Progress in Improving Project Management at the Department of Energy

2002 Assessment

Committee for Oversight and Assessment of U.S. Department of Energy Project Management

Board on Infrastructure and the Constructed Environment

Division on Engineering and Physical Sciences

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Philip R. Clark, Nuclear Corporation (retired),
Fletcher H. (Bud) Griffis, Polytechnic University,
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Bradley C. Moore, Ohio State University,
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Richard N. Zare, Stanford University.

Although the reviewers listed have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Lawrence T. Papay, Science Applications International Corporation. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was

carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Contents

Acronyms and Abbreviations

BICE	Board on Infrastructure and the Constructed Environment
CCB	Change Control Board
CCIS	Center for Construction Industry Studies
CD-0	critical decision 0, approval of mission need
CD-1	critical decision 1, approval of system requirements and alternatives
CD-2	critical decision 2, approval of project baseline
CD-3	critical decision 3, authorization to complete implementation
CD-4	critical decision 4, approval of project completion and transition to operations
CFO	chief financial officer
CPI	cost performance index
DOE	U.S. Department of Energy
EM	Office of Environmental Management
EPC	estimated project cost
ESAAB	Energy Systems Acquisition Advisory Board
ES&H	environment, safety, and health
EVMS	earned value management system
FAR	Federal Acquisition Regulations
GAO	General Accounting Office

ICPP	integrated construction project plan
INEEL	Idaho National Engineering and Environmental Laboratory
IPT	Integrated Project Team
LANL	Los Alamos National Laboratory
M&I	management and integration
M&O	management and operations
NASA	National Aeronautics and Space Administration
NIF	National Ignition Facility
NNSA	National Nuclear Security Administration
OECM	Office of Engineering and Construction Management
OMB	Office of Management and Budget
OMBE	Office of Management and Budget Evaluation
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations Office
ORP	Office of River Protection
PA&E	Office of Program Analysis and Evaluation
PARS	Project Analysis and Reporting System
PBC	performance-based contracting
PEP	Project Execution Plan
PMCDP	Project Manager Career Development Plan
PMP	*Project Management Practices*
PMSO	project management support office
PPM	*Program and Project Management* manual
PSO	Program Secretarial Office
RL	Richland Operations Office
SC	Office of Science
SNL	Sandia National Laboratories
SNS	Spallation Neutron Source
SPI	schedule performance index
SRS	Savannah River Site
UC	University of California
WBS	work breakdown structure

Executive Summary

This report is the second in a series of three annual assessments of project management at the U.S. Department of Energy (DOE). The first annual report assessed progress through mid-2001 (NRC, 2001b), and this report continues the assessment through October 2002. The assessments are being made by the National Research Council's (NRC's) Committee for Oversight and Assessment of U.S. Department of Energy Project Management. The committee has also produced two interim letter reports (NRC, 2001a, 2002a) and the proceedings of a government/industry forum on the owner's role in project management and preproject planning (NRC, 2002b). All of these reports follow up on the recommendations made by a predecessor committee in its report *Improving Project Management in the Department of Energy* (NRC, 1999). Although the detailed discussion, findings, and recommendations in the previous reports are not repeated in this report, the committee continues to endorse them, and they should be read in conjunction with this report.

The reader who has persevered through this series of publications will have observed that it becomes more and more difficult to find new things to say about project management at the DOE. Chapter 2 discusses some fundamental issues in DOE's core competencies that are identified in this and previous reports. The fundamental best practices cited as the benchmarks in the 1999 report have not changed, and the committee's primary emphasis remains the importance of learning the fundamentals of project management good practice and applying them consistently.

Since the current committee was established, there have been a number of senior management and other personnel changes at the DOE, as well as changes

in DOE's approach to project management. For the most part, the committee applauds these new directions in project management. The committee recommends that the project management changes in DOE Order O 413.3, *Program and Project Management for the Acquisition of Capital Assets,* in the draft *Program and Project Management* manual (DOE, 2000, 2002) and in other recent directives and memoranda be continued until they have had time to be effective. The committee's specific findings and recommendations regarding these documents and procedures are given in Chapter 3 of this report. The summary message here is simple: DOE should persevere in its efforts to make project management a core competency and to achieve excellence in project performance. The committee recognizes that the time required for cultural change in the DOE may be longer than that required in industrial companies, where market forces drive improvement. DOE needs to maintain the project management policies and procedures it has defined long enough to convince both DOE and contractor personnel that the changes are permanent. This report describes the progress the committee has observed and the issues that need further efforts to make DOE a leading project management organization.

Since the earliest report (NRC, 1999), NRC committees have been concerned not only that DOE is *doing projects right* but also that it is *doing the right projects*. Perhaps the most important single point that the committee has stressed, and continues to stress, is the absolute need for DOE management to develop the strategic plans that define the need for capital acquisition projects. Although the committee's reports, this one included, have dealt with many specific issues affecting project success (e.g., front-end planning, risk management, and contracting strategies), the overriding critical success factor for projects is to assure that projects are essential to and aligned with the DOE's mission (i.e., that the right portfolio of projects is selected). DOE is perhaps improving, as indicated by the recent establishment of the Office of Management and Budget Evaluation (OMBE), and there has been some progress in the National Nuclear Security Administration (NNSA) with the integrated construction project plan (ICPP) and, more recently, in the Office of Environmental Management (EM), but the department is still lacking a continuous and strong portfolio planning and management process. Portfolio planning is to programs as project planning is to projects, at a higher level. With a functional portfolio management process, all echelons in DOE would know what projects to do and the priorities given to them. At least as important, a portfolio management process would implicitly define what projects not to do and would help to insulate DOE from the political pressures brought by would-be contractors and other economic beneficiaries to engage in unnecessary and unwarranted projects.

The committee also emphasizes the role of DOE's senior management in inculcating the belief throughout the organization that projects can and will be managed effectively. The instrument in the hands of senior management that will lead to better project management is the Energy Systems Acquisition Advisory

Board (ESAAB) critical decision process. Chapter 7 discusses some means by which DOE management can determine whether even a first-of-a-kind project is ready to proceed. The role of senior managers in shaping DOE's project management culture is discussed further in Chapter 6 of this report. The committee finds that progress has been made in this area, but additional work is needed to achieve the desired cultural changes.

The committee notes that NNSA in particular has made progress in defining its mission and developing a strategic direction. EM, since completion of its top-to-bottom review, has made considerable progress in recognizing that its projects are manageable—an important first step and a prerequisite to any improvement in project management. The Office of Science (SC), too, recognizes the need for improvement of its project management. Additionally, the formation of OMBE has strengthened the strategic oversight of all DOE programs and projects and has justified the placement of the Office of Engineering and Construction Management (OECM) in the Office of the Chief Financial Officer (CFO). As recommended by the 1999 NRC report, there is now a headquarters organization with some responsibility for project management agency-wide. The committee also applauds DOE's steps to recognize improvements in project management (Chapter 10).

The committee believes that DOE has made some progress toward satisfying the recommendation made in the 1999 report—namely, that DOE needs to be doing the right projects as well as doing projects right. DOE policies and procedures, at least, emphasize the federal government's role in deciding which projects to do, how to select projects from the large number of proposals, and how to manage the portfolio of projects, leaving the details of how to do them to the contractors.

DOE expends about 95 percent of its funds through contractors. If this portion were reduced to 90 percent, it would be a reduction of about 5 percent for the contractors but an increase of 100 percent for DOE. Clearly, this is not going to happen; DOE will continue to remain dependent on contractors to run its facilities and its projects. Therefore, the committee, in the past and in Chapter 5 and Appendix D of this report, has strongly emphasized the owner's role in project management, by which DOE, as the custodian of public funds, should not abrogate to contractors project definition, acquisition strategy decisions, and project oversight. To effectively fulfill its project management responsibilities, DOE needs to expand its investment in human capital to develop a corps of qualified project managers commensurate with the value and complexity of its projects. The committee believes that an appropriate role for DOE as owner has yet to be completely defined.

The DOE, by its own analysis (DOE Contract Reform and Privatization Project Office, 2001), draws on an ever-shrinking pool of contractors to accomplish its work. DOE has stressed contractor competition as one of the means for overcoming its lack of project management experience. Where competitive bid-

ding is determined to be the preferred method of procurement, DOE should take steps to obtain adequate numbers of bids if there are qualified contractors capable of undertaking the projects. However, there is a shrinking pool of qualified contractors, and this trend is alarming. As real competition declines, the need for knowledgeable, trained, professional federal project managers inside DOE increases. The apparent shortage of such personnel in DOE has been identified before and is addressed in Chapter 4, on human capital. Further findings and recommendations on acquisition and contracting are discussed in Chapter 9.

This report continues to offer recommendations regarding project management methodology and project oversight, which are listed at the end of each chapter, where the relevant supporting information is presented. (See, in Chapter 1, "Organization of the Report," for an outline of the chapters where these specific recommendations are made.) These are essential tools, but they will be effective only insofar as there are competent DOE managers with the will to use them. The committee's view is that a corrective course has been set from the bridge, but it is still too early to tell if the ship is responding.

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Introduction

The Department of Energy's (DOE's) diverse missions are supported by hundreds of projects resulting in annual expenditures of billions of dollars. Consequently, Congress has an ongoing concern about project management in the DOE and the need to assure American taxpayers that the nation's resources are effectively and efficiently managed. In response to a directive from the Committee of Conference on Energy and Water Resources of the 106th Congress (U.S. Congress, 1997), DOE requested the National Research Council (NRC) to appoint a committee to review and assess the progress made by the department in improving its project management practices, as recommended in previous NRC reports (NRC, 1998, 1999). The principal goal of this effort is to review and comment on DOE's recent efforts to improve its project management, including a review of the following:

- Specific changes implemented by the DOE to achieve improvement (e.g., organization, practices, training);
- An assessment of the progress made in achieving improvement; and
- The likelihood that improvement will be permanent.

This oversight and assessment is planned as a 3-year effort. (See Appendix A for the statement of task.)

The NRC appointed a committee under the auspices of the Board on Infrastructure and the Constructed Environment (BICE) to undertake the review and assessment of DOE project management. The committee is composed of 10 professionals with diverse experience in academic, government, and industrial

settings and knowledge of project management and process improvement. Four members of the committee also participated in the Phase II review and assessment, and one member participated in both Phase I and Phase II. See Appendix B for biographies of the committee members.

This document is the committee's second annual report. It includes the committee's assessment of progress in improving project management at DOE as of October 2002 and provides additional discussion of what the committee determined to be key factors affecting DOE project management. The body of this report addresses some of the issues raised in the Phase II report (NRC, 1999), the committee's first annual report (NRC, 2001b), interim letter reports (NRC, 2001a, 2002a), and the proceedings of the 2001 forum on the owner's role in project management and preproject planning (NRC, 2002b). Not all the findings and recommendations in the previous reports are referred to here, although the committee continues to endorse them.

REVIEW ACTIVITIES

The committee met six times from November 2001 to October 2002 to review and assess the data on projects and project management procedures presented by the DOE project managers and representatives of the Office of Management and Budget Evaluation (OMBE), the Office of Engineering and Construction Management (OECM), the project management support offices (PMSOs) in the Office of Environmental Management (EM), the National Nuclear Security Agency (NNSA), and the Office of Science (SC). The committee also met with DOE personnel and DOE contractor personnel in Berkeley, Oakland, Livermore, and Stanford, California; Oak Ridge, Tennessee; and Richland, Washington. Committee representatives also attended the 2002 project management workshop and awards programs sponsored by OECM and met with DOE senior managers responsible for managing programs, establishing policies, and implementing project management reforms. The committee's findings and recommendations are based on briefings and documents provided by DOE. The committee's fact-finding efforts are listed in Appendix C.

ORGANIZATION OF THE REPORT

This report is organized in 10 chapters and 6 appendixes. Chapter 1, Introduction, provides background on the initiation and conduct of this review and the objectives of this report.

Chapter 2, Core Competencies, discusses overarching issues that demonstrate DOE's progress in improving project management and the committee's concern for the consistency and continuity of this improvement department-wide. The committee also discusses its concern for improving risk planning and contingency management on DOE projects.

Chapter 3, DOE Order O 413.3 and the Program and Project Management Manual, discusses the committee's observations on the evolving project management policies and procedures and recommendations for their continued improvement while maintaining a consistent approach.

Chapter 4, Human Capital, recognizes that a corps of competent project managers is the key to a successful capital acquisition program in DOE. The committee discusses the attributes of successful project managers and the need to assess the adequacy of personnel resources in the department. The committee notes the progress that has been made in training and career development for project managers and the need for this effort to continue.

Chapter 5, DOE's Role As Owner, reviews the lessons learned from the 2001 government/industry forum on the owner's role and draws on previous NRC reports on the government's role in acquisition of facilities to further define the role of federal project managers.

Chapter 6, DOE Project Management Culture, discusses the role of DOE senior managers in project management process improvement and the cultural changes that have been observed by the committee. It also discusses how the department might overcome resistance to change.

Chapter 7, Readiness to Proceed for First-of-a-Kind Projects, focuses on the types of project that offer the greatest challenge to DOE. The committee discusses the characteristics of these projects and what project managers can do to manage them successfully.

Chapter 8, Project Cycle Time Reduction, follows up on the observation in the 1999 report that DOE projects take three times longer to complete than comparable projects in industry. The committee discusses the progress that has been made and the steps that should be taken to eliminate delays.

Chapter 9, Acquisition and Contracting, discusses progress and additional steps needed for planning contractor selection, performance-based contracting, and aligning contractor incentives with departmental goals.

Chapter 10, Recognizing Project Management Successes, provides an overview of the DOE 2002 project management awards and the factors that are common to successful projects. The discussion includes projects that received awards as well as others that were nominated and considered noteworthy by the committee.

The Appendixes include additional information on the issues discussed in the report. Appendix A is the statement of task. Appendix B includes biographies of committee members. Appendix C is a list of briefings and materials reviewed by the committee for this report. Appendix D provides a checklist of the characteristics of a successful owner's representative. Appendix E provides a checklist of questions that should be asked during DOE critical decision reviews. Appendix F describes the use of flexibility to manage uncertainties in the National Ignition Facility and how this strategy can be used for other projects.

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Core Competencies

INTRODUCTION

A core competency is a capability without which an organization will fail to meet all or part of its mission requirements. Bruce M. Carnes, Director of the Office of Management and Budget Evaluation (OMBE) and Chief Financial Officer (CFO) for DOE, stated in briefings to the committee, "A major task of the Department of Energy is to manage contracts and projects to complete its diverse missions." This observation was echoed by Robert G. Card, DOE Under Secretary, at the November government/industry forum when he stated "DOE's core competency is big projects" (NRC, 2002). The committee has also noted that project management needs to be a core competency of DOE as it strives to improve the performance of projects and achieve its stated mission.[1]

AREAS OF PROGRESS

Based on the information obtained in the past year of reviewing DOE's project management processes and programs, the committee observes that many actions in various sections of the department are supporting an improvement in project management. Change throughout DOE to improve project management,

[1]Although the detailed discussion, findings, and recommendations in the committee's previous reports (NRC, 1999; 2001a; 2001b; 2002b) are not repeated in this report, the committee continues to endorse them, and they should be read in conjunction with this report.

as with change in any large organization, will take time and persistent management effort. Resistance to organizational change is a common human trait. In DOE there is a tendency to wait for policies and procedures to change again in the next administration. The committee feels that it is imperative for DOE to continue with the project management initiatives it has begun in order to maintain positive momentum within the organization.

Organizational Issues

The committee finds that the Office of Program Analysis and Evaluation (PA&E) and the Office of Engineering and Construction Management (OECM) are beginning to perform a vital function by enabling senior DOE management to determine that the selected projects are essential to and aligned with the department's mission (i.e., that they are the right projects) and that an appropriate approach for their development has been planned. The consistent management direction provided by OMBE has been a key factor in overcoming cultural resistance to increasing project management system discipline and accountability. Directives from the deputy secretary on November 15, 2001, Project Acquisition Plans and Critical Decisions; from the Director of OMBE on February 14, 2002, Mission Need Justification and Project Acquisitions Plans; and from the Director of the Office of Science on May 23, 2002, Office of Science Direction on Project Management, as well as the project management practices described in the NNSA report to Congress on its organization and operations, dated February 25, 2002, and the February 4, 2002, EM top-to-bottom program review are lending credibility to the seriousness of senior department management regarding the issue of project management. This seriousness is also evident in the actions of the Project Management Support Offices (PMSOs) in developing and implementing processes and plans to support project management in their respective areas.

Policies and Procedures

DOE convened workshops in May 2001 and March 2002 and held other regional meetings at which it solicited input from personnel in the field and headquarters for refinement of DOE Order O 413.3, *Program and Project Management for the Acquisition of Capital Assets,* and the draft *Program and Project Management* (PPM) manual (DOE, 2000, 2002). The committee believes that the June 2002 draft of the PPM manual incorporates feedback received in the review process and was a significant improvement over previous versions. The requirement of the Energy System Acquisition Advisory Boards (ESAABs) at the highest levels within DOE for approval of projects and management efforts at critical decision points is consistent with the need to ensure that the right projects are being executed and that they are being planned and managed in an effective manner. An acquisition planning process required in O 413.3 has been formal-

ized and is being improved through iterative reviews, and the use of innovative contracting methods appears to be increasing.

Management Tools

An initial version of the DOE Project Analysis and Reporting System (PARS) has been implemented and is being refined. PARS is incorporating earned value management system (EVMS) data, which are being required on all projects over $5 million. Some Web-based training courses on the application of EVMS have been developed for use while a more detailed training program is being created.

Human Capital

The draft Project Manager Career Development Plan (PMCDP) includes a comprehensive means for documenting and validating training requirements. Project management conferences were held by OECM to recognize project management successes and make them more visible. Presentations on actions that contributed to the success of award-winning projects validate and reinforce the principles contained in O 413.3.

AREAS OF CONCERN

Consistency and Continuity

The committee continues to have several areas of concern regarding DOE's ability to establish and maintain project management as a core competency. Although the committee is encouraged to observe many well-planned and managed projects that are viewed as successful, it is concerned about an apparent lack of consistency. The committee has observed recently initiated projects that are poorly planned and for which it is obvious that all of the requirements of O 413.3 have not been met. The committee has reviewed acquisition plans that are incomplete and others that have project scopes that differ from those approved at critical decision zero (approval of mission need, CD-0). Some projects have provided no project data to input into PARS, and they are not using EVMS properly or even at all. Changes in project scope have not been recognized quickly, and many projects are rebaselined, thus obscuring project management problems. These failings may be due to lack of experienced personnel, lack of training, disagreement with procedures, lack of management attention, or the inertia that works against cultural change in a large organization. The committee believes that the measures for process improvement, if applied consistently over time, will overcome these remaining problems.

Project managers at all levels are likely to be cynical about the importance of project management policies and procedures if DOE is not doing the projects that

have been selected to start or continue based on a rigorous, fair, and tough, but transparent, strategic planning process. Without a stronger ongoing strategic planning process, project managers will continue to have inconsistent responses to the department's need for high-quality project management procedures, and conformance to enhanced project management policies and procedures will probably continue to be sporadic.

The committee is also concerned about the long-term continuity of project management initiatives currently being undertaken within DOE. The political reality is that key DOE personnel change quite often. To inculcate these initiatives into the organization over the long term, an understanding of and a commitment to the idea that project management is a core competency needs to be institutionalized at all levels of the organization. This should be emphasized for the federal workforce as well as for the contractors. There is evidence that project management excellence can be accomplished at DOE through the leadership of senior management, investment in human capital (e.g., effective training and career guidance), and accountability for project performance at all levels. For DOE to sustain project management as a core competency, its processes and culture need to embrace project management as a key to organizational success.

The committee believes that the two most important things that DOE executive management can do are the following: (1) institutionalize or embed project management principles and processes into the DOE way of doing business and (2) increase the cadre of project management professionals by recognizing and nurturing those employees who regard themselves as federal project managers[2] and envision their career paths in project management. In these ways, current DOE leaders can leave a legacy of good project management that will last far beyond their terms of appointment.

Risk Management

The importance of properly considering risk was addressed in the committee's 2001 report (NRC, 2001). The committee has observed improved cognizance, approaches, and practices; however, inconsistency remains in application and commitment. Risk assessment and planning are evident to varying degrees, but a sound approach to evaluating, controlling, and mitigating risks is less evident. In other words, risk planning and implementation have not matured sufficiently to consistently provide a reliable and useful product.

The committee reviewed several risk management plans and believes that the following subjects warrant further attention:

[2]The federal project manager is generally assigned the role of the owner's representative. Although this role involves overseeing project management activities undertaken by contractor's personnel, it nonetheless requires thorough understanding of project management practices and principles.

- Utilizing the Integrated Project Team (IPT) to develop risk management plans—the IPT includes contractor personnel, but the government is responsible for making budgetary risk decisions (i.e., for approving risk-adjusted budgets or contingencies).
- Failing to identify all of the important sources of uncertainty.
- Assuming all risk factors to be independent rather than combining risk factors that are interdependent. The likelihood that all risks are statistically independent is very small.
- Providing general, rather than specific, strategies for mitigating risk.
- Excessive dependence on Monte Carlo simulations—this can obscure the relative contribution of and the interdependency between various risk factors.

The recent draft PPM provides a fairly extensive but general description of the factors to be considered in the risk assessment and management process and what is to be incorporated into the project plan. However, to achieve more consistency and produce a meaningful risk assessment and management process, it will be necessary to strengthen the guidance in the "Practice on Risk Management" that OECM plans to incorporate in the *Project Management Practices* (PMP). Prompt issuance of risk management practices is encouraged. Parallel with this, the committee continues to believe a cadre of experienced risk assessment personnel should be developed, as recommended in the 2001 assessment (NRC, 2001). In summary, there is an urgent need to augment DOE's human capital and strengthen the instructions for implementing risk management.

Contingency

Contingency allowances should be directly related to the potential risks that may be encountered on a project. During the preconceptual and conceptual planning stages, there is a tendency to underestimate the potential risks and the contingency allowance, although the lesser degree of project definition inherent in these stages of the project should dictate the need for a larger contingency. Underestimating contingency in the early planning stages portends a continual problem of revising baselines, modifying plans, and going over budget.

The NRC report *Improving Project Management in the Department of Energy* (NRC, 1999) stated that cost increases are often distorted by DOE's tendency to consider project scope as a contingency. This situation still prevails, particularly in the Office of Science (SC), which tends to use a design-to-budget approach. Such an approach compromises project control. The committee is generally opposed to the use of scope as a contingency.

Contingency is not specifically addressed in O 413.3 or the PPM. The committee perceives a need for structured guidelines for the control, allocation, monitoring, reporting, and use of contingency.

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3

DOE Order O 413.3 and the Program and Project Management Manual

INTRODUCTION

The committee's 2001 assessment (NRC, 2001) noted the issuance of O 413.3 and drafts of the *Program and Project Management* (PPM) manual and *Project Management Practices* (PMP) (DOE, 2000a, 2000b, 2002) and indicated that the documents were in the process of being revised. The order defines what is required for DOE project management, while the PPM defines how these requirements are to be achieved. The PMP is intended as commentary and examples of good project management. The order has not been revised, and the committee believes that it is appropriate and necessary for the order to provide consistent direction for DOE project management. A revised draft PPM was issued in February 2002. In March 2002, OECM conducted a review of the Order and the PPM as part of the annual DOE project management workshop and later conducted reviews at two field locations. OECM has issued revised PPM drafts and is continuing to solicit comments. OECM has decided not to reissue the PMP in printed form but to make it and others like it available on CD-ROM and the Internet. The committee fully supports this approach and believes it will create a quicker and more comprehensive outflow of information of value to those executing projects.

ANALYSIS OF CURRENT STATUS AND DIRECTION

Members of the committee attended the PPM reviews at the project management workshop and sought additional input on acceptance of the policies and

procedures from both government and contractor personnel who participated in committee meetings. (See Appendix C for a list of people participating in committee discussions.) The committee also had the opportunity to review the February, June, and August 2002 PPM drafts, which contained revisions to the requirements, directions, and guidance for program and project management. The drafts include successive improvements of the document released in October 2000 and generally respond to the recommendations in the committee's 2001 assessment. The revised format and organization make it a clearer and more usable document. Roles, responsibilities, limits of authority, and required controls and procedures are better defined but need to be reviewed to assure consistency with O 413.3. The PPM also needs to provide a well-defined procedure for tailoring requirements for small, routine, relatively simple projects. The document has been strengthened in some areas, such as project planning, but additional work is needed in other areas, such as risk management. For the most part, unnecessary material has been removed.

During the course of visits to various DOE offices and laboratories, the committee heard comments from several DOE and contractor personnel to the effect that the PPM and O 413.3 were onerous in requiring various submittals and approvals for small and uncomplicated projects. The committee believes that the generic requirements are applicable to all projects exceeding $5 million, as required by O 413.3, and that tailoring the extent and detail of submittals can accommodate the differences in the character, size, and complexity of projects. Also, raising the threshold may be warranted in certain cases for routine projects. Fundamentally, this threshold is set by the appropriate acquisition executive (e.g., the deputy secretary) to achieve the goals of the department. The committee observes that industry owners subscribe to a similar philosophy, by which executive management sets the thresholds for decisions and tailors reporting requirements to the characteristics of the projects and the needs of the organization (NRC, 2002).

Department-wide Consistency

The idea of incorporating O 413.3 into the PPM was discussed at the review sessions. The committee views this idea with alarm, noting that an order is a policy document while a manual is an implementation document. The committee believes that both are necessary, but that they should remain separate documents. The committee noted in its 2001 assessment that consistent performance of DOE projects requires a consistent department-wide approach to project management and project oversight (NRC, 2001). The 2001 government/industry forum on the owner's role demonstrated that companies with a consistently high level of project performance had enterprise-wide systems to define project management tools and processes (NRC, 2002). The committee supports the concept of defining the general principles of what is expected from DOE project managers in the depart-

mental order and defining the detailed processes for achieving those objectives in the PPM. The manual should reference the Order and identify minimum process requirements, but it can be flexible in identifying decisions and options that can be addressed in the field. To accomplish the desired project management consistency, the Order and the manual need to be closely coordinated and carry commensurate authority.

In summary, the committee endorses the concept and the approach of the revised PPM. Although it is understood that the document is still a work-in-progress and subject to a formal review process that may require further revisions, the committee believes that the current draft should be issued immediately for interim compliance.

FINDINGS AND RECOMMENDATIONS

Finding: DOE and DOE contractor personnel expressed some concern that requirements in DOE Order O 413.3 and drafts of the *Program and Project Management* (PPM) manual and *Project Management Practices* (PMP) result in excessive and unnecessary effort and cost for projects of less than $20 million; they believed these requirements should not apply to environmental projects and that front-end planning documentation and review requirements are excessive. The committee does not agree with their views but it does believe that requirements should be tailored to the complexity of the project.

Recommendation: DOE should resist efforts that reduce requirements for front-end planning and the critical decision-review process. This resistance is necessary to ensure that the process is uniform and that projects selected for execution are consistent with DOE's strategic plan. The requirements should apply to all projects over $5 million and be tailored to the complexity of the project.

Finding: The committee has observed examples of both effective and ineffective project management practices at DOE. Order O 413.3 is intended to create a consistent department-wide definition of what is required of DOE project managers. OECM is revising the PPM to better define the project management practices to be used to achieve the objectives of O 413.3. The committee believes that the Order is beginning to increase the level of consistency throughout the department. It also believes that a document to define the minimum actions required to implement O 413.3 is necessary. This document needs to carry commensurate authority and be coordinated to develop a consistent DOE approach to project management and project oversight.

Recommendation: OECM should accelerate development of the PPM and should issue the current draft immediately to guide interim compliance with

O 413.3. The Order and the manual should be separate but coordinated documents to create a consistent DOE approach to project management. The Order should continue to define what is required and remain relatively unchanged over time. The manual should continue to be a separate document to specify minimum requirements for compliance to O 413.3.

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4

Human Capital

INTRODUCTION

Many factors contribute to successful project management, but the essential component of a successful capital acquisition program is a corps of competent, experienced project managers with the requisite skills and dedication to executing their responsibilities in a professional and accountable manner. This resource had been markedly eroded in DOE (NRC, 1999); however, serious efforts have since been made to define a career development plan for DOE project management personnel. The roles of the federal project manager and the knowledge, skills, and abilities needed to be a successful owner's representative were discussed in previous reports (NRC, 1999, 2001, 2002a, 2002b) and in Chapter 5 and Appendix D in this report. Still, DOE suffers from a lack of professional training opportunities and, especially, a departmental vision for the future direction of its program and project management capabilities.

Training of project management staff has been seriously underfunded at DOE. DOE management should note that a properly conducted training program is not only a means for enhancing fundamental project management skills but also a primary means for communicating management approaches and expectations for how project management will be conducted in DOE.

KNOWLEDGE, SKILLS, AND ABILITIES

Project management is an endeavor that requires judgment, management skills, technical knowledge, and experience. It also relies heavily on relation-

ships between federal managers, contractors, vendors, and other key stakeholders. Although an organization can (and should) leverage its capabilities by contracting outside resources to plan, design, construct capital facilities, or remediate hazardous conditions, some functions should not be outsourced. (See Chapter 5 of this report for a discussion of the owner's role in project management.) Generally, owners are the critical decision makers on projects because they (1) are ultimately the beneficiaries of the facility, (2) are in a better position than contractors to make risk trade-off decisions, (3) understand their strategic interests better than any contractor, and (4) have to live with the consequences of these decisions. When outsourcing project management responsibilities, DOE should ensure that contractors have the requisite project management capabilities for the size and complexity of the project.

To be effective as a project manager representing the owner, personnel need to possess the appropriate technical knowledge and experience to understand the owner's perspective. For example, technical issues in DOE projects often require project managers to have educational backgrounds and project experience in civil engineering, architecture, mechanical engineering, chemical engineering, environmental engineering, or other disciplines. Experience working on projects of similar size, complexity, and risk is also important. As noted in the 1999 report, a single program office may not provide sufficient opportunities for professional growth, so that reassignment of project management personnel across program offices may be desirable to achieve the necessary experience and efficient utilization of personnel resources (NRC, 1999). There is no evidence that DOE intends to assign project management personnel across program office lines.

The Center for Construction Industry Studies (CCIS) conducted a study in the late 1990s that examined requirements for owners to develop successful collaborative relationships with contractors. The study team interacted with approximately 50 owner and contractor organizations, conducted 7 site visits, performed more than 70 interviews, and captured more than 100 surveys. It found that project managers acting as the owner's representative need certain skills to function in collaborative relationships with outside contractors (Davis-Blake et al., 1999, 2001). The relational skills summarized in Table 4.1 are said to contribute favorably to successful collaborative execution of projects. If an organization changes its culture to move in the direction of greater collaboration on projects, many of these skills may be lacking and project managers may have to be retrained to use them.

A project manager acting as the owner's representative needs the skills required to work with outside contractors. A DOE owner's representative should be able to work closely with contractors without losing sight of who the owner is and who the contractor is. (See Appendix D of this report for characteristics of owners' representatives.)

TABLE 4.1 Skills for Functioning in Collaborative Relationships

Category of Skill	Examples of Skills
Business	Writing and managing contracts
	Negotiation
	Managing budgets and schedules
Communication	Coordination and liaison
	Conflict management
	Cultivating a broad network of relationships
Influence	Mentoring
	Motivating
	Managing change
Managerial	Team building
	Delegating
	Being politically aware and seeing the big picture
Problem solving	Continually analyzing options and innovating
	Planning
	Considering both sides of issues, managing risk

FEDERAL WORKFORCE TRENDS

Staffing to ensure a strong and continuous stream of good project managers is a challenge to any organization that constructs capital facilities. This challenge may become more critical in light of projections that many government agencies will lose experienced personnel (GAO, 2000, 2001). However, because DOE projects (especially environmental remediation projects) tend to have long durations, DOE has the opportunity to establish a long-term career development program that will ensure a more than adequate supply of managers specifically trained to manage DOE projects.

Adequacy of Resources

In past reports, the committee expressed concern for the apparent shortage of personnel functioning as line managers and support staff for programs and projects (NRC, 2001, 2002a). In a self-evaluation inventory conducted by OECM in 2001, only 115 DOE employees classified themselves as functioning project managers. Based on the committee's experience, this figure is surprisingly low given the magnitude of the capital acquisition and environmental remediation programs at DOE, even taking into account the possibility of inconsistent language in position descriptions and misunderstanding on the part of the individuals who do not classify themselves as project managers. Many DOE personnel have not seen themselves as project managers, nor have they been seen as such by past

DOE executives, because they perceive that contractors (particularly management and operations (M&O) and management and integration (M&I) contractors) are hired to function as project managers. If there is underreporting of project managers in DOE, it may reflect a self-image problem. The open question is, If DOE personnel do not see themselves as project managers, are they truly functioning as effective DOE owner representatives? Establishing the appropriate size of the project management workforce for a particular project or combination of projects is an important and difficult task. Many variables come into play, such as complexity, scope, schedule, organizational capability (contractor and government), contractual arrangement, and the technology incorporated in the projects. Staffing requirements are dependent on the amount of work to be processed over a particular time, as well as the specialties that may be required.

The committee made several attempts to analyze the adequacy of project management personnel on the contractor and DOE staff but found it very difficult to gain a clear picture of the number of personnel engaged in project management compared with the dollar value of work under way. This situation emanates largely from the absence of resource-loaded contractor schedules and from the fact that DOE personnel are charged to a central account rather than being project funded. NNSA developed the most comprehensive accounting of DOE project management loading, which indicated that on average each project manager was responsible for the oversight of roughly $20 million of work. A simplified accounting by the Office of Science yielded roughly $25 million of work per project manager.

Assuming a $200,000 loaded cost per individual, the project management oversight cost would amount to between 0.8 and 1.0 percent of the value of the work. The Spallation Neutron Source (SNS) project at Oak Ridge National Laboratory (ORNL), a $1.4 billion project with a FY 2002 funding profile of about $280 million, is managed by approximately 55 ORNL contractor personnel and 5 federal personnel. This suggests that one DOE project manager oversees $56 million in annual expenditures, with a total expenditure for project management of less than 5 percent and a ratio of 1 DOE person to 11 contractor personnel in management, which may be low for that type of project

The committee does not have sufficient data to evaluate what these DOE project managers are doing or not doing, or what the appropriate number of federal project managers should be on a project, but it is concerned about the apparent high value of the work being overseen by each project manager.

The committee also perceives that the number of DOE personnel (115) assigned to project management is low for the scope and complexity of work DOE is charged with executing. The committee is concerned that there appears to be neither staffing policy nor standards, nor is there a consistent approach to staffing for either the contractor or the federal project managers. This can lead to inappropriate coverage (either over- or understaffing) for assuring a contractor's effective execution and for DOE properly discharging its ownership role.

Given this perceived shortage of project management personnel in DOE for the volume of project work being done, it would appear that the M&O and M&I contractors may be performing some of the functions that otherwise would be the responsibility of the federal project manager as the owner's representative. If by design or by default the M&O and M&I contractors are performing some of the functions of the owner that should not be outsourced, this could create a conflict of interest for the contractors. (See Chapter 5 for a description of these functions.)

The committee believes strongly that this issue should be assessed by DOE to ensure that DOE projects are adequately, as well as competently, staffed with appropriate project management personnel. DOE should also analyze the project management staffing of its contractors.

Sustainability of the Workforce

General Accounting Office (GAO) testimony before Congress indicated what was already common knowledge—that the federal government faces challenges in retention of personnel (GAO, 2001). Successful public and private organizations recognize the need to sustain management capabilities through succession planning and professional development. GAO also noted that stove-piped organizations will need to be better integrated organizationally if they are to make the most of the knowledge, skills, and abilities of their staff as well as establish performance-oriented management and a focus on continuous improvement. As noted above, deficiencies in human capital in the DOE may be affecting the department's ability to manage large projects. This problem is made more acute insofar as experienced project managers are underutilized—that is, they are assigned to a single program office rather than being assigned wherever they are needed by the agency as a whole.

If DOE is understaffed in the project management area, then it has both a challenge and an opportunity to rectify this situation by hiring qualified engineers at entry and midlevel positions and by training them to perform DOE-specific project management and to serve as owner's representatives. The development of mentoring programs and career paths should provide a continuous stream of project managers experienced in the way DOE performs (or intends to perform) projects. Project managers should be recognized as a DOE-wide asset. This would facilitate their movement between projects and would allow NNSA, EM, and SC to share resources in the best interests of DOE at large (NRC, 1999).

TRAINING AND CAREER DEVELOPMENT

Project managers need ongoing training and professional development to perform proficiently and to become capable of discharging increasing responsibilities. In addition to training for the presently designated project managers, there should be training for aspiring individuals who demonstrate potential to

become project managers as well as for other support personnel on the project team. DOE has an opportunity to go beyond traditional project management education, which aims at training individuals, to the training of project management teams. However, to do this, DOE would have to take control of its own training program.

In January 2001, DOE began to formulate a program to address the training and development of project managers. This effort, known as the Project Management Career Development Program (PMCDP), met its original completion date of December 2002. Once PMCDP is implemented, it is essential that supervisors provide the opportunity for individuals to attend appropriate training courses. Training, however, is not enough—supervisors should provide developmental assignments to ensure that individuals have the opportunities to maintain and enhance their skills.

The committee is deeply interested in this effort and has followed it very closely. The 2001 assessment report addressed the topic in detail (NRC, 2001). Although the committee would have preferred that the program be implemented in far less than 2 years, the committee recognizes the effort devoted to the project.

Upon reviewing the draft PMCDP, the committee believes that the depth and extent of the program are appropriate for the intended purpose. Placing the PMCDP module as a subset of the Acquisition Career Development Program covered by DOE Order O 361.1 is also considered appropriate. The proposed draft attachment to O 361.1 covering project management policies, procedures, and qualification and training requirements is quite clear and complete and should serve well as the base for the program (DOE, 1999).

The committee was particularly impressed with the draft qualification standards for each project manager level. It is centered around 10 basic management competencies: project management in general, leadership and team building, scope, communication, quality and safety, cost, time, risk, contracts, and integration. The committee endorses the selected competencies.

In addition to qualification standards, a functional requirements document has been drafted that covers the training and development requirements for eligibility to each of the four project manager levels contemplated and that tracks individual compliance with the requirements. This document will serve to advise existing and aspiring managers of their training and development needs as well as to produce an inventory of project manager competencies at DOE. Such a database would have made it simpler to develop the PMCDP.

To aid in implementing the training, the task force for the PMCDP developed 10 courses to be taught by in-house personnel with appropriate experience and 18 courses by outside contractors. These courses cover the full gamut of project management as well as some support activities. An anticipated annual schedule of courses to be offered and the weeks of training needed has also been developed. The committee previously expressed concern about the efficacy of

the extant contract for training development. This contract has not proven to be a satisfactory vehicle for accelerating project management training. The committee believes that OECM should explore obtaining needed training by other means and that educational contracts should be awarded based on the knowledge, competence, and practical experience of the proposed instructors.

The estimated annual cost of tuition for the training program to satisfy immediate needs is approximately $1.5 million (covering about 200 people for several courses each). DOE reported to the committee that its records support an estimated cost of $2,500 per course per student. The committee has also heard of difficulties in securing adequate funds for training from within the various organizational appropriations. It would appear that an alternative approach—a centralized budget for training—might be preferable for attaining the prescribed goals.

The PMCDP appears to effectively address the program manager aspect of the human capital equation but may not adequately address the needs of the concomitant support staff.

FINDINGS AND RECOMMENDATIONS

Finding: There is reason to believe, based on the reported numbers of DOE project management personnel and the volume of DOE projects, that DOE is understaffed in the area of project managers and essential project management support staff. The committee concludes that there may not be enough DOE project management personnel to discharge their responsibilities as the owner's representatives. This apparent deficiency may lead to a situation in which M&O and M&I contractors, by design or default, are performing the roles and functions that should be the prerogative of owners' representatives. This inappropriate devolution of some of the department's project management responsibilities to contractors may be creating a conflict of interest.

Recommendation: DOE project management should be staffed to the level needed to ensure that the government's interests are protected. DOE should assess whether it has enough project management personnel to properly discharge its ownership role or whether DOE understaffing in project management is permitting contractors to take on responsibilities and functions that should be reserved for the government's representatives. To do this, DOE will have to define the roles and responsibilities of federal project managers and then assess the number of project managers needed to carry out these responsibilities. The roles and responsibilities of the contractors' project managers vis-à-vis the federal project managers should also be clarified.

Recommendation: DOE should develop a vision for what project management in the department should become, and then hire, train, and promote personnel specifically to staff and fulfill this vision.

Recommendation: Concurrent with the DOE staffing assessment, DOE should also assess the project management staffing of its (M&O and M&I) contractors in terms of both quantity and quality (knowledge, background, and experience). It would be desirable to know if contractors, perhaps because of the declining competition for DOE projects, are not assigning their best managers to DOE projects.

Recommendation: DOE should estimate its future requirements for project management and other project support personnel and develop a plan to address recruitment, turnover, and retention in the future. Hiring personnel with experience in preproject planning, cost estimating, risk management, EVMS, team facilitation, and other critical skills can be a means of meeting some of those needs in the near term.

Finding: The committee perceives a need for improved utilization of existing and incoming project management personnel. This need can be fulfilled through training and career development and by facilitating the movement of personnel across organizational lines. Executing the PMCDP as a DOE-wide program will go a long way toward overcoming present training deficiencies. However, a long-term commitment to funding implementation of the PMCDP is critical.

Recommendation: The projected annual tuition expenditure for training and development of $1.5 million is considered adequate for the immediate concentrated need. Every effort should be made to allocate this amount centrally based on a DOE-wide decision, especially in the first few years, to assure implementation of the PMCDP throughout the organization. In the interim, the DOE field and project offices should continue to meet immediate needs with their own training programs.

Recommendation. In a previous report, an NRC committee recommended that DOE should "develop and maintain a cadre of professional certified project managers who would be assigned to manage DOE projects for all program offices" (NRC, 1999, p. 77). Since it is clear that DOE does not intend to implement this recommendation, the committee recommends that DOE treat qualified project management personnel as a shared resource and facilitate their movement to assignments across the organization as the needs arise. OECM, in conjunction with the operation of the PMCDP, should maintain an inventory of all project managers throughout the DOE complex, along with their experience

and capabilities, and make this inventory available to all DOE programs as they staff their projects.

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5

DOE's Role As Owner

INTRODUCTION

As noted in the committee's 2001 assessment report, DOE needs to become more involved and focused on project management activities associated with its role as owner (NRC, 2001). Because DOE relies extensively on contractors to carry out project management activities, the distinction between the roles of owners and contractors have become blurred. DOE has assumed some of its contractor's management responsibilities by directing how activities are executed, while shifting some of its ownership responsibilities to contractors by allowing them to define mission needs and projects.

GOVERNMENT/INDUSTRY FORUM ON THE OWNER'S ROLE

On November 13, 2001, the committee convened a government/industry forum on the owner's role in project management and preproject planning. The forum included presentations in case study form of successful project management organizations in industry and the importance of project management and preproject planning from DOE's perspective. The forum proceedings were published by the NRC (NRC, 2002). Through this forum, the committee sought to reinforce some of the general points made in its earlier reports:

- Successful project management requires the institution of a project management discipline that encompasses all projects. It is not sufficient to do some projects well; what is needed is consistency. All the firms represented in the

forum have well-defined, disciplined project processes, with buy-in and active participation by senior management.

- There is an absolute requirement for emphasis on project justification and identification of business (or, in the case of DOE, mission) need early in every project, even before a project is formalized. Senior corporate (agency) management must be closely involved in this process, as it is their responsibility to identify and interpret business or mission needs.
- Decision points with options for project approval, go-ahead, change, rework, or termination must be clearly identified. These decisions must be made by appropriate senior managers. The view that the need for senior management decisions slows down good projects is explicitly rejected. A good decision process actually expedites projects in that it assures that they have the necessary resources, support, and direction to proceed to successful completion and operation—not merely to the next phase.
- Accountability and responsibility for project performance must be clear and well defined across the enterprise. For the enterprise to succeed, all elements must succeed.
- A corporate organizational structure for project management must be established and maintained.
- There must be continual, formal project reviews by responsible management.
- Expectations, products, and metrics must be clearly defined for the entire process.
- There is no substitute for thorough front-end planning. This is true even (better, especially) for first-of-a-kind and one-of-a-kind projects.
- A successful project-management improvement process requires a cultural change, and cultural change is driven from the top.

Characteristics of Successful Owners

The fact that the companies with consistently successful projects were not always successful in the past was noted to illustrate their common commitment to process improvement. They achieve this improvement by focusing on the project management process as a part of the core values of the company and assuring that the process is consistent throughout the organization. They develop a corporate language to define and control the project management process as well as performance measures that guide process improvement.

The case studies emphasized the importance of the owner's role in front-end planning and senior management involvement in assuring that projects are aligned with corporate missions. The planning process emphasizes identifying possible risks and being prepared to address them and manage the changes that may be required during the project. It was noted that the greater the technical complexity of the project the greater the involvement of the owner in its planning and execution.

The clear message presented at the forum is imbedded in O 413.3 as well as the draft PPM. Of particular note is the similarity of DOE and industry project review and approval processes and that in both kinds of organizations senior managers and directors are intimately involved. At ChevronTexaco, which has a $5 billion annual capital budget, the corporation's executive committee reviews and approves projects at the $25 million level. Senior management involvement in the process is crucial.

FEDERAL PROJECT MANAGERS' FUNCTIONS

An NRC report, *Outsourcing Management Functions for the Acquisition of Federal Facilities,* states that "ownership and management functions in the facility acquisition process differ. An owner's role is to establish objectives and make decisions." The report indicates that a smart owner should be capable of performing four interdependent functions: (1) establishing a clear project definition, (2) establishing performance metrics, (3) monitoring overall project performance, and (4) providing commitment and stability to the project definition and its achievement (NRC, 2000).

The committee discusses the project management functions of the owner in this report and in its 2001 assessment report (NRC, 2001). The functions are basic and fairly well understood by DOE and DOE contractor project managers. The problem is that while they are inherently the owner's responsibility, DOE relies on M&I and M&O contractors for many of these functions. The committee believes that DOE needs to consider whether outsourcing certain management functions is restricting its ability to manage projects. These functions primarily relate to strategy—determining the mission, scope, priority, and budget of projects. The following questions should be answered when determining whether a function should be outsourced and the level of involvement of the federal project manager and the level of control that should be retained by the DOE:

- Are decisions related to the function critical to the success of the project?
- Is the management function one that requires significant responsibility and that can have an impact on the progress of the project if it is not carried out properly?
- Does the management function bind the agency to either a monetary commitment or a contract?
- Does the management function have effects beyond the scope of the project (e.g., environmental, public safety, or national security effects)?
- Does the management function infringe on mandates by government or requirements by law?
- Does the management function place unjustified and uncontrollable authority in the hands of a private provider?

• Does the management function encourage the contractor organization to make the service delivery sufficiently proprietary to the point that the agency would be committed solely to that organization for future services (NRC, 2000)?

The committee has observed a lack of understanding of the project manager's roles and responsibilities. The draft PPM lists the functions in section 2.8.1 with little elaboration. A detailed definition of the roles and responsibilities of federal project managers and contractor project managers who perform the functions of an owner's representative should be prepared by each program secretarial office (PSO). The department should then assure that the managers who are assigned these roles and responsibilities have the appropriate training, expertise, and experience. (The committee outlines the characteristics of effective owner's representatives in Appendix D.)

FINDINGS AND RECOMMENDATIONS

Findings: The forum held in November 2001 provided examples of the points made in the committee's previous reports about how industry fulfills its role as owner in planning and managing projects. In subsequent meetings with DOE and DOE contractor personnel the committee saw evidence of increased emphasis on front-end planning and a clearer understanding of DOE's role as owner. Recent policy memoranda that emphasize acquisition planning are encouraging.

Recommendation: The committee believes that in order for DOE to be an effective owner of capital acquisition projects it should:

• Consider capital projects critical to organizational success.
• Require senior management involvement in project decision making, usually at the $5 million dollar and higher level.
• Have a detailed and well-recognized internal front-end planning process.
• Capture metrics on planning effort and project performance.
• Require owner involvement and leadership in front-end planning.
• Ensure that projects support DOE's mission and are consistent with DOE's strategic plan.

Recommendation: DOE should periodically benchmark its performance in project planning and control processes and compare it with the performance of industry leaders to ensure that it is consistently utilizing the best practices.

Recommendation: Senior managers in each program secretarial organization (PSO) in DOE should develop a complete definition of the roles and responsibilities of project managers.

Recommendation: Senior managers should continue to emphasize the importance of improving the project management processes and procedures to assure long-term improvement throughout the organization.

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6

DOE Project Management Culture

INTRODUCTION

An organization's culture is not the list of values developed at an offsite meeting—those are ideals. Culture is how the organization operates. It is the core values and norms of behavior that drive the organization's actions and guide how employees think, act, and feel. The degree to which a large organization integrates its subcultures into a dominant overarching culture can vary widely. It is probably undesirable and unrealistic to try to homogenize the culture of an organization as large and diverse as DOE. However, to be successful in managing large projects, an organization must have a core set of values, principles, systems, and procedures that cut across subcultures (Hagberg and Heifetz, 2000).

> Cultural strength refers to the dominance or preeminence of certain aspects of the culture in affecting everything that happens in an organization. It also reflects the intensity with which cultural values are held and clung to. . . . Cultural congruence refers to the extent to which the culture reflected in one part of the organization is similar to and consistent with the culture reflected in another part of the organization. . . . [O]ther things being equal, the greater the total degree of congruence or fit between the various components [of an organization], the more effective will be organizational behavior at multiple levels. (NRC, 1997, p. 74)

LEADERSHIP

DOE leaders have implemented several policies to help define its project management culture over the past 12 years—e.g., O 4700 Project Management System, O 430.1A Life Cycle Asset Management (LCAM), and O 413.3 Program and Project Management for the Acquisition of Capital Assets. DOE Order O 413.3 defines current policies and procedures; however, the committee has witnessed several variations of project management procedures—some strictly following O 413.3 and others utilizing some but not all of the procedures mandated by O 413.3. Full-time, experienced project managers manage some projects, while line personnel who function as part-time project managers are managing others. Some projects utilize strict project cost controls, while others use less rigorous cost control programs. DOE has been trying to standardize its project management procedures (viz., its draft PPM for implementing O 413.3) in recent years; however, it will not achieve this goal unless senior management conveys a unified vision that effective project management is all-important, worth doing, and actively supported and expected by all senior managers throughout the department. The directives issued by the deputy secretary in 2001 and the chief financial officer in 2001 and 2002 have conveyed DOE's intent and the importance of project management policies and procedures. The committee believes that there is now greater involvement of the under secretary and assistant secretaries in project approvals.

Implementation

Key to achieving consistent implementation of policies and procedures is the existence of a DOE senior management group that is involved in the implementation. Senior managers should believe that oversight of project management is their first and most important responsibility. They should understand the processes as well as be able to articulate why such processes are important. This does not mean that senior managers need to be expert in all phases of project management, but they should be able to easily discuss the elements of the program. Personnel in the field need to be shown how and why implementation of new project management procedures make it more likely that their project will be successfully completed. Developing detailed reports and preparing answers to questions posed by senior managers improves project planning. Each time a project is rejected and resubmitted it should be better prepared to achieve success. The committee believes that reviews by the Office of Management and Budget Evaluation (OMBE) prior to Energy System Acquisition Advisory Board (ESAAB) reviews and critical decisions have helped with this process.

Communication across the levels of an organization is not easy to accomplish. Senior management needs to take advantage of each and every opportunity to explain and promote its policies, procedures, vision, and expectation of desired

outcomes. Field organizations need to be convinced that DOE's senior management is united and that its course is unwavering. Uniformity of the message, as well as its repetition, is essential for the entire organization to accept the importance of the message.

Senior management is responsible for establishing a supervisory structure that has consistent views and values. If project management is important to senior managers, then it should be important throughout the organization. A senior manager who expresses views contrary to those of project management policy can partially paralyze efforts to institutionalize policies and procedures within DOE. The issuance of orders and memos from headquarters cannot by itself realign the thinking of the field offices. Senior management can accomplish such realignment only by visiting the field offices repeatedly to deliver a consistent message. The committee recognizes that this requires the expenditure of a substantial share of the time of senior managers. To assure that this time is available, less pressing work must be delegated to others. Senior managers should avoid conveying mixed messages within the organization. If senior management has given top priority to implementing project management policies and procedures, then it should ensure that there are no competing priorities. Generally, some members of an organization are prone to comparing messages, looking for subtle differences from one day to the next. If such differences are identified they generate resistance within an organization to acceptance of anything new. While project management per se is not new, its current definitions and practices are different from previous definitions and practices, and these changes must be managed.

Opportunities for Success

One of the best opportunities for senior management to stress the importance of project management is during project review meetings. At these meetings senior managers should take an active role to demonstrate their interest. First, senior managers should be in attendance, indicating that these meetings are important and that they are willing to make time for them. Given the number of projects being managed within DOE, this in itself will be a major task for senior managers. Second, senior managers should demonstrate a commitment to project management professionalism by their own actions at DOE-wide strategic planning levels. Third, senior management should take an active role in the meeting, asking questions and prompting the project managers to consider alternatives, possible risks, and actions that can be taken if the project exceeds its baseline schedule or cost. Fourth, senior managers should be prepared to give praise when appropriate, to show their personal interest in success.

Accountability is an integral part of project management. Senior management should take an active role and share in accountability if project costs or schedules are threatened. They should help solve problems by first assessing

alternatives and then selecting the best direction. To avoid the impression that management is not committed to the process, senior managers need to devote time to achieve this level of engagement. Project justifications, recommendations, project plans, and information reports should be well prepared and reviewed at each appropriate management level. Senior managers should determine if the documents are adequate and, if not, return them for correction and communicate to the authors that management expects better performance. Senior managers also need to judge whether project managers are prepared and able to answer probing questions. (See Appendix E for a list of questions for determining whether a project is ready to proceed.) If the project managers are not prepared, senior management must not permit the project to proceed but must send it back so that better answers can be developed.

Another opportunity for senior management to demonstrate its commitment to project management excellence is to assure that adequate resources are provided. Senior management can make a positive statement by bringing additional resources to bear where they are needed for project management and project managers. Senior management also has an important role in rewarding successful project managers. Praise and recognition are the most important motivators; however, monetary rewards are usually welcomed but need not be lavish. The committee believes that the annual awards program managed by OECM has been effective in recognizing project management achievements. What most successful project managers want from senior-level corporate management is not so much monetary rewards to motivate them (good project managers are already highly motivated) but consistent support by senior management in removing the obstacles to project success. Likewise, it is important for senior management to remove a person from a position of responsibility if he or she is proving to be a poor project manager. Usually, the field level organization is aware of poor project manager performance well before senior management. Remedial action by senior managers will reinforce the importance of good project management.

ACCEPTANCE OF CHANGE WITHIN THE DOE CULTURE

The committee has gathered input on DOE's project management culture and acceptance of efforts to improve project management practices and procedures requiring cultural change within DOE. Its observations are based on input at meetings with DOE personnel and DOE contractor personnel from both the headquarters and field locations and participation in DOE project management workshops.

Change in Strategic Planning

The committee notes that there is a positive change in DOE culture reflected by the effort to develop a department-wide strategic planning system. OMBE has

created a draft planning, programming, and budgeting process for the first time in DOE history. NNSA is developing a future-years nuclear security plan, a major component of which is an integrated construction project plan (ICPP). The NNSA Program Integration Office will put the ICPP together from inputs by field activities based on their individual 10-year site plans. Using the ICPP as the basis for determining which projects are included in the annual budget submission is expected to gain broad support because managers will have a definite plan for future-year projects rather than relying on an annual scramble.

Acceptance by DOE Personnel

The committee has observed that, in general, DOE personnel agree with the need for a project management system. However, opinions differ on how the system should work. Comments from personnel raised concerns that the requirements were similar to construction specifications, too prescriptive, and hard to follow. Opportunities for tailoring the requirements were seen as positive, but even with tailoring, there was continuing concern about the applicability of the requirements to environmental projects. Discussions during the OECM project management workshop in 2002 indicated concerns about the requirements for front-end planning prior to requesting critical decision 0 (CD-0) and CD-1, and delays were expected in obtaining approval to proceed from headquarters. Workshop participants recommended raising the threshold for the value of projects required to comply with O 413.3. Their recommendations would exempt smaller projects and environmental projects and would shift approvals to lower levels in the organization.

The committee found widespread acceptance of the need to improve project management throughout the DOE complex. Based on presentations and discussions during meetings, the committee believes that the requirements of O 413.3 are generally being incorporated into projects across the board. Although concerns were voiced over delays associated with headquarters reviews and the work associated with up-front planning, the committee found no evidence of a refusal to comply or of efforts to derail the project management system. However, the committee observed that the quality and completeness of the plans and reports required for compliance with O 413.3 are not consistent. The vigor displayed in implementing O 413.3 and related efforts to improve project management vary, but cultural change has been observed throughout DOE.

One sign that change is being accepted is evident at the Richland Operations Office (RL) and the Office of River Protection (ORP). Senior managers expressed a positive view of the fundamental project management principles—including those of environmental management—contained in O 413.3 and the PPM. Further, the efforts and work products of federal employees should enhance the oversight of contracts for project management services.

Acceptance by Contractors

The committee observes that DOE contractors, perhaps even more than DOE personnel, agree that a project management system is needed, but the O 413.3 requirements and the PPM methods were not universally accepted. Nonetheless, contractors clearly intend to comply with and implement O 413.3. In several instances, even projects that had been initiated prior to the effective date of the Order are being brought into compliance. Contractors expressed concerned about possible delays resulting from headquarters reviews and the costs of implementing the requirements of O 413.3 and the PPM (e.g., independent reviews and additional documentation). While the contractor representatives who met with the committee were on cost-reimbursable contracts and presumably had the means to recover this type of additional cost, the issue was mentioned frequently.

The varying degree to which project management reforms are accepted reflects the wide range of contractor cultures. Perhaps the broad range of reactions by different DOE components reflects the diversity of missions. The NNSA mission is driven by its Department of Defense customers, and pressures from external requirements for environmental cleanup drive the EM mission. The SC mission, on the other hand, is developed by scientists in the DOE national laboratories, which are run by university contractors and are naturally resistant to direction from Washington.

The committee observed a positive response to the project management process improvement initiatives incorporated in overall management contracts. BWX Technologies has established an ongoing education program for project managers at the Y-12 plant in Oak Ridge, Tennessee. The University of California (UC) Office of the President has responded vigorously to a contract initiative by establishing process improvement programs that apply to all facilities managed by the university. The UC program includes creating an external advisory panel to provide guidance and oversight, establishing senior management positions responsible for process improvement, identifying people across the UC sites with the requisite knowledge and experience, and conducting meetings and workshops to increase awareness of new DOE procedures. The committee believes the UC program exemplifies what is needed to implement a cultural change in project management.

OVERCOMING RESISTANCE TO CULTURAL CHANGE

The reaction of DOE field personnel and contractors to current initiatives to develop and align project management culture through O 413.3 and the PPM reflects a general desire to do their jobs without interference from others. This is not unusual when considering that resistance by scientists and other highly educated people to oversight from managers is not uncommon. Acceptance of project management improvement initiatives by individuals and organizations within

DOE ranges from enthusiastic to somewhat grudging. The key to effecting cultural change and an eventual payoff from a disciplined, comprehensive project management system is consistent, long-term application. Accordingly, maintaining a course with minor adjustments, rather than starting over in a new direction every few years is essential for improving the management of projects that span several years. The continued strong personal interest and involvement that has been shown by DOE senior managers appears to be the biggest single agent of cultural change related to project management within DOE. This type of front office involvement is crucial over the long term to establishing and maintaining an effective project management system.

FINDINGS AND RECOMMENDATIONS

Finding. DOE personnel and contractors generally support the need for a comprehensive project management system but prefer a system with fewer requirements for upper management oversight.

Recommendation. DOE should resist efforts to reduce up-front planning requirements and to lower the level of authority at which critical decisions are approved. DOE should apply persistent pressure to ensure that the right projects are picked for execution and that they are planned and executed according to established policies and procedures. Procedures should continue to include a process for tailoring requirements to the size and complexity of projects.

Recommendation. DOE should assess its culture and subcultures and develop strategies to bring about organization alignment on core project management principles at all levels of the organization.

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7

Readiness to Proceed for First-of-a-Kind Projects

INTRODUCTION

A significant part of the DOE budget is spent on first-of-a-kind and one-of-a-kind environmental restoration, nuclear defense, and scientific research and development projects. By definition, there is no guidance for these projects based on previous history and project experience; as a result, first-of-a-kind projects have shown themselves to be susceptible to large cost and schedule overruns and performance shortfalls. This problem is aggravated by the tendency to measure the degree of preparation (readiness to proceed) for these projects by the same standards and metrics used for projects that are similar to others that have already been executed.

First-of-a-kind projects have greater uncertainty simply because they are first. Often the components of first-of-a-kind projects are new and require technical development, scale-up, or even research and development. Even if the individual components are commercial off-the-shelf, their integration into a new, high-performance system may be unprecedented. Senior management, faced with the alternatives—whether to wait until all technical uncertainties are resolved or to move forward concurrently with project design and the development of new technologies—will often opt for the faster approach. A first-of-a-kind project may have to proceed even with the associated risks, but these should be calculated risks. The view of the committee is not that first-of-a-kind projects should not be undertaken, but rather that management should make an informed decision based on an unbiased understanding of the risks involved and should take active measures to reduce, mitigate, and manage these risks. Unlike conventional

projects, which generally proceed sequentially in time, with no backtracking, first-of-a-kind projects need to consider and plan explicitly for rework, recycling, and iteration. This chapter addresses some of the issues peculiar to first-of-a-kind projects, their specific planning requirements, and the issues that need to be considered when determining whether a first-of-a-kind project is ready to proceed.

CHARACTERISTICS OF FIRST-OF-A-KIND PROJECTS

First-of-a-kind projects are, by definition, highly diverse, but regardless of their purpose—construction of a new weapons processing plant, decontamination and remediation of a site with unique or unusual conditions, or construction of a new scientific instrument or laboratory that could achieve scientific and technological leadership—these endeavors share a number of features. One of the significant issues in environmental restoration projects, among them decontamination and remediation, is that conditions at many sites are unknown, owing to inadequate or incomplete characterization of the wastes. Accordingly, many of these projects are one-of-a-kind because there is no site with similar conditions.

Uniqueness

First-of-a-kind projects are unique. Because they cater to specific needs, no direct historical comparisons are possible and no project managers with previous experience are available.

High Degree of Uncertainty

First-of-a-kind projects may involve development (design, construction, and operation) of new, complex, and untested structures, systems, and equipment, or substantial scale-up of laboratory or pilot processes. These difficulties are compounded by the desire to accomplish the project as soon as possible, so construction is started and many critical issues remain to be resolved once the project is under way. For some high-technology projects, scientific knowledge is developed and tested directly on the capital acquisition project and many of the critical systems are designed during construction. This concurrency of technology development and project engineering, design, and construction increases an already high degree of uncertainty.

High Cost

First-of-a-kind project costs generally increase geometrically with the number of technical groups or specialties that must be successfully integrated. Technical and other uncertainties are more difficult to manage and are more visible on

multimillion to several billion dollar ventures because of the larger number of scientific and technical specialists.

High Visibility and Public Attention

New, large projects generally attract attention from the general public and from special interest groups, and first-of-a-kind projects are no exception. This is especially true for DOE environmental restoration projects, which may involve state and local governments, public and private environmental protection groups, and other stakeholders. Information technology enables all stakeholders and concerned parties to keep a close eye on the project and to react if some of their interests are affected. The democratic process promotes a high degree of visibility for government-sponsored projects, which results in a large number of external stakeholders monitoring projects and promoting or resisting project changes.

High Impact

The success or failure of major first-of-a-kind projects can have a substantial influence on the economic, social, environmental, and developmental atmosphere in the vicinity of the project. Successful completion of the project could bring numerous local benefits, such as job creation and improvement of the local infrastructure. The attractiveness of the area as a place for investment could be enhanced. Consequently, such projects often have political components that affect decisions and make these projects hard to stop or modify once they have begun, regardless of the technological difficulties that may arise. Project failure, cancellation, or delay, for example, would have severe detrimental effects—unexpected layoffs, unusable land and facilities, and millions of dollars lost.

CHALLENGES THAT ARISE IN FIRST-OF-A-KIND PROJECTS

First-of-a-kind projects have some inherent features that make them much more prone to failure than ordinary public or private projects.

Technical Risk

The inevitable technical challenges that emerge throughout the project development and construction process create high levels of uncertainty. As mentioned above, first-of-a-kind projects are by nature concerned with the development and implementation of new technologies. These projects may require the use of nontraditional materials and new, complex, and demanding (high-performance) systems. At the beginning of the project, the only information about these innovative systems and materials is derived from scientific experiments and laboratory or pilot tests, so that construction of a first-of-a-kind facility often involves

scaling up laboratory or bench models. The ability of the process to meet the scaled-up design parameters is highly uncertain and depends on the validity of numerous scientific and technical assumptions and projections. This uncertainty creates high financial and environmental risk.

Managerial Challenges

Uniqueness and uncertainty caused by technical issues must be addressed by an adequate decision-making process (performed by DOE as the project owner) and management (performed by DOE and its contractors). A number of issues make managerial processes much more challenging than the decision-making and management processes for ordinary projects where managers have prior experience.

Uncertainty in Planning

The uncertainty caused by technical issues hinders the ability of the project team to perform accurate and realistic project planning. Thus, planning for project execution requires careful attention to risk management. First-of-a-kind projects are typically accompanied by risks of potentially large cost and schedule overruns and performance shortfalls.

Risk Management

First-of-a-kind projects involve technologies and approaches that lie on the boundary between pure science and practical implementation, which is why they involve a higher degree of uncertainty. To address this issue, an explicit risk management program should be undertaken, from the earliest phases of preconceptual planning and continuing throughout the entire project development process.

Cost and Schedule Contingency

The inherent uncertainty in project definition for first-of-a-kind projects results in more changes and a corresponding need for larger contingency for both costs and schedules, making the construction control process more difficult. Therefore, special attention must be paid to the development of a rigorous contingency tracking system. During the preconceptual and conceptual planning stages, owing in part to the strong desire to proceed with a project, there is a tendency to underestimate the potential risks. This often leads to inadequate contingency allocation. If the contingency is set at a level appropriate for a conventional project with well-defined scope, as has happened in the past, the contingency allowance will not adequately address the schedule and cost variability, resulting in a continual need to revise the project baseline.

Personnel Resources

Problems may arise because first-of-a-kind projects often need unique scientific and engineering resources. The development of new technologies requires highly qualified, experienced professionals to be involved in both design and construction. The scale and the schedule of these projects call for employing highly competent staff experienced in dealing with the uncertainty inherent in first-of-a-kind projects.

Another issue that typically creates problems during the execution of first-of-a-kind projects is the creation of a work environment that promotes teamwork. The involvement of large numbers of laboratories, contractors, and specialists with diverse backgrounds and areas of competence could create tensions if the respective tasks, responsibilities, and accountabilities are not clearly and explicitly defined. Vaguely defined roles and responsibilities can make it difficult to assess responsibility for failures. The nature of the work on first-of-a-kind projects makes it difficult to keep the staff focused on the project objectives when there are unexpected technical and scientific challenges. First-of-a-kind projects often take a long time to complete, resulting in turnover of critical, experienced project personnel.

Funding

The first-of-a-kind projects undertaken by DOE often require huge investments and entail great risks that private companies are not able to accept. Government undertakes such projects because they benefit the nation. Some projects are jointly funded by other nations to reduce each party's risk, but the principal source of funds is typically the U.S. Treasury. Congress controls these resources, and the availability of funds is subject to budget limitations, annual budget appropriations, competing interests, and other factors. Availability of funding needs to be assessed at each project decision point.

CRITICAL DECISIONS

First-of-a-kind projects call for critical go/no-go decisions at various stages of project development and execution. The timeliness of these decisions is critical for the project outcome. For acquisition executives to make these critical decisions, they need adequate information. Therefore, during the preproject planning phase of first-of-a-kind projects, special procedures are needed to assure the development of information that will facilitate a responsive decision-making process.

First-of-a-kind projects have been and can be successfully managed with respect to performance, budget, and schedule. Successful project performance depends on adequate planning and management. In first-of-a-kind projects with

technological challenges, it is often assumed that the highest priority must go to scientific and engineering issues. This is not so. The critical issues for these projects are project planning and project management, which are essential to provide the basis for successful resolution of the technological issues.

The following issues should be addressed in the review of risk assessments, project procurement and execution plans, and other management areas for first-of-a-kind projects. It is unlikely that all of these issues would be faced on any single project, but all of the methods cited here have been used on some DOE projects. The readiness to proceed from one stage of the project to the next depends on the level of definition and uncertainty; a level of definition that is acceptable for approval to proceed at CD-0 will probably not be acceptable at CD-1 or CD-2.

Project Benefits to the Public

First-of-a-kind projects may require large public investments. In return, DOE should continually demonstrate how the project will benefit the public. If the benefits to the nation are only marginally greater than the costs, the project may be at risk at any time due to budget constraints, lack of political support, or even public opposition.

Benefits as well as costs should be quantified and estimated, and cost-benefit analyses should be made at every phase of the project and reviewed by DOE management. These costs and benefits should be readily comprehensible to the stakeholders—that is, the general public, which is paying for the project.

Scope

In first-of-a-kind projects it may be very difficult to define the scope precisely at the beginning of the project. The project may require decisions at critical decision points with less than desirable definition of the systems to be used. For example, the site plan, footprint, and general arrangements of the facility may not be well defined at CD-0 or CD-1. Only a conceptual plan and general building arrangements may be available until project systems are better defined and sized. The practice of setting contingencies for costs and schedules is appropriate, but the practice of changing project scope to maintain the baseline cost and schedule is definitely not a best practice.

Costs and Schedules

In first-of-a-kind projects there are no historical cost records that can be referenced from earlier projects. DOE has to depend heavily upon judgment, analogies with previous projects, and independent (external and internal) cost reviews. As costs of first-of-a-kind projects are more uncertain owing to the

lower level of technical definition, it is essential to obtain cost estimates by several different and independent methods and sources. Bottom-up cost estimates should of course be made as soon as design information becomes available and should be updated as more information is developed. Adequate attention should be paid to the uncertainties in scope definition and the likelihood that design development will identify additional costs. Top-down cost estimates should be made using whatever parametric or statistical methods may be applicable and used as reality checks on the bottom-up estimates. It is essential that the top-down and bottom-up estimates be completely independent and prepared by different groups with no vested interest in the project. The difference between the top-down and the bottom-up estimates is one indicator of the degree of uncertainty in the project costs. If independent top-down and bottom-up estimates differ significantly, management should immediately investigate the reasons for these differences.

In first-of-a-kind projects it is difficult to schedule activities with precision because some activities may not be clearly defined until the project is well under way. Because a detailed schedule has not been set, schedule risk and contingency analysis require more attention, especially during the early stages of a first-of-a-kind project. The uncertainty inherent in first-of-a-kind projects typically requires flexibility in planning and scheduling. Options should be identified and kept open as long as necessary. Parallel technological developments and multiple suppliers, for example, can address technological risk. More hold points may be required to determine whether or not to go ahead with new or proven technology.

Special attention should be given to the schedule impacts of external events and decisions by decision makers not under DOE or contractor control, such as regulators.

Constructability

Constructability analysis is intended to identify the problems that may be faced during the course of construction. This analysis assesses the probability of the project running over budget and schedule and suggests design changes that would reduce costs and time by making the project easier to construct. Constructability analyses, performed early and often, assess the ability to carry out the project in the planned manner, within budget and schedule. Constructability analysis should be started in the very first phase of planning, whenever a design or a plan to build something is conceptualized.

Prototype Studies

In planning any new technology project, it is beneficial to build a pilot or bench model rather than immediately building the full-scale facility, so that the process design may be checked, proven, and refined earlier, at a much lower cost.

A decision to proceed with the project at CD-1, CD-2, or CD-3 should depend on the degree of confidence that the full-scale facility will perform as intended based on the performance of the laboratory-scale models.

Alternatives Studied

First-of-a-kind projects often involve new technologies that have not been proven, and it may not be clear at the outset that all the technologies will perform as required. Hence efforts are needed to identify alternatives and to maintain them until at least one has been proved successful. In many cases, early involvement of and input from equipment vendors is essential to making good decisions. The project planning and scheduling process should specify in the project schedule the dates by which these technological decisions have to be made to avoid extending the project completion date.

MANAGEMENT PLANNING AND CONTROL

As discussed above, management planning and control are the areas that need the most improvement for DOE first-of-a-kind projects. The greater technical and organizational complexity, combined with the lack of experience that is characteristic of first-of-a-kind projects, poses additional challenges for project management. The following items address such management challenges.

Organizational Breakdown Structure

All human resources and specific competencies required for the project should be recognized in the organizational breakdown structure. Consistent with the work breakdown structure, the organizational breakdown structure identifies the key project participants and assigns responsibilities. Of particular concern is the early and clear identification of the owners and the users of the facility. This has not always been clear from the outset.

Commitment Tracking System

A commitment tracking system monitors the fulfillment of responsibilities. Procedures for assigning and tracking the commitments and responsibilities of all the participating parties throughout the entire project are developed and resources for the implementation are allocated.

Integrated Documentation System

Integrated information systems designed to collect, store, and process project-related information need to be developed and implemented. These systems should

be integrated to serve the needs of DOE project management, DOE users, contractors, subcontractors, and regulators. DOE Order O 413.3 requires the use of an earned value management system (EVMS). Effective use of EVMS requires the integration of project costs with the project schedule, through a resource-loaded project network capable of generating and tracking the budgeted cost of work scheduled, the budgeted cost of work performed, and the actual cost of work performed, for all contractors and subcontractors. To meet the requirements of O 413.3, an integrated cost and schedule system should be established as soon as possible.

Risk Management

To address the greater uncertainty characteristic of first-of-a-kind projects, an explicit risk management program should be undertaken, starting from the earliest phases of preconceptual planning, and performed as a continuous process throughout the life of the project.

In risk identification and assessment**,** all potential risk factors should be recognized and evaluated. The methods for performing this evaluation depend on the degree of uncertainty and complexity. They could range from the analysis of failure modes and effects to probabilistic risk assessment. Each risk identified as significant should have a risk mitigation and management plan, and the demonstration of a satisfactory risk management plan should be a condition for proceeding at every critical decision point.

FINDINGS AND RECOMMENDATIONS

Finding: First-of-a-kind projects have been and can be successfully managed and executed by DOE, but they require particular care. The higher degree of uncertainty that attends these projects requires managers who are experienced in dealing with uncertainty and ambiguity. Not all project managers have this ability. The best project managers and management systems more than pay for themselves on first-of-a-kind projects by delivering projects on schedule with little budget overrun.

Recommendation: DOE managers and acquisition executives should pay particular attention to the unique characteristics of first-of-a-kind projects by considering the issues discussed above—for example, costs and benefits, scope, cost and schedule budgets, constructability, alternatives, management planning, and project controls—at all critical decision points.

8

Project Cycle Time Reduction

INTRODUCTION

The NRC report on DOE project management (NRC, 1999, p. 89) observed that "DOE WM (now called EM) projects took an average of three times longer to complete than comparable projects in industry and other government agencies." This observation was based on data from the mid-1990s because up-to-date information on project durations was not available. It was often unclear just when a project was actually started or when it was finished (put into operation). Nevertheless, there seems to be general consensus that most DOE projects could, and should, take substantially less time to complete.

PREREQUISITES FOR REDUCING CYCLE TIME

To reduce project cycle times, it is necessary that project management processes and procedures be consistent and effective. Previous NRC reports stated that the DOE project development process has not been in control of cost, schedule, or performance metrics; however, steps are currently being taken that are intended to bring the process under control (NRC, 2001a, 2001b, 2002a). Only when most projects are dependably under control will it really be possible to reduce process cycle times.

Proposed projects are justified on the basis of estimated budgets and schedules, and virtually all are claimed to be essential to the DOE mission, but project execution plans and critical decision (CD-0) submissions do not explicitly answer the question, How much does the project's value (to DOE and to the public)

change if it is completed earlier or later? To know whether it is beneficial to complete a given project earlier, it is necessary to estimate the net value (not the cost) of the benefits to be obtained from the project, and then to estimate the net value if the project is delivered 1 month or 1 year earlier. Earlier delivery of projects is not an end in itself but is a means of reducing the time needed to obtain the benefits conveyed by the project—and benefits obtained sooner are more valuable. This determination requires a clear distinction between value and cost.

An essential step in reduction of project cycle times is to assign higher priorities to those projects whose earlier delivery would be cost-effective, based on the net increase in value to the government attributable to the earlier receipt of benefits less the increase in cost, if any. However, the committee observed that no such cost-benefit analysis has been carried out for DOE projects. The fact that it is difficult to quantify project benefits is not regarded as an acceptable reason for not doing so. Completing projects earlier requires identifying projects that are needed sooner, which means setting priorities. Decisions on project delivery schedules will be valid insofar as they are based on objective, unbiased information.

If there were clear strategic plans for all the DOE functions, and if the DOE implemented a portfolio planning and management process, program management would be much improved. The process would be much easier: Each set of project proponents could then match its project's attributes against the known mission requirements and planned project portfolio. Proposed projects with low mission need could be deferred or terminated, and those deemed critical to mission should be advanced. This prioritization and reduction of cycle time would lead to projects completed sooner and fewer projects in the pipeline. Absent a functioning portfolio management process, project proponents and DOE managers cannot reliably determine which projects are considered to be mission critical by DOE headquarters, so they propose more projects than can or should be funded. This situation generates a requirement for senior DOE management review points (critical decision points) to determine which proposals are most valuable with respect to strategic mission requirements. The less clear the mission statement, the more management needs to be involved in the decision process.

EFFECT OF DOE ORDER O 413.3 ON PROJECT CYCLE TIME

The committee has heard from some DOE and M&O contractor personnel that the critical decision points set up in DOE Order O 413.3 have greatly increased project delays. The committee knows of no valid data confirming whether or not O 413.3 delays projects, as no projects have gone completely through the O 413.3 process. Even if such data were available, the state of the DOE historical project database is such that no statistically valid comparisons could be made. Projects that are now in construction were started before O 413.3, and those that were started under O 413.3 are only at CD-1 to CD-2. If the review process leads to projects that are completed successfully, on time, and on budget

and the absence of a review process leads to projects that overrun the schedule and budget, then the claim that project reviews delay projects becomes moot. DOE is interested in outcomes, but the outcome of interest is not the length of the review but the success of the project (DOE, 2000). Therefore, claims that O 413.3 decision points are delaying projects are unsubstantiated. If critical decision reviews take longer than deemed necessary, then DOE senior management should fix the management review process, not eliminate management reviews.

Senior management reviews actually add value to the process, even if they only weed out projects that should not proceed. As noted above, if strategic directions and mission requirements are not clearly enunciated, it is the legitimate role (in fact, the responsibility) of senior management to determine which of the proposed projects are most aligned with the strategic goals of the organization. The views of successful project managers in industry on this subject were discussed at the November 2001 government/industry forum on the owner's role (NRC, 2002b).

Making strategic decisions is what senior managers in any organization, public or private, are required to do. Senior management can delegate this authority when they have a high degree of confidence that lower echelons will replicate decisions of senior management. Absent this confidence, senior managers will have to make all strategic decisions. Given that big projects are the core of DOE's mission, senior-level management would be remiss not to be involved in critical decisions. The committee believes that authority to decide which projects will be funded should in no case be delegated to M&O or M&I contractors.

DOE Order O 413.3 essentially defines five critical decision points (CD-0 to CD-4). This does not seem to be an excessive number compared with private industry, which often requires more senior management decision points and considerably more intense senior management involvement in projects of far less dollar value than DOE projects (DOE, 2000; NRC, 2002b). What was remarkable about DOE projects in the past was their micromanagement by many midlevel managers at headquarters, combined with a relative lack of attention at high levels, even for billion-dollar projects authorized as essential to the national defense (e.g., the National Ignition Facility, prior to 1999).

In the absence of reliable data, the committee tried to explain why management review at the critical decision points takes such a long time: The committee has observed that critical decision reviews often include polished PowerPoint presentations and even rehearsal sessions prior to the actual executive review. It takes time to prepare these presentations and get them reviewed and approved by managers up the line even before they reach the ultimate decision maker. As a result, although these iterative reviews may serve a vital communications role, and the need for concurrence and political buy-in at various levels may justify this process, they strengthen the perception that the process is cumbersome and too formal.

One reason for this formality may be the general state of communication within DOE. The committee has observed a generally low degree of communication both between programs and within programs. If senior DOE managers were well informed about projects, it would not be necessary for the reviews to cover the entire project territory in such formalized briefings. The responsibility for ensuring that senior managers are well informed about projects lies both with the senior managers themselves and with the project and functional managers below them.

ELIMINATING DELAYS FROM CRITICAL DECISIONS

There are at least three ways that critical decision reviews can delay a project:

- Materials (acquisition plans, risk management plans, etc.) are inadequately prepared and are sent back for rework.
- Materials are adequate but the project is deemed unnecessary or of low priority and does not pass the critical review, and it is either terminated or recycled for further work.
- The preparations for the critical decision review are on the project critical path. Clearly, decisions are on the critical path—they are intended to be. But preparations for reviews need not be on the critical path. The requirements of O 413.3 are known. Therefore, a well-managed project should be planned such that adequate project justification and documentation, including acquisition plans and risk management plans, are standard parts of preproject planning, so that the preparations for project review presentations are not on the critical path.

Project justifications are almost universally based on the premise that the proposed project is the only possibility, exactly as it is proposed, and that the only alternative to this specific project is no project. A single alternative may be presented despite the fact that the project scope and specifications were undoubtedly the result of negotiations and compromises among all project proponents and participants. This means that if the decision maker does not like either alternative—yes or no—the justification has to go back for rework.

Inadequate preproject planning is at fault here; front-end project planning documents should address the following:

- *Alternatives to the proposed project.* If this exact project is not approved as defined, then there should be an alternative ("Plan B") for meeting mission requirements.
- *Issues, capabilities, and features not included in the proposed scope but capable of being added later on.* These might include expanding capacity, acquiring more or newer instruments, upgrading capabilities, etc. If this information is on hand, the decision maker might choose to bring some of these features forward into the proposed initial project scope.

• *Capabilities that are precluded by the proposed project scope, project architecture, or technology.* These are the opportunity costs: the things that one could not do (or could do but at prohibitive expense), now or in the future, if one were to adopt the proposed solution. Given this information, the decision maker might find that some essential or desired future capability has been ruled out by the proposed solution and therefore might require a different solution.

The failure to provide this kind of essential information has been characteristic of the DOE culture. Some project proponents told the committee that they do not trust DOE senior management to make the correct decisions, even when they have the essential information. This lack of trust in senior managers leads the senior managers, in turn, to not trust project proponents to brief them thoroughly or make the best decisions for the agency independently, whereupon they insist on making all the decisions themselves.

COMPLEXITY INCREASES THE RISK OF DELAYS

The nature of the DOE project development process encourages many projects to grow by accreting more scope and functions and by gaining internal or external political support until they become megaprojects. Adding more functions or scope increases complexity, and the difficulty of coordinating these multiple functions increases exponentially with complexity (Merrow et al., 1988). Flyvbjerg documents overwhelming evidence that the costs, durations, and risks of public works megaprojects are consistently underestimated, and DOE projects are apparently not immune from this syndrome (Flyvbjerg et al., 2002).

Some DOE capital acquisition projects are at the same time R&D projects. The reason for these dual objectives is said to be speed. Project proponents feel that they do not have time to research and refine the technology from bench scale to full scale before embarking on the full project, so the R&D is done on the full-scale capital acquisition project. Consequently, the projects are delayed for technology development and take longer than if the necessary R&D had been competed first and the costs are much higher. Technology development or R&D on a capital project provides a perfect excuse for delays and cost overruns, even when they may actually be due to other problems. In any case, if one accepts the proposition that major systems acquisition and R&D must be conducted concurrently, the R&D should not be on the critical path, and critical path activities should be buffered against the results of the R&D process. If there are technology development risks, the risks should be concentrated, not diffused throughout the project, where they will be more difficult to manage and control. If there are technical risks with system components, final system integration should not be a risk factor, as system integration and startup will certainly be on the critical path and will most likely delay the project, especially if system integration requires

rework of components to achieve compatibility. (See the discussion of first-of-a-kind projects in Chapter 7.)

REDUCING PROJECT TIME AND SUPPORTIVE MANAGEMENT CULTURE

Earlier project completion requires more flexibility on the part of all participants. DOE's ability to adjust rapidly to circumstances is limited partly by the Federal Acquisition Regulations (FAR) but even more by DOE practices. To an outside observer, a faster project process appears even less well organized than projects on normal timetables. Reduction of project cycle time depends on effective decentralized decision making. This is exactly why the project delivery process should be brought under control before attempting to deliver projects earlier. An uncontrolled process at normal speed will be worse at high speed. To perform projects faster, a high degree of trust is necessary between participants at all levels and locations. Such cohesion, which comes from a spirit of participation in a common enterprise to achieve common goals, does not always prevail at DOE or its contractors.

STAFFING FOR REDUCED PROJECT CYCLE TIME

Delivering projects early requires more dependence on good project management. DOE's deficiencies in project manager training, career paths, professional development, and related issues have been documented elsewhere. To deliver projects early and on budget, project managers must have authority and senior management support and must know how to use them to remove obstacles to project progress. DOE often assigns world-class scientists and technical experts as project team leaders; however, this can be counterproductive. In general, engineering managers, or technical leaders, should be distinct from project managers. The function of a project manager should be to keep the project on scope, on budget, and on schedule.

One place in which time could be cut from projects is the front end. This does not mean reducing time spent in project definition, preproject planning, or conceptual engineering, which the committee has emphasized in previous reports (NRC, 2001b), but reducing the time wasted getting organized and time delays due to understaffing at the front end. Project execution plans are essential and their preparation does not delay projects unless there are delays in setting up project organizations, staffing integrated project teams, making timely decisions, all of which should be avoidable. Time lost to delays here is very difficult to recover later on, and even if recovery is possible, it can be very expensive. The true cost of the front-end process is the cost (that is, the value foregone) of slow progress and later project delivery, not just the cost of staff to plan, manage, and engineer the project. Front-end planning activities should have resources assigned

on a timely basis and explicit milestones or deadlines. Many planning and engineering functions can be accomplished concurrently or in an overlapping manner. One reason many projects start slowly is that personnel are not made available from other assignments. A project has not really begun unless a project manager and an integrated project team are actually at work. There is hardly a case in which a project team was assigned too early. Early assignment of project teams is necessary to start front-end planning. Even though projects with shorter cycle times require more flexibility in the organization, they also, perhaps paradoxically, require more planning than business-as-usual projects. The planning does not necessarily entail making all decisions early; it may, however, entail more advanced planning of when decisions must be made and providing the information needed to make them.

FINDINGS AND RECOMMENDATIONS

Finding: Undersecretary Robert Card has enunciated a new strategy for Environmental Management (EM) that stresses earlier completion of site cleanup and remediation and earlier closure of sites or their turnover to private industry. The EM organization is reorganizing to fulfill this new strategy. Although it appears that much of the time reduction will be due to a reevaluation of the necessary end states, which may involve negotiations with stakeholders, the committee considers this initiative an important step toward DOE controlling its projects rather than being controlled by them, as has been the case. To make progress, it is necessary to believe that projects can be controlled and delivered earlier rather than believing that nothing can be done and that the process will require 70 years to complete. It is too early to determine whether the new EM organization will be successful, but the committee considers active attempts to get projects under control, to define strategic directions, and to align projects with strategy to be superior to passivity.

Recommendation: The strategy of achieving earlier completion of site remediation and closure or turnover of sites should, if successful, reduce environmental risks substantially and save U.S. taxpayers many billions of dollars. This initiative should be supported and continued.

Recommendation: In addition to redefining end states, DOE EM should consider all possible methods for improving its project management processes, preparing its project managers, and achieving earlier project completion, some of which are outlined above.

Recommendation: Program offices in DOE other than EM should also consider opportunities for earlier project delivery through application and implementation of the principles cited above.

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9

Acquisition and Contracting

INTRODUCTION

The committee in each of its previous reports noted the critical relationship between the use of good acquisition practices and successful project management (NRC, 2001a, 2001b, 2002). Given that contractors perform the preponderance of the agency's work, special attention must be given to three critical aspects of the acquisition process:

- Creating early on an effective and complete strategy for selecting a contractor that can later be updated and refined,
- Developing a clear, performance-based contracting plan that allows an objective means for measuring results, and
- Establishing an effective set of incentives to align contractor performance with DOE goals and outcomes.

The committee continues to emphasize the importance of sound up-front acquisition planning, performance-based contracting, and the effective use of incentives as key elements in a successful project management process. DOE has taken positive steps over the past year in each of these areas. The following sections discuss its actions regarding these acquisition methods and provide findings and recommendations for each.

DEVELOPING AN ACQUISITION STRATEGY

Chapter 5 of the August 2002 version of the draft *Program and Project Management* (PPM) manual, entitled "Definition," discusses the project definition phase (DOE, 2002). This phase includes activities that occur between the approval of mission need (CD-0) and the approval of system requirements and alternatives (CD-1). A major focus of this early phase is the development of an acquisition strategy that will be used to guide the project throughout all of its subsequent phases. As such, it provides a foundation for the overall project. A draft of the strategy is needed even before mission need is agreed to, but this draft of the strategy will be refined as the project progresses. The PPM states that the strategy should address the following topics:

- Requirement (including a summary project description);
- Project structure (including an organization chart and a listing of acquisition steps);
- Risk assessment (schedule, cost, technical as well as mitigation strategies);
- Approach to managing program/project cost and performance;
- Acquisition trade-offs and streamlining (including a discussion of the pros and cons of alternative acquisition approaches);
- Project management (general philosophy and approach);
- Support concepts and IT strategy;
- Business and contracting strategy (including ensuring maximum competition for an award, contract types, and incentives); and
- Other important considerations (i.e., other agency involvement).

For each of the items noted, the PPM provides additional guidance on ensuring that critical issues that may affect project performance are thought through early on and continue to remain a focus of subsequent efforts.

In addition to providing useful guidance to project management staff on issues to consider in developing an acquisition strategy, the PPM includes the Acquisition Strategy Approval Form. This form is to be signed by the project manager and by various senior staff up to and including the agency acquisition executive. DOE Order 413.3 requires approval of mission need and acquisition plans by senior department management (DOE, 2000). The deputy secretary approves projects of $400 million or higher, the under secretaries approve projects of less than $400 million and may delegate this authority to the assistant secretaries/program secretarial officers as they deem appropriate. As part of this process, the Office of Engineering and Construction Management (OECM) reviews draft project acquisition strategy documents and provides comments back to project staff. Although OECM does not have sign-off authority for the documents, it provides recommendations to the director of the Office of Management, Budget and Evaluation (OMBE) on whether projects should be allowed to proceed or if

deficiencies in documentation and justification need to be corrected. As such, OECM staff has worked informally with project staff to address issues before the project goes through the formal Energy Systems Acquisition Advisory Board (ESAAB) process.

From December 2001 through May 2002, OECM reviewed 21 acquisition strategy documents, and 9 proceeded on for formal approval. The committee examined some of the draft acquisition plans submitted by various DOE components. These included, among others, plans for the development of a materials facility for special nuclear materials, a technology center upgrade construction project, and a communications infrastructure modernization program. These documents reveal a significant amount of inconsistency in project team responses to the specific items listed in the PPM as part of an acquisition strategy. For example, in some, risks are detailed as well as efforts to mitigate them. In others, risks are mentioned but there is no discussion of how they are to be handled. Also, technical risk is addressed but business risk ignored in some of these acquisition strategies.

Other shortcomings that have been observed as a part of the OECM's review include risk plans that were 3 years old when submitted and therefore very likely out of date, with contractors, as opposed to federal managers, defining the acquisition strategy and outcomes. In addition, while some integrated project teams (IPTs) were identified, they had not begun to function as real teams. Acquisition strategies and, in particular, risk-management plans cannot be effectively developed without the active participation of all project interests (i.e., the IPT). Finally, the draft documents have been weak on identifying the pros and cons of alternatives to be considered as part of the critical decision on mission need, and frequently project costs at the very earliest stage are presented as point estimates rather than as a likely range of costs that would later be refined.

Another area that requires special attention in developing an acquisition strategy is the ability to attract a sufficient number of bidders to ensure an acceptable level of competition for awards. Recently there has been a decline in the bidder pool and a concentration of DOE contracts among a very few large contractors. This concentration has increased over time and is worse than the concentration observed in the 1999 NRC report (NRC, 1999). Draft acquisition plans should focus on ways to increase these pools to maximize the benefits of competition for DOE procurements. DOE should address the problem of inadequate and declining competition in all programs. This is especially critical for an agency that is so highly dependent on contractors to function. DOE should take remedial actions and set goals for increasing the bidder pools for DOE projects.

It is apparent that the project teams remain somewhat unclear about what constitutes an acquisition plan that would allow a project to proceed toward successful completion. The core elements of the acquisition plan should be a full description of the planning rationale developed by the IPT, a cost and schedule range that should be integrated with the budget, a clear focus on competition, and

a risk assessment and mitigation plan relevant to each project stage. These elements will help connect the project acquisition and financial management aspects of the project right from the start.

The OECM review process has clearly been useful in helping teams develop the appropriate level of detail for each of the critical elements of the acquisition strategy. As such, the process is forcing a greater level of front-end planning than was the case in previous projects the committee has reviewed. However, and perhaps because the process is new, the response to critical decision requirements seems to be more a matter of compliance than of using analytic tools to strengthen overall project management. The committee advocates the use of risk analysis and other analytical tools not merely for the sake of analytic rigor but rather because the analysis, if properly performed, forces the IPT to identify and confront the critical issues facing the project. The committee believes that as more acquisition strategies are developed and as more staff become familiar with the benefits of addressing these issues early in the project, support for these management tools will increase.

PERFORMANCE-BASED CONTRACTING

It is vital that DOE project management staff be well versed in techniques that allow them to identify key outcomes to be achieved through contractor efforts, to develop performance incentive targets, and to monitor and oversee contractor performance. One contracting technique in particular—performance-based contracting (PBC)—has been integral in shifting the overall focus of the acquisition process from process to outcomes. The committee strongly recommended in its previous reports that more training be provided to staff on this methodology (NRC, 2001b, 2002).

Under a performance-based contract, acquisition is structured around the purpose of the work to be performed as opposed to how it is to be accomplished. Contractors should therefore be clear about the project objectives but should also have more flexibility in determining how to meet the government's requirements. Such flexibility would be more likely to interest contractors in bidding on DOE efforts, thereby addressing the issue of declining competition, referred to above. However, it is essential that the government continue to monitor contractor performance. Much of the success of this approach is dependent on effective and ongoing communications between the government and the contractor. The government does not abdicate or delegate to a contractor its oversight responsibilities but rather works with the contractor to accomplish identified outcomes. The main point is that the judicious use of incentives can bring both the government's objectives and the contractor's objectives into complete alignment. When the government succeeds, the contractor succeeds. DOE included PBC as part of its contract reform agenda of the early 1990s and has been employing this approach in major projects at Rocky Flats, Oak Ridge, the Nevada Test Site, and elsewhere.

The federal government has encouraged the use of this technique for more than a decade, and the Bush administration has given it even greater emphasis, making it a key element of the President's management agenda. In March 2001, the Office of Management and Budget (OMB) required that 20 percent of all services contracts for FY 2002 over $25,000 be performance-based. The President's management council monitors progress related to this goal.

The committee's 2001 assessment described the basic components of a performance-based contracting template and defined how outcomes, performance metrics, quality assurance surveillance plans, and incentives all work together to produce a framework for contractor accountability (NRC, 2001). As mentioned previously, a 1998 OMB study found both cost savings (of about 15 percent) and significant increases in customer satisfaction when government agencies shifted to performance-based contracts (EOP, 1998).

Even though PBC has been a longstanding and important aspect of many DOE contracts, the initial draft PPM made no mention of it. The committee is pleased to see that the August 2002 draft points out the importance of using performance-based contracting methods as a part of good project management. It also refers to a seven-step process that has been followed by a number of government agencies in conducting performance-based acquisitions (DOE, 2002). However, PBC is an integral part of project management, and as noted in the PPM, it is one of a number of techniques that join to produce a successful project. Of interest to the committee is how effective and objective performance metrics can be developed and used in accomplishing departmental objectives.

An analysis sponsored by DOE's Office of Procurement and Assistance Management and completed in June 2002 provides some useful insight into this issue. The purpose of the analysis was to assess management techniques used by other agencies in contracts similar to those operated by DOE. One focus was the use of objective measures to assess and reward contractor performance. The categories of contracts from which comparable non-DOE contracts were selected include the following:

- Operation of complex government-owned industrial-type facilities,
- Operation of complex government-owned research and development facilities,
- Construction of unique facilities, and
- Environmental cleanup and remediation efforts.

The reviewers also sought contracts that involved large sums of money, had multiyear commitments, and presented similar risks to those faced by DOE. In all, contracts awarded by the following agencies were explored in depth:

- The National Cancer Institute of the National Institutes of Health, in Frederick, Maryland;

- The Air Force's range technical support contract for Patrick Air Force Base, in Florida;
- The joint NASA/Air Force base operations and support contract at the Kennedy Space Center, Florida;
- The NASA Jet Propulsion Laboratory, in California;
- The Air Force Pacific Missile Range Facility, in Hawaii;
- The Army Tooele Chemical Agent Disposal Facility, in Utah; and
- The NASA Plum Brook Research Station, in Ohio.

Virtually all of these contracts were in the hundreds of millions of dollars range and involved a host of support activities to be performed by the contractor. In every case, a cost-reimbursement contract was used, as is the case with DOE's management and operation (M&O) contracts. Moreover, six of the seven contracts used an award fee process for determining incentives. In this type of contract, the government sets a maximum fee amount for the contracted period and then determines after the fact how much of the fee should be awarded to the contractor. The seventh contract (Plum Brook) used an award term incentive approach. Under this model, superior performance does not result in a higher fee but in an extension of contract length.

Each of the above contracts follows a similar process for determining an award fee. Basically, performance standards and their relative importance are conveyed to contractors at the beginning of the evaluation period, which generally is 6 months. Teams of government officials are assigned to monitor and document contractor performance against these objectives, with performance information collected at the end of the period. An evaluation board then reviews the information and provides a recommendation on the fee to the fee-determining official, who is the ultimate decision maker. In each case, contractors are offered an opportunity to provide written comments or oral presentations to the evaluation committee. What was of concern in each of these contracts was the amount of subjectivity in the evaluation process. Some of the contracts identified specific performance metrics (as, for example, safety or production performance at the Tooele depot for eliminating nerve agents). However, there was always an ability to modify the fee based on subjective considerations, using such ratings as "good" or "excellent." In one of the contracts, the contractor had to successfully achieve 87 metrics as a threshold requirement before any fee could be awarded. In another, 107 metrics were monitored and the results factored into the award fee process. But these were just factors to be considered in the overall award. Clearly, having 87 or 107 metrics does little to focus the contractor's attention on the critical project issues and turns performance-based contracting into an accounting exercise.

Some of the arguments that were presented against relying on purely objective metrics for fee determination are the following:

- What can be easily measured is not critical to the contract's execution. If this is the case, objective measures would fail to bring about the right outcomes.
- There are too many uncertainties to tie the fee to such measures. For example, new areas of emphasis may arise after performance has started, or there may be unanticipated reductions in funding.
- Objective measures fail to account for unknowns. For example, an incentive for chemical disposal based solely on pure production would be dependent on knowing the liquid/gel proportion of nerve agents in shells that must be incinerated. Only then could a consistent rate of production be determined and the contractor held to that schedule.
- Objective measures do not allow the government to communicate its concerns if it believes the contractor is not being sufficiently responsive.

While the committee believes that objective measures may not necessarily be applicable to all types of contracting efforts, it believes that many of these issues or complaints can be overcome with a diligent review of the basic tasks specified in the contract. There are ways to accommodate changes to the incentive schedule just as there are ways to accommodate changes to the project scope, budget, and schedule. These views inhibit greater use of performance-based techniques and help to explain the government's reluctance to adopt a more objectively determined fee process. One of the positive aspects of using a performance-based approach was that such measures allow a better understanding of up-front expectations on performance and outcomes for all parties, while reducing the impact of unsubstantiated information on the award fee process.

INCENTIVES

The use of incentives or disincentives has been an effective contracting tool to focus the contractor and the government on the overall outcome being sought. Both are key factors in the development of virtually any type of performance-based contract. An incentive or disincentive clarifies for all parties the priority that the government is placing on a particular aspect of the contractor's performance. Ordinarily, the government provides incentives to the contractor by offering a bonus for performance above and beyond satisfactory accomplishment of contracted tasks. This is usually accomplished through a subjective award fee process similar to the one described above or through a more objective performance-based process. Cost performance can also be incentivized. Generally this type of fee involves the contractor and government sharing, by a prearranged formula, in cost underruns (the amount by which actual costs are less than target costs) and overruns (the amount by which actual costs are more than target costs). Clearly, the government must be able to make reliable target cost estimates and not simply adopt those of the contractor. If the government lacks the experience and knowl-

edge to estimate cost targets (not just historical costs incurred) through activity-based costing, then it should seek independent cost estimates.

An incentive contracting approach can include monetary and other types of rewards. In some cases, the contractor can be awarded outstanding past performance ratings that can be used by the contractor in bidding on additional work. In others, some agencies have been using an award term scheme that offers the contractor a contract extension, as described above for the National Aeronautics and Space Administration (NASA) Plum Brook facility.

In a hazardous work environment, disincentives, such as loss of fee, can be used where outcomes related to the health and safety of workers or the public are important or where there could be serious environmental impacts. Disincentives are also frequently used where vital agency operations are at stake, such as maintaining computer network operations. In every case, if additional funds are to be provided for contractor performance, the government has an obligation to ensure that the outcome (in terms of costs or benefits) is commensurate with the incentive or disincentive employed. Contractor incentives should consider the value added for the government, not merely the costs to the contractor. The DOE has a long history of using incentives to direct contractor efforts in many of its major management and operating contracts. However, Under Secretary Robert Card recently adopted a new approach to the use of incentives for the department's major environmental cleanup efforts. Under this approach, DOE is setting new funding priorities based on which sites can achieve closure most cost effectively by accelerating operations. By focusing on and incentivizing accelerated closure, and by rewarding contractors for task completion rather than ongoing efforts, DOE is sending a strong message to all of its environmental cleanup contractors to align their goals with those of the department. The committee applauds these efforts. As the department increases its emphasis on closure, it will be required to reassess funding priorities and redirect funds to those projects offering the greatest opportunity for success. In this restructuring process, the department needs to ensure that the necessary coordination is carried out with state and other regulators. In addition, it should reassess incentives already in place, particularly those focused on interim progress and goals, to determine whether they are still meaningful. The River Corridor project at DOE's Hanford site provides a good opportunity to evaluate the effectiveness of DOE's new performance-based, closure-incentivized policy.

FINDINGS AND RECOMMENDATIONS

Acquisition Strategy

Finding: The committee believes that the August 2002 draft PPM provides a good framework for addressing acquisition strategy issues and offers a useful

model for DOE project managers to follow in preparing and planning their efforts. However, it finds that the acquisition strategy documents being reviewed by OECM are of mixed quality and believes that this indicates a need for more training and development of additional reference documents. The iterative process of review and correction will also improve the overall quality of planning documents over time. The most recent draft PPM now provides clear and consistent guidance on what needs to be addressed in each draft acquisition strategy and, as such, should significantly increase the quality of the documents submitted for review.

Recommendation: The committee recommends that senior management continue to require project teams to focus on up-front acquisition planning and that it continue to use the approval process for ensuring compliance and consistency. DOE management should return documents that do not meet management expectations and should follow up by asking why these inadequacies were not fixed at lower levels. Project teams should be trained in developing effective acquisition strategies. DOE leadership should also continue to focus on competition to obtain a range of innovative approaches from a variety of contractors to meet its management, operating, and development needs.

Performance-Based Contracting

Finding: For large cost-reimbursement contracts, many factors compromise the ability of the government to use purely objective measures for assessing performance. Moreover, federal agencies are comfortable using a more traditional cost reimbursement award fee approach, in which the award fee is at the discretion of the federal project manager.

Recommendation: **A** significant amount of up-front planning by the IPT is needed to specify outcomes and identify those aspects of an overall project for which a contractor can effectively be held accountable. The committee reiterates its recommendation that training in performance-based contracting methods be provided to IPT members. In addition, DOE should collect best practices information on the use of performance-based contracting in DOE contracts and identify those activities most suitable for use of these metrics.

Incentives

Finding: DOE is reassessing its cleanup efforts, giving them a new focus on cost-effective and rapid closure of sites, and setting up incentives that can best achieve that goal.

Recommendation: DOE should reassess its use of incentives in existing contracts to ensure that they focus on closure and that interim goals are effective in driving this overall objective.

REFERENCES

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10

Recognizing Project Management Successes

INTRODUCTION

The Office of Engineering and Construction Management (OECM) initiated an annual project management workshop and awards program in October 2000 (DOE, 2000). The second workshop was conducted in March 2002, having been postponed from October 2001. The first important event planned for each workshop was the presentation of awards by the deputy secretary. The project teams being recognized for their achievements presented a brief synopsis of their projects, including factors contributing to their success and lessons learned. Each recognized project team received a plaque, and team leaders received award certificates. There is no monetary award to individuals. Recognizing merit and demonstrating that senior management is interested in achieving results through effective project management procedures and principles encourage exemplary behavior. The following summary of the 2002 awards emphasizes features of the recognized projects believed by the committee to illustrate the lessons learned that should be transferred to future project management efforts.

2002 PROJECT AWARDS

Any DOE employee or DOE contractor employee can make nominations, and a panel assembled by OECM evaluates projects. For the 2002 awards the evaluation panel comprised representatives of the OECM and one member of the committee. Sixteen nominations were submitted in 2002, which included eight nominations from the National Nuclear Security Administration (NNSA) and

eight from the Office of Environmental Management (EM). The Office of Science (SC); Office of Civilian Radioactive Waste Management; Office of Nuclear Energy, Science, and Technology; and other offices that execute projects submitted no nominations. Two of the three awards went to NNSA projects, and the third went to an EM project (DOE, 2002).

All of the nominated projects were initiated prior to implementation of DOE Order O 413.3, but they all used the principles and procedures that are now required by the Order. Half of the nomination packages specifically mentioned conformance to the requirements of the Order.

Deputy Secretary's Excellence in Acquisition Award

The top award for 2002 went to Los Alamos National Laboratory (LANL) for the Chemistry and Metallurgy Facilities Upgrades Project (DOE, 2002). This $106 million NNSA project upgraded utility and safety systems in a 550,000-square-foot, 50-year-old nuclear facility during continuous operations. Complexities of the project included extensive radiological and other hazardous material contamination, including some contamination without existing standards for mitigation; system components well beyond their design lives; rigorous quality assurance standards for nuclear-grade components; and a 6- to 12-week delay caused by the Cerro Grande wildfire. The project was completed 6 months ahead of schedule and about $12 million under budget, with no recordable worker injuries in more than 120,000 work hours. Several factors were identified by the committee as being important to success: (1) effective teamwork and trust between DOE and the University of California; (2) extensive involvement of the LANL maintenance and operations contractor; and (3) work packages that subdivided the project into 19 manageable subprojects, each with its own scope, budget, design, risk assessment, hazard analysis, and construction schedule. Significant cost reductions were realized by employing rigorous preproject planning to characterize systems and to permit the negotiation of fixed-price agreements. Progress was closely controlled by the use of an earned value management system (EVMS) on each of the subprojects to track execution on a real-time basis.

Deputy Secretary's Award of Achievement

The second award for 2002 went to the Strategic Computing Complex, also at LANL (DOE, 2002). This $106 million NNSA project constructed a 291,000-square-foot facility, which includes an immense, integrated system of computer processors capable of ultimately performing more than 100 trillion floating point operations per second. The facility will provide the capability to perform highly complex, three-dimensional computer simulations and will provide laboratory space for 300 scientists and engineers to certify the readiness of the nuclear weapons stockpile without physical testing. To meet the schedule, an early

decision was made to execute the project under a design-build contract awarded through a competitive best-value, fixed-price selection process. However, other significant benefits were also realized from the design-build process. For example, the project was completed $13 million under budget, and every schedule milestone was met or bettered, including completion of the computer floor 105 days early. The project had a good safety record, logging just one lost workday in more than 600,000 work hours. Thorough preproject planning resulted in a mission statement, functional and operational requirements, and roles and responsibilities that remained stable throughout the project. A co-located project team and a formal partnering process were fundamental to successful communication. Independent risk assessment, weekly progress reporting, a tight change control process, and EVMS enabled the project to overcome setbacks, including a 15-day delay caused by the Cerro Grande wildfire, and to remain ahead of budget and schedule.

Acquisition Improvement Award

The award for innovation in the acquisition process went to the Savannah River Site (SRS) sitewide CFC HVAC/Chiller Retrofit project (DOE, 2002). The objective of this $55 million EM project was to eliminate the use of ozone-depleting substances at the SRS. It involved replacing 48 chilled water units in 31 facilities extending over 5 million square feet and having 16,000 tons capacity; the units had been leaking refrigerant at 43,000 pounds per year, at a replacement cost of $500,000 annually. The challenges included replacing chiller systems that had accrued more than 50 years of operations and working with 10 different DOE line organizations, each having a distinct operating philosophy. The application of lessons learned from similar work resulted in the development of a multidisciplinary project team that divided the work into subprojects, each tailored to the requirements of the organization operating a particular section of the facility. The team developed a design-build ordering agreement with three leading chiller manufacturers. Installations were competitively bid among the three manufacturers using best life-cycle cost as the basis for awarding fixed-price subcontracts.

The project was completed $6 million under budget, and 22 major milestones were completed on or ahead of schedule. No recordable injuries occurred in more than 330,000 work hours. Front-end planning for each subproject dealt with the technical requirements, risk and hazard management, scope definition, and cost and schedule baselines. Buy-in and approval by subproject customers became a contract among all parties and contributed greatly to the success of the project.

OTHER NOTABLE PROJECTS

The awards program did not recognize honorable mentions; however, 5 of the remaining 13 projects nominated were considered by the awards panel to be close contenders for awards. Of these, three were NNSA projects and two were EM projects. The workshop included one more case study presentation on a successful SC project, the *B* Factory Project at the Stanford Linear Accelerator Center, which was not nominated for an award because it had been completed in 1998.

At Lawrence Livermore National Laboratory, the Contained Firing Facility project is a 33,370-square-foot addition to an existing bunker that is designed to contain blast overpressure and fragments from the detonation of up to 60 kg of high-energy explosives. This NNSA project required 3,100 cubic meters of concrete and more than 2,000 metric tons of steel, which is enough to frame a 60-story office building with the same footprint. This $53 million project was completed on schedule and under budget, and it experienced no lost-time accidents and no construction claims. Success is attributed to early establishment of an integrated project team, partnering during the construction process, and value engineering to mitigate risks from unusually high building costs in the area, unknown site conditions, skilled labor shortages, and structural steel fabrication delays.

At the Sandia National Laboratories (SNL), the Rapid Reactivation Project was a $16 million project to upgrade the capability to produce components to support the nuclear weapons stockpile. This NNSA project included constructing an additional 18,000 square feet of laboratory space, reconfiguring existing buildings, and increasing the number of neutron generators by 225 percent. The use of innovative analytical tools permitted linking the project and production schedules in order to maintain production while performing facility upgrades in the shortest possible time. Extensive preproject planning; effective teamwork and communication among the project management team, contractors, and production personnel; and real-time review and analysis of schedules enabled this difficult project to be executed on time and on budget.

A series of four infrastructure line-item construction projects at the Idaho National Engineering and Environmental Laboratory (INEEL) were executed to upgrade two electrical distribution systems, rehabilitate 45 miles of roads, and provide new security facilities, systems, and equipment. These four EM projects cost $110 million, met all technical and performance requirements, and were completed at $27 million under preliminary estimates. Effective integrated project teams, extensive up-front planning, establishment of clear roles and responsibilities, and active risk management and mitigation were key factors in the successful completion of these projects.

At the Savannah River Site, an excess powerhouse was dismantled and removed at a cost of $755,000 ($2.3 million under the preliminary demolition

estimate) through an assets-for-services contract that credited the value of dismantled equipment to the project. Through extensive front-end planning and close coordination with all involved parties, this EM project was completed 3 months ahead of schedule and with no recordable or lost-time accidents.

A processing and environmental technology laboratory at SNL was completed on time and for less than the budgeted $49 million. This 151,000-square-foot facility provides laboratory space for research and analytical support for the production, maintenance, and dismantlement of nuclear weapons. Front-end planning, tight scope control, and customer involvement contributed significantly to the success of this NNSA project.

COMMON FACTORS

Several factors contributed to the success of the projects discussed above. Most notable among these is front-end planning and a well-functioning project team that demonstrated teamwork and excellent communication. Active risk management and mitigation and tight schedule and scope control were in place for each of the successful projects. Extensive acquisition planning and the use of innovative acquisition strategies were also common factors. It was evident that lessons learned in the early phases of the projects were incorporated into planning and were used in dealing with issues that emerged during execution of the project. Finally, a clear definition of the roles and responsibilities of the project team and close coordination with the end user throughout the project were frequently cited as critical to project success.

FINDINGS AND RECOMMENDATIONS

Finding: DOE has executed several recent projects successfully and on or ahead of budget and schedule, as indicated by its 2002 project management award program.

Finding: While all projects considered for 2002 awards were initiated prior to the publication of DOE Order O 413.3, the principles and procedures required by the Order and outlined in this and prior committee reports were important factors in successful completion.

Finding: Lessons learned from briefings by award recipients have application to project personnel who did not attend the Project Management Workshop.

Recommendation: Copies of briefings by the 2002 award recipients should be distributed to all field offices that have project personnel.

Finding. NNSA and EM were the only program offices that participated in the 2002 project management awards program. Other DOE offices that execute projects had no nominations.

Recommendation: DOE should determine why the other program components did not participate in the awards program. DOE should encourage full participation in the future.

Finding: The Project Management Workshop is a step forward in recognizing exemplary projects and project managers and in building a sense of professionalism among project personnel.

Recommendation: DOE should continue and even expand this workshop in future years.

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DOE (Department of Energy). 2000. Proceedings, Program and Project Management Workshop 2000, October 17-19, 2000. Washington, D.C.; Department of Energy.

DOE. 2002. Proceedings, Program and Project Management Workshop 2002, March 19. Washington, D.C.; Department of Energy.

Appendixes

APPENDIX A

Statement of Task

In response to a congressional directive, the National Research Council has appointed a committee to review and assess the progress made by the U.S. Department of Energy (DOE) in improving its project management practices. This study includes evaluation of the implementation of recommendations in the 1999 NRC report *Improving Project Management in the Department of Energy*. The principal goal of this effort is to assess DOE's efforts to improve project management practices, including: (1) specific changes in organization, management practices, personnel training, and project reviews and reporting; (2) an assessment of the progress made in achieving improvement; and (3) the likelihood that improvements will be permanent. These tasks will also require development of a framework for evaluation and performance measures specifically tied to DOE's project management process.

APPENDIX B

Biographies of Committee Members

Kenneth F. Reinschmidt (National Academy of Engineering) is professor of civil engineering and holds the J. L. Frank/Marathon Ashland Petroleum LLC Chair in Engineering Project Management at Texas A&M University. He retired from Stone & Webster as senior vice president. He was appointed chair of this committee for his combination of expertise in the disciplines of civil engineering, project management, cost estimating, and the management of large-scale construction projects, including nuclear and fossil fuel power plant construction. He held various positions at Stone & Webster, including president and CEO of Stone & Webster Advanced Systems Development Services, Inc., and manager of the consulting group in the Engineering Department. In these positions he was engaged in structural engineering, operations research, cost analysis, construction engineering and management, and project management. Prior to his work at Stone & Webster, Dr. Reinschmidt was a senior research associate and associate professor in the Civil Engineering Department at the Massachusetts Institute of Technology, where he was engaged in interdisciplinary research on power plant engineering, design, construction, and project management. Dr. Reinschmidt served as chair of the committee that produced the recent NRC report *Improving Project Management in the Department of Energy* and was reviewer of the NRC report *Assessing the Need for Independent Project Reviews in the Department of Energy*. He is a former member of the Building Research Board of the NRC and served or chaired several other NRC committees, including the Committee on Integrated Database Development, the Panel for Building Technology, the Committee on Advanced Technology for Building Design, and the Committee on Foam Plastic Structures. He has also served on several National Science Founda-

tion review panels on construction automation, computer-integrated construction, and engineering research centers. He obtained his B.S., M.S., and Ph.D. degrees from the Massachusetts Institute of Technology.

Don Jeffrey (Jeff) Bostock retired from Lockheed Martin Energy Systems, Inc., as vice president for engineering and construction with responsibility for all engineering activities at the Oak Ridge nuclear complex. He is serving on this committee because of his experience with managing projects as a DOE contractor. He has also served as vice president of defense and manufacturing and manager of the Oak Ridge Y-12 plant, a nuclear weapons fabrication and manufacturing facility. His career at Y-12 included engineering and managerial positions in all of the various manufacturing, assembly, security, and program management organizations. He also served as manager of the Paducah Gaseous Diffusion Plant, which provides uranium enrichment services. He was a member of the committees that produced the NRC reports *Proliferation Concerns: Assessing U.S. Efforts to Help Contain Nuclear and Other Dangerous Materials and Technologies in the Former Soviet Union* and *Protecting Nuclear Weapons Material in Russia*. Mr. Bostock also served as a panel member for the annual NRC assessment of the Measurement and Standards Laboratories of the National Institute of Standards and Technology. Mr. Bostock has a B.S. in industrial engineering from Pennsylvania State University and an M.S. in industrial management from the University of Tennessee. He is a graduate of the Pittsburgh Management Program for Executives.

Donald A. Brand (National Academy of Engineering) retired from the Pacific Gas and Electric (PG&E) Company as senior vice president and general manager, engineering and construction business unit, and is currently a lecturer in the Department of Civil Engineering at the University of California at Berkeley. Mr. Brand was appointed as a member of this committee because of his expertise in the management of the design, engineering, and construction of large, complex energy-related facilities. During his 33 years with PG&E, he carried out numerous managerial and engineering responsibilities related to the design, construction, and operation of fossil fuel, geothermal, nuclear, and hydroelectric generating facilities, as well as of electrical transmission, distribution, and power control facilities. Mr. Brand's industry activities have included membership on the Electric Power Research Institute's Research Advisory Committee and on the Association of Edison Illuminating Companies' Power Generation Committee. He received a B.S. in mechanical engineering and an M.S. in mechanical (nuclear) engineering from Stanford University. He also graduated from the Advanced Management Program of the Harvard University School of Business.

Allan V. Burman is president of Jefferson Solutions, a division of the Jefferson Consulting Group, a firm that provides change management services and acquisi-

tion reform training to many federal departments and agencies. He serves as a member of this committee because of his expertise in federal acquisition, procurement, and budget reform. Dr. Burman provides strategic consulting services to private sector firms doing business with the federal government as well as to federal agencies and other government entities. He also has advised firms, congressional committees, and federal and state agencies on a variety of management and acquisition reform matters. Prior to joining the Jefferson Consulting Group, Dr. Burman had a long career in the federal government, including serving as administrator for federal procurement policy in the Office of Management and Budget (OMB), where he testified before Congress over 40 times on management, acquisition, and budget matters. Dr. Burman also authored the 1991 policy letter that established performance-based contracting and greater reliance, where appropriate, on fixed-price contracting, as the favored approach for contract reform. As a member of the Senior Executive Service, Dr. Burman served as chief of the Air Force Branch in OMB's National Security Division and was the first OMB branch chief to receive a Presidential Rank Award. Dr. Burman is a fellow and member of the board of advisors of the National Contract Management Association, a principal of the Council for Excellence in Government, a director of the Procurement Round Table, and an honorary member of the National Defense Industrial Association. He is also a contributing editor and writer for *Government Executive* magazine. Dr. Burman obtained a B.A. from Wesleyan University, was a Fulbright Scholar at the Institute of Political Studies, University of Bordeaux, France, has a graduate degree from Harvard University and a Ph.D. from the George Washington University.

Lloyd A. Duscha (National Academy of Engineering) retired from the U.S. Army Corps of Engineers in 1990 as the highest-ranking civilian after serving as deputy director, Engineering and Construction Directorate, at headquarters. He serves as a member of this committee because of his expertise in engineering and construction management and his roles as principal investigator for the NRC report *Assessing the Need for Independent Project Reviews in the Department of Energy* and member of the committee that produced the NRC report *Improving Project Management in the Department of Energy*. He served in numerous progressive Army Corps of Engineer positions in various locations over four decades. Mr. Duscha is currently an engineering consultant to various national and foreign government agencies, the World Bank, and private sector clients. He has served on numerous NRC committees and recently served on the Committee on the Outsourcing of the Management of Planning, Design, and Construction Related Services as well as the Committee on Shore Installation Readiness and Management. He now chairs the NRC Committee on Research Needs for Transuranic and Mixed Waste at Department of Energy Sites. He has also served on the Board on Infrastructure and the Constructed Environment and was vice chairman for the U.S. National Committee on Tunneling Technology. Other positions held

were president, U.S. Committee on Large Dams; chair, Committee on Dam Safety, International Commission on Large Dams; executive committee, Construction Industry Institute; and the board of directors, Research and Management Foundation of the American Consulting Engineers Council. He has numerous professional affiliations, including fellowships in the American Society of Civil Engineers and in the Society of American Military Engineers. He holds a B.S. degree in civil engineering from the University of Minnesota, which awarded him the Board of Regents Outstanding Achievement Award.

G. Brian Estes is the former director of construction projects at Westinghouse Hanford Company, where he directed project management functions supporting operations and environmental cleanup of the Department of Energy Hanford nuclear complex. He was appointed as a member of this committee because of his experience with DOE, as well as other large-scale government construction and environmental restoration projects. He served on the committee that produced the recent NRC report *Improving Project Management in the Department of Energy* and has served on a number of other NRC committees. Prior to joining Westinghouse, he completed 30 years in the Navy Civil Engineer Corps, achieving the rank of rear admiral. Admiral Estes served as commander of the Pacific Division of the Naval Facilities Engineering Command and as commander of the Third Naval Construction Brigade at Pearl Harbor. He supervised over 700 engineers, 8,000 Seabees, and 4,000 other employees in providing public works management, environmental support, family housing support, and facility planning, design and construction services. As vice commander, Naval Facilities Engineering Command, Admiral Estes led the total quality management transformation at headquarters and two updates of the corporate strategic plan. He directed execution of the $2 billion military construction program and the $3 billion facilities management program while serving as deputy commander for facilities acquisition and deputy commander for public works, Naval Facilities Engineering Command. He holds a B.S. in civil engineering from the University of Maine, an M.S. in civil engineering from the University of Illinois, and is a registered professional engineer in Illinois and Virginia.

David N. Ford is an assistant professor of civil engineering at Texas A&M University. He serves as a member of this committee because of his expertise in evaluating project management with analytical methods and simulations. He researches the dynamics of project management and the strategy of construction organizations, as well as teaching project management and computer simulation courses. Current research projects include an investigation into the causes of failures to implement fast-track processes and the value of contingent decisions in project strategies. Prior to his appointment at Texas A&M, Dr. Ford was an associate professor in the Department of Information Sciences at the University of Bergen in Norway. He was one of two professors to develop and lead the

graduate program in the system dynamics methodology for 4 years. Dr. Ford's research during this time focused on the dynamics of product development processes and included work with Ericsson Microwave to improve that company's product development processes. Dr. Ford designed and managed the development and construction of facilities during 14 years in professional practice for owners, design professionals, and builders. The projects varied in size and facility type, including commercial buildings, residential development, industrial, commercial, and defense facilities. He serves as a reviewer for the journals *Management Science, Journal of Operational Research Society, Technology Studies,* and *System Dynamics Review*. Dr. Ford received his B.C.E. and M.E. degrees from Tulane University and his Ph.D. from the Massachusetts Institute of Technology in dynamic engineering systems.

G. Edward Gibson is an associate professor of civil engineering, associate chairman for architectural engineering, and the Fluor Centennial Teaching Fellow in the Construction Engineering and Project Management program at the University of Texas at Austin. He serves as a member of this committee because of his expertise and research in preproject planning, organizational change, and the development of continuing education training programs for project managers. His research interests include organizational change, preproject planning, construction productivity, electronic data management, and automation and robotics. Dr. Gibson heads up the owner/contractor work structure thrust area of the Center for Construction Industry Studies funded by the Alfred P. Sloan Foundation. He received the Outstanding Researcher Award of the Construction Industry Institute (CII) for his pioneering work in preproject planning and is an author or coauthor of numerous articles and reports on this subject, including the CII *Pre-Project Planning Handbook* and the CII *Project Definition Rating Index* (PDRI). He also developed several CII education modules for continuing education and has taught over 125 short courses to industry in such areas as objective setting, team alignment, continuous improvement, preproject planning, and materials management. He received an M.B.A. from the University of Dallas and a B.C.E. and a Ph.D. in civil engineering from Auburn University.

Theodore C. Kennedy (National Academy of Engineering) is chairman and cofounder of BE&K, a privately held international design-build firm that provides engineering, construction, and maintenance for process-oriented industries and commercial real estate projects. Mr. Kennedy serves as a member of the committee because of his experience and expertise with the design, construction, and cost estimation of complex construction and engineering projects. BE&K companies design and build for a variety of industries, including pulp and paper, chemical, oil and gas, steel, power, pharmaceutical, and food processing. BE&K is consistently listed as one of Fortune magazine's Top 100 Companies to Work For, and BE&K and its subsidiaries have won numerous awards for excellence,

innovation, and programs that support its workers and communities. Mr. Kennedy is the chairman of the national board of directors of INROADS, Inc., and is a member of numerous other boards, including the A+ Education Foundation and the Community Foundation of Greater Birmingham. He is also a member of the Duke University School of Engineering Dean's Council and the former chairman of the Board of Visitors for the Duke University School of Engineering. He is the former president of Associated Builders & Contractors and the former chairman of the Construction Industry Institute. He has received numerous awards, including the Distinguished Alumnus Award from Duke University, the Walter A. Nashert Constructor Award, the President's Award from the National Association of Women in Construction, and the Contractor of the Year award from Associated Builders and Contractors. Mr. Kennedy has a B.S. in civil engineering from Duke University.

Michael A. Price is manager of education programs for the Project Management Institute (PMI), an international association of project management professionals that provides accreditation and training. He was appointed to this committee because of his experience and expertise in developing and evaluating project management training programs. Dr. Price is responsible for the development and implementation of operational plans for all PMI educational programs and initiatives, including accreditation of degrees in project management, selection and coordination of 150 public seminars annually, management of continuing education requirements and record keeping for 22,000 project management professionals, and identification of new educational products and programs to meet the learning needs of the global project management community. Previous to his present position, Dr. Price was director of professional practice for the American Institute of Architects (AIA) and director of programs for architecture and engineering with the Research Center for Continuing Professional and Higher Education at the University of Oklahoma. He is an active member of the AIA and has been a member of the Education System Audit Review Task Group and the site visitation team for the National Architectural Accreditation Board. Dr. Price has a B.S. in environmental design, a B. Arch., an M.Ed., and a Ph.D. from the University of Oklahoma.

APPENDIX C

Committee Fact Finding and Briefing Activities and Documents Reviewed October 2001 Through October 2002

FACT FINDING AND BRIEFINGS

2001

October 22 — Informal meeting with Bruce Carnes, director, Office of Management and Budget Evaluation (OMBE)

November 6 — Informal meeting with Robert Card, under secretary, DOE

November 13 — Government/industry forum on the owner's role in project management and preproject planning, Washington, D.C.

Robert Card, under secretary, DOE
Bruce Carnes, director, OMBE
Edward Merrow, president, IPA, Inc.
James Porter, vice president, E.I. du Pont de Nemours and Company
Steven Harker, project benchmarker, Weyerhaeuser Corp.
Joe Gregory, projects coordinator, ChevronTexaco

November 13-15 — Committee meeting 6, Washington, D.C., Review of project management and contracting reforms and improvements in project planning and project manager knowledge, skills, and abilities (KSAs)

Office of Management and Budget Evaluation
Jim Rispoli, director OECM
Office of Science
Patricia Dehmer, associate director, Office of Basic Energy Science
Iran Thomas, deputy associate director, Office of Basic Energy Science
Jim Carney, engineer, Construction Management Support
National Nuclear Security Agency
Lowell Ely, engineer, Office of International Cooperation
Edwin Wilmot, engineer, Defense Programs
Joel Leeman, engineer, Defense Programs
Dennis Miotla, director, Office of Facilities Management
Shaa Jaghoory, engineer, Office of Facilities Management
Roland Frenck, engineer, Project Management and Engineering Support
Environmental Management
James Owendoff, director, Office of the Assistant Secretary
Scott Van Camp, hydrologist, Project Completion
Steve Meador, engineer, Office of Site Closure
Marvin Garcia, engineer, Office of Project Management

Mike Goddu, GHJ Consulting, Management culture at DOE

2002

February 5-7 Committee meeting 7, Oakland, California, Project management policies and procedures and process improvement

Oakland Operations Office (OAK)
Camille Yuan-Soo Hoo, manager, OAK
Barry Savnik, lead engineer, Engineering & Facilities Management
John Gonzales, director, Engineering & Facilities Management
University of California (UC) Lab Administrator's Office
Buck Koonce, director, UC
DOE, Stanford Site Office (SSO)
Hanley Lee, engineer, SSO
Ev Valle, engineer, SSO
Stanford Linear Accelerator Center (SLAC)
John Muhlestein, director, SLAC
Jonathan Dorfan, director, Linac Coherent Light Source

- Lowell Klaisner, engineer, Large Area Space Telescope
- William Althouse, engineer
- David Burke, SLAC, Next Linear Collider

NNSA, Livermore Site Office (LSO)

- Mike Hooper, assistant manager for national security
- Sam Brinker, engineer, NNSA, Terascale Simulation Facility (TSF)
- Barry Williams, engineer, NNSA, Energetic Material Processing Center (EMPC)
- Sam Brinker, engineer, NNSA, Tritium Facility Modification (TFM) (originally called the Hydrogen Isotope Research Capability (HIRC))
- Anita Martin, engineer, NNSA, Sensitive Compartmented Information Facility (SCIF)
- Barry Williams, engineer, NNSA, Engineering Technology Complex Upgrade (ETCU)
- Scott Samuelson, NIF federal project manager, National Ignition Facility (NIF)

Lawrence Livermore National Laboratory (LLNL)

- Bernie Mattimore, deputy assistant director for laboratory services, Jim Brady, director, Projects Division
- Bob Logan, program manager, Parson's Infrastructure & Technology Group Incorporated
- Roy Neyer, engineer, TSF
- Mark Sueksdorf, engineer, EMPC
- Rick Visoria, engineer, TFM
- Roger White, engineer, SCIF
- Mark Sueksdorf, engineer, ETCU
- Ed Moses, project manager, NIF

DOE, Berkeley Site Office (BSO)

- Dick Nolan, director, BSO
- Joe Krupa, institutional manager, BSO
- Barry Savnik, engineer, BSO, Molecular Foundry
- Kathy Johnescu, engineer, BSO, Building 77 Rehabilitation Phase 2, Research Support Building and Building 62 Rehabilitation

Lawrence Berkeley National Laboratory (LBNL)

- Charles Shank, director, LBNL
- Sally Benson, deputy director, LBNL
- Kem Robinson, project integration and management officer, Super Nova Acceleration Probe (SNAP)
- James Krupnick, engineer, Molecular Foundry

Bob Camper, head, LBNL Facilities Department, Building 77 Rehabilitation Phase 2, Research Support Building and Building 62 Rehabilitation

March 19-21 Presentation and participation in DOE/OECM annual project management workshop, Arlington, Virginia

April 2 Informal meetings with John Gordon, under secretary, NNSA; Jessie Roberson, assistant secretary, EM; Robert Card, under secretary, DOE

April 3-5 Committee meeting 8, Washington, D.C., Roundtable discussions with EM, SC, NNSA, and OECM

Session 1—Current status of strategic and front-end planning and process improvement initiatives

Session 2—Current practices in risk assessment and risk management, and lessons learned from ARM pilot projects

Session 3—Revisions to O 413.3 and field response to policy directives

Session 4—Implementation of PARS and its application for project management and oversight

Bruce Carnes, CFO, director, OMBE, DOE policy and management initiatives

Jay Rhoderick, EM Project Management Support Office, Environmental Management update (top-to-bottom review, new administration, project management process improvement, project data CD-0 through CD-2)

Dan Lehman, director, SC Construction Management Support, Office of Science update (process improvement initiatives, project data CD-0 through CD-2 recent project reviews and ESAAB approvals, lessons learned from NuMI and SNS)

Willie Clark, director, NNSA Project Management Support Office, Defense Programs update (Stanford survey, process improvement, recent project reviews and ESAAB approvals, project data CD-0 through CD-2)

James Rispoli, director, Office of Engineering and Construction Management, OECM update (administration and staffing, 2002 workshop and awards, professional development and training, project oversight initiatives)

Dave Treacy, engineer, OECM, Revised Program and Project Management Manual

June 4-6	Committee meeting 9, Oak Ridge, Tennessee, Briefings and discussions Oak Ridge Operations Office (ORO) Gerald Boyd, ORO assistant manager, Environmental Management Judith Penry, CFO, Office of Assistant Manager, personnel and personnel training resources Robert Brown, assistant manager, Assets Utilization, acquisition strategies for restoration projects Jack Howard, engineer, Office of Assistant Manager, acquisition strategies for restoration projects Les Price, SNS federal project manager, role of the federal project manager Spallation Neutron Source Project Office (SNS) Thom Mason, SNS project director, Spallation Neutron Source (SNS) Barry Miller, director of procurement, SNS, innovative procurement George Malosh, assistant manager for laboratories, ORNL/SC issues Jeff Smith, deputy director for operations, ORNL, ORNL/SC issues: SNS management team, lessons learned (front-end planning, project control systems, scope to cost, contractor resources, training) Asa Kelley, BWX Technologies, Y-12, Improving Project Management Capabilities, Bill Brumley, manager, Y-12 site office, tours of BNFL project to dismantle, remove, and decontaminate the process equipment and support systems materials within K-33 and related gaseous diffusion plant buildings and the SNS construction site
July 16	Informal meetings NA-54, SC-80, and EM-6 project management support personnel
July 22	Informal meetings for progress updates with James Rispoli and OECM staff; James Decker and Daniel Lehman, SC; Everitt Beckner, Dave Beck, Dave Crandall, Greg Rudy, Willie Clark, and Roland Frenck, NNSA; Bruce Carnes, OMBE; and Paul Golan, EM

October 15-17 Committee meeting 11, Richland, Washington, Briefings to the committee and roundtable discussion of current project management issues (implementation of O 413.3, project definition for EM activities, professional development and core competencies, front-end project planning, risk analysis and management, EVMS and tracking project data, performance based contracting, etc.)

Richland Operations Office (RL)
- Wade Ballard, assistant manager for planning and integration, RL, overview of RL management culture and project management policies and procedures
- Gene Higgins, director of special initiatives, RL, RL performance-based management
- Beth Bilson, assistant manager, overview of River Corridor Project
- Jim Goodenough, lead engineer, project integration team and team training
- Mike Schlender, deputy manager, RL, closeout discussion

Office of River Protection (ORP)
- Leif Erickson, deputy manager, ORP, overview of ORP management culture and project management policies and procedures
- Matt McCormick, supervisory engineer, the River Corridor contract and contract transition, waste treatment plant project management
- Bill Taylor, assistant manager for project delivery, ORP integrated project management
- John Swailes, assistant manager, systems requirements, Tank Farm contract, performance-based project management

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APPENDIX D

Characteristics of Effective Owners' Representatives

In the private and public sector, projects that are managed well and perform well have effective owners' representatives, typically called project managers. The following are the committee's view of some of the attributes and functions that make owners' project representatives effective (NRC, 1998, 2000).

An effective owner's representative (or project manager) has the following traits:

- Appropriate skills, experience, training, and managerial and technical ability to plan, guide, evaluate, and direct the project acquisition process.
- Good communication skills.
- Rapport with, and open communications channels to, the owner's executive management. Can get the attention of upper management when decisions are needed.
- Sufficient authority, stature, and management support in the owner's organization to carry out all project management responsibilities without ambiguity or interference.
- Good rapport with, and open communications channels to, the end users of the project. Can get their attention and get them to make decisions when needed.
- Decisiveness. If additional information is needed to support a decision, takes steps to acquire it, sets a commitment date to make the decision, then makes the decision on time. Does not procrastinate. Does not second-guess decisions once made.

An effective owner's representative (or project manager) understands:

- The contract and all its provisions. Knows the limits of the contract and what constitutes constructive change.
- The owner's mission or business model and how the particular project is justified by it, fits into it, and supports it.
- The value of the project, not just its price. The price is what the owner pays for the project; the value is what it is worth.
- Costs and the factors that affect costs. Understands the dangers of scope creep and how the costs of seemingly minor changes increase geometrically with the state of completion of the project.
- The contractor's value proposition and business model; understands how contractors make money, how contractors think; what is easy for contractors and what is difficult. This does not imply that owners' representatives should adopt the contractors' viewpoint, only that they should understand it.
- The owner's and contractor's project objectives—how they are the same and how they are different.

An effective owner's representative (or project manager) can perform the following functions:

- Set up an integrated project team from the beginning and uses it effectively.
- Assure that the owner and the contractors perform adequate preproject planning.
- Develop plans and supporting information as necessary at all decision points.
- Serve as the single point of contact between the owner's organization, including users, and the contractors. Take responsibility for all owner activities. Face up to responsibility.
- Keep the focus on maximizing the owner's value through high quality, excellent performance, and early completion, as well as on holding costs to the budget.
- Design and implement means of meeting shared objectives to increase project value but defends owner objectives when decisions or actions will impact the owner and contractor differently.
- Perform a risk assessment for the project and develop a risk management plan. Identify the significant risk drivers or root causes and actively take steps to eliminate, mitigate, or manage these risks. Update the risk assessment and risk management plan and continue to manage risks actively throughout the project.
- Determine and control the management reserve (or owner's contingency).
- Solicit input from stakeholders as relevant to the project—citizens' groups, abutters, and others affected by the project. Work with these groups to prevent misunderstandings, making decisions as necessary to avoid escalation of dis-

agreements and the development of adversarial relations. Take a genuine interest in obtaining these inputs and preventing and resolving potential conflicts.

- Develop a project execution plan, maintain the plan up to date, and communicate it to all concerned. Set up clear, objective performance metrics for performance-based contracts. Avoid the use of award fees based only on subjective criteria, attractive as they may seem.
- Accept responsibility for all actions and omissions of the owner's organization. Maintain a commitment tracking system or other schedule of the owner's commitments, such as obtaining permits and sign-off on drawings, specifications, change orders, etc. Follow up to make sure that both the owner's and the contractors' commitments are met.
- Advise the owner's organization about the impacts of potential owner decisions on project value, on project performance in all relevant dimensions, and on contractors.
- Know the status of the job at all times. Monitor and track contractors' performance. Stay up to date on project problems and issues. Track the schedule performance and cost performance indices (SPI and CPI).
- Work actively to complete the project as fast as economically possible.
- Continually forecast the expected date at completion, the cost to complete, and the estimated cost at completion. Take timely and effective steps to get the project back on schedule and on budget when any deviation is forecast.
- Assure that the owner's personnel are trained and prepared to accept turnover of each system or building of the project promptly on completion. Track the to-do (punch) lists of incomplete items and their impact on the start-up schedule. Close out the project in a timely fashion. Assure that retainage and incentives are paid promptly on acceptance.
- Make the owner's expectations clear and open to all contractors.
- Build in incentives wherever possible for contractors to increase the owner's value. Recognize that it is in the owner's interest to award incentives for exceptional performance that advances the owner's value proposition.
- Maintain win-win relations between the owner and the contractors.
- Take steps to assure that the real costs and schedule impacts of changes, including the nonlinear ripple effects that can propagate through the entire project, are realistically evaluated before change orders are approved.
- Visit the site often. Be widely recognized on the site ("walks the talk"). Convey the owner's commitment to the job, to the schedule, and to the budget.
- Give directions only to the contractors' designated project managers or site representatives. Do not give direct orders or suggestions to other contractor personnel except in cases of severe safety violations and imminent loss of life, limb, or property.

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APPENDIX E

Key Questions for Readiness to Proceed

INTRODUCTION

Critical decisions depend on asking the right questions during readiness reviews. The committee notes in its 2001 assessment report and in this report that it is important for managers to ask the right questions and not allow projects to proceed until these questions have been adequately addressed. Assumptions that things will go well are inadequate. There is no uniformly correct answer, but the manager charged with making a critical decision should be satisfied that the project team has addressed each issue and has developed an answer with enough certainty to allow the project to proceed with reasonable confidence. The lists of questions that follow are intended as a guide to preparing for and making critical decisions.

PROJECT ORGANIZATION

Project Execution Plans

The Project Execution Plan (PEP), including the Project Risk Assessment and Risk Management Plan, should identify the planned actions and solutions to all risk factors to be considered by the project manager. Questions that specifically address the adequacy of risk management procedures are discussed in the risk management section.

- Is there a PEP?
  - — If not, when will it be completed? An acceptable PEP should be the sine qua non for approval to move forward with the project. Without an acceptable PEP, the project is undefined.
- Is there a Project Procurement Plan?
  - — Does it cover expediting? It may be necessary to expedite procurements on the project critical path.
  - — How many viable suppliers and contractors are available for major systems and components? If there is an inadequate number of suppliers or contractors, the project is at risk and steps should be taken to broaden the logistic base and strengthen the supply chain. This is one reason that delegating the development of PEPs to contractors may lead to conflicts of interest.
  - — Are there alternative or backup plans in case the supplier of a major component fails? The difference between a contingency plan and a contingency allowance is that a contingency plan provides the basis for assurance that the failure of a major supplier does not severely impact the project (i.e., it addresses developing alternative suppliers), whereas a contingency allowance merely provides funds to cover the additional costs if a supplier does fail. DOE PEPs typically emphasize contingency allowances to pay for risks if they occur rather than contingency plans to prevent the risks from occurring.

Integrated Project Team

Late assignment of critical personnel to the integrated project team is one of the most common causes of project delays in the front end—delays that can never be recovered. Projects often try to recover delays at the end, when reducing delivery time is very expensive, or even impossible.

- Is the experience of the project team consistent with the size and complexity of the project? Experience has shown repeatedly that experience on small, run-of-the-mill, and virtually risk-free projects is not suitable preparation for managing large, complex, and risky projects.
- Have appropriate members of the integrated project team received project management training or certification? Project management is a profession, and the managers of large DOE projects should be professionals.
- Has the team worked before on similar projects? People who have worked together previously will progress up the learning curve much faster. If they have not, additional time for team building should be allocated at the beginning (or, rather, before the beginning).
- What is the turnover rate of the project team? High turnover means changes in direction and indecision. Major projects require consistency.

High turnover of managers is a symptom of poor management and a sure recipe for project failure.

- Is there an employee motivation plan to maintain the morale of the project team over the long term of the project? At the beginning of a project, everyone is optimistic and enthusiastic. Nevertheless, the project needs to plan for motivating the project members when, inevitably, things do not go well.
- Has the Integrated Project Team (IPT) been identified?
  - — If not, when will it be named? Naming of the project team should be a requirement for moving the project forward.
  - — Are the members of the IPT assigned full time to this project? There is a tendency for personnel assigned to new projects to continue working on their old projects. This is detrimental to the success of new projects, where getting the right start in the preplanning process is critical.
  - — If not, how many are full time on the project?
  - — When will all members of the IPT be full time?
  - — How many times has the IPT team met face to face? Successful team building requires face-to-face contact, not just e-mail. If the IPT has not met several times, the project is not ready to proceed.

Project Organization

The Work Breakdown Structure (WBS) defines the assignments of project team members and the activities that they will be held accountable for. The WBS defines the project, and it should specifically include all activities related to resolution of uncertainty and risk mitigation, even if some of these activities are contingent. Note that the depth to which the WBS is defined increases over time. Without a WBS, the project remains undefined.

- Is there a WBS, including all R&D, simulation, and prototyping activities, if any? Does the WBS match the organization chart? For successful project management, the organizational breakdown structure and the work breakdown structure should be in alignment. If they are not, insufficient thought has been given to the project to permit it to proceed.
- Does the WBS match the reporting structure? See comment just above.
- Is there a WBS dictionary? There should be, so that all project participants understand the WBS.
- Is the WBS established down to (depending on the time of the decision):
  - — Level 0 (agency)?
  - — Level 1 (total project)?
  - — Level 2 (major systems milestones)?
  - — Level 3 (systems and components)?
  - — Level 4 (reporting)?

- Is the WBS broken down by system or by area? The WBS evolves with time. The initial project specification and engineering design may be broken down by system. Then, construction activities are broken down by area. Finally, start-up and testing activities are again broken down by system and function.
- Does each Level 3 item have an assigned manager? Responsibility and accountability should be assigned based on the WBS.

Cost Estimates

Cost estimates are at the core of project planning. When reviewing estimates it is important to recognize the facts and assumptions that they are based on and the degree of certainty of these facts and assumptions.

- Is there a top-down cost estimate? The top-down estimate is based on previous history, experience, records, and perhaps statistical analyses of similar projects, corrected and adjusted to the conditions of the present project. It is, in effect, benchmarking of this project against others.
- What is the confidence level in this estimate? Point estimates are never adequate, and they are particularly inadequate when dealing with top-down estimates.
- Is there a bottom-up cost estimate? The bottom-up estimate is prepared from the engineering design.
- If not, when will it be completed? The engineering cost estimate will be refined over time as the design is developed, quantities developed, and bids received.
- What is the level of confidence in this estimate? The confidence band should depend on the level of refinement.
- Do error bars or confidence limits indicate the uncertainty in all cost estimates? The establishment of confidence bands is essential to a decision to proceed. There is no reason why a DOE senior manager should have more confidence in the cost estimate than the estimators have, and the decision maker should demand to see evidence of this confidence.
- Is the cost estimate integrated with the schedule? If not, why not? Integrated cost estimates and schedules have been industry best practice for 20 years and are essential for the application of an earned value management system (EVMS). A project that states that it is in compliance with O 413.3 with regard to EVMS but does not have a cost-integrated schedule is not ready to proceed.
- Has there been a cost contingency analysis? This is related to the Project Risk Assessment and Risk Management Plan, which should be part of the PEP. Without it, there is no rational basis for setting the contingency. If not, when will it be performed?

- What are the cost contingency and/or the management reserve? The purpose of having a contingency should be explicitly defined. Then the amount of the contingency should be adequate to achieve this purpose. Contingency funds should cover contingencies and should not be just another way to increase the project budget.
- Who controls the contingency and/or the management reserve? More important than the amount of the contingency is who controls it. The manager who controls contingency should be held accountable for it. Contingency should be controlled at a level high enough in the project organization that its purpose can be achieved.
- Has there been a schedule contingency analysis? See comments just above regarding budget contingency. If not, when will it be available?
- What are the schedule contingency and/or management reserve?
- Who controls the schedule contingency and/or the management reserve?
- Who controls the technical performance contingency? Although in industry best practice technical performance and scope are considered to be fixed objectives, it appears that some DOE projects explicitly treat cost as fixed and use project scope and technical performance as contingency. The committee does not endorse this approach, because a project cannot possibly be essential to the mission of the agency if its scope and performance are variables. The decision maker should know when this is happening; it may be grounds for project termination.

Constructability and Value Engineering

Constructability is an important aspect of cost and schedule control. Lack of a constructability evaluation should be considered evidence of low confidence in the cost and duration estimates. Value engineering examines design alternatives to identify those that will achieve the project objectives most efficiently.

- Has a constructability analysis of the proposed (conceptual, preliminary) design been performed?
  - If not, when will it be performed?
  - How many constructability analyses are planned and at what points? Constructability analyses may be desirable as the design is developed and refined. Constructability analysis should not be skimped on to save money; in virtually every case, a well-done, independent, and objective constructability saves far more money than it costs.
- Has a value engineering study been performed? Value engineering is explicitly required by O 413.3.
  - If not, when will it be done?
  - How many value engineering studies are planned, and at what points?

- Are the results of the value engineering studies and constructibility analyses fed back into the engineering design process? Are they then fed back into the cost estimation and project scheduling process?

Change Control

Change control is an area in which DOE projects have been notably poor. DOE project managers have often left change control to the contractors. Whoever controls changes, controls the project.

- Has a configuration management system been set up? If not, when will it be operational?
- Has the Change Control Board (CCB) been established? If not, when will it be operational? A CCB is required by Order O 413.3. No project should proceed without one.
- Does the CCB control design scope and all changes to the baseline technical specs and reserve margins on performance? It should. If not, who does?
- Does the CCB control the cost contingency and allocate contingency to changes? It should. If not, who does?
- Does the CCB control the schedule contingency? It should. If not, who does?

Reporting and Controls

Cost tracking for EVMS is not the same as project accounting, and accounting systems are generally incapable of providing cost data on a timely, accrual basis.

- Has a commitment tracking system been established to track and control commitments to peer review boards, outside advisors, regulators, etc.? If it has not, it is certain that some commitments will be missed, to the detriment of the budget and schedule, if not to the project's overall success.
- Has an EVMS been established? If not, when will it be in place? It is a fallacy that earned value applies only to construction activities. It should apply to engineering, design, procurement, planning, and other project activities as well. If a project is not tracking earned value, how does the project manager know where the project is with respect to scope, time, and cost?
- Is there a project management control system in place to track all costs and earned value? The successful use of EVMS depends on timely reporting—accurate insofar as possible, but in any case *timely*. Note that the function of an EVMS implementation should not be just to document the past and what went wrong with the project, but to predict the future in time to do something about it.

- If not, when will it be in place? Are costs reported on an accrual basis as required by EVMS? Accrual-based cost reporting is essential.
- Are all contractors and subcontractors capable of supplying timely, accurate cost and progress data to roll up in EVMS? This point requires specific management attention, as some contractors may be inclined to promise what they cannot deliver. After the contract is signed it is too late to ask this question.
- Are costs collected at Level 5 of the WBS? If not, at what level are they collected? Any other level may require subjective judgment, and this should be questioned.
- Is the cost estimate fully integrated with the schedule? (The effective use of EVMS requires this integration.)
- Is progress reported against activities in the network schedule consistent with the costs in the WBS? EVMS requires reporting of the budgeted cost of work performed (the earned value) compared with the plan (the budgeted cost of work scheduled.)
- Are all technical performance parameters tracked and reported? In DOE projects, it is just as important to track performance and scope parameters relative to mission requirements as to track costs. DOE management should be continually aware of the ability of a project to fulfill its mission. In the past, DOE had a record not only of projects overrunning their budgets, but also of projects that had no use when they were completed.
- Is the contingency used or allocated tracked through the project? There should be a mechanism (configuration management) for tracking and reporting the release of contingency funds.
- Is the remaining unallocated contingency reported? The project manager should be able to know how much contingency is left and who controls it.
- Are the floats of all activities off the critical path controlled? Much attention is focused on the critical path. It is necessary to assure that this focus does not lead to some other path becoming critical.

Readiness

It is astonishing how many projects that push for early funding decisions turn out to be unprepared to start when the funding is approved. Consequently, they start behind schedule and then try to catch up. Management should determine whether all the prerequisites (the IPT, other project members, etc.) are in place for immediate startup when the project is authorized, and whether the project is capable of meeting the approved spending profile, before funding a project or even recommending a project for funding.

- Is this project ready to begin when funded?

Start-up and Operations

Operational factors are prime causes of uncertainty and performance failures.

- Have all operational factors and issues been identified in the Project Execution Plan and the Project Risk Management Plan?
  — For some critical systems?
  — For most systems?
  — For all systems?
- Is there a start-up and turnover organization? This should be established early in the project. It is not acceptable to have spent millions, even more than a billion dollars, before determining who will be responsible for operations and maintenance of the completed facility.
- Are representatives of the operational users and of the start-up and turnover organizations active participants in the IPT? Have they participated in risk identification and assessment studies? Project risk covers not only the risks of not meeting budget and schedule but also the risks of not meeting operational requirements.
- Have start-up issues been identified and a start-up plan initiated? The start-up plan controls the work breakdown structure in the start-up and turnover phase. In this phase, it is necessary to be able to measure progress not by quantities of materials installed but by completion of items on the punch lists required for system completion and turnover.

RISK MANAGEMENT

Critical Questions for Managing Risk

Every project has a unique set of factors that may or may not increase cost, delay schedules, and reduce the end performance of the project. The factors need to be identified and understood and steps taken to minimize any impact they have on the project.

- Have major risk factors and events been identified?
- Have all risk factors affecting technical performance, cost, and schedule been identified?
- How many risk factors are there in each category?
- Has a probabilistic risk assessment or a failure modes and effects analysis been performed? If not, one should be performed. It should also be kept in mind that the purpose of this exercise is not to compute the probability that the project will fail, but to use probabilities to prioritize the risks to be eliminated, mitigated, or managed so that the project does not fail.

- Have all moderate risk factors been identified? (See above for major risks.)
- Have all minor risk factors been identified? The purpose of identifying minor risks is to be sure they are minor and do not have to be mitigated.
- Have common causes or root causes (common mode failures) been identified? This is a major deficiency in DOE project risk assessments, in which typically all risks are assumed to be independent of each other. Insofar as this is untrue, the risk analysis is not conservative enough.
- Has a risk management plan been prepared for all the significant risk factors? It is the function of DOE management to assess whether project risks are acceptable. If not, when will it be prepared?
- Does the risk management plan have an item that lists specific actions to eliminate, reduce, or mitigate each risk factor? Without an action plan, the risk assessment is an academic exercise.
- Has the project manager signed off as accepting responsibility for the risk management plan?
- Is it recognized that the risk assessment plan is a continuous process, not a product? Some provision should be made for continual review and updating of the risk assessments.

Technology Risks

Some issues related to technological decisions may need research and development to resolve uncertainties about performance, efficiency, reliability, and other risks. DOE has often used major capital acquisition projects as R&D projects, to determine whether the technology will work after being scaled up by orders of magnitude.

- If technology is a potential risk factor, have alternatives solutions or suppliers been identified for all technologies, processes, and systems with high or moderate risk factors? As in many other areas, diversification is one effective way to mitigate risks.
- Is there a backup plan, alternative plan, or a "Plan B" for every major technical, scientific, or engineering issue? In the past, DOE has locked in on one technology before it was proven to work. Even the Manhattan District had two technical alternatives (uranium and plutonium) to improve the probability of success. Effective project management requires planning for the case that all the optimistic scientific projections do not turn out to be correct.
- How far are these alternatives carried in parallel through the design process? A budget should be provided for carrying parallel designs or technology development, because having technological options increases project value.

- At what decision point will alternatives be selected or eliminated? These decision points should be identified beforehand, in the PEP. They will probably be developed by working backward from the required project delivery date to the latest time by which a decision must be made to avoid delaying completion.
- Has all the information necessary to making a technological decision been identified?
- Have all the technical challenges and/or issues needing research and development been identified, in order to eliminate, to mitigate, or to reduce risks to acceptable levels?
- Have these risks been documented system by system?
- Is the necessary R&D program under way? It is prudent to perform the necessary R&D prior to commitment to a capital acquisition.
- If not, when will it start? When will it finish?
- Will all the R&D issues be resolved prior to the critical decision points? Give a schedule for resolution.

Prototypes, Pilots, and Bench-Scale Tests

Prototyping is one effective way to resolve risks prior to commitment to a full project. Cutting the budgets for prototyping is not a cost-effective method. DOE management should assure at critical decision points that sufficient prototyping or R&D has been completed to support the decision to proceed.

- Have prototypes been identified and built where needed to resolve questions (risks) concerning project solutions? If not, when?
- Are these bench scale or laboratory scale?
- Are these prototypes pilot plants?
- What is the scale-up factor from the prototype to the real system? Is this scale-up reasonable? How does risk increase with scale-up factor?
- Will the prototype resolve all the outstanding technical issues prior to the critical decision points? Provide the schedule for resolution.

Regulatory Risks

Regulatory requirements should, for the most part, be predictable. Managers need to identify which regulatory agencies and which regulations will be applied to the project.

- Have environmental, safety, and health issues been identified?
- Have public relations issues been identified and a public affairs office established?

- Have all regulators been consulted about possible regulatory issues and delays with the project? Regulatory issues are important in EM projects and may become more important for all DOE projects.
- Are important regulators part of the working IPT? Regulators should be involved with the project from the start. That is, regulators should be considered part of the project, not external to it.
- Are regulatory decision points identified on the project schedule? It is not adequate to simply assume in making a schedule that regulatory decisions will be made automatically.
- Are regulatory decision points on the project critical path?
  — If so, why?
  — Are there alternatives?

Schedule Risks

- Are there backup plans in case of regulatory difficulty?
- Is there a Level 0 network schedule (in addition to bar charts or Gantt charts)?
- Is there a Level 1 network schedule? If not, when will it be available?
- Is there a Level 2 network schedule? If not, when will it be available?
- Is there a Level 3 network schedule? If not, when will it be available?

QUESTIONS FOR FIRST-OF-A-KIND PROJECTS

First-of-a-kind projects are usually inherently riskier, but sometimes risky projects need to be approved—as long as they are managed accordingly. Before making critical decisions senior managers should ask critical questions to ensure that there has been sufficient planning to consider all risks and sufficient analysis to manage them. Some questions that management might wish to pose, especially for first-of-a-kind projects, are these:

- Have all the necessary technical specifications been identified?
- Are all the technical specifications complete? If not, for how many systems are the technical specifications complete?
- What is the percentage of completed technical specifications (of all systems)?
- Have all systems been identified?
- What is the likelihood that new systems will be added?
- What is the likelihood that the technical specification will require rework, iteration, and recycling through the approval channels?
- Is there demonstrated adequate reserve margin in project technical performance specifications?
- Who controls the technical performance reserve margin?
- What is the recovery plan in case there are performance shortfalls?

Simulation Models

- Is there a simulation model for project performance? If not, should there be one?
- What questions should the simulation model address? How long would it take to develop and when would results be available?
- Will the simulation assist in understanding the outstanding technical, cost, or duration issues prior to the critical decision points? Give a schedule for resolution. (To be useful, results should be obtained prior to the scheduled date of a decision that depends on those results.)
- Is this model based on firm and well-understood scientific principles, or on speculation and subjective judgments?
- Has this model been used to address what-if questions?
- Has there been a sensitivity analysis of the impacts of project technical performance shortfalls?
- How long should alternatives be carried on in the project?
- How often and by whom will reviews and analysis of the critical parameters values be evaluated?
- What should be done in case of performance shortfalls?
- What is the highest degree of uncertainty that allows proceeding to the next phase?

CONCLUSIONS

Projects have been conducted in which serious problems could have been avoided if DOE management had asked some critical questions—often simple ones. DOE managers should consider asking some of the questions outlined above at critical decision points, to avoid unanticipated delays, costs, or other obstacles to completing the project successfully, and to ensure that projects are truly ready to proceed.

Appendix F

Building Flexibility into Projects to Manage Uncertainty

Many potentially critical factors can introduce uncertainty into the design, construction, and management of DOE projects. These factors range from technical challenges inherent in research and development, to design and construction, challenges imposed by regulatory aspects and third party influence, and challenges emanating from changing conditions over the lifetime of extended projects. Managing this uncertainty calls for integrating flexibility into project management. This flexibility is particularly needed when an uncertain condition can generate an outcome that should be avoided (e.g., large costs) or captured (e.g., improved performance). One way to achieve flexibility is through developing alternative options.

An option is a right to take action without an obligation to take specific actions or to change strategies. Options add value by allowing managers to shift risk or capture added value, depending on how one or more uncertain parameters behave. For example, a contract clause permitting termination of a contract if a critical technology is not developed provides an opportunity (but not an obligation) to terminate. An options approach also inherently improves strategic thinking and project planning by helping to recognize, design, and use flexible alternatives to manage uncertainty.

Delaying commitment to a strategy until sufficient information becomes available to resolve the uncertainty is an example of managerial flexibility. An example could be a project manager recognizing that the cost and development of a specialized component depends on the design expertise of a particular vendor. The depletion of that vendor's capabilities could increase costs beyond the budget limits, constrain development of the component, or both. Alternative options are

needed that would ensure design performance or mitigate the effects when a vendor's capabilities depleted. One option might be to guarantee the continued employment of critical employees.

The use of an options approach is premised on specific rules for implementation that describe the conditions that would trigger a change in strategy. The process includes continued monitoring of the uncertain parameters, evaluating their status and impact, and changing strategies if alternative options are warranted. This should be a proactive not a reactive process.

Options in procurement for the National Ignition Facility (NIF) have been used to manage uncertainty. The following description illustrates how this has been done. The current managers of the NIF project use options (although they do not typically use that term) to manage many of the large uncertainties inherent in the project. The LLNL project manager attributed the management team's frequent use of flexibility (including options) to their focus on project objectives instead of specific solutions. This allows managers to identify multiple potential strategies to achieve success. These strategies or scenarios were used to design options. Several principles for managing uncertainty guided procurement for NIF. Examples were having two or more vendors for all major components to reduce the risk of a sole supplier inflating prices and avoiding a manufacturing role for LLNL to reduce the risks of uncertain project funding and schedules. LLNL contributed its strength (scientific expertise and funding) and focused vendor efforts on their strengths (technology development and manufacturing).

The laser glass production strategy for NIF illustrates the use of options to address a common but important acquisition question: How many parallel development efforts should be supported? More than $350 million will be spent to produce more than 3,000 pieces of laser glass, weighing about 150 pounds each. Laser glass begins as slabs of very high quality glass called "blanks." The large volume of blanks and the project schedule and budget required a production rate 30 times faster and 5 times cheaper than had been demonstrated on prototype lasers, necessitating the development of a new glass production technology and manufacturing facilities. Because glass vendors could not justify funding the development of glass production technology, the project itself invested in this technology. The development of a high-volume, continuous-melting glass production process included two critical uncertainties—whether the technology could make the glass and whether the quality of the glass would be acceptable. The threat posed by these uncertainties was that if development efforts failed in either way, the project could be delayed too long to meet its deadline and would incur very high unbudgeted costs. Although LLNL had established relationships with experienced laser glass vendors, none could guarantee successful development a priori. Therefore, it became clear during laser glass procurement planning that alternatives to a one-vendor strategy should be considered. LLNL considered two types of procurement strategy for glass production technology development. A base strategy was to invest in a single production development effort, helping

the manufacturer where possible and hoping for a successful development. An alternative strategy would simultaneously invest in two independent development efforts by two glass producers, increasing the likelihood that at least one effort would be successful. This strategy allowed LLNL to avoid the consequences of having no successful glass production system if only one effort was successful. The cost of the basic strategy is the cost of investing in one vendor (approximately $12 million). Investing in multiple vendors would purchase opportunities to proceed with successful vendors at two or more points in time, when each uncertainty was resolved. The option costs are the funds required to invest in a second vendor up to the uncertainty resolution times (approximately $12 million each). The flexible strategy uses two options to abandon an unsuccessful vendor when the technology feasibility and glass quality uncertainties are resolved.

NIF managers considered the two-vendor strategy attractive for both economic and noneconomic reasons. The following factors were considered. If a single vendor was selected the development might succeed. But if the single vendor failed, the costs to the project in time, money, and political consequences would prevent the project from meeting its targets. In contrast, if two vendors were selected, none, one, or two could succeed. The likelihood of two failures was considered low. One success would allow NIF to exercise its option by abandoning the unsuccessful vendor, and two successes would provide manufacturing and pricing flexibility in addition to meeting minimum needs. The avoided costs of project failure if investments were made in two vendors were informally estimated to greatly exceed the additional cost of investing in a second vendor (0.5% of the project budget). Therefore, the option was considered more valuable than its cost. Based on this reasoning, DOE and LLNL contracted with two vendors to support parallel development efforts.

The uncertainty about the technology's viability was resolved in early 1999, when both vendors successfully produced pilot runs of glass using a continuous-melting process. Largely because of the remaining uncertainty surrounding the quality, NIF chose to not abandon either vendor. Uncertainty with regard to quality was resolved near the end of 2000, when both vendors demonstrated the ability to generate the required glass quality. Because both vendors succeeded, NIF purchased valuable production and pricing flexibility that can help manage other project uncertainties (e.g., schedule).

CONCLUSIONS

DOE has used flexible project management strategies to manage highly uncertain projects. Successfully managing uncertain project conditions requires a proactive approach that models multiple possible conditions, forecasts the outcomes of potential actions, and guides managers as the project develops. A proactive approach includes plans for specific actions that will be taken based on

specific future conditions and does not merely react to conditions after uncertainty has been resolved.

In 1997, the National Ignition Facility Risk Management Plan identified the major cost and schedule risk at NIF to be the risk of "not getting congressional required budget authorization and appropriation" (LLNL, 1997, p. 10). In fact, there were many greater risks at NIF having to do with technical and project management issues, as events were to show. However, in a more recent example at the Office of River Protection (ORP), Waste Treatment Plant (WTP), the major project risk is identified as "unfunded estimated project cost (EPC) owner's contingency: If Congress does not authorize an additional $435 million to cover ORP contingency allowances (includes normal estimating variability and risk allowances), then the WTP will not meet schedule and life-cycle ORP costs will increase and schedule milestones will be missed." Risk assessments should deal with risks, and not be vehicles for passing the buck and evading accountability for managing risks.

REFERENCE

LLNL (Lawrence Livermore National Laboratory). 1997. National Ignition Facility Risk Management Plan. Livermore, Calif.: Lawrence Livermore National Laboratory.