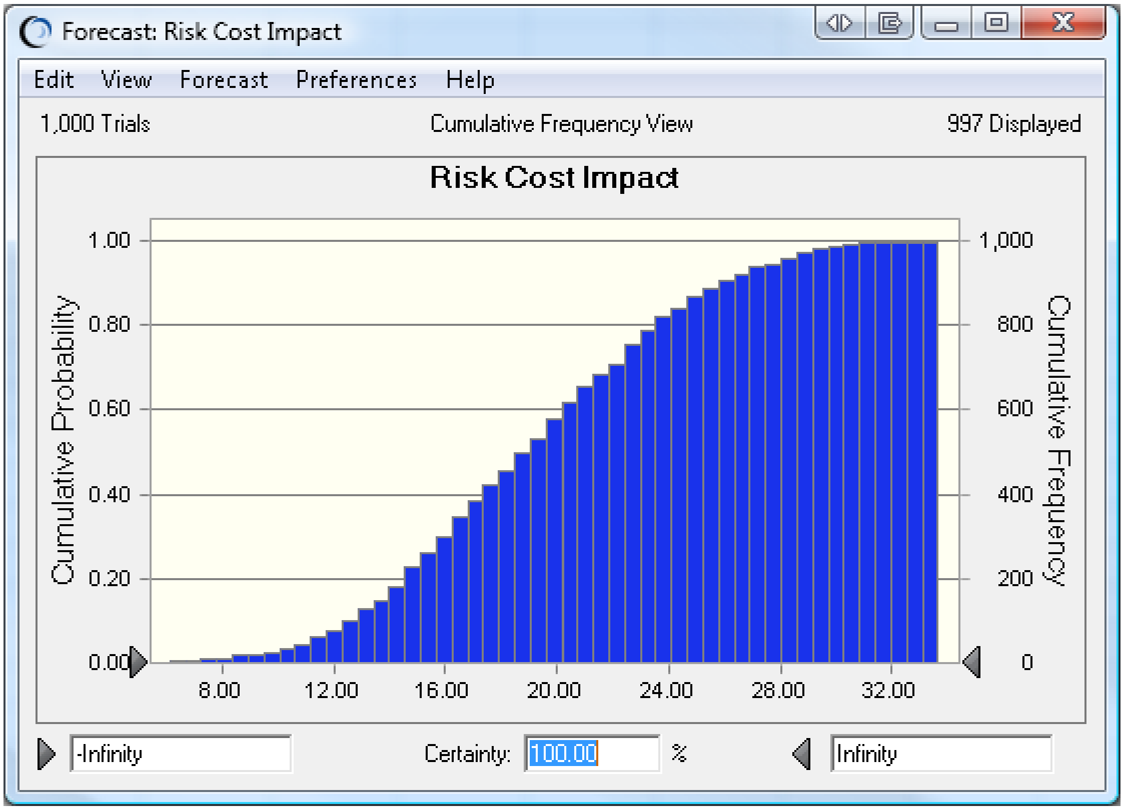


Figure 6. Example Output of Monte Carlo Analysis of Cost Risk Impacts

Percentiles	Risk Cost Impact ($M)
0%	6.11
10%	12.84
20%	14.79
30%	16.23
40%	17.65
50%	19.05
60%	20.50
70%	22.32
80%	23.77
90%	26.08
100%	35.35

5. Cost Estimating Uncertainty

- Using the project cost estimate, define the range of cost estimating uncertainty. This is usually done at a summary level and may appear similar to the following:

Cost Estimate Uncertainty

WBS	Description	Cost Range, $ million		
		Best Case	Most Likely (Baseline Cost)	Worst Case
2.1	Preliminary Design[1]	15	15	15
2.2	Final Design	9	10	12
3.0	Construction	85	92.5	115
4.0	Project Management	9.5	10	11
5.0	Construction Management[2]		7.4	
		8% of Construction	8% of Construction	10% of Construction
6.0	Title III Design[2]		6.5	
		7% of Construction	7% of Construction	9% of Construction
7.0	OPCs	6	8.6	11
	Total		150	

Notes: In actual practice, Cost Estimate Uncertainty can be modeled in a variety of ways. This may be done using a lower level of the WBS or by breaking the project down into key cost drivers (e.g., bulk commodities – quantities and pricing; labor – productivity and rates; equipment pricing; engineering – hours and rates; etc.).
1 – Since Preliminary Design is assumed complete, this cost is frozen for purposes of this example.
2 – In an actual model, it may be better to use percentages of construction cost to model these uncertainties in order to recognize the close correlation that exists.

- Input the cost estimate ranges into the Monte Carlo analysis tool to estimate the cost estimate uncertainty for the contractor.

- Analyze the results from the Monte Carlo to determine the cost estimate uncertainty at the desired confidence level. For this example, assume the results show a cost estimate uncertainty of $5 million at the 80% confidence level.

6. Contractor Management Reserve

- Add the cost contingency (derived from the risk analysis) to the cost estimate uncertainty contingency, at the same confidence levels, to derive the total MR for the contractor. For example:

Contributions to MR from cost risks	$23.75 million
Contributions to MR from schedule risks	$1.25 million
Contributions to MR from Cost estimating uncertainty	$5.0 million
Total MR	$30.0 million

B. DOE Contingency

The DOE Contingency discussed here is the contingency needed to mitigate project risks that are within the project baseline but are generally beyond the contractor's control. It is additive to the MR portion determined in Section A. The steps to follow for DOE Contingency are similar as for MR. Projects should contact their sponsoring program office for additional general and project-specific guidance.

1. Risk Identification.

- The IPT defines the bounding (enabling) assumptions for the project.

  Examples:

  - Funding will be available according to the funding profile.
  - There will be no extraordinary ES&H incident or other event that causes an extended shutdown.

- The IPT then identifies the risks (threats and opportunities) associated with the project, and assigns a risk owner to each risk. The two risk lists may resemble the following (only a few threats and opportunities are listed to exemplify the process):

Threats

ID	Threat	Owner
DOE-T-001	Adequate power is not available to the contractor resulting in schedule delays and increased project costs.	FPD
DOE-T-002	The site requires some groundwater cleanup prior to construction which will increase project costs.	ES&H Manager
DOE-T-003	GFS/I are delayed resulting in schedule delays and increased project costs.	Contracting Officer

DOE-T-004	Construction contractor fails to meet performance expectations which will result in schedule delays and increased project costs.	FPD

Opportunities

ID	Opportunity	Owner
DOE-O-001	General contractors will consider fixed price, incentivized contract which will reduce project costs.	Contracting Officer
DOE-O-002	Government provided equipment is available for sharing with another project in the area which will reduce project schedule and reduce project costs.	Contracting Officer

Follow Steps 2 and 3 above for MR (Example Section A, Steps 2 and 3).

4. Risk Assessment – Quantitative Analysis

- Estimate cost and schedule impacts for each primary or residual risk, reported as best case, most likely, and worst case.

- Input the cost impact ranges into the Monte Carlo analysis tool, along with the probability of occurrence, to estimate the cost contingency associated with DOE risks.

- Input the schedule impact ranges into the Monte Carlo analysis tool, along with the probability of occurrence, to estimate the schedule contingency associated with DOE risks that affect the Critical Path.

- Analyze the results from the Monte Carlo to determine the cost and schedule contingency at the desired confidence level. Calculate the cost impact due to schedule contingency using the hotel load. For this example, assume the results show the following:

    - Cost contingency due to cost risks - $15.5 million at 80% confidence level.

    - Cost contingency due to schedule risks - $1.5 million.

    - Schedule contingency – 6 months at 80% confidence level.

5. Cost Estimating Uncertainty

- Determine cost estimating uncertainty for DOE costs that are outside of the contractor scope, if applicable (e.g. other direct costs or services).

- Using the cost estimate for DOE costs, define the range of cost estimating uncertainty.

- Input the cost estimate ranges into the Monte Carlo analysis tool to estimate the cost estimate uncertainty for DOE costs.

- Analyze the results from the Monte Carlo to determine the cost estimate uncertainty at the desired confidence level. For this example, assume the results show a cost estimate uncertainty of $3 million at the 80% confidence level.

6. DOE Contingency

   Add the cost contingency (derived from the risk analysis) to the cost estimate uncertainty contingency, at the same confidence levels, to derive the total MR for the contractor. For example:

Cost contingency due to cost risks	$15.5 million Cost
Contingency due to schedule risks	$1.5 million Cost
Estimating uncertainty	$3.0 million
Total DOE Contingency	$20.0 million

Note: The preceding example represents a simplistic approach towards MR and DOE contingency derivation. This example could have also incorporated a Monte Carlo analysis for the cost and schedule contingency attributable to schedule estimate uncertainty. Good risk management practice dictates that further sensitivity analyses should be employed in order to determine the MR and DOE contingency contributions from individual cost risks, schedule risks, and estimating uncertainty. This enables the IPT to assess and monitor where the greatest potential impact to project performance baseline might originate. Chapter 13 of the GAO Cost Estimating and Assessment Guide provides a more thorough discussion of sensitivity analysis, including the steps for performing sensitivity analysis.[8]

C. Total MR and Contingency

Based on the assessment of all project risks and cost estimating uncertainty, the total project contingency based on the simplified example is as follows:

Management Reserve	$30 million
DOE Contingency	$20 million
Total MR and DOE Contingency	$50 million

[8] Reference for further examples for the application of the suggested Risk Management Process: Allan J. Chilcott, Risk *Management - A Developing Field of Study and Application,* **Cost Engineering**, September 2010.

This is added to the base costs of $150 million, which results in a Total Project Cost of $200 million.

8.0 ATTACHMENTS

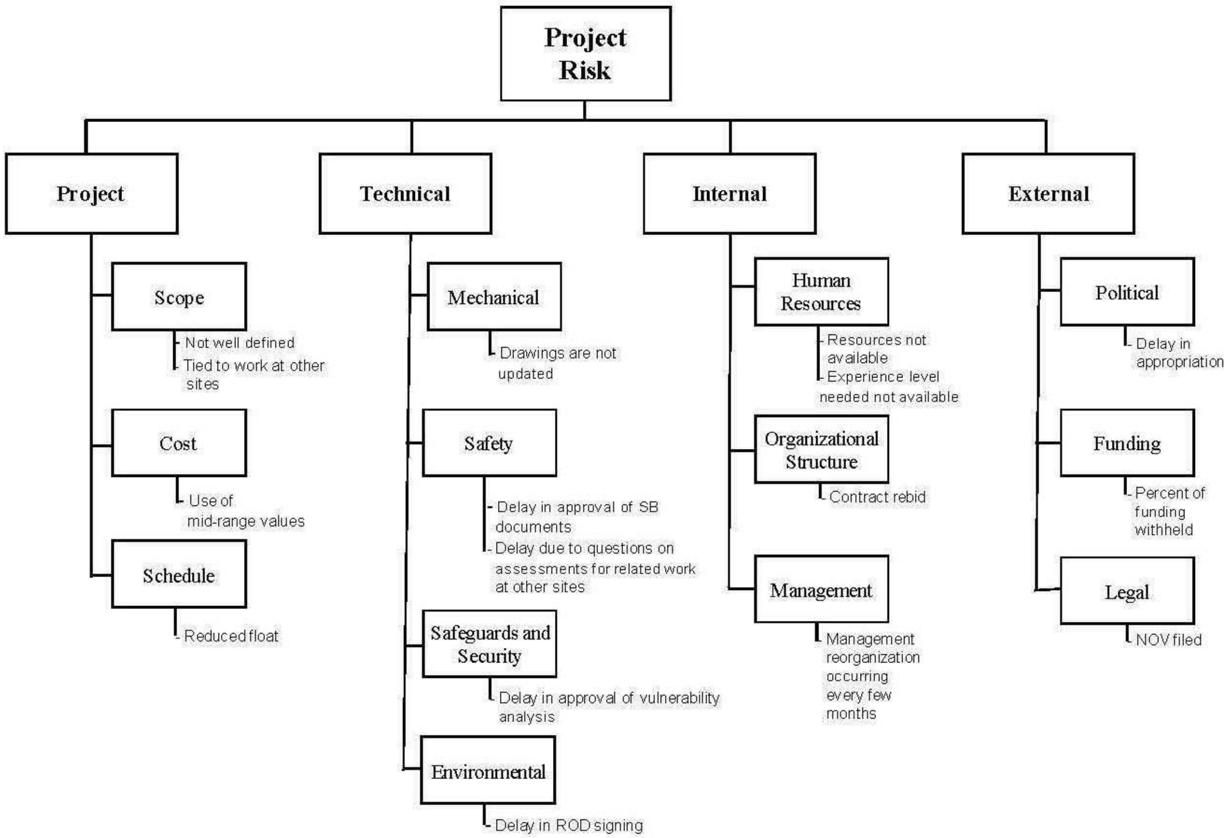
The forms provided in this section are only suggested formats and may be modified as required by the program office, site office, or the project. All forms can be modified to work with numerous commercially available software programs. Fields suggested for forms may be supplemented or deleted as necessary, although certain fields may be noted as necessary for the purposes of analysis or reporting within the text of the guide regarding that type of reporting.

Before modifications are made to the fields on the forms, verify that the field is not one that is considered necessary for the purposes of analysis or reporting.

Attachments 11, 12, 13, and 14 in this document provide suggested recommendations and additional clarification guidance on the definition, derivation, and use of the terms contingency and management reserve in risk management for DOE projects. Specifically:

- Attachment 11 – Risk Identification, Development and Use of Contingency and Management Reserve (Supplementary Information)
- Attachment 12 – Cost and Schedule Contingency Development Process (Supplementary Information).
- Attachment 13 – Contingency Estimate Inputs and Interface Needs (Supplementary Information)
- Attachment 14 – Management and Reporting Management Reserve and Contingency (Supplementary Information)

Attachment 1. Risk Breakdown Structure—Example One



See reference – Hillson, D. A. (2007), ―Understanding risk exposure using multiple hierarchies, published as part of 2007 PMI Global Congress EMEA Proceedings – Budapest.

Risk Breakdown Structure—Example Two

Level 0	Level 1	Level 2	Level 3
Project Risk	Project	Scope	Not well defined
			Tied to work at other sites
		Cost	Use of mid-range values
		Schedule	Reduced float
	Technical	Mechanical	Drawings are not updated
		Safety	Delay in approval of SB documents
			Delay due to questions on assessments for related work at other sites
		Safeguards and Security	Delay in approval of vulnerability analysis
		Environmental	Delay in ROD signing
	Internal	Human Resources	Resources not available
			Experience level needed not available
		Organizational Structure	Contract rebid
		Management	Management re-organization occurring every few months
	External	Political	Delay in appropriation
		Funding	Percent of funding withheld
		Legal	NOV filed

Attachment 2. Risk Status Report

Item		Number	Comments
1	Risks Open		
2	Risks Closed		
3	Monitoring Trigger Pending Within Three Months		
4	Residual Risk Handling Response Enacted		
5	Residual Risk Moved to Primary		
6	Secondary Risk Moved to Primary		

Attachment 3. Risk Responsibility Assignment Matrix

	Federal Project Director[1]	Integrated Project Team	Subject Matter Expert	Contractor Project Manager	Other—Identify[2]
Risk Planning					
Risk Identification					
Qualitative Analysis					
Quantitative Analysis					
Handling Response					
Monitoring and Control					
Risk Communication					

Legend					
Responsible	Accountable	Reviews	Approves	Contributes	Prepares

Notes:

1. For M&O contracts, the FPD may be a Contractor Project Director.
2. Other could be Contractor Control Account Manager.

Attachment 4. Probability Scale/Schedule Consequence Criteria

Probability Scale Example

Very High	>90%		
High	75-90%	Moderate/High	60-75%
Moderate	26-74%	Moderate/Moderate	40-60%
Low	10-25%	Moderate/Low	25-40%
Very Low	<10%		

Schedule Consequence Scale Example

Very High	12-24 months		
High	12-18 months	Moderate/High	9-12 months
Moderate	3-12 months	Moderate/Moderate	6-9 months
Low	0-3 months	Moderate/Low	3-6 months
Very Low	0-0.5 months		

Cost Consequence Scale Example

Very High	$10M-$100M		
High	$1-$10M	Moderate/High	$0.5-$1.0M
Moderate	$100K-$1M	Moderate/Moderate	$250-$750K
Low	$10-$100K	Moderate/Low	$100K-$250K
Very Low	<$10K		

Notes:

- The criteria for each category may be adjusted depending on the size and duration of the project. For instance,a 6-month impact may be Moderate for a 10-year project, but Very High for a 2-year project. Similarly, a $1M impact may be very high for some projects where other longer/larger projects may have risks that exceed $1B.A category can be expanded to facilitate the elicitation of risks from subject matter experts. In the above probability and schedule scales, the “Moderate” scale was expanded.

- Categories may be overlapping or non-overlapping.

Attachment 5. Risk Register

The risk register or risk log is a database often captured in a database such as Access or Excel or other risk management software tool. The format is dictated by the size of the project and the ease of compiling the necessary reports. Following are the names of the fields that should appear in the risk register and a description of those fields. The database should be capable of generating reports based upon querying various fields and dates for open risks and trigger dates as well as handling responses that are currently operable.

Risk: Risk as identified and should include the cause, the risk likelihood, and the effect (consider separate sub-fields for each to allow search capabilities on common causes of risks). The preferred statement should be in the affirmative to gain the most effective risk handling responses or strategies.

Risk Identification Number: Unique identification number for the risk. WBS: WorkBreakdown Structure identification number.

Risk Owner: Person responsible for tracking, monitoring, documenting, and ensuring the handling response or strategy is implemented and reported upon.

Risk Category: Category assigned for grouping or from Risk Breakdown Structure analysis.

Risk Status: Open or closed.

Risk Assumptions: Any assumptions pertaining to the risk itself. The identification of assumptions may be clues to other risks.

Risk Probability and Basis: Likelihood of this event occurring. Use the appropriate qualitative risk analysis matrix.

Risk Consequence and Basis: Outcome of this event. Use the appropriate qualitative riskanalysis matrix.

Risk Level: The intersection of the probability and consequence on the appropriate qualitativerisk analysis matrix, which determines the overall potential risk impact to the project.

Risk Monitoring Trigger: Early warning signs that this risk is about to occur.

Success Metric: Measure by which the Federal Project Director or Contractor Project Manager will know that the avoidance strategy or handling response or strategy has been successful.

Avoidance Strategy: If there is an avoidance strategy to eliminate risk completely it should goin this field. Avoidance is a type of risk handling strategy.

Risk Handling Strategy: Step-by-step (similar to a project plan) approach to eliminating or reducing the risk if no avoidance strategy is immediately available; includes the dates for completion. Include the probability of success for the risk handling strategy and consider probabilistic branching to account for the handling strategy failing.

Cost (for risk handling strategy): Necessary cost for implementing the handling strategy. Cost Assumptions: Assumptions that relate to the cost contingency values.

Schedule (for handling strategy): Necessary schedule for implementing the risk handling strategy.

Schedule Assumptions: Assumptions that relate to the schedule contingency values. Residual Risk: Remaining risk once the risk handling strategy is completed.

Risk Handling Strategy for Residual Risk: May be filled in depending upon the level of risk perceived by the Federal Project Director or the Contractor Project Manager.

Residual Risk Probability and Basis: Likelihood of this event occurring. Use the appropriate qualitative risk analysis matrix.

Residual Risk Consequence and Basis: Outcome of this event. Use the appropriate qualitative risk analysis matrix.

Residual Risk Level: The intersection of the probability and consequence on the appropriate qualitative risk analysis matrix, which determines the overall potential risk impact to the project.

Secondary Risk: Risk arising as a direct result of the implementation of a risk handling strategy.

Secondary Risk Probability and Basis: Likelihood of an event occurring. Use the appropriate qualitative risk analysis matrix.

Secondary Risk Consequence and Basis: Outcome of an event. Use the appropriate qualitative risk analysis matrix.

Secondary Risk Level: The intersection of the probability and consequence on the appropriate qualitative risk analysis matrix, which determines the overall potential risk impact to the project.

Trigger Date: Early warning sign of the date that this risk is about to occur.

Trigger Metric: Event, occurrence or sequence of events that indicates the risk may be about to occur, or the pre-step for the risk indicating that the risk will be initiated.

Attachment 6. Cost/Benefit Analysis

Often captured as Benefit/Cost = Return on Investment (or Investment Outcome). For the purposes of this Guide, the steps are:

- Identify the costs and benefits
- Quantify in units
- Calculate units into dollar value
- Calculate costs and benefits into time
- Project the net benefits and costs

These benefits and costs can be distributed over time using the same Monte Carlo simulation methodology, if desired.

Reference: Boardman, Greenberg, Vining & Weimer, Cost-Benefit Analysis Concepts andPractice, Prentice Hall, 3rd Edition, 2005.

Attachment 7. Opportunity Matrix

						Consequence
Probability	Opportunity Matrix	Negligible	Marginal	Significant	High Impact	Very High Impact
	Cost	Minimal or no consequence. No impact to Project cost.	Small increase in meeting objectives. Marginally increases costs.	Significant increase in positive chance to meet allocated costs.	Goals and objectives are more achievable. Removes serious threats to project costs.	Project proceeds without threat to budget within the mission space.
	Schedule	Minimal or no consequence. No impact to Project schedule.	Small increase in meeting objectives. Marginally impacts schedule.	Significant increase in positive chance to meet allocated schedule.	Goals and objectives are more achievable. Removes serious threats to project schedule.	Project proceeds without threat to schedule within the mission space.
	Very High >90%	Low	Moderate	High	High	High
	High 75% to 90%	Low	Moderate	Moderate	High	High
	Moderate 26% to 74%	Low	Low	Moderate	Moderate	High
	Low 10% to 25%	Low	Low	Low	Moderate	Moderate
	Very Low <10%	Low	Low	Low	Low	Moderate

Note: Matrix is suggested only, as each site may have a site-specific matrix.

Attachment 8. Risk Identification Checklist

Below is a list of risk areas within this Risk Identification Checklist. Below each risk area (i.e., Front-End Planning Risks) is a listing of related risks. Many of the risks listed in this attachment can have significant impacts on a project's technical performance, cost, and schedule status. Not alllisted risks will be applicable to every program. Not all risks are normally under the direct control of the Federal Project Director.

Risk Areas

1. Front-End Planning Risks
2. Market Related Risks
3. Technical Risks (Hazard Category 1, 2, & 3 Projects)
4. Budget Risks
5. Contract/Specification/Statement of Work Risks
6. Site Risks
7. Staffing Risks (Federal and Contractor)
8. Organizational Risks (Federal and Contractor)
9. Project Execution Risks
10. Regulatory Compliance/Oversight Risks
11. Ineffective Governmental Oversight/Contract Administration Risks

Context for use of this checklist: This checklist may be used as a follow-up to a brainstorming session or other methodology such as interviews, risk breakdown structures or diagramming techniques to ensure that all currently identified DOE areas of concerns have been covered. It is not intended as a complete checklist and may be used in conjunction with other checklists as the user may see fit. The checklist should not be used in lieu of the brainstorming session and other methods of risk identification, but as a checklist it is intended to check the work done by the risk identification team members. Many of the risks listed in this attachment can have significant impacts on a project's technical performance, cost, and schedule. Note that not all listed risks will be applicable to every project.

1. Front-End Planning Risks

    - Expectations and/or requirements that:

        - Have not been identified.

- Are unrealistic.
- Are incomplete.
- Are unstable.
- In conflict with each other.

- Incomplete or inaccurate identification of constraints:
  - Funding/budget resources.
  - Political support.
  - Staff and contractor resources.
  - Procedural.
  - Regulatory.
- Unrecognized or underestimated complexities caused by:
  - The number of systems, structures, components.
  - The number of requirements and constraints.
  - Technical challenges.
  - Technical interfaces.
  - Organizational and functional interdependencies.
  - Nonlinearity.
  - Unstable or dynamic environments.
  - Schedule demands.
- Excessive, unrealistic, or unrecognized assumptions.

2. Market Related Risks.

- Limited vendor/contractor availability and/or interest because of external market conditions.
  - Availability of other work (the existence of a seller's market).
  - Volatile prices.

- Limited or uncertain availability of materials, labor, components, and/or constructionequipment.
- Limited availability of financing to cover cash flow delays.

- Reduced vendor/contractor interest because of contract imposed terms and conditions thatincrease their risks.
  - No recovery of damages for owner-caused delays.
  - Full indemnity for damages.
  - Ambiguous acceptance criteria.
  - Financial responsibilities for force majeure.
  - Cumulative impact of multiple change orders.
  - Owner-mandated subcontractors.
  - Differing site conditions.
  - Transfer of design responsibility to constructors and suppliers.
  - Waiver of claims due to time limits.
  - Standards of care clauses such as "highest and best industry standards" and "in a workmanlike manner."
  - Fixed price contracts.
- Reduced vendor/contractor interest because of the uniqueness of the tasks or performance requirements.

3. Technical Alignment Risks (Hazard Category 1, 2, & 3 Projects)

- Technology maturity.
- Safety-in-design (STD 1189-2016).
- Design margins/degree of conservatism.
- Definition, selection, and implementation of quality assurance requirements.
- Safety-class and significant fire protection systems.
  - Fireproofing of structural steel.
  - Combustible loadings.

  - Degradation of HEPA filters.
  - Fire detection and suppression system activation mechanisms.
  - Hydrogen & flammable gas generation/accumulation.

- Seismic/structural.
  - Ground motion.
  - Snow load and wind.
  - Adequacy of geotechnical investigations.
  - Soil settlement.
  - Soil-structure interaction analyses.
  - Load paths for seismic and settlement induced forces.
  - Finite element analysis.
  - Structural computer codes.

- Confinement.
  - Strategy.
  - Adequacy of confinement barriers.
  - Magnitude of the radiological source term.

- Criticality standards.

- Chemical process safety.

- Technical defensibility of calculations and designs. Security
  - Physical security.
  - Cyber security.
  - Information security.

4. Budget Risks

- Incomplete or inaccurate funding/budget resources.

- Decrements in funding/budget.

- Funding profile changes that impact budget.

5. Contract/Specification/Statement of Work Risks

   - Unclear or Loose Technical Requirements:

     - Built system does not meet Government requirements.
     - Excessive rework following Government clarification of requirements.
     - Contractor naming loose technical requirements to maximize profits.

   - Conflicting or Excessive Requirements

     - Conflicting Requirements generate excessive rework or inefficient operations.
     - Failure to use performance-based contracting.

   - Inadequate Incentives

     - Incorrect Contract Type to promote effective contractor performance.
     - Poorly developed performance-based incentives or award fee plan.

6. Site Risks

   - Access constraints.
   - Underground/soil conditions.
   - Wind and flooding.
   - As-built conditions.
   - Utility availability/capabilities.
   - Coordination with other construction activities.

7. Staffing Risks (Federal and Contractor)

   - Inadequate staffing for the size, complexity, and/or challenges of the project.
   - Inadequate formal education/certification/training.
   - Personnel/organizations lack experience on similar projects.
   - Recruitment issues.

     - Remote location.

  - Moving Expenses.

- Personnel turnover.
  - High level of personnel turnover.
  - Inadequate succession approach for key and critical personnel.
- Unwillingness to seek out or utilize lessons learned by others. Inadequate cognitive skills.
  - Lack of situational awareness.
  - Inabilities to recognize evolving patterns (connect the dots) and/or recognize warning signs.
  - Inability to foresee and avoid the obstacles the project will experience.
  - Inability to adjust to changing situations or environments.
  - Inability to foresee the secondary effects or unintended consequences of decisions oractions.

8. Organizational Risks (Federal and Contractor)

- Lack of organizational alignment.
  - Different organizational cultures.
  - Different organizational priorities.
  - Different levels of motivation.
  - Contractor unfamiliar with Federal processes
- Unclear or overlapping roles, responsibilities, and/or authority.
- Organizational fragmentation/excessive outsourcing and use of subcontractors.
- Lengthy decision/approval chains.

9. Project Execution Risks

- Document, design, and/or construction rework:
  - Design and Documentation Quality Issues.
  - Inadequate Configuration Control.
  - Design Integration and Scheduling Issues.

- Inadequate Testing.
- Learning curves.
  - Individual.
  - Corporate.
- Coordination/integration of individual tasks/efforts.
- Iterative development.
  - Evolving Requirements.
  - Evolving Technology.
  - Continued Integration with Related Systems.
  - Waterfall vs. Spiral vs. Evolutionary Development.
- Approval Process.
  - Approval times.
  - Imposition of Excess or Ineffective Requirements.
- Logistics problems.
- Supply chain management challenges.
  - Long lead time procurements.
  - Limited vendor availability.
  - High-inflation for high-demand commodities/products.
  - Vendor quality control.
- Productivity and Efficiency Issues.
  - Lack of applicable productivity, cost, and schedule data/benchmarks.
    - For cost estimates.
    - For probability distributions.
  - Ineffective contractor management.
  - Labor relations/labor productivity.

   - Inadequate training.
   - Improper Incentives (contract, management, and/or labor).

10. Regulatory Compliance/Oversight Risks

- Changing regulatory requirements.
- Regulator disapproval of proposed technological approach/design.
- Regulator directed changes.
- Excessive delays to obtaining regulator's approvals.

11. Ineffective Governmental Oversight/Contract Administration Risks

- Delayed problem recognition and resolution because of:
   - Inadequate systems for measuring performance.
   - Construction/procurement releases before final designs are sufficiently complete.
   - Ineffective project reviews, inadequate use of project management tools.
   - Lengthy/ineffective feedback loops.

- Imposition of Additional or Ineffective Requirements.

- Change Control Issues.
   - Excessive number of changes.
   - Cost/benefit analyses of changes not analyzed and/or ineffective analysis.
   - Changes imposed at a less than optimal stage of design/construction.
   - Changes not identified/tracked. Failure to expeditiously negotiate changes.
   - Ineffective negotiation process (poor cost estimating, inability to isolate cost of changes, late negotiations).
   - Contractor uses changes process to hide poor technical, cost and schedule performance.

Attachment 9. Risk Monitoring Checklist

Item Number	Item	Yes/No	Comment
1	Risk handling strategy was implemented as planned		
2	Risk handling strategy was effective		
3	Back-up risk handling strategy was required to be implemented		
4	Risk assumptions were valid		
5	Project assumptions were valid		
6	Risk monitoring trigger was valid		
7	Risks were correctly noted in risk reports		
8	Risk was on team meeting agendas		
9	Risk monitoring was conducted per the Guide		
10	Risk was integrated into Earned Value discussions		
11	Were unidentified risks discovered		
12	Was contingency associated with a given risk sufficient		
13	Were risks captured in the risk register and updated		
14	Was a risk brainstorming session or scenario planning session used to identify risks		
15	Was a subsequent session for identification of risk conducted to update the risks identified		
16	Were lessons learned captured during the risk process		
17	Were lessons learned distributed during the risk process to the project team		
18	Were lessons learned distributed during the risk process to other project teams		
19	Were any systems analysis or decision analysis methodologies applied, especially for such items as technology readiness level implementation		

Attachment 10. Management Reserve or Contingency Use Report

The CPM will generally use this as a management reserve report. If funds are applied outside of risks captured on the risk register, the explanation should be captured on the report and accepted by the site office FPD.

Risk Realized: ID #, WBS #	Management Reserve Expended	Schedule Contingency Expended	Comments

Attachment 11. Risk Identification, Development and Use of Contingency and Management Reserve (Supplementary Information)

This DOE Guide provides detailed guidance on an effective risk management process (programs may adopt other acceptable methods/approaches as determined appropriate by the program office).The contents under this Section should be interpreted as unqualified recommendations and clarification guidance for the definition, derivation and use of the terms contingency and MR in risk management for DOE projects. Contingency and Management Reserve (MR) are project cost elements directly related to project risks and are part of the project cost estimates.

The specific confidence level (CL) used to develop the project performance baseline estimate is determined by the project's FPD/Integrated Project Team (IPT) and is approved by the Acquisition Executive. The project confidence level should be based on but not limited to the project risk assumptions, project complexity, project size, and project criticality. At a minimum, project performance baselines should be estimated, budgeted, and funded to provide a range of 70-90 percent confidence level for DOE capital asset projects. Projects should check with their program sponsor for additional guidance. The confidence level for Major Items of Equipment may be significantly different from the construction of conventional facilities that will house the equipment. If a project has a performance baseline change, the FPD should consider reanalyzing the risks at a higher confidence level for budgetary requests and funding profiles to ensure project completion.

This DOE Guide defines four categories of contingency, each of which were discussed throughoutthe document.

DOE contingency budget is identified as funded contingency for use by the FPD. Contingency is the risk based, quantitatively derived portion of the project budget that is available for managing risks within the DOE performance baseline. At a minimum, DOE capital asset project costs shouldbe estimated to provide a range of 70-90 percent confidence level.

DOE schedule contingency is the risk-based, quantitatively derived portion of the overall project schedule duration that is estimated to allow for the time-related risk impacts and other time-relatedproject uncertainties. Project schedule contingency should be estimated to provide a range of 70-90 percent confidence level.

Contractor management reserve budget is determined by the contractor and is the risk based, quantitatively derived portion of the contract budget base (CBB) that is set aside for management purposes to handle risks that are within the contractor's contractual obligations. Once the CBB has been established, it is allocated by the contractor to MR and the Performance Measurement Baseline (PMB). The contractor's determination of MR is not intended to justify a post contract increase to theCBB. MR is maintained separately from the PMB and is utilized through the contractor's change control process. MR is not used to resolve past variances (positive or negative) resulting from poor contractor performance or to address issues that are beyond the scope of the contract requirements. Use of MR should follow EVMS rules per EIA-748D.

Contractor schedule reserve is determined by the contractor, and is the risk based, quantitatively derived portion of the overall contract schedule duration estimated to allow the contractor time to manage the time-related impacts of contractor execution risks and other contractor duration uncertainties within the contract period. Contractor schedule reserve does not add time or schedule duration to the contracted end date.

The quantitative methodologies used to analyze DOE projects should use an objective analysis to evaluate project cost and schedule estimate uncertainties and discrete project risks. The analysis should aggregate the probability and consequences of individual risks, and cost and schedule uncertainties to provide an estimate of the potential project costs.

The purpose of the quantitative risk analysis is to provide risk-based project budget and completiondate estimates using statistical modeling techniques such as Monte Carlo, Quasi-Monte Carlo, sensitivity simulations, and other stochastic methodologies depending upon the project data.

While the use of the Monte Carlo simulation is one of the standards used by DOE, the use of alternate forms of quantitative analysis may be used in conjunction with Monte Carlo simulation to validate contingency conclusions. Other recognized forms of quantitative analysis that are often used include: decision trees, influence diagrams, system dynamics models, and neural networks.

Figure A-1 below shows the typical components of the DOE project performance baseline representing the fundamental building blocks used in this protocol.

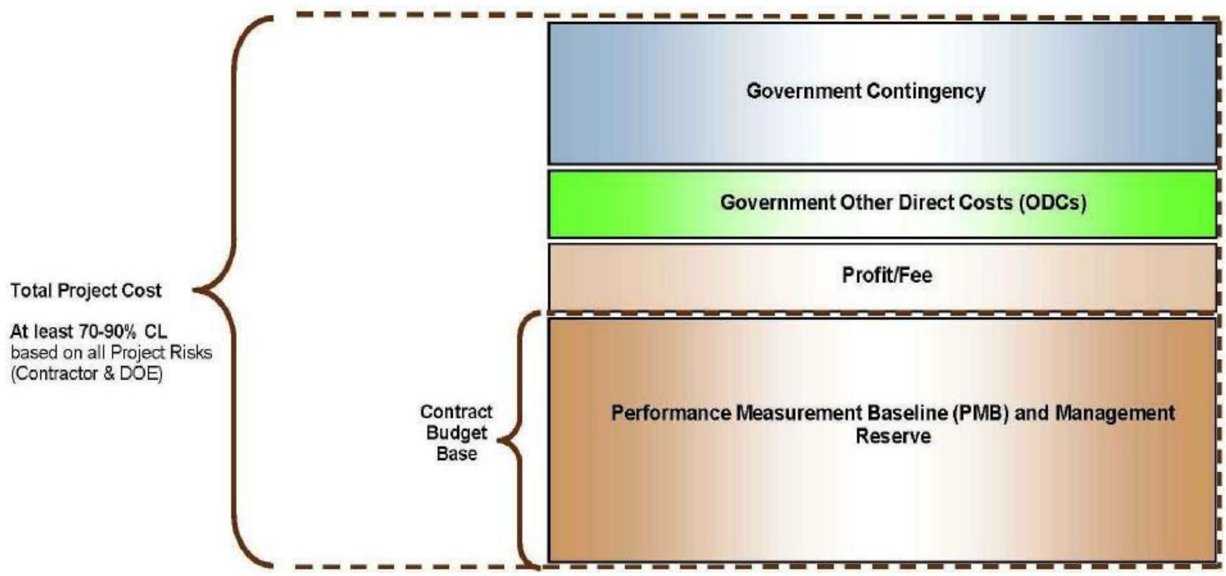


Figure A-1. Performance Baseline Components for Capital Asset Projects

Attachment 12. Cost and Schedule Contingency Development Process (Supplementary Information)

The contents under this Section should be interpreted as unqualified recommendations and clarification guidance for the definition, derivation and use of the terms contingency and MR in risk management for DOE projects.

DOE O 413.3B requires that DOE project estimates be developed based on qualitative and quantitative analysis of project risks and other uncertainties. The DOE qualitative and quantitative analysis process begins in the project's planning stage with the identification of project risks during the initial project planning phase prior to the first Critical Decision (CD) point (approval of mission need). After CD-0, project development and planning documentation are prepared that include the initial Federal Risk Management Plan (FRMP) as part of the preliminary Project Execution Plan (PEP). During this phase of the project, the initial development of the project risk register is initiated with the identification of potential project risks and enabling assumptions.

At CD-1, the baseline scope is refined enough to develop a preliminary baseline cost range and schedule. The FRMP continues to evolve as the project scope is refined, new risks are added to the risk register and existing risks are re-examined and the project knowledge base increases.

In preparation for the CD-2 project phase, the project performance baseline estimate is refined to include risk handling costs and evaluated to determine the project budget needed to provide an appropriate confidence level (CL) to ensure the project's success. The identified DOE project risks are qualitatively and quantitatively evaluated to determine the likelihood of occurrence and the potential impacts to the project should the risk events occur.

Quantitative Contingency Analyses

This DOE Risk Management Guide states that the purpose of the quantitative risk analysis is to provide budget and completion date estimates that include the effects of the project risks and other project uncertainties using statistical modeling techniques such as Monte Carlo analyses or other similar methodologies. Other forms of quantitative analysis may be used in conjunction with Monte Carlo simulation including: (projects may adopt other acceptable methods / approaches as determined appropriate by the program office).

- Decision trees.
- Influence diagrams.
- System dynamics models.
- Neural networks.

This document assumes Monte Carlo methodologies will be used in the development of the cost and schedule baseline models. The diverse and unique nature of DOE projects characterized by an assortment of distinct technologies, physical locations, project duration, and project size has a significant impact on the risk profile of each DOE capital asset project that makes it impossible to establish a prescriptive procedure or single quantitative risk model for determining a project's contingency needs. Consequently, only a basic framework is used to outline considerations essential in the development of DOE contingencies.

Cost and Schedule Risk Models

DOE contingency risk models are used to evaluate the effects of risk impacts and estimate uncertainties on project cost and schedule performance baselines. The results of the risk analysis are used to establish the cost and schedule contingency needed by the project to provide a suitable confidence level for DOE project success. The analyses may use one or more risk models to evaluate the cost impacts and the associated schedule impacts.

For each risk, a percent or percentage distribution is assigned to the probability (the likelihood of the risk occurring), a dollar value or dollar value distribution is assigned to the cost impact, and a schedule duration impact or duration distribution is assigned to the affected activity in the schedule.

In general, the concept is implemented as:

$$EV = \sum P_{Ri} \times CI_{Ri} \ (SI_{R1})$$

Where: EV = Expected Value of cost impact (or duration impact) of all risks

P_{Ri} = Probability distribution function of a risk occurring

CI_{Ri} = Cost Impact distribution function of a risk occurrence

SI_{R1} = Schedule Impact distribution function of a risk occurrence

[Note: $\sum$ is not the summation of individual expected values for each risk, but represents a stochastic process (e.g. Monte Carlo simulation) using the collective probabilities and cost/schedule impacts for all the identified risk events.]

Figure A-2 is a sample from a DOE construction project risk register showing the residual risk data elements used for modeling the probability of occurrence (Probability %) and the triangular distribution representing a three-point estimate of the anticipated range of cost and schedule impacts.

Risk #	Owner	Risk Description	Residual Risk									
			Likelihood	Consequence	Risk Score/Rank	Probability %	Cost Impacts ($)			Schedule Impacts (mo)		
							Best Case	Most Likely	Worst Case	Best Case	Most Likely	Worst Case
T47	**Federal**	Nonperformance of contract to provide shielded overpack containers leads to project delays and cost.	Unlikely	Significant	Moderate	40%	850,000	3,000,000	6,000,000	$0	$0	$0
T52	**Federal**	Oversight organizations interpret requirements different than implementation, leading to cost and schedule impacts.	Likely	Significant	Moderate	60%	-	3,000,000	6,000,000	$0	1 month	3 months
T12	**Contractor**	Failure of crane results in delayed removal of canisters, impacting schedule.	Unlikely	Marginal	Low	40%	100,000	200,000	1,400,000	1 day	2 days	2 weeks
T61	**Contractor**	Calibration services are unavailable causing shut down of operations.	Very Unlikely	Marginal	Low	10%	100,000	410,000	715,000	1 day	4 days	7 days
T266	**Contractor**	Hot cell cannot be designed to meet active ventilation strategy increasing design and construction cost.	Very Unlikely	Critical	Moderate	10%	3,200,000	7,000,000	20,000,000	1 month	2 months	5 months

Figure A-2. Sample Risk Register.

The results of Monte Carlo analyses are generally summarized by a probability distribution function (PDF) and a cumulative distribution function (CDF), as shown in Figure A-3. The PDF, also described as a probability density function, represents the distribution of the analytical model outcomes. As an example, the Monte Carlo analysis may be designed to estimate the cost or duration of a project. The PDF represents the number of times a certain cost or duration is achieved. The CDF is a statistical function based on the accumulation of the probabilistic likelihoods of the analytical analysis. In the case of the DOE risk analysis, it represents the likelihood that at a given probability the project cost or duration will be at or below a given value. As an example, the x-axis might represent the range of potential project cost values evaluated by the Monte Carlo simulation and the y-axis represents the project's probability of completion.

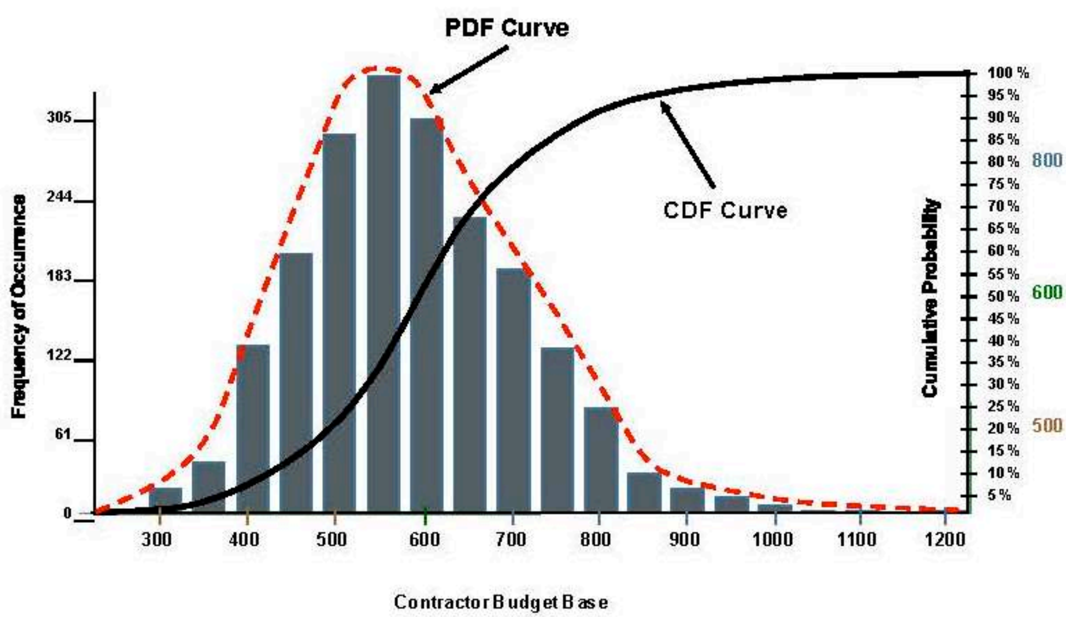


Figure A-3. PDF and CDF.

An advantage of an integrated cost and schedule risk model is the ability to capture schedule related costs impacts, such as level-of-effort (LOE) support activities that increase project costs as schedule related risk impacts delay or extend work efforts. Integrated risk models increase the flexibility of the risk analysis and reduce the amount of manual coordination needed to model cost and schedule risk impacts.

Project risks and the associated cost and schedule impacts are the primary inputs to the risk model and are maintained within the project's risk register. Figure A-4 depicts a conceptual risk model showing typical inputs and outputs.

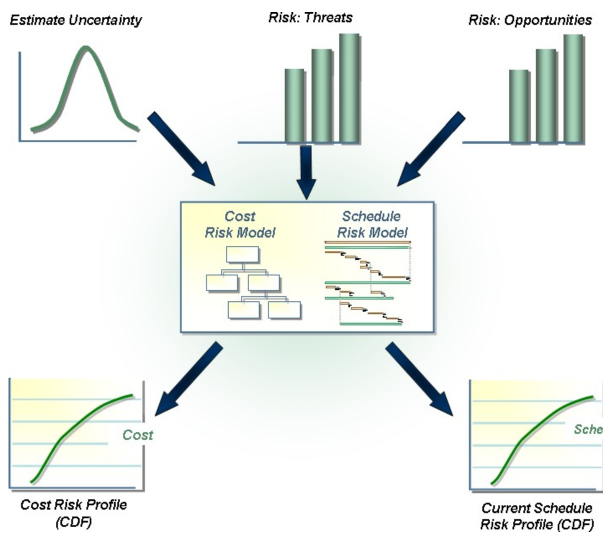


Figure A-4. Conceptual Risk Analysis Process.

Cost Risk Model

DOE capital asset projects should be estimated to provide a CL adequate to ensure project success which includes evaluation of all project risks. Risk models should include contractor execution risks and DOE project risks. The risk cost model should provide an estimate of the Performance Baseline with a range of 70-90 percent confidence level for success (recommended), which includes the contractor's CBB, profit/fee, and government other direct costs. The contractor MR is determined by the contractor and represents the amount of the CBB that will be used for project management purposes for accomplishing the work scope within the contractor's contractual PMB.

When developing risk models, care should be exercised to assure the risk models are developed using appropriate performance baseline information and project risk assumptions.

The recommended cost risk model should:

- Include contractor execution risks, DOE risks, and all estimate uncertainties that are within the project baseline.

- Contain enough detail to allow segregation of contractor execution risks and DOE risks.

- Contain enough detail to allow project risks to be associated with the Work Breakdown Structure (WBS) they affect.

- Include a provision for uncertainty ranges in cost escalation rates for the project.

- Allow correlated DOE risks that affect multiple cost elements, e.g., escalation rates, to be modeled at a high level to preserve the dependent relationship among correlated risks.

- Include sufficient information to estimate costs associated with uncertainties in task durations consistent with the schedule risk model.

- Allow for inclusion of threats and opportunities.

- Allow risk impacts to be placed in the appropriate fiscal year to support the identification of annual contingency budgeting and reporting requirements.

DOE Schedule Risk Model

Schedule risk models should be based on the DOE project performance baseline schedule. If practical, the DOE schedule risk model should be developed to include the schedule impacts of the contractor execution risks and DOE project risks, as well as any schedule duration uncertainties.

The recommended schedule risk model should:

1. Contain both contractor execution risks and DOE risks that fall within the project baseline.

2. Contain enough detail to allow segregation of contractor execution risks and DOE risks.

3. Contain enough detail to distinguish among DOE schedule activities that have different degrees of schedule uncertainty and should include estimate uncertainties.

4. Contain enough detail to allow specific DOE risk events to be associated with the schedule activity that they affect.

5. Estimate the schedule impact on LOE activities so cost increases associated with schedule slippages can be calculated and incorporated into the contingency estimates.

Allow for alterations in activity duration that result from implementation of DOE risk handling strategies or opportunities.

Integrated Schedule and Cost Risk

Integrated schedule and cost risk, also known as JCL analysis, generates a representation of the likelihood a project will complete its scope and achieve its key performance parameters on time and within budget. Conduct this analysis with a prioritized risk management plan and a fully burdened resource-loaded integrated master schedule with uncertainties associated with activities. The process uses software tools that examine the schedule and cost implications of the hypothetical realization of risks or manifestations of uncertainty to generate an integrated probability distribution.

AACE RP 57R-09, Integrated Cost and Schedule Risk Analysis Using Risk Drivers and Monte Carlo Simulation of a CPM Model, provides a method for simultaneously considering schedule and cost risks. Implement JCL in preparation for CD-2 and thereafter on major systems projects.

Determining Contingency Amounts

A common method used to evaluate risk model results is through the use of CDF curves, also referred to as S-curves. As an example, for a cost risk model, the S-curve represents the probability of completing the project at or below a given project cost. In this example the x-axis represents the range of potential project cost values estimated by the Monte Carlo simulation and the y-axis represents the probability of project completion. Figure A-5 illustrates two S-curves for a hypothetical project. The S-curve on the left is based on the CBB and the S-curve on the right is for the DOE capital asset project performance baseline and includes the contractor execution risks and DOE project risks.

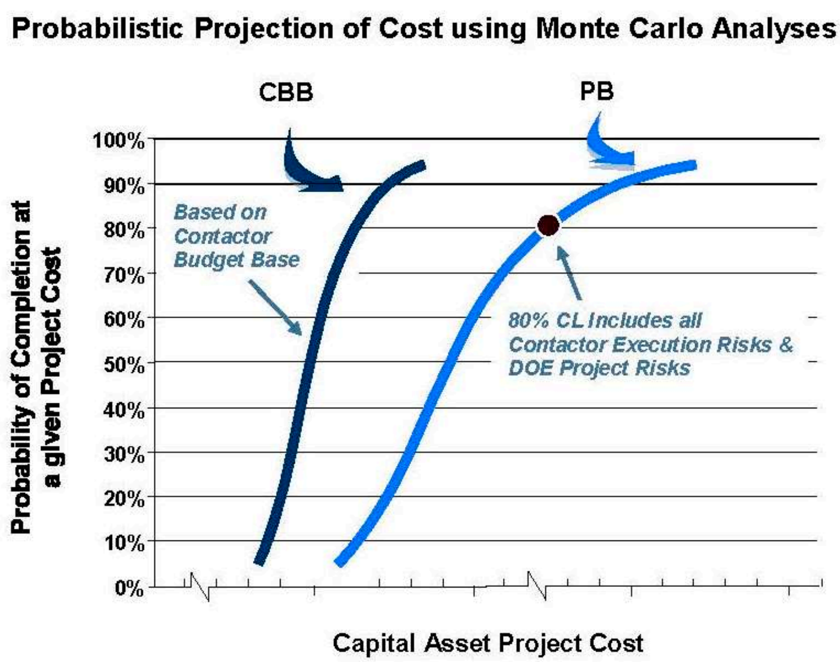


Figure A-5. S-Curves of Contractor CBB and DOE Performance Baseline.

Parametric Estimating of Contingency

AACE RP 42R-08, Risk Analysis and Contingency Determination Using Parametric Estimating, offers an approach to estimating contingency, but not MR, based on cost data from similar completed projects. Another AACE RP, 44R-08, Risk Analysis and Contingency Determination Using Expected Value, provides a basis for generating inputs to the methodology appearing in AACE RP 42R-08. Use the spreadsheet calculator included in AACE RP 43R-08, Risk Analysis and Contingency Determination Using Parametric Estimating – Example Models as Applied for the Process Industries, to make calculations more efficient and transparent. The calculator collects cost and project definition level information. The contingency estimates produced following this methodology best support cost estimate ranges generated prior to CD-0 and CD-1.

Determining Schedule Contingency

The DOE schedule contingency is based on the same risks used in the development of the DOE cost contingency. The DOE schedule contingency should be developed using a critical path schedule. Schedule activities that are affected by an identified risk or duration uncertainty are modeled in the schedule risk analysis with an appropriate probability distribution.

The calculation of schedule contingency is an iterative process requiring an initial analysis of the schedule to determine the base schedule contingency values followed by a revision of the schedule to adjust work scope to meet the existing selected key milestones and deliverable dates.

The FPD may alternately choose to apply the DOE schedule contingency to the end of milestones and/or the project completion date to determine the expected completion date should project risks be realized that delay the anticipated project completion. Note that this differs from contractor schedule reserve, which cannot add time or schedule duration to the contracted end date.

Risk Model Outputs

To support the required budgeting, management, and reporting requirements of the project, the risk analysis should provide the following:

- The risk analysis models should be able to produce a PDF and a CDF for the project.
- The risk analysis models should be able to produce a PDF and a CDF for each selected milestone.
- The models should be capable of performing a sensitivity analysis for project cost and schedule elements. Risk analysis sensitivity results are typically presented as tornado diagrams that provide an analytical and visual representation of risk event impacts.
- Ideally, the model should place resulting contingencies in a time frame to allow for fiscal year budgeting of DOE contingency. Figure A-6 illustrates how contingency budget projections can be depicted.

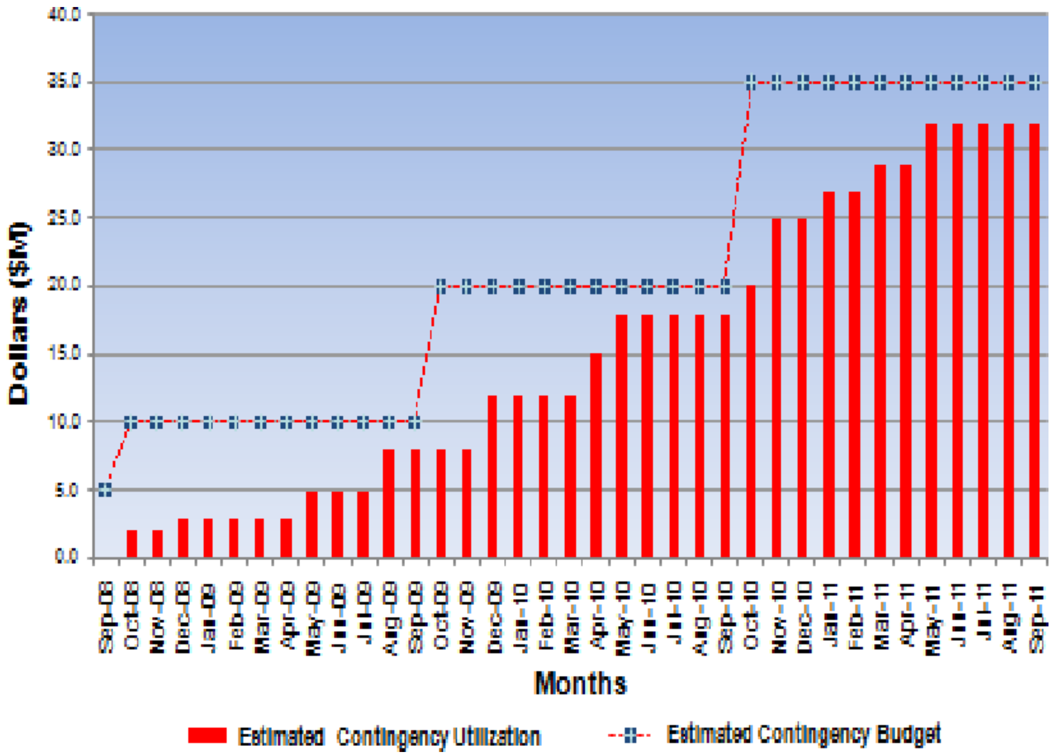


Figure A-6. Contingency Budget Projection.

Updating Contingency Analyses

The IPT should analyze project risks and update the risk register on a continual basis. Quantitative cost and schedule contingency analyses should be updated periodically throughout the project life-cycle. At a minimum, the DOE quantitative analysis should be reviewed semi-annually and updated if necessary. Monthly project performance reporting should include a review of the use of MR and contingency.

As needed, the FPD should update the project contingency analysis to determine if scope revisions or unanticipated risks present the potential for future budget shortfalls or extensive project delays based on new information. The identification of new or unanticipated risks and project uncertainties do not necessarily provide justification for increasing the project completion date, the TPC, or the project budget and funding profiles originally established.

The contents under this Section should be interpreted as unqualified recommendations and clarification guidance for the definition, derivation and use of the terms contingency and MR in risk management for DOE projects.

DOE O 413.3B requires that DOE project estimates be developed based on qualitative and quantitative analysis of project risks and other uncertainties. The DOE qualitative and quantitative analysis process begins in the project's planning stage with the identification of project risks during the initial project planning phase prior to the first Critical Decision (CD) point (approval of mission need). After CD-0, project development and planning documentation are prepared that include the initial Federal Risk Management Plan (FRMP) as part of the preliminary Project Execution Plan (PEP). During this phase of the project, the initial development of the project risk register is initiated with the identification of potential project risks and enabling assumptions.

At CD-1, the baseline scope is refined enough to develop a preliminary baseline cost range and schedule. The FRMP continues to evolve as the project scope is refined, new risks are added to the risk register and existing risks are re-examined and the project knowledge base increases.

In preparation for the CD-2 project phase, the project performance baseline estimate is refined to include risk handling costs and evaluated to determine the project budget needed to provide an appropriate confidence level (CL) to ensure the project's success. The identified DOE project risks are qualitatively and quantitatively evaluated to determine the likelihood of occurrence and the potential impacts to the project should the risk events occur.

Quantitative Contingency Analyses

This DOE Risk Management Guide states that the purpose of the quantitative risk analysis is to provide budget and completion date estimates that include the effects of the project risks and other project uncertainties using statistical modeling techniques such as Monte Carlo analyses or other similar methodologies. Other forms of quantitative analysis may be used in conjunction with Monte Carlo simulation including: (projects may adopt other acceptable methods/approaches as determined appropriate by the program office).

- Decision trees.
- Influence diagrams.
- System dynamics models.
- Neural networks.

This document assumes Monte Carlo methodologies will be used in the development of the cost and schedule baseline models. The diverse and unique nature of DOE projects characterized by an assortment of distinct technologies, physical locations, project duration, and project size has a significant impact on the risk profile of each DOE capital asset project that makes it impossible to establish a prescriptive procedure or single quantitative risk model for determining a project's contingency needs. Consequently, only a basic framework is used to outline considerations essential in the development of DOE contingencies.

Cost and Schedule Risk Models

DOE contingency risk models are used to evaluate the effects of risk impacts and estimate uncertainties on project cost and schedule performance baselines. The results of the risk analysis are used to establish the cost and schedule contingency needed by the project to provide a suitable confidence level for DOE project success. The analyses may use one or more risk models to evaluate the cost impacts and the associated schedule impacts.

For each risk, a percent or percentage distribution is assigned to the probability (the likelihood of the risk occurring), a dollar value or dollar value distribution is assigned to the cost impact, and a schedule duration impact or duration distribution is assigned to the affected activity in the schedule.

In general the concept is implemented as: $EV = P_{Ri} \times_{CI_{Ri}} (SI_{R1})$

Where: EV = Expected Value of cost impact (or duration impact) of all risks

P_{Ri} = Probability distribution function of a risk occurring

CI_{Ri} = Cost Impact distribution function of a risk occurrence

SI_{R1} = Schedule Impact distribution function of a risk occurrence

[Note: ∑ is not the summation of individual expected values for each risk, but represents a stochastic process (e.g. Monte Carlo simulation) using the collective probabilities and cost/schedule impacts for all the identified risk events.]

Figure A-2 is a sample from a DOE construction project risk register showing the residual risk data elements used for modeling the probability of occurrence (Probability %) and the triangular distribution representing a three-point estimate of the anticipated range of cost and schedule impacts.

Risk #	Owner	Risk Description	Residual Risk									
			Likelihood	Consequence	Risk Score/Rank	Probability %	Cost Impacts ($)			Schedule Impacts (mo)		
							Best Case	Most Likely	Worst Case	Best Case	Most Likely	Worst Case
T47	**Federal**	Nonperformance of contract to provide shielded overpack containers leads to project delays and cost.	Unlikely	Significant	Moderate	40%	850,000	3,000,000	6,000,000	$0	$0	$0
T52	**Federal**	Oversight organizations interpret requirements different than implementation, leading to cost and schedule impacts.	Likely	Significant	Moderate	60%	-	3,000,000	6,000,000	$0	1 month	3 months
T12	Contractor	Failure of crane results in delayed removal of canisters, impacting schedule.	Unlikely	Marginal	Low	40%	100,000	200,000	1,400,000	1 day	2 days	2 weeks
T61	Contractor	Calibration services are unavailable causing shut down of operations.	Very Unlikely	Marginal	Low	10%	100,000	410,000	715,000	1 day	4 days	7 days
T266	Contractor	Hot cell cannot be designed to meet active ventilation strategy increasing design and construction cost.	Very Unlikely	Critical	Moderate	10%	3,200,000	7,000,000	20,000,000	1 month	2 months	5 months

Figure A-2. Sample Risk Register.

The results of Monte Carlo analyses are generally summarized by a probability distribution function (PDF) and a cumulative distribution function (CDF), as shown in Figure A-3. The PDF, also described as a probability density function, represents the distribution of the analytical model outcomes. As an example, the Monte Carlo analysis may be designed to estimate the cost or duration of a project. The PDF represents the number of times a certain costor duration is achieved. The CDF is a statistical function based on the accumulation of the probabilistic likelihoods of the analytical analysis. In the case of the DOE risk analysis, it represents the likelihood that at a given probability the project cost or duration will be at or below a given value. As an example, the x-axis might represent the range of potential project cost values evaluated by the Monte Carlo simulation and the y-axis represents the project's probability of completion.

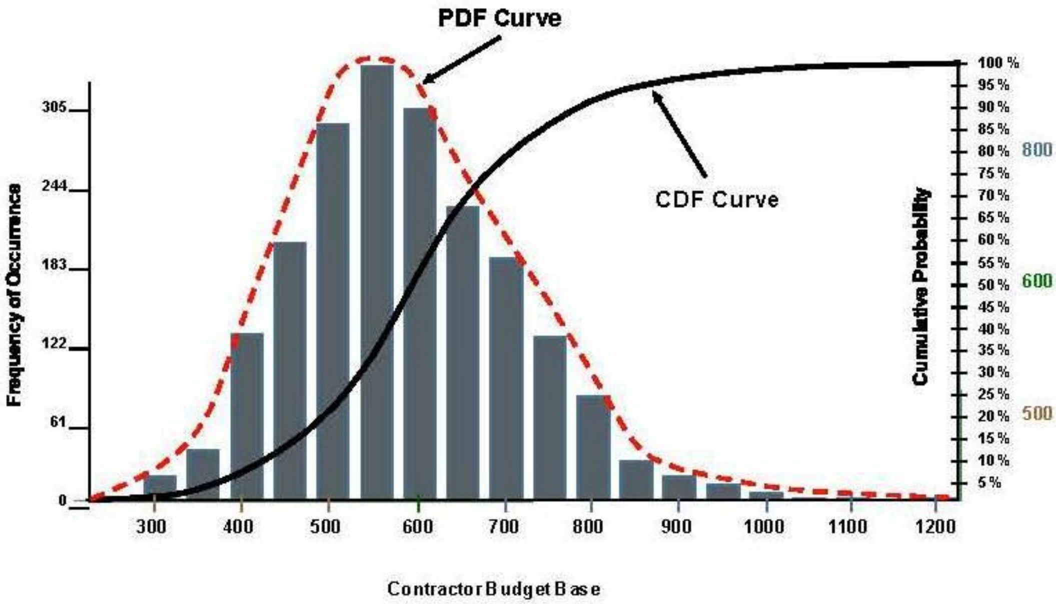


Figure A-3. PDF and CDF.

An advantage of an integrated cost and schedule risk model is the ability to capture schedule related costs impacts, such as level-of-effort (LOE) support activities that increase project costs as schedule related risk impacts delay or extend work efforts. Ideally, the integrated risk model is based on a life-cycle resource loaded critical path schedule to which cost and schedule risks and cost and schedule uncertainties are applied. Integrated risk models increase the flexibility of the risk analysis and reduce the amount of manual coordination needed to model cost and schedule risk impacts.

Project risks and the associated cost and schedule impacts are the primary inputs to the risk model and are maintained within the project's risk register. Figure A-4 depicts a conceptual risk model showing typical inputs and outputs.

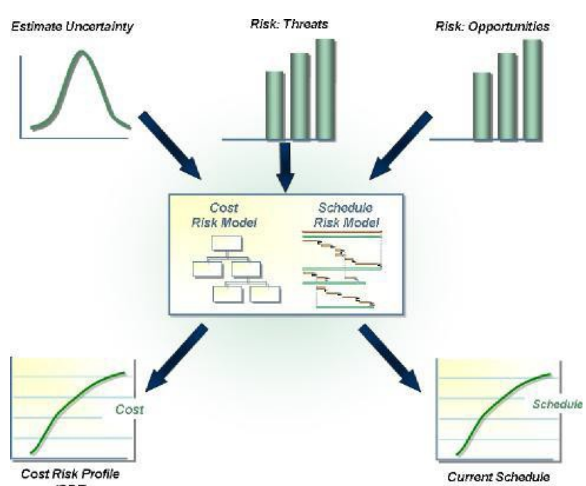


Figure A-4. Conceptual Risk Analysis Process.

Cost Risk Model

DOE capital asset projects should be estimated to provide a CL adequate to ensure project success which includes evaluation of all project risks. Risk models should include contractor execution risks and DOE project risks. The risk cost model should provide an estimate of the Performance Baseline with a range of 70-90 percent confidence level for success (recommended), which includes the contractor's CBB, profit/fee, and government other direct costs. The contractor MR is determined by the contractor and represents the amount of the CBB that will be used for project management purposes for accomplishing the work scope within the contractor's contractual PMB.

When developing risk models, care should be exercised to assure the risk models are developed using appropriate performance baseline information and project risk assumptions.

The recommended cost risk model should:

- Include contractor execution risks, DOE risks, and all estimate uncertainties that are within the project baseline.
- Contain enough detail to allow segregation of contractor execution risks and DOE risks.
- Contain enough detail to allow project risks to be associated with the Work Breakdown Structure(WBS) they affect.
- Include a provision for uncertainty ranges in cost escalation rates for the project.
- Allow correlated DOE risks that affect multiple cost elements, e.g., escalation rates, to be modeled at a high level to preserve the dependent relationship among correlated risks.
- Include sufficient information to estimate costs associated with uncertainties in task durations consistent with the schedule risk model.
- Allow for inclusion of threats and opportunities.
- Allow risk impacts to be placed in the appropriate fiscal year to support the identification of annual contingency budgeting and reporting requirements.

DOE Schedule Risk Model

Schedule risk models should be based on the DOE project performance baseline schedule. If practical, the DOE schedule risk model should be developed to include the schedule impacts of the contractor execution risks and DOE project risks, as well as any schedule duration uncertainties.

The recommended schedule risk model should:

- Contain both contractor execution risks and DOE risks that fall within the project baseline.

- Contain enough detail to allow segregation of contractor execution risks and DOE risks.
- Contain enough detail to distinguish among DOE schedule activities that have different degrees of schedule uncertainty and should include estimate uncertainties.
- Contain enough detail to allow specific DOE risk events to be associated with the schedule activity that they affect.
- Estimate the schedule impact on LOE activities so cost increases associated with schedule slippages can be calculated and incorporated into the contingency estimates.
- Allow for alterations in activity duration that result from implementation of DOE risk handling strategies or opportunities.

Integrated Schedule and Cost Risk

Integrating schedule and cost risk, also known as JCL analysis, generates a representation of the likelihood a project will complete its scope and achieve its key performance parameters on time

and within budget. Conduct this analysis with risks, prioritized by likelihood of realization and impact, appearing in the risk management plan and a fully-burdened resource-loaded integrated master schedule with uncertainties associated with activities. The process uses software tools that examine the schedule and cost implications of the hypothetical realization of risks or manifestations of uncertainty to generate an integrated probability distribution (see Figure A-5). AACE RP 57R-09, Integrated Cost and Schedule Risk Analysis Using Risk Drivers and Monte Carlo Simulation of a CPM Model, provides a method for simultaneously considering schedule and cost risks. Implement JCL on major systems projects in preparation for CD-2 and thereafter.

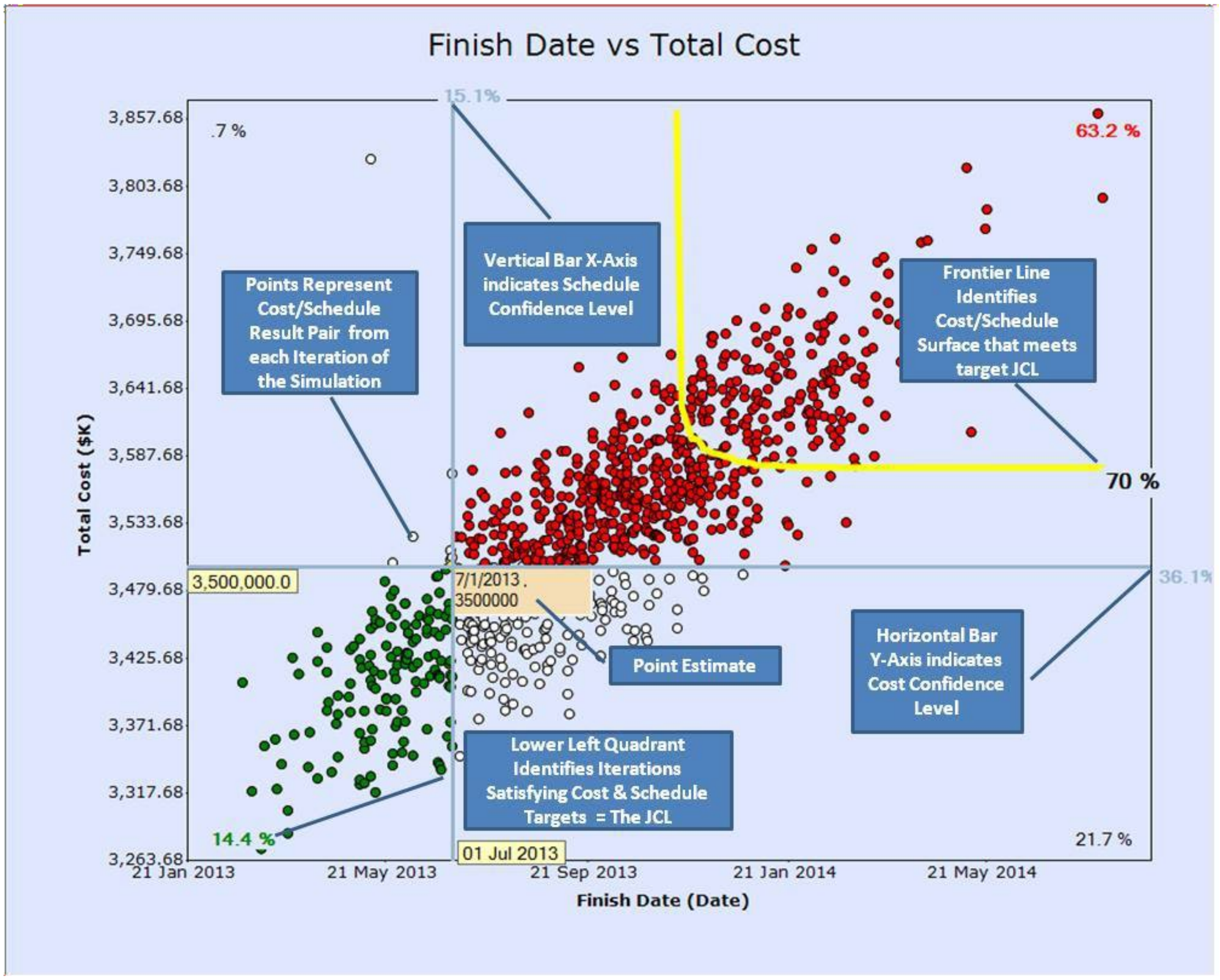


Figure A-5. Determining Contingency Amounts

A common method used to evaluate risk model results is through the use of CDF curves, also referred to as S-curves. As an example, for a cost risk model, the S-curve represents the probability of completing the project at or below a given project cost. In this example the x-axis represents the range of potential project cost values estimated by the Monte Carlo simulation and the y-axis represents the probability of project completion. Figure A-6 illustrates two S-curves for a hypothetical project. The S-curve on the left is based on the CBB and the S-curve on the right is for the DOE capital asset project performance baseline and includes the contractor execution risks and DOE project risks.

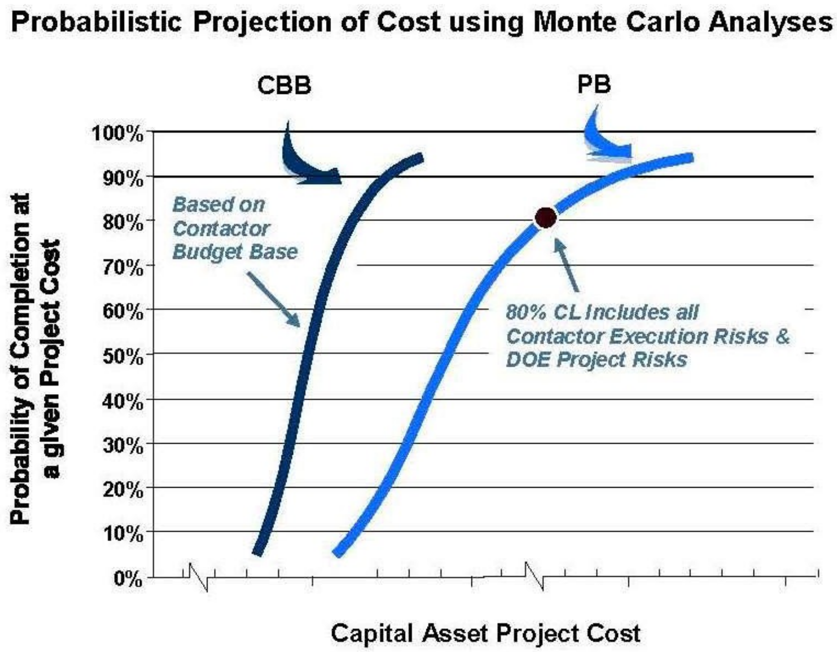


Figure A-6. S-Curves of Contractor CBB and DOE Performance Baseline.

Parametric Estimating of Contingency

AACE RP 42R-08, Risk Analysis and Contingency Determination Using Parametric Estimating,offers an approach to estimating contingency, but not MR, based on cost data from similar completed projects. Another AACE RP, 44R-08, Risk Analysis and Contingency DeterminationUsing Expected Value, provides a basis for generating inputs to the methodology appearing in AACE RP 42R-08. Use the spreadsheet calculator included in AACE RP 43R-08, Risk Analysisand Contingency Determination Using Parametric Estimating – Example Models as Applied for the Process Industries, to make calculations more efficient and transparent. The calculator collects cost and project definition level information. The contingency estimates produced following this methodology best support cost estimate ranges generated prior to CD-0 and CD-1.

1. Determining Schedule Contingency

The DOE schedule contingency is based on the same risks used in the development of the DOE cost contingency. The DOE schedule contingency should be developed using a critical path schedule. Schedule activities that are affected by an identified risk or duration uncertainty are modeled in the schedule risk analysis with an appropriate probability distribution.

The calculation of schedule contingency is an iterative process requiring an initial analysis of the schedule to determine the base schedule contingency values followed by a revision of the schedule to adjust work scope to meet the existing selected key milestones and deliverable dates.

The FPD may alternately choose to apply the DOE schedule contingency to the end of milestones and/or the projectcompletion date to determine the expected completion date should project risks be realized that delay the anticipated project completion. Note that this differs from contractor schedule reserve, which cannot add time or schedule duration to the contracted end date.

Risk Model Outputs

To support the required budgeting, management, and reporting requirements of the project, the risk analysis should provide the following:

- The risk analysis models should be able to produce a PDF and a CDF for the project.
- The risk analysis models should be able to produce a PDF and a CDF for each selected milestone.
- The models should be capable of performing a sensitivity analysis for project cost and schedule elements. Risk analysis sensitivity results are typically presented as tornado diagrams that provide an analytical and visual representation of risk event impacts.
- Ideally, the model should place resulting contingencies in a time frame to allow for fiscal year budgeting of DOE contingency. Figure A-7 illustrates how contingency budget projections can be depicted.

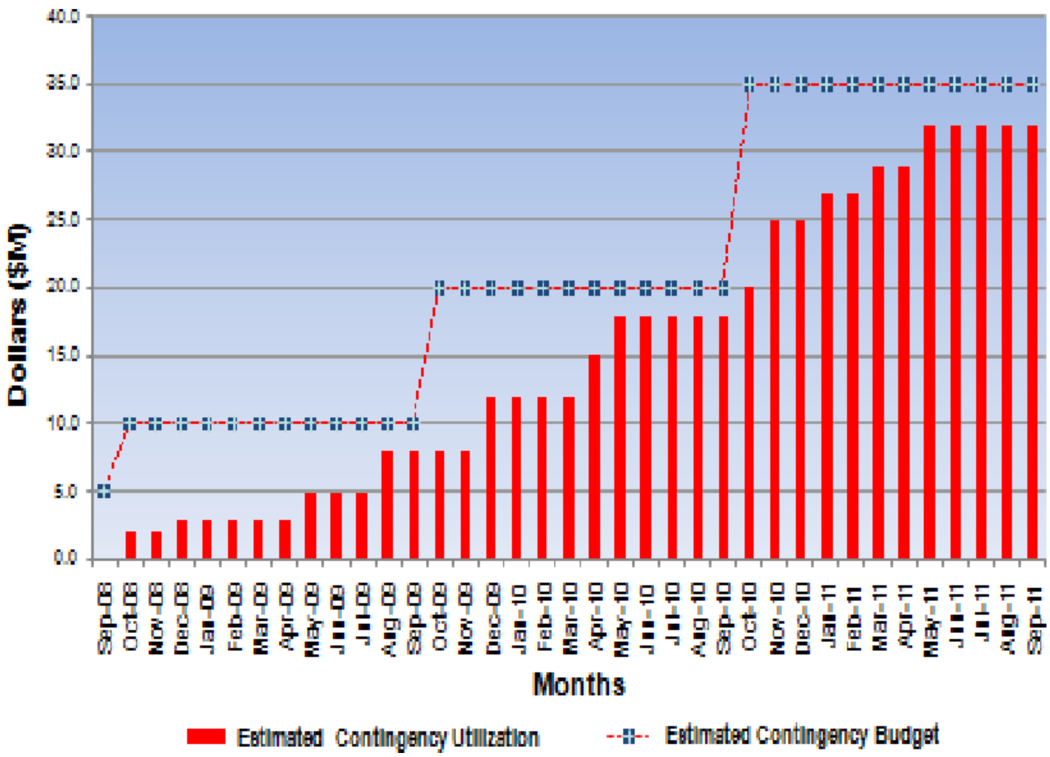


Figure A-7. Contingency Budget Projection.

Updating Contingency Analyses

The IPT should analyze project risks and update the risk register on a continual basis. Quantitative cost and schedule contingency analyses should be updated periodically throughout the project life-cycle. At a minimum, the DOE quantitative analysis should be reviewed semi-annually and updated if necessary. Monthly project performance reporting should include a review of the use of MR and contingency.

As needed, the FPD should update the project contingency analysis to determine if scope revisions or unanticipated risks present the potential for future budget shortfalls or extensive project delays based on new information. The identification of new or unanticipated risks and project uncertainties do not necessarily provide justification for increasing the project completion date, the TPC, or the project budget and funding profiles originally established.

Attachment 13. Contingency Estimate Inputs and Interface Needs (Supplementary Information)

The contents under this Section should be interpreted as unqualified recommendations and clarification guidance for the definition, derivation and use of the terms contingency and MR in risk management for DOE projects.

Development of cost and schedule contingency for capital asset projects requires rigorous analysis of potential risks, mitigation plans, and opportunities. Collaboration and interfaces are needed between the people who are knowledgeable and conversant with the specific risks of the project and those who are familiar with the probabilistic methods to reduce bias and to produce realistic quantification of projects risks. Thus close synergy is needed between the project people who understand the risk and risk impacts, and the specialist (tool driver) who has intimate understanding of simulation models, but may not know much about the project (see Attachment 12, Figure A-4, Conceptual Risk Analysis Process, for inputs into the quantitative cost and schedule risk models).

Risk Management Input

The quantitative risk analysis inputs identified within the DOE Risk Management Guide may include but are not limited to:

- DOE and contractor risk management plans.
- Historical records (especially where similar risks were handled).
- Actual costs to date.
- Critical Path analysis.
- Subject matter experts.
- Delphi techniques.
- Interviewing staff, crafts, retirees, and others familiar with similar work efforts at the site or other sites.
- Technical records such as safety analysis documents including the risk and opportunity assessment, quality assessments, safeguards and security analyses, and environmental assessments.

Beyond the inputs proposed in the Risk Management Guide, the project schedules should integrate the contractor and DOE schedules to allow the use of Monte Carlo simulation software.

To facilitate Monte Carlo analysis, all schedules and cost estimates should include the following characteristics:

- Activities in the schedules should be logically linked and should have a well-defined critical path.

- Critical path and near-critical path activities should have duration uncertainties defined.

- A resource loaded schedule is required by DOE O 413.3B and can be used for integrated cost/schedule risk models.

- LOE activities should be clearly identified, logically linked, and declared as a type LOE activity, e.g., not a fixed duration activity. (Modeling requirements of scheduling details will vary by application.)

- Risks should be mapped to schedule activities or the lowest WBS element in a higher level schedule.

- Co-dependent risks should be clearly identified and evaluated to segregate impacts. Complete DOE and contractor cost estimates should be available. Schedule uncertainties should be defined for eachWBS element.

- If an integrated cost/schedule model is not being performed, hotel loads or minimum safe conditions should be defined.

Estimate Uncertainty

Estimate uncertainties are fundamental contributors to cost growth and are expected to decrease over time as the project definition improves and the project matures. Estimate uncertainty is a function of, but not limited to, the quality of the project scope definition, the current project life-cycle status, and the degree to which the project uses new or unique technologies. Estimate uncertainties occur throughout the DOE baseline. One approach to account for estimate uncertainty is to use uncertainty ranges established by the professional societies such as the AACE International, Table A.1, or other estimating guidance. Estimate uncertainty contributesto both cost and schedule contingency. The Table A-1 could be used for both cost and schedule estimate uncertainty and should be done separately for evaluating quantitative impacts on project contingency.

Table A-1. Estimate Uncertainty Range as a Function of Estimate Class.

Class of Cost Estimate	Estimate Uncertainty (Low Range)	Estimate Uncertainty (High Range)
Class 5 – Concept Screening	-20% to -50%	+30% to +100%
Class 4 – Study or Feasibility	-15% to -30%	+20% to +50%
Class 3 – Budget Authorization	-10% to -20%	+10% to +30%
Class 2 – Control or Bid	-5% to -15%	+5% to +20%
Class 1 – Check Estimate	-3% to -10%	+3% to +15%

Risk Events

Risk events, by definition, include both threats and opportunities (see Attachment 15, Glossary). These risk events may or may not happen at some future time. An example of a risk event identified as a threat would be if a new technology fails to work as expected. An example of a risk event identified as an opportunity would be the elimination of project work scope as a result of a new technology.

Risk events can be represented as probabilistic distributions that identify the likelihood of the risk event occurring with separate distributions that describe the consequence or impact to the project if the risk event occurs. Risk events have schedule and/or cost consequences. One should consider the impacts that realized risks might have on the critical path or near-critical path resulting in increases to the overall project schedule affecting escalation of costs, overhead costs, and other project execution costs associated with work scope delays and/or extensions.

In summary, when assessing the project risks the FPD, IPT, and Project Manager should:

- Consider and distinguish between estimate uncertainty and risk events.
- Quantify the risk likelihood, and the risk cost and schedule impacts.
- Identify the activities in the schedule that are affected by the risks.
- Estimate the cost of each risk handling strategy for consideration as additional baseline work scope and consider the ramifications of excluding the handling strategy in the baseline work scope.
- Consider the potential impacts of secondary risks resulting from specific risk handling strategies.
- Quantify the residual risks likelihood, and the residual risks cost and schedule impacts.

Categories of Risk

Development and management of project cost and schedule contingency requires clarity regarding risk ownership and risk characterization.

Project risks are potential threats or opportunities categorized as:

- DOE program/portfolio risks.
- DOE project risks.
- Contractor execution risks.
- Unknown-unknowns.

As described in this DOE Risk Management Guide, identification of contractor execution (performance) risks, DOE project risks, and DOE programmatic risks are assessed by the IPT.

- DOE Program/Portfolio Risks are risks that are owned and managed outside of the project and cannot be managed within the project funding. These are typically associatedwith the Enabling or Bounding Assumptions referenced in the Risk Management Plan. Portfolio risks are owned and managed by DOE and represent inter-dependent risks common to more than one project. The cost and schedule impacts of program/portfolio risks are not, and should not, be included in a project's contingency calculation. Examples include:
  - Closure of Waste Isolation Pilot Plant.
  - National repository opening later than anticipated.
  - Congressional funding reductions.
  - DOE funding reductions.
  - Re-programming.
  - Stakeholder changes.
  - Site mission changes.
  - Regulatory and Statutory changes.
  - DOE directives.
- DOE Project Risks are risks that are within the project baseline but are generally beyond the contractor's control and are managed at the project level. Risks cannot be effectively shared between DOE and the contractor and should be handled by partitioning them into separate DOE and contractor risks. Examples of DOE risks include:
  - Major technological failures.
  - Coordination across site programs.
  - Changes due to direction from Agency senior management.
  - Unusual weather delays.
  - Interpretation of Regulatory and Statutory requirements (how clean is clean).
  - Procurement (government furnished services and items (GFS/I).
  - Contractor performance (based on work history).

- Contractor Execution Risks are those that may fall within the contractor's contractual obligations. Examples include:
    - Material availability (non-GFS/I).
    - Market pricing.
    - Failure of the design (non-GFS/I).
    - Labor availability.
    - Productivity
    - Procurement (supplier performance, and product availability).
    - Subcontractor performance.
    - Safety (compliance, occurrences and events, etc.).
    - Basic process uncertainty.
    - Normal weather delays.
- Unknown-unknowns (can also be DOE project risks) are program risks that are identified during the execution of the project through either routine risk management practices or because they have been realized.

It is not possible to identify all risks at the onset of a project. As new risks are identified, they should be added to the risk register. Unidentified risks might originally be unanticipated because the probability of the event is so small that its occurrence is virtually unimaginable. Alternatively, an unidentified risk might be one that falls into an unanticipated or uncontrolled risk event category. This would include Hurricane Katrina-type events or an event that materialized because of other events outside the project baseline control.

Attachment 14. Management and Reporting of MR and Contingency (Supplementary Information)

The contents under this Section should be interpreted as unqualified recommendations and clarification guidance for the definition, derivation and use of the terms contingency and MR in risk management for DOE projects.

The integrated project baseline, cost, schedule, and risk analysis process is used to identify and quantify the various risks and uncertainties that have the potential to affect project performance.

Use of Contingency

Contingency should be used to pay for, or recover from, the impacts of realized DOE project risks,poor performance, and DOE estimating uncertainties and inaccuracies incurred in the execution ofthe project baseline. DOE contingency is managed through a formal baseline configuration changecontrol process and utilization should be reported as the contingency is expended. It is important to reiterate that contingency and MR should not be used to resolve past negative variances resulting from poor contractor performance and MR is not to be used to address issues that are beyond the scope of the contract requirements. Cost variances should be preserved during project realignments and/or re-sequencing of project activities.

To a greater or lesser extent, the occurrence of a risk event or the impact of the risk event may be mitigated at the direction of the FPD. The FPD may adopt various risk handling strategies that decrease a risk’s likelihood of occurrence or decrease the anticipated risk impact should the risk event occur. While all project budgets should include funds for risk management (including risk mitigation strategies to reduce the probability and/or consequence of risk events) within their budget, the project budget should not be viewed as the primary means to deal with risks after a risk event occurs. These funds are intended to be used to pursue the selected mitigation strategies in the FRMP. For example, conducting research and development to mitigate a specific risk does not mean the funds are held as contingency until the event occurs. The funds are intended to be used to prevent the event from occurring, or to reduce its impact. Consequently, the risk mitigation effort should be an active work package within the WBS that is scheduled and executed as part of the project work scope. Various risk handling strategies are discussed in the DOE Risk Management Guide.

Project Change Control Processes

When a contractor risk is realized, the contractor uses the contractor’s change control process, employing standard Earned Value Management System practices and procedures, to transfer contingency or MR to the PMB. As contingency or MR is utilized, the PMB is adjusted to reflect the change and the CBB remains unchanged. If a contractor opportunity is realized, contingency or MR can be increased and the PMB is decreased accordingly, while the CBB remains unchanged. The contractor’s change control process and the necessary approval thresholds are documented in the contractor’s Project Management Plan.

When a DOE risk is realized, contingency budget may be transferred to the project. However, this should not occur until the impact of the realized risk has been determined, necessary changes to the contract have been identified and coordinated with the contracting officer. The transfer of contingency budget to the project PMB should not occur until the contract has been modified. The FPD and the Contracting Officer use the Project and Contract Change Management processes to ensure the project baseline and the contract remain aligned. The baseline change control process and the necessary approval thresholds are documented in the PEP.

Monitoring and Evaluating

Since contractor cost and schedule reserves and DOE cost and schedule contingency are finite resources, their use should be monitored, tracked, and evaluated as part of the ongoing project control function. The reporting requirements for cost and schedule reserve and DOE cost and schedule contingency usage can be tailored to meet the project needs.

Monitoring and Evaluating Contractor Reserves and DOE Contingencies

Contractors should plan the usage of MR and schedule reserves and FPDs should plan the usage of DOE cost and schedule contingencies over time, based on the anticipated risk occurrences and impacts. MR and DOE contingency should be time-phased over the project duration, allocated byfiscal year. Trending usage of these resources may indicate larger unforeseen issues as latent risks become visible. Figure A-8 is an example of a utilization curve showing the planned and actual resource usage.

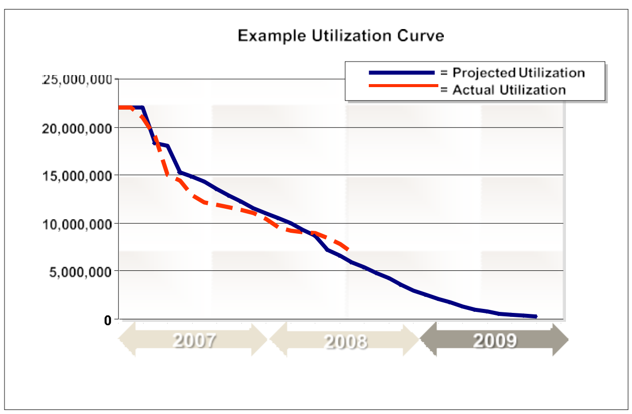


Figure A-8. Example of a Utilization Curve.

Summary of MR Reporting Elements

The following information should be considered as part of periodic project reports by the FPD: (Note: The FPD should coordinate with their program office organization about their specific guidelines and requirements which may vary depending upon the project size and complexity.)

- MR and schedule reserve available at the beginning of the month. An updated MR utilization curve.
- An update of schedule reserve utilization, if applicable.

- A list of realized risks (threats and opportunities) that required usage of MR and schedule reserves (amount changed, Risk Identification (ID), and Title/Description of risk).
- A list of risks that were realized and funded by delay of scope (amount, Risk ID, Title/Description, Change Control ID #, and scope that was delayed).
- A list of risk opportunities that were realized and the days of schedule that were gained and/or MR gained.
- Adequacy of remaining contractor MR and schedule reserves.
- Cost Performance Index (CPI) and Schedule Performance Index (SPI).

Summary of DOE Contingency Reporting Elements

The following information should be considered as part of periodic project reports by the FPD: (Note: The FPD should coordinate with their program office organization about their specific guidelines and requirements which may vary depending upon the project size and complexity)

- DOE cost and schedule contingency available at the beginning of the current month.
- Updated DOE project contingency utilization.
- Update of DOE schedule contingency utilization.
- List of risks (threats and opportunities) that required use of cost and schedule contingency (amount changed, Risk ID, Title/Description of risk, and previously unidentified risks).
- List of risks that were realized and funded by delay of scope (amount, Risk ID, Title/Description, Change Control ID #, and delayed work scope).
- List of risk opportunities that were realized and the days of schedule that were gained and/orDOE project contingency gained.
- Adequacy of remaining DOE cost and schedule contingencies.
- List of closed project risks.
- List of newly identified project risks.
- List of risks nearing realization.
- Updated risk register.

Attachment 15. Glossary

This glossary of terms is derived within the context of how terms are used in the guide.

Acquisition Strategy: A high-level business and technical management approach designed to achieve project objectives within specified resource constraints. It is the framework for planning, organizing, staffing, controlling, and leading a project. It provides a master schedule for activities essential for project success, and for formulating functional strategies and plans.

Activity: An element of work performed during the course of a project. An activity normally has an expected duration, an expected cost, and expected resource requirement.

Actual Cost: The costs actually incurred and recorded in accomplishing work performed.

Assumptions: Factors used for planning purposes that are considered true, real or certain. Assumptions affect all aspects of the planning process and of the progression of the project activities. (Generally, the assumptions will contain an element of risk.)

Avoid (Avoidance): A risk handling strategy in which project activities are planned in such a way as to eliminate the potential threat. In general, avoidance is the most desirable risk handling strategy.

Baseline: A quantitative definition of cost, schedule, and technical performance that serves as a base or standard for measurement and control during the performance of an effort; the established plan against which the status of resources and the effort of the overall program, field program(s), project(s), task(s), or subtask(s) are measured, assessed, and controlled.

Bias: A repeated or systematic distortion of a statistic or value, imbalanced about its mean.

Bounding Assumption: Identified risks that are totally outside the control of the project team and therefore cannot be managed (i.e., transferred, avoided, mitigated, or accepted). Bounding assumptions are also referred to as enabling assumptions in the context of opportunity risks.

Brainstorming: Interactive technique designed for developing new ideas with a group of people.

Capital Asset Projects: A unique effort to acquire or perform additions, improvements, modifications, replacements, restorations, rearrangements and reinstallations, and major repairs but not ordinary repairs and maintenance. The project acquisition cost of a capital asset includes both its purchase price and all other costs incurred to bring it to a form and location suitable for its intended use. Capital assets include the environmental remediation of land to make it useful, leasehold improvements and land rights.

Change Control: A process that ensures changes to the approved baseline are properly identified, reviewed, approved, implemented and tested, and documented.

Co-dependent Risk: Co-dependent project risks are generated when intermediate deliverables or outcomes (two or more projects or sub-projects at the same site) interlock in such a way that if both projects are not successfully completed, neither can be successfully completed.

Communication Planning or Plan: Process and plan for determining the information and communication needs of the project stakeholders. Identifies who needs what information, when they will need the information, and how it should be presented, tracked, and documented.

Confidence (Confidence Level): The probability that a cost estimate or schedule can be achieved or bettered. This is typically determined from a cumulative probability profile (see Cumulative Distribution Function) that is the output from a Monte Carlo simulation.

Consequence: Outcome of an event. (Normally includes scope, schedule, and cost.)

Contingency: The portion of the project budget that is available for risk uncertainty within the project scope, but outside the scope of the contract. Contingency is budget that is not placed on the contract and is included in the Total Project Cost. Contingency is controlled by federal personnel as delineated in the PEP.

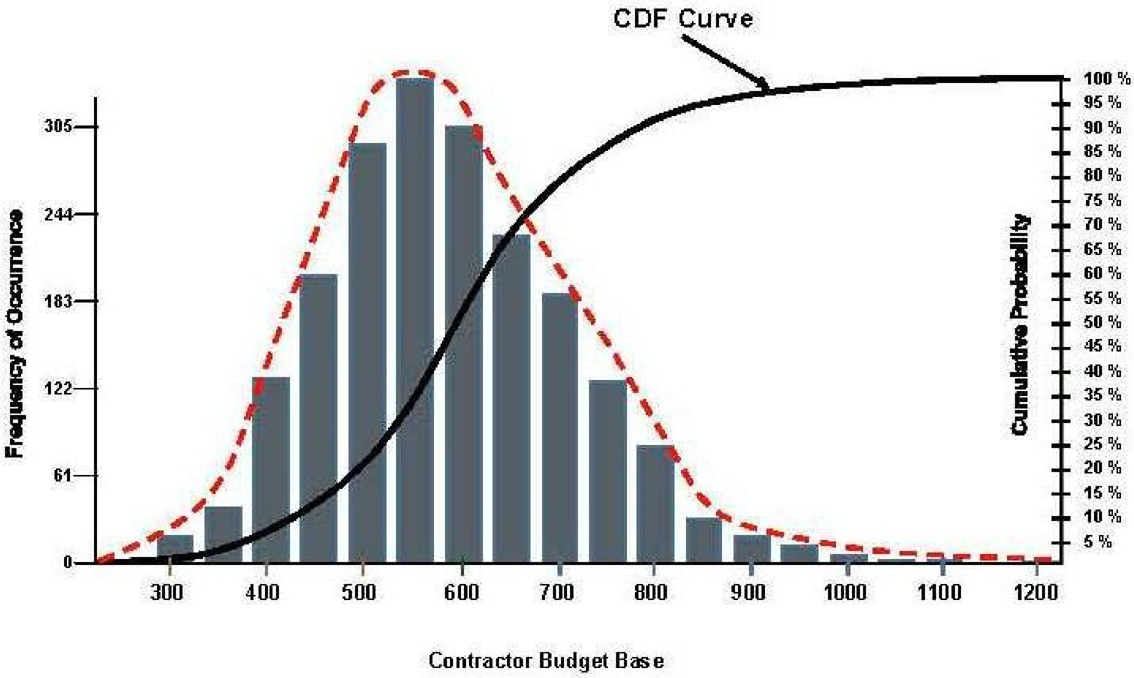
Contractor Project Manager (CPM): The contractor official who is responsible and accountable for successful execution of the contractor's project scope of work subject to the contract terms and conditions. The CPM interfaces with the Federal Project Director.

Correlation: Relationship between variables such that changes in one (or more) variable(s) is generally associated with changes in another. Correlation is caused by one or more dependency relationships. Measure of a statistical or dependence relationship existing between two items estimated for accurate quantitative risk analysis.

Cost Estimate: A documented statement of costs estimated to be incurred to complete the project or a defined portion of a project.

Critical Path: A logically related sequence of activities in a critical path schedule having the longest duration. The total float is zero. A delay in any activity will have a corresponding impact on the completion date of the project.

Cumulative Distribution Function (CDF): A statistical function based on the accumulation of the probabilistic likelihood of occurrences. In the case of the DOE risk analysis, it represents the likelihood that at a given percentage the project cost or duration will be at or below a given value. As an example, the x-axis might represent the range of potential project cost values evaluated by theMonte Carlo simulation and the y-axis represents the project's probability of completion. (See figure A-3 and below.)



Decision Analysis: Process for assisting decision makers in capturing judgments about risks as probability distributions, having single value measure, and putting these together with expected value calculations.

Delphi Technique: Technique used to gather information used to reach consensus within a group of subject matter experts on a particular item. Generally, a questionnaire is used on an agreed set of items regarding the matter to be decided. Responses are summarized, further comments elicited.

The process is often repeated several times. Technique is used to reduce bias in the data and to reduce the bias of one person, one voice.

Decision Trees: A diagram that shows key interactions among decisions and associated chain events as they are understood by the decision maker. Branches of the tree represent either decisions or change events. The diagram provides for the consideration of the probability of each outcome.

DOE Contingency: Cost contingency for risks that are within the project's baseline but outside the contractor's management control. DOE contingency is held by DOE.

DOE Schedule Contingency: Duration allowance used to adjust schedule for realized risks that are within the project baseline, and outside the contractor's control.

Earned Value Management System (EVMS): Is the integrated set of processes used to implement the standard and its criteria. In its simplest form, EVMS can be implemented without any software. Software simply enhances productivity, allows the implementation of EVMS more economically and facilitates managing complex projects. EVMS is not software.

Enabling Assumption: Identified risks that are totally outside the control of the project team and therefore cannot be managed (i.e., transferred, avoided, mitigated, or accepted).

Estimate: Assessment of the most likely quantitative result. (Generally, it is applied to costs and durations with a confidence percentage indication of likelihood of its accuracy.)

Estimate-at-Completion: The current estimated total cost for project authorized work. EAC equals the actual cost to a point in time plus the estimated costs to completion.

Estimate to Complete (ETC): The current estimated cost for remaining authorized work to complete the project.

Expert Interviews: Process of seeking opinions or assistance on the project from subject matter experts (SMEs).

Estimate Uncertainty: The inherent accuracy of a cost or schedule estimate. Represents a function of the level of project definition that is available, the resources used (skill set and knowledge) and time spent to develop the cost estimate and schedule, and the data (e.g., vendor quotes, catalogue pricing, historical databases, etc.) and methodologies used to develop the cost estimate and schedule.

External Risks: Risks outside the project control or global risks inherent in any project such as global economic downturns, trade difficulties affecting deliverables such as construction materials or political actions that are beyond the direct control of the project.

Feedback: System concept where a portion of the output is fed back to the input.

Fishbone Diagram: Technique often referred to as cause and effect diagramming. Technique often used during brainstorming and other similar sessions to help identify root causes of an issue or risk. Structure used to diagram resembles that of a fish bone.

Government Other Direct Costs: Government Costs that are needed for the project such as government furnished services, items and equipment, government supplied utilities (if directly metered), and applicable waste disposal fees.

Hotel Loads: A term used to identify the cost associated with level of effort activities and fixed costs that will be incurred until a given piece of work is complete. These costs can include the costs for project management and administration and other direct costs associated with generic facilities, rentals, and other indirect costs that are not part of the direct production activities.

Impact Scores: Convergence of the probability and consequence scores.

Influence Diagram: A graphical aid to decision making under uncertainty, it depicts what is known or unknown at the time of making a choice, and the degree of dependence or independence (influence) of each variable on other variables and choices.

Initiation: Authorization of the project or phase of the project.

Internal Risks: Risks that the project has direct control over, such as organizational behavior and dynamics, organizational structure, resources, performance, financing, and management support.

Joint Cost and Schedule Confidence Level (JCL): "A process that combines a project's cost, schedule, and risk into a complete picture. JCL is not necessarily a specific methodology . . . or a product from a specific tool. The JCL calculation includes consideration of the risk associated with all elements, regardless of whether or not they are funded from . . . appropriations or managed outside of the project. A JCL identifies the probability that a given project or program cost will be equal to or less than the targeted cost AND that the schedule will be equal to or less than the targeted schedule date."[9]

Key Risk: Key risks are a set of risks considered to be of particular interest to the project team. These key risks are those estimated to have the most impact on cost and schedule and could include project, technical, internal, external, and other sub-categories of risk. For example, on a nuclear design project, the risks identified using the Risk and Opportunity Assessment process may be considered a set of key risks on the project. Key Risks should be interpreted to have the same meaning as "Critical Risks" as referred to in DOE O 413.3B.

Lessons Learned: Formal or informal set of "learning" collected from project or program experience that can be applied to future projects or programs after a risk evaluation. Lessons learned can be gathered at any point during the life of the project or program.

Level-of-Effort: Baseline scope of a general or supportive nature for which performance cannot be measured or is impracticable to measure using activity-based methods. Resource requirements are represented by a time-phased budget scheduled in accordance with the time the support will likely be needed. The value is earned by the passage of time and is equal to the budget scheduled in each time period.

Management Reserve (MR): An amount of the total contract budget withheld for management control purposes by the contractor. MR is not part of the performance measurement baseline.

Milestone: A schedule event marking the due date for accomplishment of a specified effort (baseline activity) or objective. A milestone may mark the start, an interim step, or the completion of one or more activities.

Mitigate: To eliminate or lessen the likelihood and/or consequence of a risk.

Mitigation Strategy: The risk handling strategy used to eliminate or lessen the likelihood and/or consequence of a risk.

Monte Carlo Analysis: A method of calculation that approximates solutions to a variety of mathematical problems by performing statistical sampling experiments on a computer; applies to problems with no probabilistic content as well as to those with inherent probabilistic structure.

Neural Networks: Information processing paradigms inspired by the way biological neural systems process data.

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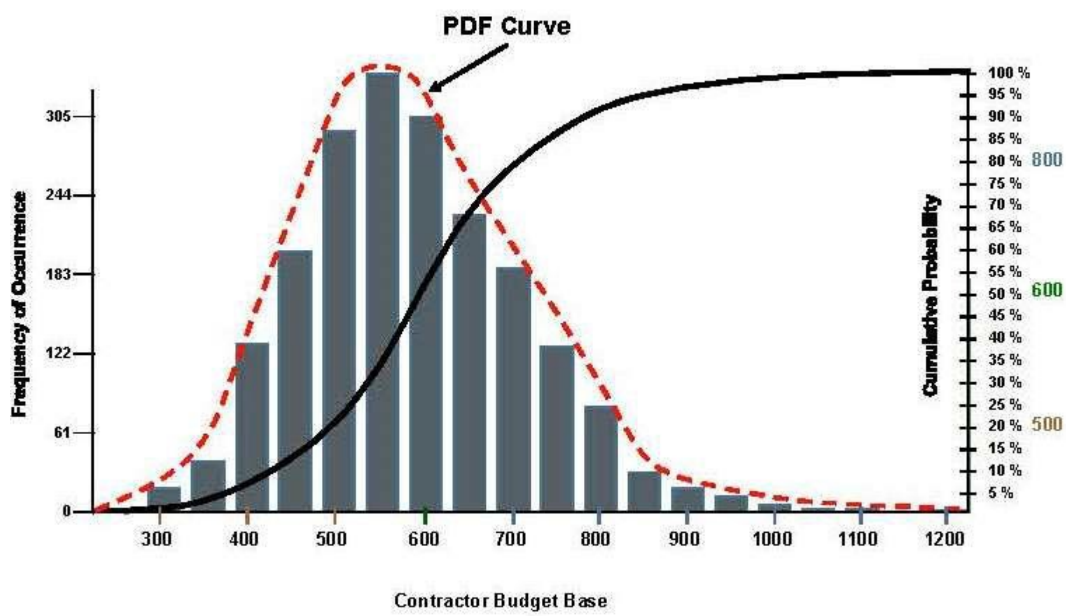
[9] NASA Cost Estimating Handbook, Appendix J, Section 1, February 2015, https://go.usa.gov/xv37H.

Opportunity: Risk with positive benefits.

Primary Risk: Initial risk entry in the risk register. A residual or secondary risk can become a primary risk if in the case of a residual risk the primary risk is closed and the Federal Project Director and/or Contractor Project Manager determines the residual risk should be made the primary risk or the risk entry in the risk register. The secondary risk can become the primary risk in the risk register if the Federal Project Director and/or Contractor Project Manager determine that it should become the risk entry based upon the realization of the trigger metric or other determining factor.

Probability: Likelihood of an event occurring, expressed as a qualitative and/or quantitative metric.

Probability Distribution Function (PDF): A probability distribution, also described as a probability density function, represents the distribution of the probability of an outcome. As an example, the Monte Carlo analysis may be designed to estimate the cost or duration of a project. The PDF represents the number of times a certain cost or duration is achieved. (See figure A-3 andbelow.)



Program: A portfolio of projects and/or other related work efforts managed in a coordinated way to achieve a specific business objective.

Program Risks: Events identified as potential threats or opportunities that are within the program baseline cost or schedule.

Project Execution Plan (PEP): DOE's core document for management of a project. It establishes the policies and procedures to be followed to manage and control project planning, initiation, definition, execution, and transition/closeout, and uses the outcomes and outputs from all project planning processes, integrating them into a formally approved document. A PEP includes an accurate reflection of how the project is to be accomplished, resource requirements, technical considerations, risk management, configuration management, and roles and responsibilities.

Project Management Plan (PMP): The contractor-prepared document that sets forth the plans, organization and systems that the contractor will utilize to manage the project. Its content and extent of detail of the PMP will vary in accordance with the size and type of project and state or project execution.

Project Risk: Risks that are captured within the scope, cost, or schedule of the project.

Qualitative Risk Analysis: Involves assessing the probability and impact of project risks using a variety of subjective and judgmental techniques to rank or prioritize the risks.

Quantitative Risk Analysis: Involves assessing the probability and impact of project risks and using more numerically based techniques, such as simulation and decision tree analysis for determining risk implications.

Residual Risk: Risk that remains after risk strategies have been implemented.

Risk: Factor, element, constraint, or course of action that introduces an uncertainty of outcome, either positively or negatively that could impact project objectives. This definition for risk is strictly limited for risk as it pertains to project management applications in the development of the overall risk management plan and its related documentation and reports.

Risk Acceptance: An informed and deliberate decision to accept consequences and the likelihood of a particular risk.

Risk Analysis: Process by which risks are examined in further detail to determine the extent of the risks, how they relate to each other, and which ones are the highest risks.

Risk Analysis Method: The technique used to analyze the risks associated with a project. Specific categories of risk analysis methods are:

- Qualitative - based on project characteristics and historical data (check lists, scenarios, etc.).

- Risk models - combination of risks assigned to parts of the estimate or project to define the risk of the total project.

- Probabilistic models - combining risks from various sources and events (e.g., Monte Carlo, Latin hypercube, decision tree, influence diagrams, etc.).

Risk Assessment: Identification and analysis of project and program risks to ensure an understanding of each risk in terms of probability and consequences.

Risk Assumption: Any assumptions pertaining to the risk itself.

Risk Breakdown Structure: Methodology that allows risks to be categorized according to their source, revealing common causes of risk on a project.

Risk Category: A method of categorizing the various risks on the project to allow grouping for various analysis techniques such as Risk Breakdown Structure or Network Diagram.

Risk Communication: An exchange or sharing of information about risk between the decision-maker(s), stakeholders, and project team. (The information can relate to various information sources such as the existence, nature, form, probability, severity, acceptability, treatment, or other aspects of risk.)

Risk Documentation: The recording, maintaining, and reporting assessments, handling analysis and plans, and monitoring results.

Risk Event: A potential (identified or unidentified) condition (threat or opportunity) that may or may not occur during the execution of a project.

Risk Handling: Strategies developed with the purpose of eliminating, or at least reducing, the higher risk levels identified during the risk analysis. The strategies may include risk reduction or mitigation, risk transfer/share, risk avoidance, and risk acceptance.

Risk Handling Strategy: Process that identifies, evaluates, selects, and implements options in order to set risk at acceptable levels given project constraints and objectives. Includes specific actions, when they should be accomplished, who is the owner, and what is the cost and schedule.

Risk Identification: Process to find, list and characterize elements of risk.

Risk Management: The handling of risks through specific methods and techniques.

Risk Management Plan: Documents how the risk processes will be carried out during the project.

Risk Mitigation: Process to reduce the consequence and/or probability of a risk.

Risk Modeling: Creation of a physical representation or mathematical description of an object, system or problem that reflects the functions or characteristics of the item involved. Model building may be viewed as both a science and an art. Cost estimate and critical path schedule development should be considered modeling practices and not exact representations of future costs, progress, and outcomes.

Risk Monitoring and Tracking: Process of systematically watching over time the evolution of the project risks and evaluating the effectiveness of risk strategies against established metrics.

Risk Owner: The individual responsible for managing a specified risk and ensuring effective treatment plans are developed and implemented.

Risk Planning: Process of developing and documenting an organized, comprehensive, and interactive strategy and methods for identifying and tracking risk, performing continuous risk assessments to determine how risks have changed, developing risk handling plans, monitoring the performance of risk handling actions, and assigning adequate resources.

Risk Register: Database for risks associated with the project. (Also known as risk database or risk log.)

Risk Threshold: Defined or agreed level of acceptable risk that risk handling strategies are expected to meet.

Risk Transfer: Movement of the risk ownership to another organizational element. (However, to be successfully and fully transferred, the risk should be accepted by the organization to which the risk is being transferred.)

Schedule Baseline: Time phased project activity durations and milestone commitment dates by which projects are accomplished. The approved project schedule is a component of the overall project plan. The schedule baseline provides the basis for measuring and reporting schedule performance.

Schedule Contingency: Time allowance used to adjust schedule for realized DOE risks; based on the schedule risk analysis.

Schedule Reserve: Time allowance used to adjust schedule for realized risks within the contractor's baseline.

Secondary Risk: Risk arising as a direct result of implementing a risk handling strategy.

Simulation (Monte Carlo): Process for modeling the behavior of a stochastic (probabilistic) system. A sampling technique is used to obtain trial values for key uncertain model input variables. By repeating the process for many trials, a frequency distribution is built up, which approximates the true probability distribution for the system's output. This random sampling process, averaged over many trials, is effectively the same as integrating what is usually a very difficult or impossible equation.

String Diagram: Technique used to analyze the physical or proximity connections within a process. Technique is often used to find latent risks.

System Dynamics Models: System Dynamics Modeling is a methodology for studying and managing complex feedback systems. Feedback refers to the situation X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. One cannot study the link between X andY and, independently the link between Y and X and how the system will behave. Only the study of the whole system as a feedback system will lead to correct results.

Technical Risk: Risks that include disciplines such as mechanical, electrical, chemical engineering, safety, safeguards and security, chemistry, and biology.

Threat: Risk with negative consequences.

Triangle Distribution: Subjective distribution of a population for which there is limited sample data. It is based on knowledge of the minimum and maximum and an inspired guess as to what the modal value might be. It is also used as an alternative to the Beta distribution in PERT, CPM, and similar forms of project management tools.

Trigger Date: The date for which a trigger metric is forecasted to be realized.

Trigger Metric: Event, occurrence or sequence of events that indicates the risk may be about to occur, or the pre-step for the risk indicating that the risk will be initiated.

Uncertainty: A term used to describe the inherent unknowns and inaccuracies related to costs and schedule estimates, as differentiated from risks.

Unidentified Risks: Risks that were not anticipated or foreseen by the IPT or by DOE-HQ staff members. Unidentified risks might originally be unanticipated because the probability of the event is so small that its occurrence is virtually unimaginable. Alternatively, an unidentified risk might be one that falls into an unanticipated or uncontrolled risk event category. (These risks are also categorized as unknown-unknown risks.)

Value Engineering: Value engineering (VE) is a structured technique commonly used in project management to optimize the overall value of the project. Often, creative strategies will be employed in an attempt to achieve the lowest life cycle cost available for the project. A VE effort is a planned, detailed review/evaluation of a project to identify approaches to providing the needed assets.

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