Risk Management Guide for Large Facilities

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1. INTRODUCTION

1.1 Objectives

The National Science Foundation (NSF) requires large facility awardees to engage in formalized risk assessment and management during the planning and construction of sponsored large facilities, as specified in the NSF Large Facilities Manual (LFM)[1]. This document is a supporting "module" to the LFM, and is referenced in *Chapter V: Special Topics* of that document. It amplifies on the topics of risk and risk management that are introduced in Chapter II of the LFM.

The objectives of this Risk Management Guide (RMG) are:

- To provide an overview of the risk management process from an NSF perspective.
- To guide the NSF Program Officer (PO) as to their responsibilities in the area of risk management.
- To enable the NSF PO to understand how and when a risk assessment should be performed and when a Risk Management Plan (RMP) should be written and what it should address.
- To help the NSF PO understand the benefits of risk management and the importance of risk management in ensuring project success.
- This document is not intended to be a comprehensive discussion of the subject of risk management. Additional sources of information are listed in Appendix C.

1.2 Definitions

Risk is the degree of exposure to an event that might happen to the detriment of a program, project, or other activity. It is described by a combination of the probability that the risk event will occur and the consequence of the extent of loss from the occurrence, or impact. This is best expressed in a risk statement which is structured something like 'If event E occurs with a probability of P, then consequence C will impact the project negatively.' Risk is an inherent part of all activities, whether the activity is simple and small, or large and complex. The relative size or complexity of an activity may or may not be an indicator of the potential degree of risk associated with that activity.

Risk management is the art and science of planning, assessing, and handling future events to avoid unfavorable impacts on project cost, schedule, or performance to the extent possible. [In this Guide, favorable outcomes are considered to be opportunities.] As widely practiced, risk management is a structured, formal, and disciplined activity focused on the necessary steps and planning actions to determine and control risks to an acceptable level.

The undesirable alternative to risk management is crisis management, a *post-hoc* resource-intensive process constrained by a restricted set of available options.

2. RISK MANAGEMENT IMPLEMENTATION AND DEFINITION OF ELEMENTS

The goals of a formal and pro-active risk management effort are to:

[1] NSF Large Facilities Manual (LFM), available on line at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=lfm

- Provide feasible, stable, and well-understood user requirements, supported by leadership, stakeholders, and integrated with program decisions
- Further a close integrated partnership with users, industry, and other stakeholders
- Supply a planned, on-going risk management process integral to the acquisition process, especially to the technical planning (PEP) processes, and other program related partnerships
- Facilitate continuous, event-driven technical reviews to help define a program that satisfies the user's needs within acceptable risk
- Ensure continuous and iterative assessment of risks

Risk management should be incorporated in each phase of the project life cycle to enhance the likelihood of project success by decreasing the likelihood of unanticipated cost overruns, schedule delays, and compromises in technical performance, quality and safety. The key to successful risk management is early recognition, planning and aggressive execution. Good planning enables an organized, comprehensive, and iterative approach for identifying and assessing risks and risk handling options. Consequently, NSF policy promotes *forward-looking, structured, informative, and continuous* risk management that begins as early as possible in the project life cycle. The LFM requires Awardees to commence risk management early in the Conceptual Design stage of the project. Early initiation of risk management ensures that critical technical, schedule, and cost risks are addressed with mitigating actions incorporated into planning and budget projections.

Whereas most organizations manage performance risk, equal emphasis must be placed on managing cost and schedule risks. An underlying premise is that if costs are too great, and there are ways to reduce them, then the NSF may reduce performance requirements to meet cost objectives. Cost control and effective risk management involve planning and scheduling events and demonstrations to verify solutions to cost, schedule, performance risk issues by applying the principles of continuing integrated risk management.

Trade-off analysis is essential to attain a favorable balance between cost, schedule, performance, and risk. Risk Assessments are critical to the process since they provide managers with essential data to assist in the cost, schedule, performance, and risk trade decisions.

In addition, the risk management process should cover hardware, software, the human element, and integration issues.

2.1 Risk Management Plan (RMP)

The Awardee's Risk Management Plan (RMP) is incorporated into its Project Execution Plan (PEP).

A successful RMP will:

- Describe methods of identifying, analyzing, prioritizing, and handling risks
- Offer guidance on monitoring risk reduction progress and for acquiring adequate resources to handle risk
- Assign specific responsibilities for the management of risk
- Prescribe the documenting, monitoring, and reporting processes to be followed

- Identify risks and completed risk analyses
- Develop, resource, and implement risk mitigation plans
- Provide acquisition and support strategies consistent with risk level and risk mitigation plans
- Establish thresholds and criteria for proactively implementing defined risk mitigation plans
- Define a set of success criteria for performance, schedule, and cost elements
- Formally document the risk management process.

2.2 Acquisition Strategy and Plan

The NSF accomplishes most of its project efforts through the award of CAs to primarily non-profit educational institutions. From an acquisition perspective, the primary focus of the NSF is on the Awardee's acquisition strategy and plan and on the approval of subcontracts over some threshold, typically established by the Business Officer and defined in the CA.

The Awardee's acquisition strategy should describe how risk is to be handled and must identify which risks are to be shared with the subcontractor and which are to be retained by the Awardee or the NSF. The Awardee determines how much of each risk is to be shared with the subcontractors. The Awardee should not require subcontractors to accept financial risks that are inconsistent with their ability to handle them. Financial risks are driven, in large measure, by the underlying performance risks, especially technical and programmatic, inherent in a program. The NSF PO should, therefore, ensure that the Awardee selects the proper type of contract based on an appropriate risk assessment, to ensure a clear relationship between the selected contract type and project risk. An example would be the use of cost-reimbursable-type contracts for development projects. The NSF PO should utilize the Project Advisory Team (PAT) for his/her project to provide assistance in reviewing the Awardee's proposed acquisition strategy and plan any proposed subcontracts requiring NSF approval.

2.3 Earned Value Management (EVM)

Earned Value Management (EVM), along with risk management, is one of the most important project management tools available to the NSF and the Awardee. EVM[2] is a widely used process of continual measurement of actual achievements against a detailed performance plan that facilitates prediction of the final costs and schedule of a project during construction. EVM implementations are also generally termed "EVM systems" or EVMS.

2.4 Contingencies

A key output from the risk analysis effort is the establishment of appropriate contingency[3] or reserves within the project cost estimates and schedules at the confidence levels selected. A probabilistic approach is essential since a simple algebraic addition of best case outcomes underestimates contingency and worst case outcomes overestimates contingency.

2.4.1 Cost Contingency

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[2] For further information see Fleming and Hoppleman as referenced in Appendix C.

[3] Additional details on contingency may be found in the module Definition and Use of Contingency Resources in NSF Facility Construction http://www.inside.nsf.gov/bfa/lfp/guide/docs/contingency.doc . See also Weiss, Appendix C.

Cost contingency is that portion of the project budget required to cover "known unknowns." It includes items such as planning and estimating errors and omissions, minor labor or material price fluctuations, design developments and changes within the project scope, labor productivity losses due to congestion or contractor interferences, and variations in market and environmental conditions. Such events are in the control space of the project and are considered 'internal risks.' Contingency usually excludes items such as major scope changes, (changes in end product specification, capacities, and building sizes), extraordinary events such as major strikes and natural disasters, and escalation and currency effects.[4] These events are not in the control of the program and are considered 'external risks.' In the Government project environment, contingency is often added to the base project cost estimate to increase the likelihood that the project can be completed within publicized cost and schedule objectives. This practice has been implemented in part to meet Congressional expectations that cost and schedule baselines for Federal projects will not be exceeded.

Contingency funds are held by the Awardee. Depending on the project, the release of contingency funds may require concurrence of the PO, the NSF Business Officer (BO), or both. It is expected that contingency funds will be expended during the execution of the project.

2.4.2 Schedule Contingency

Schedule contingency should also be included in the project baseline description (PBD). Like the cost contingency, schedule is controlled by the Awardee. Schedule contingency is usually added in the form of dummy activities along the critical path or near-critical paths in a logic network diagram for a project. An advanced, structured variation of this technique is the critical chain method, for further information see Leach as referenced in Appendix C. Another more risky and less recommended method is simply to add a single activity at the end of the project to create artificial schedule float. Sometimes, schedule contingency can be embedded as additional durations for tasks that involve a high degree of uncertainty or risk. This approach is not recommended, as it is often difficult to identify the amount of schedule contingency which has been embedded by the schedule estimator.

3. ROLES AND RESPONSIBILITIES CONCERNING RISK MANAGEMENT[5]

Risk management is a shared responsibility of NSF staff and the Awardees. The four main players in risk management for NSF projects are: the NSF PO, the NSF BO (also known as Contracting Officers or Grants and Agreements Officers), the Awardee and the Awardee's Risk Manager.

Effective risk management is also facilitated via involvement of other project stakeholders at NSF, such as members of the Project Advisory Team (PAT), as well as the input of outside experts in critical risk areas (e.g., technology, design, manufacturing, construction, networking, logistics, schedule, and cost).

3.1 Roles

[4] Ibid, AACE International.

[5] Additional detail on Roles and Responsibilities in NSF Large Facilities Projects may be found in Roles and Responsibilities of NSF Staff Involved in the Management and Oversight of Large Facilities
http://www.inside.nsf.gov/bfa/lfp/guide/docs/roles.doc

The role of the NSF PO is to manage the performance of the Cooperative Agreement (CA) or contract entered into between the NSF and the Awardee. The role of the BO is to ensure the legality of the CA or contract. The role of the Awardee is to perform the task as defined in the CA or contract. Within that performance context, the Awardee or subawardee employee must formulate and implement the project's RMP in accordance with the present Guide.

Most of the risk planning and risk assessment activities will be performed by the Awardee under the oversight of the NSF Program Officer (PO). The Awardee will define the RMP as part of the PEP for the project (1.2.1 above). The NSF PO will perform a separate Risk Assessment from an NSF perspective, identifying agency-specific risks and mitigation strategies, and document this in the Internal Management Plan (IMP) for the project. All Risk Assessments are then ideally reviewed at least monthly throughout the life of the project and updated as required.

A key concept is that the NSF shares the risk with the Awardee, but does not transfer risk exclusively to the Awardee. All project risks, whether primarily managed by the NSF PO or by the Awardee, must be visible to the NSF PO.

3.2 Responsibilities

3.2.1 Shared Responsibilities

Some shared risk responsibilities include:

- Devising a list of standard reports that will satisfy project and oversight needs most of the time.
- Risk identification relying on the skill, experience, and insight of project personnel and subject matter experts (SMEs), as well as the Awardee's project manager, the NSF PO, the NSF BO, and other supporting staff, including consultants and advisors.
- Selection of risk handling action.
- All Risk Assessments should be reviewed at least monthly throughout the life of the project and updated as required.
- During the project's implementation phase, the Risk Register should be reviewed regularly, at least monthly, with the Awardee's management team and the NSF PO and BO.

3.2.2 NSF PO Responsibilities

Project cost, including contingency development and management is an area in which the NSF PO will want to include in monthly risk reviews. A detailed bottom-up cost estimate tied to the project Work Breakdown Structure (WBS) is developed. The risk management and contingency development processes that augment the initial cost estimate, creating the baseline or risk adjusted cost (RAC). Risk management and contingency development and usage are closely-related areas as specified below in Section 3.4. The PO will want to set metrics to quantify specific trends and thresholds in the EVMS to track the use of contingency as well as overall cost.

The NSF PO will want to ensure that the project baseline includes adequate levels of budget contingency[6]. For projects containing a significant component of technical risk, or projects with

[6] Refer to Chapter V of the Large Facilities Manual, and the link to Definition and Use of Contingency Resources in NSF Facility Construction.

a high degree of uncertainty, the contingency can represent 20 to 50 percent of the project cost, or even more. The project contingency will be held by the Awardee, as an essential project management tool. However, use of contingency to manage risk must be reported to NSF, and concurrence from NSF is required when contingency use exceeds a threshold defined in the CA. In all cases, the NSF PO will closely monitor contingency usage and track it to overall risk performance and handling, particularly with regard to the ensemble of potential liens on future contingency use and where they are encountered within the project schedule.

The NSF PO will want to keep close tabs on the project schedule. The most important item is the critical path for the project and the amount of float or schedule contingency available on the critical path when the project has certain fixed milestones. The NSF PO will want to closely monitor activities on the critical path and will want to ensure that all identifiable risks to activities on the critical path are being actively managed by the Awardee. Schedule usually drives cost in a project, so the NSF PO will also want to examine any near-critical paths (paths with minimal float) that can become the critical path for the project should they experience delays.

The NSF PO will want to ensure that the Awardee has an active risk management process. Risk management is NOT a one-time event, but it should continue throughout the duration of the project. Risk management meetings should be conducted by the Awardee on at least a monthly basis, and often as frequently as weekly. One very useful risk management tool is the Risk Register, an example of which can be found as Table 3-8. The NSF PO will want to ensure that active risk management and control is being performed for the high risks, as defined in Section 3.3 and Figure 3-1, on the project.

The NSF PO will want to structure oversight processes so that they are not a limiting factor in the development of the project – since that can be a risk to budget and schedule. The project development should be limited by the rate at which technical developments can be completed, not the rate at which oversight steps are approved, oversight processes should be planned accordingly. The NSF PO can also utilize the oversight, or review, process to assist in the risk identification process and to ensure that the Awardee is performing risk handling in an adequate manner. In general, the more time a PO spends working with the risk process, the better the risk management performance of the program and, hence, the lower the risk over time.[7]

The NSF PO and the NSF BO can influence the acquisition strategy for complex projects with multiple participants by ensuring that there is a strong integrating organization in place, or by structuring the award such that the NSF makes a single award, with all the other entities involved in a project reporting in a hierarchical fashion to the single NSF Awardee (as subawardees). The NSF PO should attempt to balance the scientific need for wide participation with the need to have clean reporting relationships and responsibilities.

The NSF PO should also ensure that the costs associated with implementing risk handling strategies are included in the project cost estimate (Project Baseline Definition). Usually, after these risk handling strategies have been implemented, the risk consequence is reduced to a value known as the "residual risk." The NSF PO should ensure that the Awardee is quantifying these risk reduction results.

The NSF PO should, therefore, ensure that the Awardee selects the proper type of contract based on an appropriate Risk Assessment, to ensure a clear relationship between the selected contract type and project risk. An example would be the use of cost-reimbursable-type contracts for development projects.

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[7] See Effective Risk Management: Some Keys to Success by E. H. Conrow (2006) pages 127 to 155.

In addition, there are a number of other NSF PO responsibilities:

- The NSF PO should identify risk and cost driving requirements during the Conceptual Design Stage of the project to know where tradeoffs may be possible.
- The NSF PO always has a stewardship responsibility to the taxpayer to develop a capable system and can never be absolved of that responsibility.
- Therefore, all project risks, whether primarily managed by the NSF PO or by the Awardee, must be visible to the NSF PO.
- The NSF PO should carefully review the risk analyses that have been performed by the Awardee to ensure that they have conducted a comprehensive risk identification process and have analyzed those risks.
- The NSF PO should utilize the PAT for their project to provide assistance in reviewing the Awardee's proposed acquisition strategy and plan and any proposed subcontracts requiring NSF approval.
- The NSF PO should also review critical subcontracts to ensure that the NSF's interests are protected. The intention here is to establish balance between cost, schedule, performance, and risk early in the acquisition process and to manage to a cost objective.
- The NSF PO will perform a separate Risk Assessment from an NSF perspective and include such in the IMP for the project.
- The NSF PO should carefully review the risk analyses that have been performed by the Awardee to ensure that they have conducted a comprehensive risk identification process and have analyzed those risks.
- Most of the detailed risk management activities will be conducted by the Awardee. The NSF PO should make sure that the Awardee has written a RMP, even in skeletal form, during the Conceptual Design Stage of the project, and that this evolves as the project plan matures.
- The NSF PO and the NSF BO must be aware of the major project risks when the acquisition instrument, usually a CA, is developed.
- In most cases, the NSF PO will want to minimize the amount of Government Furnished Equipment (GFE) or services that the NSF provides to the Awardee, if possible to reduce this potential source of performance risk.
- Also, the NSF PO should ensure that adequate risk handling strategies, as outlined in Section 3.4, have been developed for the major project risks.

3.2.3 NSF PO Responsibilities in International Situations

Effective risk management is also essential in performing facilities projects that are international in scope or have multiple performing organizations; projects of this nature are inherently more risky. The NSF PO must take steps to identify and quantify the increased risks and take risk handling actions to mitigate, transfer, or avoid the added risks wherever possible. International projects will introduce increased risk in areas such as:

- Government-to-government relations
- Government instability
- Currency fluctuations
- Funding uncertainties
- Management complexities
- Project integration
- Transportation requirements
- Other logistical requirements

- Import-export and International Traffic in Arms Regulations (ITAR)
- Cultural differences

For example, it is often useful to define contributions to a project from an international partner in terms of the actual hardware to be delivered, rather than specifying a set financial contribution. This helps to transfer the financial performance risk to the international partner rather than having the NSF or the Awardee assume the risk.

3.2.4 NSF BO Responsibilities

The NSF PO and the NSF BO must be aware of the major project risks when the assistance award, usually a CA, is developed.

The NSF PO and the NSF BO can influence the acquisition strategy for complex projects with multiple participants by ensuring that there is a strong integrating organization in place, or by structuring the award such that the NSF makes a single award, with all the other entities involved in a project reporting in a hierarchical fashion to the single NSF Awardee (as subawardees).

Thus, the NSF PO and the NSF BO should make sure that the necessary oversight processes are well thought out and absolutely necessary. The NSF PO can also utilize the oversight, or review, process to assist in the risk identification process and to ensure that the Awardee is performing risk handling in an adequate manner. In general, the more time a PO spends working with the risk process, the better the risk management performance of the program and, hence, the lower the risk over time.[8]

3.2.5 Awardee Responsibilities

The Awardee's responsibilities as Risk Manager include:

- The Awardee determines how much of each risk is to be shared with the subcontractors, in the acquisition strategy and plan.
- The Awardee should not require subcontractors to accept financial risks that are inconsistent with their ability to handle them.
- Documentation should be done by those responsible for planning and collecting and analyzing data, i.e., the Awardee in most cases.
- Definitions used by the Awardee should be consistent with NSF definitions for ease of understanding and consistency.
- The Awardee should periodically review the RMP and revise it, if necessary. Some events such as: (1) the baselining of a project, (2) preparation for a major decision point, (3) technical audits and reviews, (4) an update of other project plans, and (5) a change in major project assumptions may drive the need to update an existing RMP.
- It is important that the Awardee analyze the risk events and consequences using some standardized methodology.

4. Selected References for Risk Management

[8] See Effective Risk Management: Some Keys to Success by E. H. Conrow (2006) pages 127 to 155.

Document	Description
AACE International Recommended Practice No. 10s-90 Cost Engineering Terminology	Excellent reference on general costing and EVM. Useful for cost estimating and coordinating cost with risk.
Acquisition Community Connection	Primary reference tool for defense acquisition work force; contains over 1,000 mandatory and discretionary publications and documents which promulgate acquisition policy and guidance. https://acc.dau.mil/CommunityBrowser.aspx
Acquisition Software Development Capability Evaluation, AFMC Pamphlet 63-103, 15 June 94.	Describes one approach to conducting an Industry Capabilities Review. This two-volume pamphlet was generated from material originated at Aeronautical Systems Center. The concepts support evaluations during source selection and when requested by IPT's. The material presented in this pamphlet also can be tailored to apply to system and hardware risk management.
Capability Maturity Model for Software (SM-CMM), Version 1.1,/CMU/SEI-93-TR-24, February 1993.	This is a tool that allows an acquiring organization to assess the software capability maturity of an organization.
Continuous Risk Management Guide, Software Engineering Institute, Carnegie Mellon University, 1996.	Provides a risk management methodology similar to the one described in the *Deskbook*. Its value is that is subdivides each process into a series of steps; this provides useful insights. Appendix A describes 40 risk-management techniques, the majority of which are standard management techniques adapted to risk management. This makes them a useful supplement to the *Deskbook* identified techniques.
Cost Risk Analysis for HTW Remediation Projects, U.S. EPA, 1992	Useful for environmental remediation projects.
Critical Chain Program Management,, Lawrence Leach, 2000	The first and still the best reference on CCPM by the man recommended by the Goldratt Institute.
Definition and Use of Contingency Resources in NSF Facility Construction http://www.inside.nsf.gov/bfa/lfp/guide/docs/contingency.doc	Provides guidance and information on the use of contingency in NSF large facility projects
DOE Project Management Practices Guide, Practice # 14, February 1, 2003.	Provides a very detailed description of the project risk management process, tools, procedures, and techniques. Includes a sample Risk Management Plan.
DoD 4245.7-M, Transition from Development to Production, September 1985.	Provides a structure for identifying technical risk areas in the transition from a program's development to production phases. The structure is geared toward development programs but, with modifications, could be used for any acquisition program. The structure identifies a series of templates for each of the development contractor's critical engineering

Document	Description
	processes. The template includes potential areas of risk and methods for reducing risk in each area.
Earned Value Project Management, Fleming and Hoppleman, 1996	The text used by the majority of introductory courses. A great single reference for this tool.
Effective Risk Management: Some Keys to Success, Edmund H. Conrow, 2006, 2nd Edition	Provides classic presentation of qualitative project risk analysis (Conrow wrote the original DoD RMG).
Foundations of Risk Analysis, Terje Aven, 2005	Probably the most general, strategic, and abstract of all the risk references herein.
Handbook of Parameter Estimation for Probabilistic Risk Assessment (NUREG/CR-6823), 2003	Advanced reference on PRSA and quantitative analysis.
Introductory Statistics (6th Edition), Neil A. Weiss, 2001	One of the standard introductory texts in statistics. Understandable yet thorough.
Management of Project Risks and Uncertainties, Construction Industry Institute, 1989	Provides a very good overview of risk management for traditional construction projects.
MIL-STD 881, DOD Handbook: Work Breakdown Structure, 2 Jan 1998	The complete reference on the topic of implementing a WBS.
NAVSO P-3686, Top Eleven Ways to Manage Technical Risk, October 1998.	Contains the Navy approach to risk management with baseline information, explanations, and best practices that contribute to a well-founded technical risk management program.
NAVSO P-6071.	Navy "best practices" document with recommended implementations and further discussion on the material in DoD 4245.7-M.
Project Management Body of Knowledge, PMI, 2004 (Third Edition)	Provides a high level description of the risk management process, tools, and techniques. Generally accepted as the foremost authoritative reference on project risk management.
Probability Methods for Cost Uncertainty Analysis, P.R. Garvey, 2000	The essential text on developing a cost estimate with probability.
Probabilistic Risk Analysis: Foundations and Methods, Tim Bedford and Roger Cooke, 2001	Probably the best text on subject.
Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners, 2002	Arguably the best introductory reference.
The Psychology of Intelligence Analysis, Richard Heuer	A reference on decision making under uncertainty based on a long and stellar career in intelligence analysis. In it, especially Chapter 12, Heuer systematically shows how Bayesian Analysis can be

Document	Description
	used and the steps that must be taken to ensure estimative probabilities are reliable.
Reliability and Risk : A Bayesian Perspective, Nozer Singpurwalla, 2006	One of three books by author that provide the definitive Bayesian approach to reliability and risk assessment.
Risk Management, AFMC Pamphlet 63-101, July 1997.	An excellent pamphlet on risk management that is intended to provide PM's and the PM with a basic understanding of the terms, definitions, and processes associated with effective risk management. It is very strong on how to perform pre-contract award risk management.
Risk Management Concepts and Guidance, Defense Systems Management College, March 1989.	Devoted to various aspects of risk management.
Risk Management Critical Process Assessment Tool, Air Force SMC/AXD, Version 2, 9 June 1998.	Provides guidance and extensive examples for developing RFP Sections "L" and "M," plus source selection standards or risk management. Also includes technical evaluation and review questions, which are helpful for assessing a risk management process; and risk trigger questions, which are helpful for risk identification.
Risk Management Guide for Defense Acquisition, Sixth Edition (Version 1.0), August, 2006	The premier program risk management reference
Risk Modeling, Assessment, and Management, Yacov Y. Haimes, 2nd Edition, 2004	The advanced mathematical treatment of quantitative risk analysis.
A Software Engineering Capability Maturity Model, Version 1.01 Software Engineering Institute (Carnegie Mellon University), Technical Report, December 1996.	Describes an approach to assess the software acquisition processes of the acquiring organization and identifies areas for improvement.
A Systems Engineering Capability Maturity Model, Version 1.0 Software Engineering Institute (Carnegie Mellon University), Handbook SECMM-94-04, December 1994.	Describes one approach to conducting an Industry Capabilities Review. Section PA 10 (pp. 4-72–4-76) discusses software risk management. The material presented in this handbook also can be tailored to apply to system and hardware risk.
Systems Engineering Management Guide, Defense Acquisition University Press, January 2001, Section 15.	Devoted to risk analysis and management and provides a good overview of the risk management process.
Taxonomy-Based Risk Identification, Software Engineering Institute, Carnegie Mellon University, CMU/SEI-93-TR-6 (ESC-TR-93-183, June 1993.	Describes a method for facilitating the systematic and repeatable identification of risks associated with the development of a software-intensive project. This method has been tested in active Government-funded defense and civilian software development projects. The report includes macro-level lessons learned from

Document	Description
	the field tests.
USACE Cost Risk Analysis Guidance Document, 1992.	Useful for traditional construction projects.
“Using Data Types and Scales for Analysis and Decision Making”, Periseau and Oswalt, Acquisition Review Quarterly, Spring 1994, V 1, N 2, pp 146-152.	A quick and easy to read but mathematically rigorous discussion of scales and their impacts on the mathematics of risk analysis.

5. Acronyms

BO	Business Officer
CA	Cooperative Agreement
DOD	Department of Defense
DOE	Department of Energy
EVM	Earned Value Management.
EVMS	Earned Value Management System
FMECA	Failure Mode and Effects Criticality Analysis
GFE	Government Furnished Equipment
IMP	Internal Management Plan
IMS	Integrated Master Schedule
IPT	Integrated Process Team
NSF	National Science Foundation
OSHA	Occupational Safety and Health Administration
PAT	Project Advisory Team
PEP	Project Execution Plan
PBD	Project Baseline Description
PMBOK	Program Management Book of Knowledge
PMI	Program Management Institute
PO	NSF Program Officer (also known as Program Manager)
PRA	Probabilistic Risk Assessment or Analysis
RAC	Risk Adjusted Cost
RMG	Risk Management Guide
RMP	Risk Management Plan
SME	Subject Matter Expert
SOW	Statement of Work
T&PRA	Technical and Programmatic Risk Analysis
WBS	Work Breakdown Structure

6. Glossary

A ***Concern*** is a potential risk event whose probability, consequence, and future root cause are, as of yet not defined well enough to be understood or quantified.

Consequence is the outcome of a future occurrence expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain, expressed in terms of impact.

Contingency is the amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs.[9]

The ***Future Root Cause*** is the reason, which, if eliminated or corrected, would prevent a potential consequence from occurring. It is the most basic reason for the presence of a risk.

An ***Issue*** is a problem or consequence which will occur with a probability of one. A current issue was likely a risk in the past that was ignored or not successfully mitigated.

A ***Problem*** is a risk that has already occurred and whose consequence has already had impact.

Risk is a measure of the potential inability to achieve overall project objectives within defined cost, schedule, and technical constraints. It has three components: (1) a future root cause, (2) the probability assessed at the present time of that future root cause occurring, and (3) the consequences of failing to achieve that future occurrence. The relationship between the two components of risk—probability and consequence—is complex. To avoid obscuring the results of an assessment, the risk associated with an event should be characterized in terms of its two components. As part of the assessment, there is also a need for backup documentation containing the supporting data and assessment rationale.

Risk analysis is the process of examining each identified risk area or process to refine the description of the risk, isolating the cause, and determining the effects. It includes risk rating, quantification, and prioritization in which risk events are defined in terms of their probability of occurrence, impact of their consequence, and relationship to other risk areas or processes.

Risk documentation is recording, maintaining, and reporting assessments, handling analysis and plans, and monitoring results. It includes all plans and reports for the NSF PO and NSF and Awardee decision authorities.

Risk events are things that could go wrong in a project. The events should be defined to a level where an individual can comprehend the potential consequence and its causes. For example, a potential risk event for a turbine engine could involve a turbine failure due to a turbine blade vibration.

Risk identification is the process of examining the project areas and each critical technical process to identify and document the associated risk, including future root causes.

[9] For additional details on contingency please see the Contingency Module http://www.inside.nsf.gov/bfa/lfp/guide/docs/contingency.doc

Risk handling is the process that identifies, evaluates, selects, and implements options in order to set risk at acceptable levels given project constraints and objectives. This includes the specifics on what should be done, when it should be accomplished, who is responsible, and the associated cost and schedule. Its execution determines what planning, budget, and requirements and contractual changes are needed, provides a coordination vehicle with management and other stakeholders, directs the teams to execute the defined and approved risk mitigation plans, outlines the risk reporting requirements for on-going monitoring, and documents the change history. The most appropriate strategy is selected from these handling options.

Risk management is the act or practice of dealing with risk. It includes planning for risk, assessing (identifying and analyzing) risk areas, developing risk-handling options, monitoring risks to determine how risks have changed—including and tracking future root causes and their consequence, and documenting the overall risk management program.

Risk management planning is the process of developing and documenting an organized, comprehensive, and interactive strategy and methods for identifying and tracking risk areas, developing risk-handling plans, performing continuous risk assessments to determine how risks have changed, and assigning adequate resources.

Risk monitoring and control is the process that systematically tracks and evaluates the performance of risk-handling strategies throughout the project life cycle and develops further risk-handling options, as appropriate. It feeds information back to the other risk management activities of planning, assessment, and handling.