Improving Project Management in the Department of Energy

Committee to Assess the Policies and Practices of the Department of Energy to Design, Manage, and Procure Environmental Restoration, Waste Management, and Other Construction Projects

Board on Infrastructure and the Constructed Environment

Commission on Engineering and Technical Systems

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Preface

The 105th Congressional Committee of Conference on Energy and Water Development directed the U.S. Department of Energy (DOE) to undertake a review and assessment of its overall management structure and processes for identifying, managing, designing and constructing facilities (House Report 105-271). The language directed that this review be done by an impartial, independent organization with expertise in the evaluation of government management and administrative functions. Consequently, DOE requested that the National Research Council (NRC) conduct a study to review the policies, procedures, and practices used by DOE to identify, plan, design, and manage its portfolio of projects. The goal of the study was to develop recommendations to improve DOE's oversight and management of projects.

A committee formed under the auspices of the NRC's Board on Infrastructure and the Constructed Environment was chartered to review and assess the procurement and management of DOE's major construction projects, as well as its environmental restoration and waste management projects. The Committee to Assess the Policies and Practices of the Department of Energy to Design, Manage, and Procure Environmental Restoration, Waste Management, and Other Construction Projects comprised 13 experts with backgrounds in project management, contracting, budgeting and estimating costs; environmental remediation and waste management; civil, environmental, and nuclear engineering; government management and administration; and systems and performance analysis. The committee had extensive collective experience with DOE policies, procedures, and practices for identifying project requirements, developing scopes of work, executing and managing design, preparing cost estimates and schedules, selecting contract types, and executing and managing environmental restoration, waste management, and construction projects.

The committee as a whole met four times over a six-month period, and a subgroup convened for one writing session. The committee also visited various DOE field and operating offices, laboratories, and construction sites and met with representatives from many program and operating offices in Washington, D.C. Invitations were extended to DOE's senior-level management, program managers, and project managers, as well as contractors and various stakeholders with an interest in DOE's projects. The committee thus was given presentations by representatives of the diverse elements involved with projects and project management.

Despite the daunting task of reviewing and assessing DOE's policies and practices to design, manage, and procure environmental restoration, waste management, and other construction projects in just six months, the committee was able to reach a clear consensus on the findings and recommendations.

On behalf of the committee, I would like to thank DOE headquarters, field offices, sites, and laboratory staffs, as well as the contractors and the many other individuals who provided information for this study for their time, patience, and openness in discussing these complex issues. The committee found many knowledgeable, informed, concerned, thoughtful, and, unfortunately, frustrated people in DOE and among its contractors; many of their ideas and suggestions are reflected in the findings and recommendations of the committee.

Many aspects of DOE's development, delivery, and management of projects could be improved significantly. Congress has expressed its interest in improving the process by requesting this study, and many DOE employees and contractors expressed a similar interest during the course of this study. The committee found no single reason why DOE projects often fail to meet their anticipated costs and schedules. Rather, the committee found that many factors, sometimes called the DOE culture, contribute to the high failure rate. The issues are not insurmountable however; other federal agencies and private-sector organizations do successfully deliver capital facilities, as well as environmental remediation and wastes management services, in similarly complex settings.

The committee recognizes that many DOE projects, although they are desirable and valuable, are essentially part of the discretionary budget and that DOE's total budgets have been under pressure. The perception that project acquisition funds are not being spent wisely generates even more pressure to reduce them. In the final analysis, Congress may not be able to manage projects directly, but it can control losses by reducing the funding for them. Consequently, if DOE does not make program-wide improvements, funding for all of its projects will be jeopardized. Excessive costs and unmet schedules attributable to project mismanagement have delayed the essential cleanup of contaminated sites, increased the potential exposure of the public to contamination, increased costs to taxpayers, and reduced the number of essential projects that can be funded. Current and future projects in DOE's portfolio include both conventional construction projects and projects of enormous scope, complexity, and cost, including the cleanup of by-products of the Cold War and facilities critical to scientific discovery for the next century. These important projects, and the people of the United States, deserve excellent project management, and the goal of this committee has been to provide recommendations that can be used by DOE to improve project delivery and performance.

Kenneth F. Reinschmidt, *chair*
Committee to Assess the Policies and Practices of the Department of Energy to Design, Manage, and Procure Environmental Restoration, Waste Management, and Other Construction Projects

Acknowledgment

This report has been reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council (NRC) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the NRC in making the 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 contents of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The following individuals participated in the review of this report:

Donald Brand, Pacific Gas and Electric Company (retired)
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Theodore Stern, Westinghouse Electric Corporation (retired)

While the individuals listed above have provided many constructive comments and suggestions, responsibility for the final content of this report rests solely with the authoring committee and the NRC.

Contents

Executive Summary

The U.S. Department of Energy (DOE) and its predecessor agencies have been at the center of many of the great achievements in science and engineering in this century. They have built many of the world's best research facilities, funded excellent academic research, and developed and maintained the nuclear arsenal. DOE's diverse missions are supported by hundreds of projects, ranging from hazardous waste cleanups at individual sites of the weapons complex to the construction of scientific facilities. Many are complex one-of-a-kind projects that rely on technologies that are unproven at field scale. DOE currently spends billions of dollars annually and plans to construct more than $20 billion worth of defense, energy research, environmental management, fissile materials disposition, and other projects in the next five years. In recent years DOE's budget has been dominated by the monumental task of environmental restoration and waste management to repair damage caused by the production of nuclear weapons in the past.

Documentation shows that DOE's construction and environmental remediation projects take much longer and cost about 50 percent more than comparable projects by other federal agencies or projects in the private sector. Moreover, DOE projects commonly overrun their budgets and schedules, leading to pressures for cutbacks that have resulted in facilities that do not function as intended, projects that are abandoned before they are completed, or facilities that have been so long delayed that, upon completion, they no longer serve any purpose. In short, DOE's record calls into question the credibility of its procedures for developing designs and cost estimates and managing projects.

To identify the root causes of these problems, this committee reviewed

DOE's performance on projects and assessed the organizations and procedures by which they are carried out. The objectives of this study, which were established in the 105th Committee of Conference Report on Energy and Water Development are to (1) review and assess the processes used by DOE and its contractors to identify project requirements, develop scopes of work, execute and manage designs, prepare cost estimates, select contract types, and execute and manage environmental restoration, waste management, and construction projects; (2) assess the level of oversight and experience of personnel in field offices and at DOE headquarters; (3) analyze the effectiveness of current DOE practices and recommend improvements; and (4) recommend guidelines for management and contracting that would help DOE establish an overall departmental process with more control of projects to reduce cost and schedule overruns. In the collective opinion of the committee, if DOE acts upon the findings and recommendations of this report, project performance would be significantly improved.

The fundamental deficiency is DOE's organization and culture, which do not provide a focus for project management. As a result, the processes used by field offices, operations offices, and their contractors for planning and executing projects are inconsistent; lessons learned about cost estimating techniques, project review processes, change control mechanisms, and performance metrics are not transferred from one project to another; and there is no systematic program for recruiting and training professional project managers and no career path for project management. Related fundamental problems are a general lack of accountability and unclear lines of authority. The areas of authority of field and operations offices, contractors (who perform most of DOE's work), and DOE headquarters programs are complex and overlapping. Problems vary by location, reflecting the influence of local management and local contractors.

Although DOE has attempted to address these problems, in the view of many people inside and outside of DOE (including this committee), it has not succeeded. The creation of the Office of Field Management might have become the basis for an effective DOE project management organization, but the office took on only an advisory and oversight function, essentially as an advocate for the field offices with DOE headquarters. The Contract Reform Initiative (intended to increase competition and accountability in DOE project acquisition through new approaches to project financing and contracting) was a positive step that has some successes to its credit, but it has not achieved substantive or consistent results. The adoption of the recommendations from the National Research Council Phase I report to implement independent external project reviews, and the recent establishment of internal project reviews in the major program offices could become an important tool for continued improvements.

The committee compared DOE's project management practices with the standard practices used by private industry and other government agencies and found that DOE falls far short of best practices in a number of areas:

- organization-wide project management policy
- clear definitions of responsibility and accountability
- control of changes in the scope, cost, and definition of projects
- state-of-the-art project management systems
- identification, dissemination, and implementation of lessons learned
- preproject and preconstruction planning
- scope definition at the project baseline stage
- assessing and managing project risk
- setting contingency allowances based on risk
- cost estimation and scheduling
- objective performance-based incentives
- performance measurement and progress reports
- DOE-wide financial reporting systems
- cost and performance databases and information systems
- selection, training, and qualification of project managers
- project management core competency and organization

FINDINGS AND RECOMMENDATIONS

DOE's portfolio of projects is large, complex, and sophisticated. Many projects are one of a kind, involving unique systems, processes, and technical challenges. Delivering projects of this magnitude that meet baseline costs and schedules is a constant challenge that requires excellent management. The findings and recommendations that follow provide guidelines for lifting DOE's project management to a level commensurate with other agencies and private industry. No single change will raise DOE's project management to the level required for such vital and expensive projects, because the problems are pervasive and cultural, and resolving them will require more than a quick fix. DOE must undertake a broad program of reform for the entire project management process.

This program of reform is set out in the recommendations, culminating in the recommendation that an office of project management be established to implement these reforms and drive cultural changes in DOE. To be effective, the proposed project management office must include the staff necessary to support the project managers and must provide consistent methods and systems for cost estimation, risk analysis, contracting, incentives, change control, progress reporting, and earned value management. The reform will require full and continuing support of the Secretary of Energy to ensure the support of program offices, field offices, and the entire DOE project management organization.

Policies, Procedures, Documentation, and Reporting

Finding. DOE does not have adequate policies and procedures for managing projects. No single authority is responsible for enforcing or ensuring that project management tools are used.

Finding. DOE has developed comprehensive practice guidelines for the design and construction phases of projects but has not developed comparable guidelines for the early conceptual and preconceptual phases, when the potential for substantial savings is high.

Finding. Many DOE projects do not have comprehensive project management plans to define project organization, lines of authority, and the responsibilities of all parties.

Finding. DOE does not effectively use value engineering to achieve project savings, even though federal agencies are required to do so.

Finding. DOE project documentation is not up to the standards of the private sector and other government agencies.

Finding. DOE does not have a consistent system for controlling changes in project baselines.

Finding. DOE does not effectively use available tools, such as earned value management, to track the progress of projects with respect to budget and schedule.

Finding. ISO 9000 provides a certification process by which an organization can measure itself against its stated goals, but DOE has not obtained certification. The certification process would help DOE remake the entrenched operating procedures and standards that have accumulated over the past 50 years.

Recommendation. As a part of its project management system, DOE should issue fundamental policies, procedures, models, tools, techniques, and standards; train project staff in their use; and require their use on DOE projects. DOE should develop and support the use of a comprehensive project management system that includes a requirement for a comprehensive project management plan document with a standard format that includes a statement of the project organization covering all participating parties and a description of the specific roles and responsibilities of each party.

Recommendation. DOE should update the project performance studies to document progress in these areas and extend the benchmarking baseline to include all major DOE construction projects. The study results should then be used to improve project procurement and management practices.

Recommendation. DOE should mandate a reporting system that provides the necessary data for each level of management to track and communicate the cost, schedule, and scope of a project.

Recommendation. DOE should establish a system for managing change that provides traceability and visibility for all baseline changes. Change control requirements should apply to the contractor, the field elements, and headquarters.

Recommendation. DOE should establish minimum requirements for a cost-effective earned-value performance measurement system that integrates information on the work scope (technical baseline), cost, and schedule of each project. These requirements should be included in the request for proposals.

Recommendation. DOE, as an organization, should obtain and maintain ISO 9000 certification for all of its project management activities. To accomplish this, DOE should name one office and one individual to be responsible for acquiring and maintaining ISO 9000 certification for the whole department and should require that consultants and contractors involved in the engineering, design, and construction of projects also be ISO 9000 certified.

Recommendation. DOE should establish an organization-wide value-engineering program to analyze the functions of systems, equipment, facilities, services, and supplies for determining and maintaining essential functions at the lowest life-cycle cost consistent with required levels of performance, reliability, availability, quality, and safety. Value engineering should be done early in most projects, and project managers should take the resulting recommendations under serious consideration.

Project Planning and Controls

Finding. DOE preconstruction planning is inadequate and ineffective, even though preconstruction planning is one of the most important factors in achieving project success.

Finding. DOE often sets project baselines too early, usually at the 2- to 3-percent design stage, sometimes even lower. (An agreement between Congress and DOE's chief financial officer for establishing baselines at the 20- to 30-percent design stage is scheduled to be implemented in fiscal year 2001.)

Finding. DOE often sets project contingencies too low because they are often based on the total estimated cost of a project rather than on the risk of performing the project.

Finding. DOE does not always use proven techniques for assessing risks of major projects in terms of costs, schedules, and scopes.

Recommendation. DOE should require that strategic plans, integrated project plans, integrated regulatory plans, and detailed project execution plans be completed prior to the establishment of project baselines. To ensure facility user and program involvement in the preconstruction planning process, DOE should require written commitments to project requirements from the ultimate users.

Recommendation. DOE should significantly increase the percentage of design completed prior to establishing baselines. Depending on the complexity of the project, the point at which project baselines are established should be between the completion of conceptual design and the completion of the preliminary design, which should fall between 10 and 30 percent of total design. The committee supports continuing efforts by Congress and the DOE to develop project baselines at a point of adequate definition beginning with fiscal year 2001.

Recommendation. Baseline validation should be assigned specifically to the project management office recommended in this report. The Military Construction Program of the U.S. Department of Defense, which requests planning and design funds for all projects in the preliminary design stage on the basis of total program size, is a potential model for DOE.

Recommendation. DOE should establish contingency levels for each project based on acceptable risk, degree of uncertainty, and confidence levels for meeting baseline requirements. The authority and responsibility for managing contingencies should be assigned to the project manager responsible for doing the work. In the process of evaluating potential projects, DOE should apply risk assessment and probabilistic estimating techniques, as required by the Office of Management and Budget.

Skills, Selection, and Training of Personnel

Finding. DOE's failure to develop project management skills in its personnel is a fundamental cause of poor project performance. DOE has shown little commitment to developing project management skills, as indicated by the lack of training opportunities and the absence of a project management career path. Successful organizations recognize that project management skills are an essential core competency that requires continuous training.

Recommendation. DOE should establish a department-wide training program for project managers. To ensure that this program is realistic, practical, and state of the art, DOE should enlist the assistance of an engineer/construction organization with a successful record of training project managers. DOE should establish criteria and standards for selecting and assigning project managers, including documentation of training, and should require that all project managers be trained and certified. DOE should also require that all contractors' project managers be experienced, trained, and qualified in project management appropriate to the project.

Project Reviews

Finding. Independent project reviews are essential tools for assessing the quality of project management and transferring lessons learned from project to project.

Finding. External independent reviews of 26 major projects are under way to assess their technical scope, costs, and schedules. The reviews so far have documented notable deficiencies in project performance verifying the committee's conclusion that DOE's project management has not improved and that its problems are ongoing. However, DOE has yet to formalize and institutionalize a process to ensure that the recommendations from these reviews are implemented.

Finding. Various DOE program offices are also developing the capability of conducting internal independent project reviews.

Recommendation. DOE should formalize and institutionalize procedures for continuing independent, nonadvocate reviews, as recommended in the Phase I report of the National Research Council to ensure that the findings and recommendations of those reviews are implemented. DOE should ensure that reviewers are truly independent and have no conflicts of interest.

Recommendation. All programs that have projects with total estimated costs of more than $20 million should conduct internal reviews, provided that the value of the reviews would be equal to or greater than the costs of conducting them. Deciding if an internal review is justified for a given project should be the joint responsibility of program management and the project management organization. The decision should be based on past experience with similar projects, the estimated cost of the project, and the uncertainty associated with the project. Internal reviews are expensive and take up the time of valuable people, so they should not be undertaken lightly. However, under the present circumstances, the committee believes that more internal reviews would be justified. The project management organization should manage these reviews for the director or assistant secretary of the cognizant program office. The results of these reviews should be taken by the program office to the Energy Secretary's Acquisition Advisory Board (ESAAB), and used as a basis for the decision whether to continue the project.

Acquisition and Contracting

Finding. Traditional DOE contracting mechanisms, such as cost-plus-award-fee and manage-and-operate (M&O) arrangements, are not always optimal for DOE's complex mission. These approaches are being replaced with more effective approaches based on objective performance incentives, but change has been slow.

Finding. DOE's long history of hiring contractors to manage and operate its sites on the basis of cost-plus-award-fee contracts has created a culture in which neither DOE nor its contractors is sufficiently accountable for cost and schedule performance.

Finding. DOE does not use effective performance-based incentives and does not have standard methods for measuring project performance.

Finding. DOE does not effectively match project requirements and contracting methods. Mismatching often results in cost and schedule overruns.

Finding. The numbers of bidders on major DOE contracts has been declining and in some cases have not elicited truly competitive bids. This may indicate that projects are not being appropriately defined and packaged and that the disincentives to bid often outweigh the incentives.

Recommendation. DOE should strengthen its commitment to contract reform focusing on the assessment and quantification of project uncertainties, the selection of the appropriate contract type and scope for each job, and increased use of performance-based incentive fees rather than award fees to meet defined project cost and schedule goals. A comprehensive risk analysis should be conducted before deciding whether to issue fixed-price contracts for work that involves a high level of uncertainty (such as new technology or incomplete characterization). Specific contract scopes and terms should be negotiated to define both DOE and contractor responsibilities to prevent cost overruns. Clear, written roles, authorities, and responsibilities should be established for DOE headquarters, field elements, contractors, and subcontractors for each contract. Guidelines should be provided for the appropriate times in the project for the selection of contractors.

Recommendation. DOE should develop written guidelines for structuring and administering performance-based contracts. The guidelines should address, but need not be limited to, the following topics: the development of the statement of work; the allocation of risks to whomever would be most effective at controlling the risks (either DOE or the contractor); the development of performance measures and incentives; the selection of the contracting mechanism; the selection of the contractor; the administration of the contract; and the implications of federal and DOE acquisition regulations. DOE should train its employees in the roles and responsibilities of a performance-based culture and then hold both employees and contractors accountable for meeting these requirements.

Recommendation. DOE should provide financial rewards for outstanding contractor performance to attract bids from the best contractors. A DOE-wide policy should be developed that provides fiscal rewards for contractors who meet or exceed schedule, cost, and scope performance targets. Contractor fees should be based on contractor performance.

Recommendation. DOE employees and contractor employees essential to projects should be trained in acquisition and contract reform. The training of source selection officials and members of source evaluation boards should be expedited; a minimum level of training should be a prerequisite.

Organizational Structure, Responsibility, and Accountability

Finding. DOE's organizational structure makes it much more difficult to carry out projects than in comparable private and public sector organizations. Successful corporations and agencies responsible for major projects arrange their organizations to provide focused and consistent management attention to projects.

Finding. Too many people in DOE act as if they were project managers for the same project, and too many organizations and individuals outside the official project organizations and lines of accountability can affect project performance.

Finding. Compliance with DOE's policy requiring the establishment of performance agreements and self-assessments from the field has been limited and slow.

Recommendation. To improve its project management performance, DOE should establish an office of project management on a level equal to or higher than the level of the offices of assistant secretaries. Department-wide project management functions should be assigned to the project management office, and the director of this office should have the authority and the resources to set and enforce reporting requirements for all projects. Other responsibilities, such as property and asset management, should be assigned to existing DOE headquarters offices. To be successful, the office of project management must have the full and continuing support of the secretary, the under secretary, the deputy secretary, and of all of the program offices and field offices as a top-down management initiative.

1

Department of Energy Projects

INTRODUCTION

The U.S. Department of Energy (DOE) and its predecessor agencies have been at the center of many great achievements in science and engineering. They have built many world-class research facilities, funded excellent academic research, and developed and maintained nuclear weapons that deterred war for decades. DOE's current diverse missions (energy systems, nuclear weapons stewardship, environmental restoration, and basic scientific and technological research) are supported by hundreds of projects, ranging from cleanups of hazardous waste at individual sites of the weapons complex, such as the Hanford Tank Waste Remediation System, to the construction of scientific facilities, such as the National Spallation Neutron Source. Many of these projects are unique, complex, and rely on technologies that have not been proven at field scale. In recent years, DOE's budget has been dominated by the monumental task of environmental restoration and waste management, largely in connection with past nuclear programs. DOE anticipates that a minimum funding level of $5.75 billion per year through 2006, and a total of $147 billion by 2070 will be necessary to complete the 353 cleanup projects in its current program (DOE, 1998a).

It is well documented by internal and external audits and independent statistical analyses that DOE construction and environmental projects generally take longer and cost substantially more than comparable projects by other federal agencies or in the private sector (see Chapter 2 and Appendix A for details). DOE's waste management projects, for example, cost on average almost

50 percent more than comparable industrial projects (IPA, 1993, 1995). Moreover, DOE's projects commonly overrun their budgets and schedules, leading to pressures for cutbacks that have resulted in facilities that failed to function as intended, facilities that had to be abandoned before they were completed, or facilities that were so long delayed that, upon completion, they no longer served any purpose. These problems have characterized not only the construction of sophisticated and complex facilities for scientific research and projects that involve the handling of radioactive and toxic waste, but also conventional construction projects. In fact, DOE's entire record calls into question the credibility of its procedures for developing designs and cost estimates and for managing its projects. To identify the roots of these problems, this committee reviewed the performance of DOE projects and assessed the organizations and procedures by which they are carried out. The committee believes the findings and recommendations in this report could significantly improve DOE's project performance.

This study is the second phase of a two-phase study by the National Research Council (NRC). Phase I, which focused on the need for independent project reviews, concluded that DOE's problems are more institutional than technical (NRC, 1998). The report recommended that DOE use independent external reviews for certain projects, but concluded that these reviews would not solve the systemic problems of cost and schedule overruns, which involve DOE's policies and procedures for identifying, planning, procuring, and managing projects. This report is a review of those issues.

Statement of Task

The objectives of this study were set forth in the Committee of Conference Report on Energy and Water Development (U.S. Congress, 1997):

- Review and assess the processes used by DOE and its contractors to identify project requirements, develop scopes of work, execute and manage designs, prepare cost estimates, select contract types, and execute and manage environmental restoration, waste management, and construction activities.
- Assess the level of oversight and experience of personnel in field offices and at DOE headquarters.
- Analyze the effectiveness of current DOE practices and recommend improvements.
- Recommend guidelines for management and contracting that would help DOE establish an overall departmental process with more control of projects to reduce project cost and schedule overruns.

This report focuses on DOE's management structure in the context of projects and does not assess DOE's overall organizational and management structure.

Nevertheless, the committee interpreted the request to review DOE's "overall management structure and process for identifying, managing, designing, and construction facilities" to allow a discussion of DOE-wide management, policies, and procedures when necessary.

ORGANIZATIONAL COMPLEXITY

DOE is a large, complex organization that has grown by accretion for more than 50 years, adding new missions and absorbing subsidiary organizations. Its structure and procedures reflect that history. DOE was created in response to the energy crisis of the 1970s to reduce the nation's dependence on foreign oil supplies, exploit new sources of energy, and improve energy efficiency. The Energy Act of 1977 (P.L. 95-31) merged the policy and regulatory functions of the Federal Energy Administration, energy supply and demand technology functions, nuclear research, nuclear weapons programs of the Energy Research and Development Administration (ERDA), and various energy-related programs of the Department of the Interior. DOE inherited from its predecessor agencies the nation's nuclear weapons program, five power marketing agencies, and a host of other activities, such as the functions of the Energy Information Agency and the Federal Energy Regulatory Commission.

DOE's nuclear and scientific research missions originated in efforts by the military to develop the atomic bomb during the Second World War. After the war, the Atomic Energy Commission (AEC), the successor of the Manhattan Engineering District of the Corps of Engineers, was established as an independent agency for civilian control of nuclear weapons and nuclear energy, and given enormous legal, financial, and self-regulatory powers. Oversight of the AEC was limited by the need for security and secrecy. The AEC established a system of government-owned, contractor-operated (GOCO) laboratories, which was to become the world's greatest scientific and industrial complex. The contractors worked under comprehensive management and operations (M&O) agreements, with few restrictions and little supervision. Programs and facilities were compartmentalized for security reasons, and some were duplicated to ensure the survival of essential functions after a nuclear attack. Procurement strategies for engineering, technical services, and facilities emphasized speed over cost and accountability. Little attention was paid to environmental effects, leaving vast amounts of radioactive and toxic wastes.

Over the decades, DOE's focus has shifted to meet changing national needs. In the late 1970s, the emphasis was on energy development and regulation. In the 1980s, nuclear weapons again took priority. Since the end of the Cold War, DOE has pursued a variety of diverse missions, including the environmental cleanup and restoration of the nation's nuclear weapons production facilities, stewardship of nuclear weapons, research and development in energy and basic science, and management of the power marketing administrations.

The organizational structure to carry out these missions is a complex array of public and private enterprises that includes headquarters, operations offices, field offices, laboratories, M&O contractors, and subcontractors. DOE manages a vast infrastructure of facilities and associated programs and projects.

Some institutional legacies of the nuclear weapons program included decentralization, a system of field offices, and reliance on private contractors. Contracting accounted for $16.2 billion, or about 91 percent of DOE's obligations in fiscal year 1997 (GAO, 1999), the majority with M&O contractors. DOE has always had a limited core staff of professional managers and engineers, and as the department took on new programs and missions, the field offices developed their own contracting processes in isolation from headquarters and from one another.

Relationship between Headquarters and Field Offices

DOE's organization includes 12 headquarters program offices, 10 major operations offices, and two large field offices with more than 50 major contractor-operated facilities. Most project activities are managed by the operations or field offices, which oversee the M&O contractors. Projects are funded, however, by the headquarters program, most of them headed by assistant secretaries, which provide funds and policy guidance to contractors but do not oversee them directly. In this arrangement, roles and responsibilities are unclear, and management authority is blurred (IDA, 1997; LOB, 1997; GAO, 1999).

Program Offices

The mission of the Office of Environmental Management (EM), created in 1989, is to reduce threats to health, safety, and the environment from contamination and waste at DOE sites, generated mostly by DOE's predecessors. EM is the largest DOE office, accounting for approximately $6 billion of the $16.8 billion appropriation for fiscal year (FY) 1998 (or 36 percent) (DOE, 1998b). EM's mission includes (1) waste management (treatment, disposal, and storage of a wide variety of radioactive, nonradioactive, and mixed waste); (2) the stabilization of nuclear material and spent fuel and the deactivation and decommissioning of surplus facilities; (3) the remediation and environmental restoration of sites that have been contaminated by DOE activities; and (4) technology development to improve the effectiveness of site cleanup. EM is also involved with national programs for transportation and pollution prevention, as well as for landlord functions, including security and infrastructure support. Once entirely self-regulated, EM and its predecessors experienced intense pressure to negotiate binding milestones to bring contaminated sites into compliance with environmental regulations and agreements. EM is largely subject to the requirements of a multitude of agreements that have been negotiated with federal, state, and local agencies.

The Office of Defense Programs (DP) was formerly responsible for manufacturing, managing, and maintaining the nuclear weapons complex. Today DP's mission is the stewardship of the weapons stockpile. DP is the second largest DOE office, with a budget in FY 1998 of approximately $4 billion (25 percent of DOE appropriations) and a federal workforce of about 2,000, which oversees about 25,600 contract employees in GOCO facilities (DOE, 1998b).

The Office of Science (SC) (formerly the Office of Energy Research) is the third largest DOE office, with a budget in FY 1998 of approximately $2.5 billion, about 15 percent of DOE's appropriations (DOE, 1998b). SC's mission is to support basic research to advance the fundamental science knowledge base, as well as train future scientists. Many of SC's activities require specialized, often unique, research facilities, such as particle accelerators and detectors and nuclear reactors. Energy production and related research are the primary focus of SC programs, although its activities have expanded to include a range of other areas, such as materials, mathematics, and earth science. SC is also the oversight, planning, policy, and support office for the energy and multipurpose research laboratories.

The Office of Nuclear Energy, Science, and Technology (NE) is the fourth largest DOE office, with a FY 1998 budget of approximately $1 billion, about 6 percent of DOE's appropriations (DOE, 1998b). NE provides government expertise in nuclear engineering and technology, helping to maintain economic and technological competitiveness and access to diverse energy sources.

The Office of Energy Efficiency and Renewable Energy (EE) develops cost-effective technologies that protect the environment and support the nation's economic competitiveness. The FY 1998 budget for EE was approximately $863 million, nearly 5 percent of DOE's appropriation (DOE, 1998b). EE programs include research, development, and market deployment through private sector partnerships.

The Office of Nonproliferation and National Security (NN) is responsible for DOE's activities related to the nonproliferation of nuclear weapons, nuclear safeguards and security, classification and declassification, and emergency management. The FY 1998 budget for NN was approximately $657 million, about 4 percent of DOE's appropriation (DOE, 1998b).

The Office of Fossil Energy's (FE) budget for FY 1998 was approximately $367 million, about 2 percent of DOE's appropriation (DOE, 1998b). FE conducts and sponsors research on fossil fuels and manages the petroleum reserves owned by the federal government.

The Office of Civilian Radioactive Waste Management (RW) had a FY 1998 budget of approximately $346 million, about 2 percent of DOE's appropriation (DOE, 1998b). The mission of RW is to dispose of the nation's commercial and defense spent nuclear fuel and high-level nuclear waste. RW is responsible for the construction and operation of the high-level radioactive waste repository and is evaluating the Yucca Mountain site in Nevada. If this site is selected, the earliest it will be able to accept waste or commercial spent fuel will be 2010.

The mission of the Office of Fissile Materials Disposition (MD) is to provide for the safe long-term storage of all weapons-usable fissile materials and the safe disposition of surplus materials. Disposition will involve the construction of facilities to treat, pack, and store these materials. The FY 1998 budget for MD was approximately $100 million, about 1 percent of DOE's appropriation, but is expected to increase considerably in the near term as these facilities are approved for construction (DOE, 1998b).

The five power-marketing administrations (PMAs) (Alaska Power Administration, Bonneville Power Administration, Southeastern Power Administration, Southwestern Power Administration, and Western Area Power Administration) are distinct organizations within DOE. The mission of the PMAs is to market power generated at federal multipurpose water projects at the lowest possible rates consistent with sound business practices. Each PMA has a specific geographic boundary, responsibilities, and system of projects. Four of the five PMAs receive annual appropriations, but Bonneville Power Administration has been on a self-financed basis since 1974. The FY 1998 budget for the PMAs was approximately $241 million, about 1.5 percent of DOE's appropriation (DOE, 1998b).

The two remaining program offices (the Office of Environment, Safety, and Health and the Energy Information Administration) have no significant project responsibilities and were beyond the scope of this study.

Laboratories

A significant organizational component of DOE is its laboratories. The DOE laboratory system is generally considered to include 10 major multiprogram (national) laboratories and many smaller, more focused laboratories. All of the national laboratories and most of the other DOE laboratories are federally funded research and development centers that are owned and funded by the government but staffed and operated by universities or private contractors.

The current laboratory system can be traced back to the origins of atomic weapons development during WWII. The arrangement of government-funded facilities operated by nongovernment staff with the appropriate expertise (the GOCO system) became the model for the nuclear weapons laboratories, as well as for civilian atomic energy, science and engineering, and materials research and development laboratories, and for other DOE laboratories.

Activities at the DOE laboratories (the largest government laboratory system) support four major mission areas: national security, science and technology, energy resources, and environmental quality. DOE's obligations for the laboratories were approximately $7.6 billion in FY 1998. The laboratories employ about 56,000 (federal and contractor) people (Boesman, 1998).

DOE Culture

In the course of this study, numerous DOE employees, including those in senior management positions, cited “DOE culture,” without defining it, as an explanation for the failure of many projects. In the committee’s opinion, blaming the “culture” for failure to execute is itself an expression of that culture. Because this term is commonly used by DOE personnel the committee attempted to define it and determine how it affects DOE project performance.

A culture is a set of implicit or tacit beliefs that pervades an organization and affects how it behaves and responds to its environment. It is the unstated way an organization sees itself and the way it really works, which is often very different from the formal organizational chart. Culture encompasses the values an organization holds. For example, the organizational culture of the DOE laboratories can be briefly described as science-driven, motivated to discover new knowledge, particularly about nuclear physics. Knowledge discovery is open-ended, continuous, and not easily planned and scheduled. A science driven culture was evident from the very beginnings (Manhattan Engineering District) of DOE. “In the earliest stages of development, organizations tend to be dominated by an adhocratic culture—characterized by an absence of formal structure, creativity and entrepreneurship, fluid and nonbureaucratic methods, and an emphasis on individuality, freedom, and flexibility among employees” (Druckman et al., 1997, p. 89). The weapons laboratories, at least in the past, were technology-driven, motivated and organized to pursue overriding national defense goals involving nuclear technology, such as advanced weapons design, development, production, and testing. The major activities of the weapons laboratories were organized around these goals in an atmosphere of secrecy, urgency, and self-sufficiency, and other issues, such as costs, openness, public scrutiny, and environmental protection, were given less attention. Because contractors were also motivated by technology and national defense, the atmosphere was cooperative rather than competitive or adversarial and favored contracting methods that assigned no financial risk to the contractor. Little distinction was made between government personnel and contractor personnel, because all of them were working toward the same goals and shared the same views.

DOE, which was assembled from a heterogeneous collection of agencies, inherited a diversity of cultures, and although DOE’s missions changed in response to external conditions, the culture did not necessarily change with it. For example, with the end of the Cold War and an acceleration of changes in mission, the culture of the national laboratories has remained predominantly scientific and technology-driven, although the focus of their activities in many cases has changed from nuclear weapons to pure science or to civilian applications.

“Organizational expansion ultimately produces the need to emphasize structure, standard procedures, and control—that is, a hierarchy-focused culture. Such a shift makes members feel that the organization has lost the friendly, personal feeling that once characterized the workplace, and the focus on reduction of deviation, standardization, and restraint may give rise to escalating resentment or rebellion" (Druckman et al., 1997, p. 89). This description fits DOE today. DOE has found it difficult to develop a culture consistent with successful execution of its new roles. The culture throughout much of DOE headquarters and the field elements is one of preserving the *status quo* and can be characterized as bureaucratic and driven by process and politics.

Reorganizations of DOE

Every secretary of energy has made organizational changes at DOE. Some have favored centralization; others have given field offices and programs greater autonomy. DOE's organizational structure as of January 1999 is shown in Figure 1-1. An assistant secretary or director heads each program office. Reporting to each assistant secretary are a principal deputy assistant secretary and several deputy assistant secretaries, each of whom is responsible for a subprogram. Historically, assistant secretaries have been granted significant independence, and programs (and subprograms) are free to follow their own agendas, regardless of their impact on other DOE components. These vertical "stovepipes" of authority are characteristic of the department.

DOE field offices and operations offices and their contractors carry out the work on DOE projects. These offices are also responsible for evaluating the results. Field offices and contractors are primarily beholden to one another and have little or no incentive to promote the interests of one program or another. However, it is not uncommon for program offices to extend their influence to a field office and its contractors. This organization makes professional project management difficult because the field offices and headquarters program offices often have different priorities, and contractors may have a difficult time deciding whose directions to follow. Poorly characterized roles and responsibilities also make it impossible to assign accountability for success or failure (see Chapter 2).

In the 1990s, two major attempts have been made to reform the relationship between headquarters and the field offices in managing projects. Neither reform has been allowed to take full effect, however, and the resulting organization is even more constricted around its historic stovepipes.

Creation and Demotion of the Office of Field Management

In 1994 the (then) secretary of energy reorganized the reporting relationships between the field offices and the headquarters programs by creating the position of associate deputy secretary for field operations, who was intended to be a senior career professional with management authority over most of the field offices, and especially the management of their projects. However, before this new organization and position could become fully functional, a new secretary of energy was

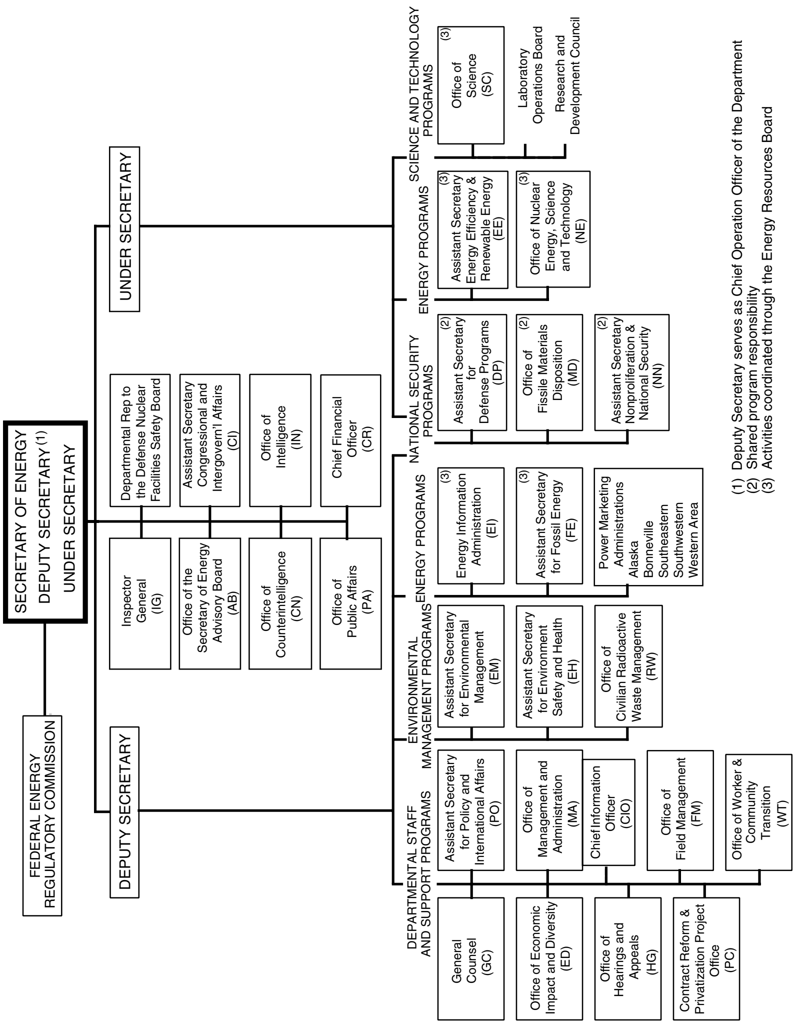

FIGURE 1-1 Organization of the U.S. Department of Energy, as of January 1999.
Source: DOE Office of Field Management.

appointed who in turn made fundamental changes in DOE's organizational structure that had the effect of negating the previous changes. The associate deputy secretary became a director (Office of Field Management [FM]), as such only one of several staff offices reporting to the deputy secretary. Since then, field managers have reported both to the director of FM and to one or more program assistant secretaries. However, certain selected site offices, such as the Rocky Flats Environmental Technology Site, report directly to the secretary of energy, while others continue to report through the program assistant secretaries. A similar lack of consistency and clarity of authority and responsibility was found to be a contributing cause of the problems of the superconducting super collider project, because oversight and accountability actually decreased under the ad hoc organizational structure set up specifically for this project (DOE, 1996).

Life-Cycle Asset Management Program

Beginning in 1994, the secretary of energy initiated an effort to give program and field offices greater management flexibility by reducing the number of DOE orders and headquarters-mandated requirements. DOE's Order 4700.1, Project Management System (detailed, prescriptive procedures for managing and reporting projects) was replaced with the Life-Cycle Asset Management (LCAM) Program (DOE Order 430.1, recently revised and replaced with 430.1A) and an evolving collection of "Good Practices Guides" (e.g., "Critical Design Criteria," "Risk Analysis and Management," and "Performance Measures") (DOE, 1998c). Although compliance with the general principles and methods contained in LCAM is required, this document (nor the accompanying Good Practice Guides) does not provide metrics by which to measure performance (or the lack of it). Therefore, practically everyone can say they have followed these principles, and no one can be proven wrong. DOE's lack of a basis for measuring project performance has made it impossible to ensure consistency or excellence in the management of projects.

IDENTIFICATION AND EXECUTION OF PROJECTS

Many DOE programs require the development and use of capital facilities. FM was established to provide policy, oversight, and support for headquarters and field organizations. LCAM (DOE Order 430.1A), the operative policy on managing physical assets includes the following definition of a project:

> In general, [a project is] a unique effort that supports a program mission with defined start and end points, undertaken to create a product, facility, or system with interdependent activities planned to meet a common objective/mission. Projects include planning and execution of construction/renovation/modification/environmental restoration or decontamination and decommissioning efforts, and large capital equipment or technology development activities. Tasks that do

not include the above elements, such as basic research, grants, and operations and maintenance of facilities, are not considered projects (DOE, 1998c).

LCAM divides projects into four categories according to the degree of management authority, planning, and support required: strategic systems, major systems, line item projects, and general plant projects.

Strategic systems are acquisitions for which the total project cost (TPC) exceeds $400 million or that are stand-alone efforts to advance DOE's strategic goals. In addition to TPC, DOE Notice N 430.1, section 4 (i) states that "Strategic System designation by the Secretary shall consider risk factors, international implications, stakeholder interest and/or national security. Critical Decisions (CDs) (generally approval of mission need, project baselines, start construction, and completion/start of operations) for Strategic Systems are the responsibility of the Acquisition Executive" (DOE, 1997). Some secretaries of energy have retained executive authority for acquisitions, but most secretaries have delegated the responsibility either to the deputy secretary or the under secretary.

Major systems are acquisitions for which the TPC ranges from $100 million to $400 million or that support significant programmatic objectives and goals. Critical decision responsibility for major systems is delegated to the appropriate program secretarial officers, who sometimes delegate the responsibility for certain decisions to operations or field managers. *Line item projects* usually have a TPC of $5 million to $100 million, appear as single line items in the federal budget, and are typically intended to enhance existing operations and capabilities. *General plant projects* have a TPC of less than $5 million and consist mainly of projects that maintain existing facilities and infrastructure.

Project Phases

The planning and construction process normally has four phases (although this varies slightly from organization to organization in DOE). *Preconceptual phase* activities take place before a project is formally defined and include identifying ideas, making preliminary evaluations of their feasibility, and documenting the need for the project. Costs in the preconceptual phase do not accrue to the TPC. In the *conceptual phase,* technical and project requirements are defined and necessary resources are identified. In this phase of the project, a conceptual design report and project execution plan are prepared, both of which are critical in setting the scope, cost, and schedule baselines. Costs for the conceptual phase of the project are included in the TPC. The *execution phase* includes design and construction of the project and the transition to start-up and acceptance. A *closeout decision* may be made at any time during the life of a project. Generally by the time of the closeout phase, the project has been completed and turned over for operations. Closeout can also be the termination of an incomplete project or the retirement of a facility at the end of its life cycle (NRC, 1998).

The environmental restoration and waste management projects of EM have a different structure, driven by statutory mandates and other legally binding requirements and decision-making processes. Most decisions for these projects are made at the site level, but some must be deferred to DOE headquarters. EM projects are generally organized in three phases: the assessment/remedial investigation/feasibility study (RIFS); remediation/cleanup; and closeout. In a recent report, *Accelerating Cleanup: Paths to Closure*, EM provides for the first time, a project-by-project description of the technical scope, cost, and schedule of all 353 projects at DOE's remaining 53 cleanup sites in the United States (DOE, 1998a). That report breaks the process down into six phases to account for the significant role of public participation in decision making: (1) planning; (2) study, in which projects are characterized and alternative solutions are evaluated; (3) recommendations, in which a preferred solution is identified; (4) decision; (5) implementation; and (6) monitoring.

ORGANIZATION OF THIS REPORT

The succeeding chapters of this report assess DOE's performance and offer findings and recommendations for improving project management. Chapter 2 reviews DOE's track record in project performance, including the planning and budgeting process and the aspects of management and accountability that affect project performance. Chapter 3 discusses using project reviews as a management tool. Chapter 4 assesses the contracting and acquisition methods used by DOE. Chapter 5 discusses in more detail the committee's recommendation for the establishment of a project management office as the center for excellence in project management at DOE.

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2

Project Management

INTRODUCTION

DOE's inability to complete projects on time and on budget has been widely reported by the U.S. Congress (1998a, 1998b), the General Accounting Office (GAO) (1996, 1997, 1999), the Defense Nuclear Facilities Safety Board (DNFSB) (1997), and DOE's Office of Inspector General (DOE, 1995a, 1996a, 1997a), among others. In 1996, Congress requested that the GAO review DOE's ability to complete major systems acquisitions (projects with TPC of more than $100 million) within originally estimated costs and time schedules. GAO found that between 1980 and 1996, 31 of the 80 DOE major system acquisition projects had been terminated prior to completion, 34 were continuing although over budget, and 15 had been completed (GAO, 1996). GAO noted that management problems and ineffective oversight had led to cost overruns, schedule slippages, and project terminations. The DNFSB also raised concerns about ineffective project management in its analysis of schedule slippage in DOE's spent nuclear fuel project at Hanford, Washington, citing the lack of sound project management as the principal reason (DNFSB, 1997). Furthermore, the DNFSB reported that poor project management practices can become a safety issue when project delays increase or prolong risk to the public, workers, and the environment (Conway, 1998).

DOE's problems in completing many projects on time and on budget can be partially attributed to the complexity, uniqueness, and frequent changes in these projects, but these difficulties are exacerbated by DOE's shortcomings in project management. Among the deficiencies are an organizational structure unsuited to managing projects, inadequate techniques for planning and executing projects, the lack of review processes, poor change control mechanisms, and the lack of performance metrics and risk evaluations.

DOE faces major challenges in upgrading its project management system. But unless the system is improved in several areas, DOE will continue to have excessive cost overruns, inordinate time delays, improper project formulation, and a dissatisfied Congress and stakeholders. In this chapter the committee first reviews DOE's record of performance in carrying out projects. This is followed by a discussion of DOE's project organization and structure, procedures, policies, and accountability. The chapter ends with a review and assessment of DOE's project planning, budgeting and estimating, and the processes used to assess risk, track progress, and control change.

RECORD OF PROJECT PERFORMANCE

Do DOE projects exceed their schedules and budgets more often and by larger amounts than projects of similar size and complexity with similar risks executed by other government agencies or private industry? The committee sought an objective answer to this question in a variety of independent analyses by the GAO and by DOE's independent contractor, Independent Project Analysis (IPA). These studies over the past decade have documented DOE's difficulties in meeting project schedules and budgets. The failings are attributed to the inherent difficulty, complexity, and changes in much of the work, deficiencies in DOE's policies and practices, constricting contractual arrangements, problems with project management, a complex cumbersome organization, and complicated inefficient administrative practices. (See Appendix A for information on problems with DOE's performance.)

Studies by the General Accounting Office

GAO has issued numerous reports related to DOE's construction, procurement, and contracting practices (for a recent review, see GAO, 1999). Many of these reports have centered on contractor performance and the appropriateness of contractor costs. Others have focused on DOE's difficulties in delivering major projects within baseline costs, schedules, and scope. GAO reported that only 15 of the 80 major systems projects initiated between the 1980 and 1996 had been completed, and many of those were behind schedule and over cost. Thirty-one projects were terminated before completion. GAO attributed the failures to four factors, not all of which are completely under DOE's control (GAO, 1996):

- flawed incentives for contractors
- lack of DOE personnel with the skills to oversee the contractors' operations
- DOE's unclear or changing missions
- incremental funding of projects

Statistical Analyses of Costs and Schedules

In the past, DOE has commissioned quantitative analyses of its management of environmental remediation and waste management projects by IPA (1993, 1995, 1996). In these studies, statistical comparisons were made of DOE environmental remediation and waste management projects with comparable projects performed by private industry and other government agencies (primarily the U.S. Army Corps of Engineers). Although the committee was unable to examine the models IPA developed and used in these analyses, and therefore cannot comment on their validity, these studies constitute the only available cross-sectional and longitudinal analyses of DOE's project performance.

DOE has not challenged the results of these studies. In fact, it made them the basis of a major reform effort that included a two-day "stand-down" (cessation of EM project activity to discuss solutions to the problems identified in the studies) on January 26 and 27, 1994. The stand-down was ordered by the secretary of energy as recommended by the EM assistant secretary. DOE also arranged for an update of previous IPA analyses to benchmark and calibrate improvements (IPA, 1996).

Although the specific projects examined, the sizes of the samples (76 projects in December 1990, 65 projects in November 1993, 22 projects in December 1995, and 48 projects in April 1996), the statistical models, and IPA's database of industrial and governmental projects used for comparison all varied from study to study, some elements were common to all of them. All of IPA's studies focused on four outcomes:

- cost performance, or the absolute cost of DOE projects compared to the absolute costs of industry and other government agencies, normalized for comparability
- cost overruns, or the relative increase in DOE project costs compared to the original budgets
- schedule performance, or the absolute duration of DOE projects compared to the duration of projects by industry and other government agencies, normalized for comparability
- schedule slippage, or the relative increase in DOE project durations compared to the original schedules

Project Costs and Cost Overruns

The combined results of two IPA studies (1993, 1995) showed that DOE waste management projects cost 48 percent more on the average than comparable projects by industry and other government agencies; and DOE environmental remediation projects cost about 33 percent more. The average cost overruns were about 48 percent for environmental remediation projects and about 42 percent for waste management projects, compared to an average of about 3 percent for industry and other government agencies. Moreover, the variability in cost growth from project to project was far higher than in industry. Thus, not only did DOE projects actually cost about 40 percent more than comparable industrial projects (the "DOE tax"), they overran their initial cost estimates by about 45 percent, indicating that DOE either has a problem with controlling costs or a problem with estimating costs, or both (IPA, 1993).

The 1996 update of project performance showed that DOE waste management projects cost 33 to 43 percent more than similar projects carried out by the private sector, and cost overruns were between 22 and 36 percent. DOE improved somewhat on the cost of environmental remediation projects during the period, lowering the average cost to 25 percent more than the private sector. However, DOE cost overruns for environmental remediation were substantially unchanged, averaging 50 percent (IPA, 1996).

Schedules and Schedule Slippage

DOE waste management projects took an average of three times longer to complete than comparable projects by industry and other government agencies. The original schedules slipped an average of 52 percent, compared to an industry average of 17 percent (IPA, 1996). Thus, even though DOE's initial schedules were much longer than for similar projects by others, they nevertheless slipped more. DOE performance on environmental remediation projects was better, with durations only about 18 percent longer than those of comparable projects, but the average slippage was about 42 percent (IPA, 1996).

In the 1996 update, IPA forecasted some improvements in costs and durations, but these were extrapolations for projects that had not yet been completed (IPA, 1996). No follow-up study has been made since April 1996 to determine whether these expectations were realized, but even with the predicted improvements, DOE's project costs and schedules would still be much higher than those of comparable projects by industry.

Changes in Project Scope to Meet Contingencies

Cost increases in DOE projects are often distorted by DOE's tendency to consider project scope as a contingency. In other words, if it appears that the project will overrun its budget, DOE reduces the original authorized scope of a project to meet the budget, or increases the scope to use up any apparent underruns (IPA, 1990). These adjustments bias project costs upward.

Project Definition

Project definition is a continuing problem for DOE. IPA's statistical analyses showed that inadequate project definition (detailed planning of scope, objectives, resources) accounts for 50 percent of the cost increases for environmental remediation projects (IPA, 1993). IPA also found that in waste management projects, definition is usually done after only 6 percent of the design is complete, while the industry average is 15 percent (IPA, 1995). Project definition is closely correlated with cost growth (see Project Planning section below for details). IPA found that of the 48 percent DOE cost premium for waste management projects, 11 percent could be eliminated if DOE's project definition were improved to equal the average for the private sector (IPA, 1996).

Value Engineering

In one study, IPA estimated that the cost of conducting an effective value-engineering program is about 0.5 percent of the anticipated savings (IPA, 1996). LCAM (DOE's broad guidance for project management and acquisition) defines value engineering as "an organized effort, directed by a person trained in value engineering techniques, to analyze the functions of systems, equipment, facilities, services, and supplies to achieve the essential functions at the lowest life-cycle cost that is consistent with required performance, reliability, availability, quality, and safety" (DOE, 1995a). Yet the DOE inspector general concluded that DOE has not fully developed and implemented an effective value-engineering program (DOE, 1998a). The U.S. Army Corps of Engineers has reported a $20 return for every dollar spent on value engineering, and GAO has reported that value engineering usually results in a net saving of 3 to 5 percent of project costs. DOE savings for FY 1996 were about 0.2 percent, by comparison, according to a report by the DOE Office of Inspector General (DOE, 1998a).

Project Team Turnover

The turnover rate for DOE project managers is nearly twice that of industry, and this rate has worsened over time (IPA, 1995).

Lack of DOE Involvement at the Project Level

DOE waste management projects are generally led by project managers from contractor organizations, and DOE often has little or no representation on the project team (IPA, 1996). Although DOE's involvement at the project level has increased significantly since 1993, DOE's representation on project teams is still far less than the average involvement of owners in private sector projects. Because DOE has little involvement at the project level, control of the project is in the hands of contractors, and DOE is often not in a position to provide effective oversight. All project owners are frequently called upon to make decisions, and if the owner is not closely involved and his decisions are not timely, the project budget and schedule will suffer. DOE is at a further disadvantage when contractor project managers are not adequately trained as project managers. Successful owners in similar situations compensate by developing effective methods for owner representation and oversight. It is a truism in the industry that good clients make good projects, and owners who are knowledgeable, informed, experienced, and involved make the best clients.

MANAGEMENT STRUCTURE, PROCEDURES, AND ACCOUNTABILITY

The management of DOE projects takes place within a complex organizational structure that does not have established, consistent procedures for managing projects. Various policies and guidelines are available, but they are inconsistently applied by program and field offices. DOE has no central authority with the mission of ensuring that projects are managed properly, although FM provides administrative and oversight functions within the limits of its authority.

This section begins with a description of DOE's project management and organization. This is followed by a review of guidance documents and procedures for project management. The section concludes with an overview of existing DOE policies and procedures for project management.

Project Management and Organization

The three principal secretarial offices (programs) (Office of Science, EM, and DP, which account for approximately 75 percent of DOE's obligations) as well as the other offices have distinctive methods and traditions of project management. Oversight responsibility for project management department-wide is assigned to FM, but, according to DOE policy and LCAM, project management is the job of the field offices. When FM was established, it was intended to be the organization within DOE accountable for project performance. The FM office was headed by an associate deputy secretary (now classified as a director), who was expected to have management authority over most of the field offices. However, this role never materialized. In fact, FM does not have line authority over any office or program.

DOE projects are developed and funded under the direction of the program offices and managed by the field organization responsible for oversight of the contractor's implementation of the project. For major engineering or construction projects, a DOE project manager is assigned and, if necessary, a technical support organization is provided. Project managers may be responsible for more than one project at a time if the projects do not warrant full-time managers.

Most projects are managed by operations and field offices that oversee design, construction, and operations that are actually carried out by contractors and subcontractors. Management approaches vary with the type of contract (see

Chapter 4). The M&O (management and operations) and M&I (management and integration) contractors, which run many of DOE's larger facilities, are responsible for the facilities (including construction) at their sites, although direction, oversight, and approval authority are retained by the DOE operations office.

The contractor's project organization generally mirrors that of the DOE organization that manages the contract, with each component of DOE's organization having a counterpart in the contractor's. The organization is dictated largely by the request for proposal (RFP), which defines the scope of work and other requirements, such as the work breakdown structure, project control systems, reporting responsibilities, and regulatory requirements. The contractor prepares a detailed work breakdown structure and project organization chart, designating the roles and responsibilities for each function.

Once the functional roles and responsibilities and organizational structure have been solidified, descriptions are developed for key personnel, indicating individual roles and responsibilities, levels of authority, and reporting relationships. For major system acquisitions, the contractor's project manager is generally selected early to provide leadership and direction during the preparation of the proposal.

After the contract has been awarded, the project manager and key staff members begin the process of building a team. Policies and procedures are developed and implemented, and technical, cost, and schedule baselines are established. Communication is established within the project and with the customer (DOE and/or the M&O or M&I contractor). Periodic performance reports are prepared for the management of the contractor and DOE, including cost and schedule performance reports, variance analyses, and manpower reports. The contractor is supposed to conduct quarterly program review meetings, attended by personnel from DOE headquarters, the field office, and the M&O or M&I contractor. At these meetings problems are identified, action plans developed, and implementation tasks assigned to a lead organization and a responsible individual.

Project Management Guidance Documents

Project management at DOE is governed by four documents, in hierarchical order. At the highest and most general level is DOE Order 430.1, LCAM (Life Cycle Asset Management), which was originally implemented in 1995 and was recently revised with DOE Order 430.1A (DOE, 1995b). LCAM is often dismissed by DOE staff as pertaining mainly to program management, but its tenets are applicable down to the project level. The second document, the Joint Program Office Direction on Project Management (JPODPM), is a list of procedures for project management that is signed by the three Principal Secretarial Offices (DP, ER, and EM), the Director of RW, and the office managers responsible to them.

The third document is the Energy Systems Acquisition Advisory Board (ESAAB) Notice (N 430.1), which addresses decision making by headquarters. The fourth is a set of about 30 LCAM Good Practices Guides (GPG-FM-20-various), which expand on the basic principles of LCAM. A diligent project manager would use LCAM to clarify responsibilities, JPODPM for procedural guidance, and the Good Practices Guides for specifics in carrying out project management tasks. Three of the four contain mandatory requirements.

Life-Cycle Asset Management

The purpose of LCAM is defined as follows:

> [LCAM] establishes high-level Departmental requirements in planning, acquiring, operating, maintaining and disposing of DOE's physical assets. The Order phases out 13 prior Departmental Orders in these functional disciplines and incorporates industry standards, a graded approach, and performance objectives. The LCAM Order focuses on performance or outcomes over process and allows the Operations/Field Offices the flexibility to develop their own systems once a site-specific performance agreement has been implemented. The LCAM Order specifies the minimum project management system requirements that all projects must comply with (DOE, 1995b).

In short, LCAM outlines a strategy for facility management, from initial planning through final disposition. Unlike the detailed project management directions and guidelines in the earlier DOE Order 4700.1, Project Management System (which LCAM replaced), LCAM contains only general guidelines for project management. The process, it says (in the "Requirements" section), "shall be an integrated, systematic approach that shall ensure, but shall not be limited to … a project management system based on effective management practices that is sufficiently flexible to allow for the size and complexity of the project." The section concludes with 15 requirements that lead to conceptual design, project execution, and project operation. LCAM does not address the issues of reporting, federal and contractor responsibilities, or accountability. It does not specify an evaluation, reporting, or monitoring formula and does not provide guidelines for making specific critical decisions.

The 430.1A revision to LCAM includes as an attachment the Contractor Requirements Document, which contains requirements for contractors that are similar to those imposed on DOE. LCAM concludes with a list of the responsibilities of the organizational elements of DOE. The program office responsibilities include: (1) reviewing infrastructure activity of field elements in coordination with FM; (2) reviewing field element performance, including design, scope, and cost; and (3) peer reviews of programs under its authority. Field elements are responsible for (1) coordinating all review and external oversight activities of the contractors; and (2) conducting independent design, scope, and cost reviews when the size and complexity of a project warrant them.

Joint Program Office Direction on Project Management

The JPODPM, which was finalized in January of 1996, was the result of LCAM's assignment to program offices the authority to provide guidance to the field, and is intended to supplement the limited project management guidance found in LCAM (DOE, 1996b). JPODPM applies only to the participating programs that have signed the directive (i.e., EM, ER, DP and RW). A program level distribution memo describes the document.

> The JPODPM provides joint program direction to their respective field project management organizations. EM, ER, DP, and RW have consolidated their basic project requirements in the areas of planning, reporting, approval and change control thresholds. The JPODPM provides supplementary requirements to the LCAM Order in areas where the programs are in need of specific products or documents. The JPODPM may be used for project-specific technical reviews at the discretion of the participating Program Project Management Team members (DOE, 1996b).

The directive assigns responsibilities for critical decision for major systems and other line-item projects, based on a "graded" approach to meet the needs of individual projects. JPODPM applies to major systems, to other line-item projects, to operating/expense-funded projects, and to general plant projects and capital equipment. According to JPODPM guidelines, however, the DOE headquarters program office determines the degree of planning and documentation required.

The JPODPM requires that the outcome of the conceptual phase of a document be documented in a conceptual design report (CDR) or other appropriate document. The approved CDR is the basis for project design and planning. Following the CDR, JPODPM requires that either a strategic system execution plan (SSEP), a project execution plan (PEP), or, for an environmental restoration projects, a management action process (MAP) document be developed by the field element. The SSEP, PEP, or MAP constitutes an agreement between the headquarters organization and the field element and describes the management responsibilities and commitments for the project. The PEP also includes the schedule milestones, costs, project deliverables, project baselines (including project controls, change controls, and thresholds for change), and if applicable a performance-based measurement process. The PEP and the CDR combined are the foundation for setting the scope, cost, and schedule baselines for a project.

The JPODPM includes an implementation schedule and requires that all projects be in compliance. Any departure must be reported to the appropriate headquarters program office. Table 2-1 shows the project management decision and approval levels for all programs except environmental restoration.

Energy Systems Acquisition Advisory Board Notice

The ESAAB focuses on the authority and responsibility for making the four

TABLE 2-1 Project Management Decision, Documentation, and Approval Levels Based on Total Estimated Cost

Decision Document	Strategic Systems (as designated by the DOE secretary)	Other Line Item Projects (≥ $50m)	Other Line Item Projects (< $50m)	General Plant Projects (< $2m)
Approval of mission need (Critical Decision 1)	DOE secretary or as delegated	HQ program office	HQ program office	Field element
Conceptual Design Report	DOE secretary or as delegated	HQ program office	Field element	Field element
Approval of baseline (Critical Decision 2)	DOE secretary or as delegated	HQ program office	Field element	Field element
Approval to start construction (Critical Decision 3)	DOE secretary or as delegated	Field element	Field element	Field element
Completion/start of operations (Critical Decision 4)	DOE secretary or as delegated	Field element	Field element	Field element

Source: DOE, 1996b, Attachment 1.

critical decisions (CDs), rather than on the technical and documentary material on which the decisions are based. The CDs are: (1) approval of mission need; (2) approval of baseline; (3) start of construction; (4) completion or start-up of operations. The stated purpose of the ESAAB is described below as:

> The ESAAB Notice provides supplemental requirements to the LCAM Order that "dovetail" with the Department's physical asset management processes and clarifies Secretarial level processes in executive decision-making. The ESAAB Notice addresses the Headquarters' decision-making process for project critical decisions and baseline change control (DOE, 1997b).

Good Practice Guides

FM has issued more than 30 LCAM Good Practice Guides as references for project managers. The guides, which range from "Test and Evaluation" to "Comprehensive Land-Use Planning," provide information for meeting ESAAB, LCAM, and JPODPM requirements. These nonmandatory guides are intended to assist operations and field offices in developing performance-based management systems. The guides are based on industry practices and are not prescriptive.

Lack of Systematic Policy Application

DOE's policy guidelines for project management have not been applied widely or systematically. Because the guidelines are largely voluntary and because there is no central management authority, the guidelines do not provide the basis for a professional project management organization. Most DOE projects are done by contract, and many contractors have their own management systems, which they use in lieu of DOE's. The scope of the Contractor Requirements Document addition to LCAM is broad enough that almost any project management system deployed by a contractor will comply. The guidelines for project management are not clear enough to ensure effective oversight by DOE in its role of "managing the contractor."

Finding. DOE does not have adequate policies and procedures for managing projects. No single authority is responsible for enforcing or ensuring that project management tools are used.

DOE employees associated with projects told the committee that the JPODPM is the most useful of the DOE project management documents. But many admitted not feeling constrained to follow its directions in their particular applications. In the committee's judgment, the project management documents are not detailed enough to ensure the effective implementation of a project management system. For example, DOE projects do not consistently use project management plans (PMPs) to define the organization of projects and the roles and responsibilities of the parties involved, although such plans are standard in industry and the JPODPM calls for them (see examples in Chapter 3).

Although the committee appreciates that guidelines must allow for flexibility to meet special circumstances and to make room for innovation, the voluntary nature of the guidelines has become an invitation to nonadherence, and license for each headquarters program office, operations office, and field office to proceed in its own way. In fact, individual offices throughout DOE have also issued project management documents that vary in scope and quality.

In general, the early stages of projects have been overlooked. For example, DOE has had limited success in implementing value engineering practices, which often must be completed during the early phases of a project to have a significant impact on costs. DOE has developed (although not consistently applied) comprehensive practice guides for the design and construction phases of projects but has not developed comparable guidelines for the early conceptual and preconceptual phases of projects when the potential for substantial savings is high in both time and cost (NRC, 1998). The committee considers CD-1 (approval of mission need) and CD-2 (approval of baselines) essential for defining credible and achievable project baselines.

Finding. DOE has developed comprehensive practice guidelines for the design and construction phases of projects but has not developed comparable guidelines for the early conceptual and preconceptual phases, when the potential for substantial savings is high.

Finding. Many DOE projects do not have comprehensive project management plans to define project organization, lines of authority, and responsibilities of all parties.

Finding. DOE does not effectively use value engineering to achieve project savings, even though federal agencies are required to do so.

Recommendation. As a part of its project management system, DOE should issue fundamental policies, procedures, models, tools, techniques, and standards; train project staff in their use; and require their use on DOE projects. DOE should develop and support the use of a comprehensive project management system that includes a requirement for a comprehensive project management plan document with a standard format that includes a statement of the project organization covering all participating parties and a description of the specific roles, authorities, and responsibilities of each party.

Recommendation. DOE should establish an organization-wide value-engineering program to analyze the functions of systems, equipment, facilities, services, and supplies for determining and maintaining essential functions at the lowest life-cycle cost consistent with required levels of performance, reliability, availability, quality, and safety. Value engineering should be done early in most projects, and project managers should take the resulting recommendations under serious consideration.

Criteria for Critical Decision

The decision process for DOE's strategic and major systems is intended to ensure informed, objective, well documented decision making in CDs, baseline change proposals, and final site selection. The process also implements OMB Circular A-109, Major Systems Acquisitions. CDs for strategic systems are the responsibility of the acquisition executive. For major systems, that responsibility is usually delegated to the program secretarial officers, who have sometimes delegated certain decision responsibilities to operations or field managers. For much of EM's work, the CD process has been modified to allow for annual acquisition reviews of project status.

The ESAAB advises the acquisition executive on CDs for strategic systems. ESAAB, which is comprised of cognizant secretarial officers, validates the status and readiness to proceed with the decision requested by the acquisition proponent. The intent of this process is to provide an executive-level review and validation prior to a CD that commits DOE to the next phase of the acquisition.

However, DOE often disregards the intent of the ESAAB oversight process. The acquisition executive may classify systems that meet the total project cost threshold of strategic systems as major systems, which are subject to lower level approvals (e.g., the High Level Waste Removal from Filled Waste Tanks Project at the Savannah River Site). This delegation of approvals has placed the authority for CDs with the program offices, and sometimes even operations or field office managers, and it appears to circumvent the purpose of the ESAAB, which is to ensure that acquisition decisions are properly reviewed and independently validated. Authority over projects by those closest to day-to-day activities should be balanced with executive responsibility and accountability.

Performance Analysis and Reporting

Minimum reporting requirements covering costs, schedules, technical execution, accomplishments, and other issues, as applicable to various management levels, are shown in Table 2-2. As expected, the basic information for these reports is generated at the field level. However, the committee noted some instances when negative news about a project was not reported in a timely manner to a higher authority. This reflects an inherent cultural difficulty within the organization of communicating openly across horizontal levels and through vertical levels. DOE has attempted to improve communications and to operate more like a matrix organization, but not all DOE personnel seem comfortable with this approach.

Finding. DOE project documentation is not up to the standards of the private sector and other government agencies.

Recommendation. DOE should mandate a reporting system that provides the data necessary for each level of management to track and communicate the cost, schedule, and scope of a project.

Recommendation. DOE should update the project performance studies to document progress in these areas and extend the benchmarking baseline to include all major DOE construction projects. The study results should then be used to improve project procurement and management practices.

Life-Cycle Cost

OMB Circular A-109, Major Systems Acquisitions, requires that agencies make capital asset decisions on the basis of life-cycle, rather than initial cost. However, the budget process is structured in a way that encourages Congress and

TABLE 2-2 Minimum Project Reporting Requirements (Source: DOE, 1996b, Attachment 1)

	Financial Status	Cost	Schedule
Secretary of Energy (quarterly reports on strategic systems only)	Current status and evaluation of schedule, work execution, financial, current or potential problems pertaining to established baselines (i.e., estimate, or overall mission).		
Program Manager (quarterly reports for all other projects)	Current fiscal year and cumulative to-date amounts for budget authority allotted and funds which have been obligated.	At the total project level, current fiscal year and cumulative to-date planned, earned value (if required), and incurred costs; annual and total project estimates at completion.	Current status on headquarters program level schedule milestones, baseline or planned dates, comparing actual to forecasted dates.
Field Element (frequency of reporting is specified in the Project Execution Plan)	Information needed to meet statutory, legislative, and regulatory requirements as determined by field project manager for risk mitigation or oversight.	Report requirements as specified by the headquarters program element, including those may need on project-specific risk evaluations for risk mitigation.	

Technical	Work Execution	Accomplishments and Issues
and cost conditions as needed to describe schedule milestones, total cost		Top-level issues/ accomplishments on strategic systems include potential or imminent baseline changes that require secretarial approval or attention. Departmental strategic topics include external stakeholders, litigation, environmental, safety, health, procurement, human resources, and risk-level changes.
Current status on headquarters program level technical objectives (i.e., requirements as described in an approved project execution plan); current status compares the technical requirement with a determination of progress and problems toward meeting the technical requirement.	Current status of work done toward accomplishment of headquarters program level technical objectives of a project; evaluation of schedule, technical, financial, and cost progress and problems, including cause of problems, impacts, and corrective actions.	Significant accomplishments relating to project execution, as well as project related issues that require headquarters office(s) assistance.
project manager, coordinated with the written into contracts based and information determined necessary		Participants shall report any issues that departmental attention.

agencies to make decisions based on initial cost. This approach interferes with finding the best solutions to problems and can markedly increase the ultimate cost of projects. The committee urges DOE to make its internal decisions based on life-cycle cost and to urge other decision-making authorities to do the same in the best overall interest of the government.

Personnel

DOE is aware that demanding accountability commensurate with authority for project results will require stronger management and oversight (DOE, 1998b). GAO has concluded that the difficulties of hiring, training, and retaining people with the requisite skills for overseeing and managing contractors' operations has contributed to cost and schedule overruns (GAO, 1996). The DNFSB has repeatedly reported that the lack of expertise among project managers has been a problem and was the major contributor to schedule overruns on the Hanford Spent Nuclear Fuel Project (DNFSB, 1997). In 1993, the DFNSB recommended that DOE increase the qualifications for personnel at nuclear sites, particularly personnel involved with project management (DNFSB, 1993). In response to that recommendation, DOE established higher standards for project managers at nuclear facility sites, but they have not been fully implemented. Other attempts to train DOE project managers systematically across the organization have had limited success. Consequently, inadequate technical and managerial skills are still contributing factors in higher project costs and delays (GAO, 1999).

Finding. DOE's failure to develop project management skills in its personnel is a fundamental cause of poor project performance. DOE has shown little commitment to developing project management skills, as indicated by the lack of training opportunities and the absence of a project management career path. Successful organizations recognize that project management skills are an essential core competency that requires continuous training.

Recommendation. DOE should establish a department-wide training program for project managers. To ensure that this program is realistic, practical, and state of the art, DOE should enlist the assistance of an engineer/construction organization with a successful record of training project managers. DOE should establish criteria and standards for selecting and assigning project managers, including documentation of training, and should require that all project managers be trained and certified. DOE should also require that all contractors' project managers be experienced, trained, and qualified in project management appropriate to the project.

Lack of Focus on Project Management Expertise

DOE does not have a central direction for project management. FM was intended to have line authority over field managers but was never given that authority, and today FM has only advisory and oversight functions. Field managers continue to report both to the director of field management and to one or more program assistant secretaries. In short, FM provides staff support but is not a major influence on project management practices (Peters, 1998). In fact, based on its present organizational position, FM cannot effectively direct or oversee project management. Its main instrument of oversight is a quarterly report on the status of major and strategic systems and the administration of the annual project validation process to support the chief financial officer in the budget process.

Studies by IPA (1996), the Construction Industry Institute (CII, 1991, 1994), and the Business Roundtable (BRT, 1997) have found that better-than-average project systems have some form of central organization that is responsible for controlling project definition, maintaining discipline, and integrating management activities. In the absence of an organization to maintain control over project management and carry out uniform policies, DOE has relied on program and field elements to accomplish projects.

In addition to modifying its organizational framework to support project management, DOE should benchmark project management against generally accepted industry practices. Based on the collective expertise of committee members, the committee developed a list of characteristics that contribute to the successful completion of large, often one-of-a-kind projects. The characteristics, which are presented in Appendix C, are formatted as a checklist and do not define a process but could be used as a checklist for DOE projects.

Quality Performance Standards Based on the ISO 9000 Process

Many organizations that have recently reorganized to improve quality have sought certification through the International Standards Organization (ISO) a Geneva-based international agency responsible for global standardization which has established quality performance standards in the ISO 9000 process. These standards have been widely embraced by private sector and government organizations both here and abroad. In its simplest application, the ISO 9000 process requires that an organization define what it does, how it will do it, what records will be kept, and who the responsible parties are for all operations. The organization must then show that its policies and procedures are (1) consistent with the organization's purpose; (2) universally applied, understood, and followed; and (3) continued as the basis of doing business. For an organization to be certified, it must clearly define its purposes, missions, and goals; purge excessive procedures and policies; and replace them with simple, straightforward documents that provide only essential instructions to staff. The organization then undergoes a certification review coordinated by the ISO. Reviewers note extraneous or conflicting instructions, and shortcomings in the quality performance program. Certification shows that the operation has a clear plan, procedures, and policies.

ISO 9000 certification tends to reduce paperwork, eliminate nonessential activities, reduce operating costs, and improve performance. But it requires a sustained effort by the leaders and staff of the organization. Annual recertification requires that the organization continue to operate in the certified mode. A process like ISO 9000 certification could help DOE remake the operating policies, procedures, and standards that have accumulated over the past 50 years.

Finding. ISO 9000 provides a certification process by which an organization can measure itself against its stated processes, but DOE has not obtained certification. The certification process would help DOE remake its operating procedures and standards and make its practices consistent with its procedures.

Recommendation. DOE, as an organization, should obtain and maintain ISO 9000 certification for all of its project management activities. To accomplish this, DOE should name one office and one individual to be responsible for acquiring and maintaining ISO 9000 certification for the whole department and should require that consultants and contractors involved in the engineering, design, and construction of projects also be ISO 9000 certified.

PROJECT PLANNING

DOE's project planning has not been effective, although there are exceptions, such as the successful Advanced Photon Source Project at Argonne National Laboratory and the B-Factory at the Stanford Linear Accelerator Center. Recurrent problems with project management have raised questions about the credibility of DOE's conceptual designs and cost estimates (NRC, 1998). Findings by the Business Roundtable (BRT, 1997), the Construction Industry Institute (CII, 1991, 1994) and several years of research and studies of hundreds of projects by IPA (1993, 1995, 1996) show that preconstruction planning is one of the most important factors in successful projects.

Preconstruction Planning

In March 1998, a government-industry forum on capital facilities and core competencies was held in Washington, D.C. The forum was sponsored by the Business Roundtable, the Naval Facilities Engineering Command, and the Federal Facilities Council, of which DOE is a member. The forum report concluded:

> The best capital project systems maintain the in-house resources necessary to develop and shape projects in the advance planning phase and to bind the owner functions together to find the right project and prepare for efficient execution. Finally, they all maintain some form of central organization responsible for preparing the work process, for advance planning, to provide the skills and resources, to pull in critical core competencies, and to provide the interpersonal organizational structure that binds the operations, business, engineering, maintenance, outside organizations, and affected project systems (Federal Facilities Council, 1998).

Through research and practice, the construction industry has also documented the benefits of preconstruction planning in terms of cost and schedule. Many committee members also have firsthand experience with preconstruction planning and the associated processes and documentation. Effective preconstruction planning involves several steps. First, it requires that in all aspects of the project, key personnel (design, construction, start-up, maintenance, and operations) be involved from the outset. Second, a strategic plan must be developed that defines mission needs and relates them to project requirements. Third, an integrated project plan must be prepared that addresses the overall strategy for acquiring the end product or service, identifies the interfaces, and establishes measures of success. Fourth, an integrated regulatory plan must be developed to identify regulatory interface points and requirements and to establish constraints and boundary conditions that must be accommodated. Fifth, a detailed project execution plan can be prepared to establish the tactics, organizational relationships, roles and responsibilities, and precise steps for executing the various aspects of the project.

Finding. DOE preconstruction planning is inadequate and ineffective, even though preconstruction planning is one of the most important factors in achieving project success.

Recommendation. DOE should require that strategic plans, integrated project plans, integrated regulatory plans, and detailed project execution plans be completed prior to the establishment of project baselines. To ensure facility user and program involvement in the preconstruction planning process, DOE should require written commitments to project requirements from the ultimate users.

Setting Baselines Prematurely

A baseline is a set of technical, scope, cost, and schedule parameters that describe the expected capabilities, cost, and duration of a project. In principle, baselines are based on adequate definition of engineering designs, with appropriate allowances for uncertainties (contingencies), and are included in budget submissions. However, there is often considerable pressure to adjust estimated costs to fit the anticipated budget authorization. For example, some DOE personnel stated that Congress would not approve project capital requests of more than $1 billion, so estimates were adjusted to be below this number. Such practices inevitably result in cost overruns and/or subsequent reductions in project scope.

DOE generally establishes project baselines after only 2 or 3 percent of the design work has been completed (Tavares, 1998), which the committee believes is premature. The consensus in private industry, the Department of Defense's Military Construction Program, and the U.S. Army Corps of Engineers Civil Works Program is that the appropriate point to develop a project estimate suitable for budgeting is at the 30 to 35 percent design completion stage (McGinnis, 1998).

DOE has no designated source of funding for the preparation of baselines, and apparently does not explicitly budget for prebaseline engineering, making it difficult for project managers to support preconstruction planning. Other federal agencies have recognized the value of prebaseline engineering and budget for it accordingly. For example, the Department of Defense's Military Construction Program includes a line item for planning-and-design funds in the preliminary design stage in its budget requests to Congress.

DOE has recently made some attempts to set baselines at a more credible stage of design. According to a recent report, "Managing to the Baseline," FM has made improved baselines its highest priority (DOE, 1998b), and corresponding efforts are under way with Congress and the Office of Management and Budget (OMB) to revise upward the required design content of project baselines and to provide the appropriate design funding in the FY 2001 budget (Peters, 1998). DOE's chief financial officer has supported this effort by including the revision of project baselines as part of the FY 2001 budget call. If total funds for baseline preparation are not increased, fewer projects will probably be undertaken by each program.

Changing the baseline funding levels might appear to reduce the flexibility of program managers to manage their programs. Nevertheless, the committee believes that the possibility of reducing the overall number of projects would be much less damaging than premature baselines have been. The committee believes that agreements between DOE, OMB, and Congress on better baseline definition should be established as soon as possible.

Finding. DOE often sets project baselines too early, usually at the 2- to 3-percent design stage, sometimes even lower. (An agreement between Congress and DOE's chief financial officer to establish baselines at the 20- to 30-percent design stage is scheduled to be implemented beginning with fiscal year 2001.)

Recommendation. DOE should significantly increase the percentage of design completed prior to establishing baselines. Depending on the complexity of the project, the point at which project baselines are established should be between the completion of conceptual design and the completion of the preliminary design, which should fall between 10 and 30 percent of total design. The committee supports continuing efforts by Congress and the DOE to develop project baselines at a point of adequate definition beginning with the fiscal year 2001.

Recommendation. Baseline validation should be assigned specifically to the project management office recommended in this report. The Military Construction Program of the Department of Defense, which requests planning and design funds for all projects in the preliminary design stage on the basis of total program size, is a potential model for DOE.

Project Estimates and Budgets

Project estimates are not the same as budgets. An estimate is a forecast of project costs. A budget includes the estimate plus contingency factors to cover future uncertainties, modified by professional judgment. A budget may be a target figure for the project, a cap that the project must meet, and a tool for project discipline (discussions of DOE's project costs, estimates, contingencies, and durations can be found in Appendix A and Appendix B). It is often erroneously believed that reducing budgets can reduce costs, but this is rarely true; reducing budgets may only increase budget overruns. Costs can be reduced, however, by faster project completion, reductions in project scope, better project definitions, redesigns, value engineering, rigorous change control, better quality control, more effective management, and more efficient design and construction through stronger incentives, shared lessons learned, and more effective competition.

Considerable pressure has been generated from within DOE and from OMB to reduce project budgets to fit the funds expected to be available (OMB, 1997). Cost overruns are inevitable, however, if project budgets are arbitrarily reduced without associated reductions in scope.

Managing Risk and Contingency

Contingency allowances are required to pay for unforeseen but inevitable circumstances that cause costs to increase during the course of a project. Confidence bands can be established statistically on the basis of experience with other projects, taking into account the location, project complexity, and outside influences. Unjustified reduction of contingency is not a method to save money, and often results in extra costs associated with delays for acquiring additional funds or reducing the project scope to pay for unforeseen occurrences.

Unfortunately, experience suggests that risk management is not central to DOE's planning, budgeting, and acquisition process (DOE, 1998c; OMB, 1997). DOE, as a government agency, should be risk neutral. In general, however, DOE appears to be risk-averse in terms of cost and schedule accountability. At the same time, DOE has often taken the following risks on projects that private industry, or even other government agencies, would not have taken:

- commitments to cleanup and remediation projects based on unproven technologies
- commitments to a single cleanup technology without investigating alternatives
- awarding fixed-price contracts without clearly defined scope or conditions
- initiating remediation projects before wastes have been adequately characterized
- initiating projects based on estimates made at very early stages of definition with very low degrees of confidence
- initiating projects without adequate preconstruction planning
- initiating projects before project managers and other required staff have been identified

DOE cost estimates violate OMB's policy on contingency allowances in a number of ways (OMB, 1992): the effects of uncertainty are not analyzed; no probability distributions are given for costs; past biases or over-optimism in cost estimates are not considered in preparing new cost estimates; no sensitivity analyses are performed; and cost estimates are not expected values.

Based on the committee's observations, DOE, Congress, and other stakeholders do not communicate with each other effectively about estimated project costs and durations. Even the definitions of cost estimates and contingencies are inconsistent. Sometimes the estimated cost of a project is confused with the baselined TPC or the appropriated budget for the project. In many cases, the estimated cost for a project (numbers based on preliminary designs), the baseline TPC (more accurate numbers), and the project budget (allocated funds) differ. In the end, of course, TPC will equal the funds allocated. But, DOE often complicates the situation by failing to communicate its difficulties. Although there is a great deal of talk about risk, definitions of the term vary. Because DOE has no standard method for assessing project risk comparing projects, methods, and contracts is difficult.

DOE often bases contingency allowances on a fixed percentage of the total estimated cost rather than on an assessment of the risks of success and failure, and contingency allowances on DOE projects are routinely low (see Appendix B). Contingencies should accurately reflect the risks and uncertainties inherent in the work and should relate to the degree of uncertainty (e.g., the fewer unknowns, the lower the contingency). One-of-a-kind projects, which have many unknown characteristics and may involve unproven technologies, have a higher probability of not meeting initial estimates. Allowances for cost growth and unknown costs should be developed through risk, contingency, or scenario analyses. Sources of bias should be addressed through sensitivity analyses and independent reviews that evaluate the assumptions used in the cost and duration estimates, and cost and duration estimates should be robust against changes in assumptions. An explanation of the basis for the contingency allowances in a cost estimate should be submitted with the project proposal. Confidence factors, or the likelihood that a given budget or schedule will not be exceeded, should be associated with all cost and duration estimates at all stages, so project proponents, participants, and sponsors all have a clear idea of the risks of overruns.

DOE project estimates, however, do not contain all of this information. DOE often presents point estimates with no indication of their reliability and seems to take no cognizance of the fact that some projects have higher risks of overrunning estimated costs and schedules and should therefore have higher contingency allowances.

The availability of small, yet powerful, computers has ushered in a new era of risk assessment and analysis. Many firms and government agencies are using risk analysis techniques to identify, measure, and manage project risks. Yet DOE seldom conducts formal risk assessments or analyses for its projects. Results from risk analyses can be used to define contingency amounts for both budget and schedule. Technical performance risk assessments can be used to guide design decisions away from risky alternatives. Risk assessments conducted early in the project life cycle can afford a project team an opportunity to identify project risks and mitigate their effects. Periodic project risk assessments can be used to suggest effective contracting arrangements for shifting and sharing project risks. Considering the size and technology of DOE projects, it is very surprising that DOE conducts so few formal project risk assessments.

Finding. DOE often sets project contingencies too low because they are often based on the total estimated cost of a project rather than the risk of performing the project.

Finding. DOE does not always use proven techniques for assessing risks of major projects in terms of costs, schedule, and scope.

Recommendation. DOE should establish contingency levels for each project based on acceptable risk, degree of uncertainty, and desired confidence levels for meeting the baselines. The responsibility and authority for managing contingencies should be assigned to the project manager responsible for doing the work. In the process of evaluating potential projects, DOE should apply risk assessment and probabilistic estimating techniques, as required by the Office of Management and Budget.

Tracking Project Progress

Earned value is a method for tracking progress that relates the actual cost of the work performed to the budgeted cost and schedule (Abba, 1997). Comparisons of planned values to actual performed (earned) values provides an objective assessment of cost performance. The Department of Defense and other organizations use earned value as a metric and an early warning system for managing projects. DOE, however, does not use it. Moreover, DOE has no consistent system for objectively, rather than subjectively, tracking progress and predicting cost and schedule overruns.

Finding. DOE does not effectively use available tools, such as earned value management, to track the progress of projects with respect to budget and schedule.

Recommendation. DOE should establish minimum requirements for a cost-effective earned-value performance measurement system that integrates information on a project's work scope (technical baseline), cost, and schedule. These requirements should be included in the request for proposal.

Change Control

Change control is the systematic evaluation, coordination, and approval or disapproval of proposed changes in the established design baselines. Change control includes verification that approved changes have been incorporated into the technical configuration baseline and the contract budget baseline.

Because changes to the scope, cost, or schedule of a project may be proposed after a baseline has been established, the project must have a clear and efficient process for managing these changes. Once a baseline has been set, a rigorous change control procedure should be established to maintain technical, cost, and schedule discipline. Change control requires that a current working cost estimate be kept up to date with all approved changes and that all impacts of all proposed changes be fully evaluated and priced out prior to approval. The LCAM Order (DOE Order 430.1), DOE's broad guidance for project management, includes this requirement, but there seems to be no mechanism for producing and maintaining a running estimate. For example, a 1997 LCAM self-assessment report by the Savannah River Operations Office noted that there was no policy or procedural requirement to have a working estimate throughout the life of a project (DOE, 1997c). Without an up-to-date working estimate, cost and schedule increases may be deferred until a periodic review, which usually results in unanticipated cost growth, delays, and reworking.

DOE's baseline management and change control systems have evolved from a very formal, detailed system that was defined in superseded documents, such as DOE Orders 4700.1 and 4300.1. Today the DOE change control process is rather loosely guided by DOE's LCAM Order and its implementing directives (JPODPM and ESAAB Notice N 430.1). The JPODPM provides the most detailed guidance, including explicit decision-making authority.

DOE's policy guidance states that it is the responsibility of the field office—not DOE headquarters—to direct or oversee the contractor because the field office is accountable for the contractor's performance. Despite this, managers in field offices told the committee that many managers in DOE headquarters continue to communicate directly with contractors. Even if they are primarily seeking information, these conversations often become *de facto* directives that can lead to changes in scope, cost, or schedule. Even a request for information outside normal reporting channels may divert contractor personnel and raise costs.

The absence of a disciplined change control process makes it difficult to hold contractors accountable for delivering projects that meet agreed cost, schedule, and scope requirements. It also diverts funds from necessary maintenance of operational and site infrastructure and erodes the confidence of DOE's stakeholders, including Congress and regulators. With a properly functioning change control system, project managers can monitor and control changes, limiting them to changes based on authorized internal project replanning or contractual obligations.

Finding. DOE does not have a consistent system for controlling changes in project baselines.

Recommendation. DOE should establish a system for managing change that provides control, traceability, and visibility for all baseline changes. Change control requirements should apply to the contractor, the field elements, and headquarters.

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3

Use of Project Reviews to Improve Execution

INTRODUCTION

Until 1994, DOE and its predecessor agencies had a formal structured review process, defined in DOE Order 4700.1, which was replaced in 1995 by LCAM (DOE Order 430.1). LCAM and the implementing LCAM Good Practices Guides (discussed in Chapter 2) gave program offices full discretion to decide how to manage projects, including how and when to conduct reviews. Since then, with two exceptions, the committee observed that reviews have been initiated on an ad hoc basis. The two exceptions include a semiformal program for project reviews begun about 15 years ago for ER (now Office of Science) projects. This review process has become more structured recently but is not a completely independent review process. The other structured project review process used by DOE is the procedure developed on the basis of the Phase I NRC report (NRC, 1998).

INDEPENDENT PROJECT REVIEWS

In Phase I of this study, the NRC outlined recommendations for project selection, the content of project reviews, and the capabilities of independent reviewers. Although that report focused on the projects of fiscal year 1998, the process could be used on a continuing basis. That report found that DOE had developed comprehensive guidelines for reviews during the design and construction phases of a project, but not for the preconceptual and conceptual phases (when cost and schedule benefits are the highest). The committee believes that vigorous reviews to establish valid project definition, including cost, schedule, and scope of work baselines, in the preconceptual and conceptual phases are vital to successful project execution and to controlling costs.

Based on the recommendations of the Phase I study, DOE has contracted for independent reviews to assess the technical scope, cost estimates, schedules, and supporting data for DOE projects in accordance with congressional language. These independent reviews have highlighted the problems in DOE's management and execution of projects. The findings and recommendations of the initial independent reviews, which have been transmitted to Congress, document deficiencies similar to those found by this committee and others, indicating that difficulties with project management continue. For example, the Spent Nuclear Fuel Dry Storage Project at the Idaho National Engineering and Environmental Laboratory is a "privatization" project with a TPC of $105 million. The independent reviewer found many deficiencies in planning, execution, and contracting for this project. First there was no PEP. Second, DOE headquarters had not been informed that the project was likely to exceed its TPC. Third, there was no formal procedure for selecting the privatization contract and no record of the analysis underlying that decision (Lockwood-Greene Technologies Corporation, 1998).

In a review of the Stockpile Management Restructuring Initiative Project at DOE's Pantex facility, many weaknesses were found in budgeting and planning. The schedules for some of the subprojects were "extremely conservative." Cost estimates for many of the routine demolition and construction activities were "very high." Too many layers of management were involved in approving "small, straightforward projects." The reviewers found that 8 of the 12 subprojects lacked adequate justification for proceeding (questionable economic benefits, reduced operational flexibility, or failure to take account of changing circumstances) (Foster Wheeler Environmental Corporation, 1998a).

An independent review of the Atlas Project of Los Alamos National Laboratory (a project to improve simulation of nuclear weapons performance) found that the project was unlikely to be completed within the baseline cost estimate and recommended that a variety of steps be taken to improve cost estimation (Cadmus Group and Project Performance Corporation, 1999).

A review of the Stockpile Management Restructuring Initiative at the Kansas City Plant called it "a well run, well managed project" but identified a number of weaknesses in cost estimation, including a failure to allow for $3.2 million for the installation of start-up equipment. The review team recommended measures to improve risk assessment and cost-benefit analysis and to streamline review and approval procedures (Foster Wheeler Environmental Corporation, 1998b).

The Jupiter Corporation (1998a), reviewed the Pit Disassembly and Conversion Facility Project of the DOE Office of Fissile Material Disposition and found that the project managers had not taken into account the applicability of Nuclear Regulatory Commission licensing standards and other regulatory requirements, although Congress has required that DOE meet those standards. In addition, the project had failed to document the analysis supporting its choice of contract type.

According to the independent reviewer, the Nuclear Materials Storage Facility Renovation project of Los Alamos National Laboratory has a number of deficiencies in cost estimation, scheduling, and procurement. The project managers corrected many of these problems while the review was under way, which resulted in substantial improvements (CETROM, 1998a).

CETROM Consulting Engineering Corporation (CETROM, 1998b) reviewed the Rapid Reactivation Project (to ensure that the United States could increase its nuclear weapons manufacturing if necessary). The project was found to be generally successful, although the contingency allowances for schedules were too small.

An independent review of the Dual Axis Radiographic Hydrotest Facility project found that it was generally successful and well managed. The reviewers recommended however, better coordination of procurement documentation among the several national laboratories involved (Jupiter Corporation, 1998b).

An independent review of the Chemistry and Metallurgy Research Facility Upgrades project of Los Alamos National Laboratory (LANL) (which had been suspended in 1997 because of rapidly growing costs and scope and was partially resumed in 1998) found serious weaknesses in setting baselines. Reviewers found that the original cost, scope, and schedule baselines had not been changed to meet current DOE missions, and they recommended that new baselines be established. They also observed that management at DOE headquarters, disregarding stated policy, had inserted itself into the approval process for changes in the baseline (Jupiter Corporation, 1998c).

The review of the Nuclear Materials Safeguards and Security Upgrades Project at LANL found that although a detailed schedule risk analysis was performed as part of the Critical Decision Review process, other risks, such as construction performance and the effects of ongoing changes to the project management process at LANL, had not been taken into account. The reviewers suggested that the schedule risk analysis be updated to incorporate all identified risks and lessons learned (CETROM, 1998c).

DOE program offices, in association with FM, are currently conducting external reviews in accordance with the processes and criteria recommended in the NRC Phase I report. Briefings and draft reports provided to the committee show that program offices are also developing a process to sponsor their own internal project reviews modeled partly on the existing procedures now used by the Office of Science and partly on the criteria and guidelines recommended in the NRC Phase I report. These internally-run project reviews will be considered to be independent reviews (by DOE) as long as they are conducted outside of the project's line management and the reviewers are technically capable and have no conflicts of interest. Setting aside the question of whether an "internal independent project review" is an oxymoron, the critical factor is whether the project review will increase the likelihood that cost, schedule, and technical scope baselines will be met. The objective of an independent assessment should be to evaluate a project from the standpoint of project management leading up to approval of the baseline (CD-2), including technical scope, cost estimates, schedules, and supporting data. The assessment should determine whether the baselines are accurate and whether the project, as formulated, is executable. A fundamental requirement is that reviewers not be advocates for the project. This requirement will be met for the external project reviews being administered by FM. However, independence could also be achieved by using trained, skilled, and knowledgeable DOE employees from outside the cognizant program and operations offices. The team would have to be balanced by outside members.

DOE should adopt a graduated approach, with the depth of detail determined by the relative importance and cost of the project. The NRC Phase I report, recommended that independent reviews be conducted for all projects with TECs of more than $20 million and projects or project activities with TECs of $5 million to $20 million if they meet the following criteria:

- DOE has little or no experience with the proposed delivery method (e.g., privatization of waste management).
- The technology is new or requires significant research and development to show that it will be workable at field scale.
- The project does not obviously or strongly support the mission objectives in DOE's Strategic Plan.
- The projects has had significant cost or schedule overruns or has a high potential for overruns.
- The projects managed by an operations office that has a history of project overruns, failures, or terminations.
- Characterization for the project is incomplete.

This committee supports the process and criteria set forth in the NRC Phase I report and the procedure developed to conduct the independent, non-advocate reviews. However, the benefits of conducting reviews will not be fully realized until DOE adopts a process to ensure that recommendations are properly reviewed and action is taken. Furthermore, in no case should an internal review be considered to replace independent external reviews.

Finding. Independent project reviews are essential tools for assessing the quality of project management and transferring lessons learned from project to project.

Finding. External independent reviews of 26 major projects are under way to assess their technical scope, costs, and schedules. The reviews so far have documented notable deficiencies in project performance verifying the committee's conclusion that DOE's project management has not improved and that its problems are ongoing. However, DOE has yet to formalize and institutionalize a process to ensure that the recommendations from these reviews are implemented.

Finding. Various DOE program offices are also developing the capability of conducting internal independent project reviews.

Recommendation. DOE should formalize and institutionalize procedures for continuing independent, nonadvocate reviews, as recommended in the Phase I report of the National Research Council to ensure that the findings and recommendations of those reviews are implemented. DOE should ensure that the reviewers are truly independent and have no conflicts of interest.

Recommendation. All programs that have projects with total estimated costs of more than $20 million should conduct internal reviews, provided that the value of the reviews would be equal to or greater than the costs of conducting them. The decision to proceed with internal reviews should be made by program management, depending on past experience with similar projects, the estimated cost of the project, and the uncertainty associated with the project. Internal reviews are expensive and take up the time of valuable people, so they should not be undertaken lightly. However, under the present circumstances, the committee believes that more internal reviews would be justified. The project management office should manage these reviews for the director or assistant secretary of the cognizant program office using nonadvocate reviewers. The results of these reviews should be taken by the program office to the Energy Secretary's Acquisition Advisory Board (ESAAB), and used as the basis for deciding on whether to continue the project.

OTHER FORMS OF PROJECT REVIEW

Project Reviews of the Office of Science

DOE's Office of Science has a long-established system of peer reviews to corroborate the scientific and technical feasibility of its projects. Peer review teams are established during the preconceptual or conceptual phase and participate in formulating the project to meet preconceived needs. Periodic reviews are also conducted during the later phases of the project. In addition to addressing the technical and scientific aspects of a project, some team members are assigned to address cost estimates and construction schedules (albeit not as rigorously). These reviews cannot be called fully independent, however, because the teams tend to be composed of internal proponents and external members with indirect interests in the projects. Therefore, they may not give full consideration to alternatives for achieving the goals of a project or question the need for the project itself. These reviews are systematic, however, and they do produce audit trails of the decision-making process.

The committee believes that peer review panels should not include internal proponents or others with conflicts of interest. The panel should be made up of individuals with broad interests and should be able to develop alternative scenarios for accomplishing the project goals and assess rigorously cost estimates and construction schedules. In no case should internal reviews be considered as replacements for independent external reviews.

Special Panels of Experts

If in-house expertise is lacking or if the viability of proposed solutions must be assessed, DOE has occasionally convened special panels of experts to provide technical advice on complex or unusual issues. The committee endorses this approach.

Environmental Management Quarterly Management Review

In addition to the review process specified under the LCAM Order, EM conducts its own quarterly performance reviews in conjunction with all operations offices. These extensive reviews cover many established milestones, line items, and projects in the areas of waste management, environmental restoration, science and technology, and nuclear material and facility stabilization. The committee recognizes the management and technical challenges facing DOE in the environmental management arena and is highly supportive of EM's efforts to conduct these reviews. Despite these efforts, however, projects have not performed at a level comparable to that of the private sector or other federal agencies.

Reviews by the Defense Nuclear Facilities Safety Board

The DNFSB was created in part to review the design, construction, operation, and decommissioning of DOE's defense nuclear facilities to ensure that activities at those facilities are conducted in such a way that the health and safety of the public, including the environment and workers, are protected. The DNFSB and its staff conducts reviews to identify potential health and safety concerns. The primary mechanism used by the DNFSB to promote action is the issuance of recommendations to the secretary of energy on specific areas of concern. The DNFSB has great latitude in selecting projects to review, in access to individual projects, and in recommending safety and health issues to be addressed. The DNFSB does not manage DOE's work, but it does influence DOE projects when the health and safety risks warrant intervention.

Independent Reviews Using Statistical Models

EM has engaged IPA to review its project management system twice since 1993. IPA has a large database of private and government contracts, used mainly for analyzing cost and schedule overruns for industrial, chemical process, and other projects similar to DOE's environmental restoration and waste management projects. IPA found that EM project costs were much higher than those of industry (typically 48 percent higher) or other government agencies and had more schedule slippages (IPA, 1993). IPA has also undertaken analyses for individual DOE projects (see Appendix A), in which the project parameters are used in a statistically-fitted model to determine if the project is consistent with the norms from other projects. The findings from these studies showed that intensive project reviews are necessary at all stages, especially in the early stage of establishing a baseline.

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4

Acquisition and Contracting

INTRODUCTION

DOE is the largest civilian contracting agency in the federal government. In fiscal year 1997, DOE obligated approximately $16.2 billion, or almost 91 percent of its total obligations, to contractors (GAO, 1999a). DOE and its predecessor agencies have traditionally managed sites through large blanket M&O (management and operating) contracts, in which a single contractor was responsible for an entire site and was reimbursed for all costs, in addition to receiving a management fee. These contracting practices produced some remarkable accomplishments in the development of weapons and production of fissile material in an environment in which national defense, and not cost, was paramount. However, as DOE's mission has changed and concerns have been raised about DOE's control of its contractors, DOE contracting—and especially the M&O arrangement—has been called into question.

DOE's attempts to reform its acquisition and contracting methods have not produced lasting positive results. In fact, GAO continues to designate DOE contracting as a high-risk area vulnerable to waste, fraud, abuse, and mismanagement. GAO has repeatedly found that DOE enters into contracts with little or no competition, reimburses contractor costs uncritically, and is lax in overseeing contractors (see, for example, GAO, 1997a, 1997b). GAO found that contractors with M&O contracts often failed to control costs because the expenses were assumed by the government (GAO, 1997b).

In 1993, a Contract Reform Team was appointed directly by the secretary of energy to review DOE's contracting procedures. The team's report, *Making*

Contracting Work Better and Cost Less, recommended nearly 50 reforms including: (1) using performance-based contracts; (2) increasing competition for contracts; (3) improving management and cost controls; and (4) making performance-based criteria and other incentives part of DOE contracts (DOE, 1994). The Contract Reform Team suggested specific measures for implementing these recommendations. As a result, DOE revised its policies and procedures to encourage competition and provide incentives to contractors to improve their performance and control costs.

This chapter discusses the origins of DOE contracting practices, describes contracting structures and methods, assesses the current state of contract reform, and recommends changes in contracting practices that would improve DOE's project performance.

CONTRACTING PRACTICES

Wartime Origins of the Management and Operating Contract

Many of DOE's contracting practices date from the Second World War when the national emergency, the development of new weapons, and secrecy were the highest priorities. Although the initial wartime effort was under the direction of the Manhattan Engineer District of the U.S. Army Corps of Engineers, President Truman personally called on the chief executives of companies such as DuPont and General Electric to help protect the nation's security by assigning their best technical experts to the nuclear weapons effort. Many of the wartime research, design, and construction contracts included, or eventually evolved into the management and operations of these facilities, and establishing a contracting system that has continued for over 50 years.

During the Cold War, the M&O cost-plus-award-fee contract was extensively used for designing, building, and operating critical nuclear weapons facilities. The M&O contract was intended to ensure flexibility and rapid response, to exploit technological developments, and to respond to international crises. The M&O contract typically contained a very general work scope under which the government reimbursed essentially all contractor costs and paid an additional fee based either on a fixed fee schedule or an incentive fee based on achieving contract goals, such as production of a specified quantity of a specified product.

The M&O contract approach provided flexibility in a rapidly changing technological and geopolitical environment. At Hanford and Savannah River, five nuclear reactors, two major chemical processing plants, five coal-fired power plants, railroads, and highways were built in less than five years for less than $5 billion. New cities were created in remote areas, such as Los Alamos, Hanford, Oak Ridge, Savannah River, Rocky Flats, and the Nevada Test Site.

Changing World Conditions

Since the end of the Cold War, the emphasis has shifted from weapons production to environmental cleanup, from secrecy to openness, and DOE's expenditures and cost accounting have come under intensive scrutiny. The M&O cost-plus-award-fee contracting strategy has not always transferred successfully to the new missions of environmental remediation and cleanup. M&O contracts provided weak financial controls (because all costs were simply passed through to the government); emphasized process rather than results; lacked clear lines of authority, responsibility, and accountability; and contributed to cost growth (DOE, 1995a). These weaknesses, which had always existed, became more apparent in the post-Cold War era when much of DOE's spending was no longer shrouded in secrecy and national security was less of a concern.

Finding. DOE's long history of hiring contractors to manage and operate its sites on the basis of cost-plus-award-fee contracts has created a culture in which neither DOE nor its contractors is sufficiently accountable for cost and schedule performance.

Contracting Structures

In general, determining which contracting method to pursue for a project should be part of the acquisition strategy developed during the preconstruction planning phase. The criteria for choosing a contracting method are cost effectiveness for the government and meeting the technical requirements of the project. Although an analysis of the selection is required by Federal Acquisition Regulations (FAR 16.103(d)), DOE has not always conducted and documented its selection (Jupiter Corporation, 1998).

Various contract methods are available to DOE, and the selection of the most suitable contracting approach is critical for effective and efficient project delivery. Some of these contracting methods are unique to DOE, while others are common federal acquisition practices. Selection of the best contract type for the job is very important because contractors respond differently to different contracts. But it may also be said that the most important decision is the selection of the right contractor.

Cost-Plus-Fixed-Fee Contracts

Cost-plus-fixed-fee contracts are structured so that almost all legitimate costs are reimbursable, with a predetermined fee added. These contracts are used when controlling costs is a lower priority than other factors, such as time. The open-ended reimbursement and fixed fee provide little incentive for the contractor to focus on the cost effectiveness or efficiency of his performance, and costs may grow as a result.

Cost-Plus-Award-Fee Contracts

Cost-plus-award-fee contracts are similar to cost-plus-fixed-fee contracts except that the amount of fee payable (up to a limit specified in the contract) is subject to an assessment of contractor performance. Cost-plus-award-fee contracts are most suitable for projects with goals that are not clearly definable in measurable and objective terms. This includes ongoing work that does not have clearly defined end points, such as administrative support and research and development projects. Although the award fee offers flexibility to the contract manager by providing incentives for superior performance, the subjective nature of the award process makes it subject to charges of bias, favoritism, and abuse and may lead to disputes between the contractor and the awarding official.

Performance-Based Contracts

The performance-based contract is a variation of the cost-plus-award-fee contract. Fees depend on the contractor meeting well defined objectives of cost, schedule, and scope. Performance-based contracts are suited to a large variety of activities—including many DOE projects—for which performance objectives can be clearly stated and are measurable. The evaluation criteria and methods for measuring performance must be clearly defined and agreed to by DOE and the contractor before the contract is awarded; adjustments are made to reflect changing requirements (i.e., adverse events that are clearly beyond the contractor's control). Subjective performance evaluations and award fees should be used only when the nature of the work does not lend itself to objective measurement.

Fixed-Price Contracts

Some DOE contractors have successfully used fixed-price contracts in subcontracting routine services. The cost savings achieved in those limited cases, however, are not universally transferable to other activities. For example, fixed-price contracts are generally inappropriate for work involving major uncertainties, such as work involving a new technology, poorly characterized waste and site conditions, or open-ended work scopes. Fixed-price contracts may be more difficult to reconcile with accelerating project development through the use of design-build approaches. If a design-build contractor is brought on early in the project, as is often desirable, some form of cost-plus contract may be more appropriate, or a combination of cost-plus contracting that can be transitioned to a fixed-price contract as the design is defined. If appropriately used, fixed-price contracts can result in lower costs to the government; if inappropriately used, they can result in cost overruns, project delays, and litigation. The use of fixed-price contracts can create incentives for the contractor to cut costs at the expense of quality and can be conducive to the development of adversarial relations between owner and contractor. The skills required to manage a fixed-price contract management are very different from those required for cost-plus-award-fee or cost-plus-fixed-fee contracts. DOE managers with experience exclusively in the latter contract forms require extensive reeducation before they can successfully manage fixed-price contracts.

Fixed-price contracting can be successful if the project is well defined (sites conditions are well characterized and projects are at an advanced stage of engineering); significant risks have been identified; the contractor and DOE staff are knowledgeable about the project; DOE staff are capable of providing adequate oversight; uncertainties have been allocated equitably between the parties; and sufficient information is available to price the work realistically. However, DOE has sometimes executed fixed-price contracts that did not meet these conditions.

Privatization Contracts

In the privatization contract the contractor is responsible for financing and building the project at his own cost. Outside of DOE, *privatization* usually means an arm of government decides, for whatever reason, not to build a facility itself but to engage private industry to design, build, finance, own, and operate the facility, and sell services back to the agency or directly to the public. Situations in which this method has been used include such facilities as toll roads and bridges, prisons, and (nontoxic) waste disposal facilities. Under privatization, private industry assumes most or all of the financial risks. Because private firms are risk averse, in major privatization projects it is common for them to form consortia to spread the risks over several companies.

In the case of DOE, "DOE's privatization strategy relies on the use of competitively awarded fixed-price performance contracts through which DOE purchases waste cleanup services from private contractors. Although under privatization DOE does not pay until these services are delivered, funds set aside each year to pay for these contracts are part of DOE's annual budget request" (GAO, 1999a). Note that here the "fixed price" is the price to be paid for the "waste cleanup services," not the cost of building the facility.

DOE privatization may also apply to existing government facilities. The January 1997 report, *Harnessing the Market: The Opportunities and Challenges of Privatization* (DOE, 1997c), defines privatization as the transfer of ownership and control of a good or service currently provided by the government to a private (commercial) sector firm. The report states that DOE emphasizes three major types of privatization: (1) divestiture of functions; (2) contracting out or outsourcing; and (3) asset transfers (DOE, 1997c). The benefit of these types of privatization is that the private contractor can perform the same functions more efficiently than DOE and still make a profit by using fewer employees or more effective methods. Presumably, this is because the private contractor does not have to operate under the same restrictions as DOE does. Otherwise, privatization may have no cost advantage.

DOE also often uses the term "privatization" to apply to a variety of contracting methods. The *EM Privatization Program Management Plan* (DOE, 1998a) focused on contracting out or outsourcing to reach programmatic goals and selected as its method of privatization the purchase of an end product or service through an open fixed-price competition. Although privatization contracts can maximize the use of fixed-price arrangements, the types of work that EM must accomplish through privatization cover a wide range of technical difficulty and performance risk, and other types of contracts (such as fixed-price incentive, fixed-price redeterminable, and unit price contracts) should be considered.

When DOE proposed using privatization for some projects in hopes of achieving cost savings, Congress appropriated $330 million in fiscal year 1997 to support five projects and an additional $200 million in fiscal year 1998 for one ongoing project and four new ones. In fiscal year 1999, DOE requested almost $517 million for work on existing projects and one new project, but Congress appropriated only $228 million because of DOE's problems in implementing the program and because of cost and schedule uncertainties. These concerns also prompted Congress to require that DOE provide detailed analyses of privatization contracts for congressional review before incurring any additional contractual obligations (GAO, 1998a).

Recent developments at the Tank Waste Remediation System (TWRS) project at Hanford have underscored the complexity of trying to privatize highly risky ventures. Although a number of technical issues are still unresolved at Hanford, DOE has renegotiated the contract so that the government may be in a position to guarantee funding by private sources. In this case, DOE determined that the cost of private financing would be prohibitive unless DOE assumed the financial risks (DOE, 1998b). DOE's other recent experiences with privatization include the Idaho Advanced Mixed Waste Treatment Project, Oak Ridge Transuranic Waste Treatment, and Transuranic Waste Transportation in Carlsbad, New Mexico.

Privatization may or may not lead to lower costs. The cost of private financing is substantially higher than that of government financing, but there may be offsetting cost savings elsewhere. Contract terms, especially with regard to roles and responsibilities, should be carefully defined to ensure that DOE is not responsible for cost and schedule overruns that are clearly the contractor's responsibility and that the contractor's interests are protected. Privatization can be advantageous to the government in appropriate situations, but it is not all-purpose contracting solution and should be used carefully.

Finding. DOE does not effectively match project requirements and contracting methods. Mismatching is likely to result in cost and schedule overruns.

CONTRACT REFORM

Following the report of the Contract Reform Team, the secretary of energy in 1994 initiated a broad program of contract reform that included the following elements:

- increased competition
- cost reduction
- increased use of fixed-price contracts
- increased contractor liability
- performance criteria and measures
- performance-based incentives
- results-oriented statements of work

The contract reform placed great emphasis on the use of performance-based contracts, under which contractors would be evaluated against objective performance measures, and incentive fees would be used to reward excellent performance. To work effectively, these contracts would require clearly stated, results-oriented performance measures established prior to the start of work. Although the shift to a performance-based system of contracts was required by LCAM, Order 430.1 (DOE, 1995b), DOE has had difficulties in changing to this system at various sites (DOE, 1997a, 1997b, 1998c).

Although the reforms incorporate lessons learned from the DOE inspector general's review and other DOE assessments, neither a consistent, effective method of setting and measuring project performance nor a database of activity-based costs has been developed. Without these tools, DOE cannot take full advantage of performance-based incentives (GAO, 1998b).

Management and Integration Contracts

Another contract reform initiative was the use of management and integration (M&I) contracts rather than M&O contracts. In M&I contracts, DOE selects a prime contractor with project integration skills to manage a site and oversee and integrate the work performed by a team of "best-in-class" specialized subcontractors. This differs from the M&O approach, in which the M&O contractor performs most of the work with its own forces. Operations and major projects are now managed under M&I contracts at the Hanford, Mound, Rocky Flats, and Oak Ridge sites, and some of the difficulties with implementing M&I contracts have been documented (DOE, 1997d).

Progress

The stated objective of DOE's contract reform is to improve the efficiency and cost-effectiveness of its contracting system. However, widespread implementation of reforms has been slow. Cost savings have also been difficult to document because contract reforms have been combined with other initiatives, making it difficult to segregate their effects. It is apparent, however, that the implementation of contract reform has varied by location and program.

An obstacle to contract reform has been that DOE and contractor personnel are not familiar with the new management and contracting approaches. An in-depth knowledge of procurement and contract-management techniques is essential to the successful implementation of reform measures, and the training of DOE and contractor employees, including source selection officials and members of the source evaluation board, should be a priority. Reform has also been slowed because competitions for contracts have had to be reopened or existing contracts modified.

Finding. The traditional DOE contracting mechanisms, such as cost-plus-award-fee and M&O arrangements, are not always optimal for DOE's complex missions. These approaches are being replaced with approaches based on objective performance incentives, but change has been slow.

Recommendation. DOE should strengthen its commitment to contract reform focusing on assessment and quantification of project risks and uncertainties, the selection of appropriate contract type and scope for each job, and increased use of performance-based incentive fees rather than award fees to meet defined project cost and duration goals. A comprehensive risk analysis should be conducted before deciding whether to issue fixed-price contracts for work that involves a high level of uncertainty (such as new technology or incomplete characterization). Project risks should be allocated to those most capable of controlling the risk. Performance incentives are an essential mechanism that should be used to encourage DOE contractors to accept project risks. Specific contract scopes and terms should be negotiated to define both DOE and contractor responsibilities to prevent cost overruns. Clear, written roles, authorities, and responsibilities should be established for DOE headquarters, field offices, contractors, and subcontractors relevant to each contract undertaken.

Establishing Performance Measures

One of the requirements for effective performance-based contracting is to define what needs to be done in objective, measurable terms. The contractor and DOE must both have a clear idea of what is expected and of how success will be rewarded. If milestones are unreasonable, they will act as disincentives. If they are unclear, they will provide incentives for the wrong behavior. As the basis for its contracts, DOE should specify what must be done, allow contractors to decide how they will do it, provide effective oversight, user commitment to project scope, timely decision-making, and evaluate performance.

DOE's success in establishing and managing performance-based contracts has been limited. In an assessment of DOE's implementation of the Government Results and Performance Act of 1993, GAO found that work was begun on many 1998 contracts before annual goals and incentive fees had been agreed upon. At the Nevada Operations Office, work began before measures had been established, and milestones were added after the work was completed. As a result of this and similar incidents, a requirement was established that all performance objectives and incentive fees be submitted to headquarters for approval before the start of negotiations with the contractor. This requirement increased the time needed to establish performance measures. Review and approval in 1998 took from 4 to 19 weeks, with an average of 10 weeks (GAO, 1998c). The M&I contract at Hanford was complicated by such a large number of performance measures (more than 200 have been used) that they had to be bundled into groups. Failure to meet just one performance item in a group could result in no fee being awarded for the whole bundle. Furthermore, a significant portion of the fee items at Hanford are for administrative tasks rather than physical work (Hatch, 1998).

The draft EM Business Process Handbook requires that baselines, including performance metrics, be established for all EM projects. The field project manager or its operations manager, in partnership with the contractor, is required to define the major performance metrics for management and control of the project. The performance measures include scope attainment, schedule and milestone attainment, and cost profile attainment (DOE, 1998d). Although the committee recognizes that the establishment of performance goals in contracts is a significant step forward in contract reform, DOE does not have a complex-wide means or process to evaluate performance measures. So as long as each headquarters office, each site, and contractors within sites use different systems, evaluating the efficiency of performance measures throughout DOE is all but impossible.

Performance-based incentives should be carefully designed to reward excellent performance and can be used to encourage DOE contractors to accept more risk, when contractor assumption of risk is advantageous to the government. The Department of Defense and the U.S. Army Corps of Engineers Civil Works Program have pursued government-contractor partnerships, but DOE has yet to embrace them. Based on the evidence presented to the committee, DOE does not have the necessary experience, knowledge, skills, procedures, or abilities to prepare good performance measures.

Finding. DOE does not sufficiently use effective performance-based incentives and does not have standard methods for measuring project performance.

Recommendation. DOE should develop written guidelines for structuring and administering performance-based contracts. The guidelines should address, but need not be limited to, the following topics: the development of the statement of work; the allocation of risks to whomever would be most effective at controlling the risks (either DOE or the contractor); the development of performance measures and incentives; the selection of the contracting mechanism; the selection of the contractor; the administration of the contract; and the implications of federal and DOE acquisition regulations. DOE should train its employees in the roles and responsibilities of a performance-based culture and then hold both employees and contractors accountable for meeting these requirements.

Appendix C includes a description of the characteristics of successful megaprojects or systems acquisitions and stresses the importance of the project owner being focused and committed to ensure success. The committee believes that DOE, as an owner, must demonstrate that objectively measured, excellent performance will be rewarded and favored over simple compliance with regulations. DOE should demonstrate its commitment to excellence by highlighting and rewarding productive work. Regulatory compliance should be a means towards achieving excellence, not an end in itself. Once a shift to performance-based contracting becomes part of the agency's culture, the committee believes that the requirements for general compliance audits and reviews should be reduced dramatically.

COMPETITION AND IMPROVED PROJECT PERFORMANCE

DOE contracting reform has long been considered a potential source of considerable cost savings for two reasons: (1) DOE contracts for a tremendous amount of work; and (2) cost overruns by DOE contractors have been extensively documented. Recent DOE contracting has emphasized competition as the method most likely to achieve cost savings. The committee felt it necessary to question the premise that structuring contracts to improve competition would lead directly to savings. The objective of contracting is to get the job done properly at the best possible price. Ideally, qualified contractors capable of doing the job compete among themselves to perform the work on the expectation of earning a profit. This competition drives down the cost, thereby ensuring that the government gets the best possible price. If this simple model were valid, every DOE solicitation would attract a number of well qualified bidders. Experience has shown, however, that this has not happened.

Declining Numbers of Bidders for DOE Projects

Although DOE has increased its use of competition when awarding contracts for managing and operating its facilities (GAO, 1999b), recent solicitations for M&O, M&I, and other major contracts have attracted fewer bidders than in the past. The recompetition of the M&O contract at the Savannah River Site is an example. Westinghouse Savannah River Corporation, the incumbent contractor, was the only bidder, having created a team that included most of its potential competitors—a practice that appears to be increasingly common among DOE bidders. DOE publicly expressed its general satisfaction with Westinghouse's performance before the contract was opened for competition, which might have discouraged others from submitting bids. This is not an isolated case. DOE announced its decision to extend the contracts with the University of California at both the Lawrence Livermore and Lawrence Berkeley National Laboratories before it had negotiated a new contract with the university. In these cases, the absence of competition limited DOE's ability to amend the existing contracts to its advantage.

The Hanford TWRS privatization project is an example of a high-risk project with a limited number of qualified bidders and a complex contracting strategy. The TWRS cleanup project involves 177 underground storage tanks containing highly radioactive liquids and other waste materials. In 1994, DOE began to pursue a privatization strategy for the project in order to purchase waste-processing services from best-in-class companies instead of building its own facilities. In 1996, DOE selected two contractors for a two-part, first phase of the project (Part A to develop preliminary project and facility plans and Part B wherein the contractor would fully finance, design, construct, operate, and deactivate waste-treatment plants on a fixed-price basis). Following Phase I Part A (a 20-month contract with two bidders), a Part B contract was awarded to a single contractor, British Nuclear Fuels, Ltd. (BNFL). GAO reported that the structure of the project is substantially different from the initial privatization strategy, in that it does not shift most of the financial risk to the contractor. The contract calls for DOE to pay BNFL for most of the debt incurred in building and operating the facility if BNFL defaults on its loans. The design phase and the date to reach agreement on a final contract price have been extended, and the total cost has risen from $4.3 billion to $8.9 billion—including $2 billion in DOE support costs (GAO, 1998d).

Incentives to Bidders

Overall, it is expensive for a contractor to bid on a major DOE project, and the successful bidder has no guarantee that the work will be profitable. In considering whether to compete for a major DOE contract, prospective bidders must weigh the benefits and risks as well as proposal-related costs. Commercial contractors then balance the potential rewards and risks to determine how the project compares with other business opportunities. The committee noted several factors that could significantly deter a contractor from bidding on DOE projects: high proposal preparation costs and attendant risks to capital (Fluor Daniel Hanford reportedly spent about $10 million to win the Hanford M&I contract, and unsuccessful bidders spent similar amounts [Hatch, 1998]); the advantages of incumbent contractors; the growing complexity of management and technical requirements; and DOE's history of making new regulations retroactive and otherwise altering agreements. In the current DOE contracting environment, contractors are not usually paid 100 percent of their potential fees, regardless of their performance. For example, the new DOE fee policy often requires that contractors propose a fee discount when bidding on contracts. Under this fee policy, field managers have greater discretion to withhold all or part of a contractor's fee, regardless of the agreed metrics. If these practices are continued, the committee believes they could preclude the success of performance-based contracts.

The Federal Acquisition Regulations and the Department of Energy Acquisition Regulations govern DOE procurements but do not specify the minimum number of bidders to ensure adequate competition. The size of the bidder pool varies, of course, with the type and size of the contract. Generally, for straightforward work that is well defined and understood, the more qualified bidders the better. For routine waste cleanup projects using largely known technologies, innovative approaches to managing and executing the work should result in lower costs and possibly shortened schedules. Very large, complex projects, particularly those involving new technologies or high risks, such as the Hanford TWRS, are likely to have a small pool of bidders primarily because few firms are qualified.

DOE has a number of contracts that expire in the next two years that could be extended or reopened to competition, including Rocky Flats Environmental Test Site, Fernald Environmental Management Project, Y-12 Plant, Kansas City Plant, Waste Isolation Pilot Plant, and the Nevada Operations Office Support. If DOE conducts negotiations before deciding whether to extend or recompete the contracts, there would probably be more competition. However, it is not clear that more competition, in and of itself, will result in either lower costs or improved performance.

Although DOE has taken steps towards reforming its contracting practices, major challenges remain. To improve contract performance, it is critical that DOE move from an adversarial to a collaborative relationship with its contractors. The committee believes that the key to improving contracting is a commitment to obtaining the most qualified contractor at the best price using the best acquisition strategy for the project at hand. This requires strong leadership, careful planning, and a flexible management structure committed to making decisions and implementing changes that encourage and enable improved contract performance.

Finding. The number of bidders on major DOE contracts has been declining indicating that the disincentives to bid often outweigh the incentives.

Recommendation. DOE should provide financial rewards for outstanding contractor performance to attract bids from the best contractors. A DOE-wide policy should be developed that provides fiscal rewards for contractors who meet or exceed schedule, cost, and scope performance targets. Contractor fees should be based on contractor performance.

Recommendation. DOE and contractor employees essential to projects should be trained in acquisition and contract reform. The training of source selection officials and members of source evaluation boards should be expedited; a minimum level of training should be a prerequisite.

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5

Organizing for Excellence in Project Management

INTRODUCTION

The challenges facing DOE are extreme in many ways. DOE spends billions of dollars annually on projects. It has plans to construct more than $20 billion worth of defense, energy research, environmental management, fissile materials disposition, and other projects in the next five years. DOE estimates that cleanup of existing wastes from the weapons program alone will cost $147 billion (in constant 1998 dollars) and take more than 70 years (DOE, 1998); others estimate these costs to be more than $200 billion (Probst and McGovern, 1998). These projects themselves are large and complex. The sites are often incompletely characterized, the necessary technologies are not always fully tested; and the political pressures for results are great.

DOE's portfolio of projects demands a sophisticated and adaptive project management system that can manage project risks systematically; control cost, schedule, and scope baselines; develop personnel and other resources; and transfer new technologies and practices efficiently from one project to another, even across program lines. Given DOE's critical missions, its portfolio of current and future projects, and its scientific and technological resources, DOE should be an example of excellent project management for the federal government. Unfortunately, it is not. As a result, both projects and the agency have suffered. DOE is seriously handicapped by its reliance on a project management organization that is less a system than a collection of approaches that DOE adopted from its predecessor agencies. By operating as an aggregate of independent agencies composed of the various program offices and field offices, DOE cannot take advantage of the economies of scale inherent in its vast capital development program. At the highest levels, DOE has often recognized the need for change, but reforms have not been effective.

In fact, DOE's project performance, as this committee and many other observers have documented (see Chapters 1–4 and Appendix A), shows it to be one of the most inefficient organizations in the federal government. DOE appears to have wasted billions of dollars in the past decade, and it continues to waste millions each year. If present practices continue and estimates that DOE projects cost 50 percent more than necessary continue to hold, then DOE will spend more than $50 billion unnecessarily on waste cleanup projects alone. DOE's many attempts to improve performance, reduce costs, and implement contract reform have been ineffective, as has been shown at length in previous chapters. Field offices and program offices continue to operate virtually autonomously with respect to project management. DOE's Good Practice Guides are purely advisory and have little applicability to actual projects, and general guidelines cannot compensate for DOE's lack of project management skills and leadership. In short, there is widespread confusion over roles, authority, and responsibilities and a lack of accountability and effective oversight.

DOE has too few personnel with the appropriate experience, training, and education to meet the agency's current project management responsibilities. Considering the scale and number of DOE projects, it should be a leader in both formal and on-the-job training of project managers. Instead, it has no credible project manager training program, a certification program that has been years in the making but has not yielded significant results, and no identifiable career paths for project managers. Program offices devote significant effort and resources trying to manage projects with well intentioned personnel who do not have the requisite education and experience in project management and are not committed to project management as a career.

Other agencies and the private sector realized long ago that project management is a professional discipline that must be learned and practiced. The best public agencies and private firms engaged in capital project development maintain central organizations with core competencies in project management, project planning, coordination, and human resources development. These organizations provide structure, continuity, and leadership that foster cooperation both internally and externally.

The committee recognizes the unique problems DOE often faces because many DOE projects are highly complex and dependent on new technology. However, the committee has found that even conventional infrastructure projects done "inside the DOE fence" are prone to overruns. The root problem with these projects is not just complexity, but changes caused by those outside the line of responsibility having the power to influence project performance and outcomes. This report stresses the need for change control systems and change management, as well as giving project managers the capability and the authority to control the budget, but DOE project managers have little ability to control changes that come from outside the project. Even with substantial improvements in project management, it will be difficult to complete projects on time and on budget if changes continue to proliferate.

Changes disrupt projects, and frequent changes disrupt projects disastrously. The impacts of changes go far beyond the costs of the changes themselves. Changes to DOE projects have increased as a growing number of stakeholders have influence over projects but no responsibility for them (i.e., DOE senior management and the Congress). Congress has passed legislation requiring public input and has been directly involved in some projects through the incremental budgeting process. DOE secretaries have contributed to the problem by continually altering the department's organizational structure and policies and by failing to back up project management against pressures for project changes. Most major projects, particularly those in the public sector, are under continual pressure for changes, but these pressures must be resisted if a project is to be completed even approximately on time and on budget. Many managers inside DOE noted that DOE fails to "push back" against the pressures for change originating from within the agency or from without. The concept that all changes should be accommodated because it is more important to satisfy all critics than to stay on budget or on schedule seems to be an unfortunate part of DOE's culture. Yielding to pressures for change may be politically expedient, but it does not get projects built on time or on budget. Projects that go over budget prevent other essential projects from being completed. Projects that are delayed to accommodate changes are projects that are not performing their functions. If a project is necessary, then it is necessary to finish it on time. If it is not necessary to finish a project on time, then it is not necessary to do it at all.

If changes are a major part of DOE's problems, and if the changes cannot be stopped or at least resisted, then budget and schedule overruns will continue. DOE must find the political strength to resist pressures for project changes, or cost and schedule overruns will continue even as DOE continues to be blamed for them and new committees are commissioned to determine why DOE can not execute projects on time and on budget. The committee finds that DOE needs an internal advocate for projects who can resist such pressures and recommends that DOE establish a project champion whose primary goal is on-time, on-budget performance.

The evidence presented to the committee regarding DOE's project management has demonstrated numerous deficiencies and shortcomings. In the opinion of the committee, DOE will continue to experience significant project cost and schedule overruns unless the present organizational structure is changed. For DOE to improve its project performance and to gain the trust of Congress and the public, DOE must establish a project management organization that can meet the challenges of its missions and programs.

Changing DOE's Project Management Culture

DOE's culture is not conducive to effective project management and execution. The committee's review and assessment of DOE's organization and culture revealed that little emphasis has been placed on project management, responsibility, and accountability. The committee recognizes that the delivery of projects effectively and efficiently requires a culture of professionalism that is project-driven and committed to deliver projects on time and on budget. Project professionals are judged, and judge themselves, by their ability to meet budgets and schedules, to overcome all physical and organizational obstacles, by whatever (legal and ethical) means, in order to achieve the objective. Project professionals are unashamed champions and proponents of their projects and may even consider it appropriate to defy organizational authority and break organizational rules when they think it necessary to get the job done. They accept responsibility for their actions and take risks when they feel confident that they can control these risks. This culture is found in the engineering-construction industry, as well as in some government agencies (e.g., the U.S. Army Corps of Engineers and the Naval Facilities Engineering Command).

From the evidence of project performance and the observations of the committee, it appears that the DOE culture is not matched to the requirements of successful project delivery. In fact, many in DOE would agree. The comment that "the DOE must become results-oriented rather than process oriented" or "compliance-driven" or some equivalent, was made by a number of DOE personnel at various sites and is officially promulgated in the DOE Strategic Plan (DOE, 1997). Can the present dominant culture of DOE which is "dysfunctional" (as many DOE personnel stated) with respect to successful project execution, be changed?

> The stronger the culture—that is, the more pervasive it is in the organization—the more inertia it generates. Strong cultures are more resistant to managerial intervention than weak ones. The levers creating strong cultures therefore lead to both effectiveness and ineffectiveness in organizations. Strong cultures, on one hand, can lead an organization to the "success breeds failure" syndrome in which organizations refuse, or are unable, to adapt to changing environmental demands. (Druckman et al., 1997, p. 87–88)

The committee concludes that substantial cultural changes are needed in DOE and that many DOE personnel who have expressed their frustration with the current culture and their inability to change it would welcome leadership in this area. Changing the culture within the context of an existing organization is admittedly difficult, but the committee believes it is possible, given strong leadership and support from the secretary's office.

The committee believes that DOE is urgently in need of leadership to change the project management structure. The following section of this chapter discusses the committee's recommendation for the creation of a project management office that would provide a framework for significantly changing organizational behavior. Long-term systematic change to DOE project management will occur with behavior changes that are adopted along with the various recommendations on improving DOE's project management system and structure. Rather than simply calling for DOE to change its culture, the committee believes that DOE's culture can be changed most effectively by changing DOE processes, changing expectations, and positively reinforcing excellence in results rather than compliance with processes. The cultural change "levers" available to the secretary are the recommendations throughout this report, including the following:

- Create a culture of excellence in project management and execution.
- Establish the goal of becoming a leader in project management skills, methodology, technology, systems, and performance.
- Promulgate clear directions on project management policy, stressing that completion of projects to scope, on time, and on budget is of the highest priority.
- Provide clear definitions of responsibility, authority, and accountability for all personnel involved in projects. Prohibit interference from outside the chain of responsibility. Clarify DOE field office and contractor roles, responsibilities, authorities, and relationships.
- Enhance preconstruction planning, so that scope definition, baselines, budgets, contingencies, and schedules are realistic, and everyone involved understands what will be done, and when. After budgets are fixed, design and construct the project to meet the budget.
- Engage user managers early and require that users be committed to project scope, requirements, budget, and schedule.
- Ensure that user/client decisions are made in a timely manner to avoid project delays.
- Provide objective, standard methods for assessing project risks and uncertainties, and assign realistic budgets, schedules, and contingencies.
- Give the assigned project manager authority to control the project budget and schedule (including contingencies).
- Institute contracting methods that select contractors who are committed to the goals of the project and the organization. Develop contract management procedures that hold contractors accountable for performance without creating a counterproductive adversarial atmosphere.
- Institute rigorous identification and control of changes, especially changes in scope. Make it clear that scope, budget, and schedule are inextricably linked and prohibit changes in scope that cannot be accommodated in the assigned budget.
- Provide consistent, uniform methods for tracking projects (e.g., earned value analysis) and disseminate this information so that all parties

understand the status of every project with respect to its established scope, budget, and schedule.

- Provide a uniform financial accounting system for all projects.
- Train and qualify project managers in the classroom and on sites.
- Provide visible, recognized career paths for professional project managers.
- Assign increasing responsibilities to successful project managers.
- Create a climate of learning and openness to outside ideas, criticism, and standards through external project reviews, ISO 9000 certification, and participation in professional project and construction management organizations.
- Measure performance by results and provide positive incentives for the successful completion of projects on time and on budget.
- Provide a highly visible core competency in project management, an agent for cultural change, a role model, and a champion for project managers by establishing and supporting an office of project management that reports directly to the secretary.

OFFICE OF PROJECT MANAGEMENT FOR THE DEPARTMENT OF ENERGY

The committee recommends that DOE establish and staff a new office of project management to manage projects and to serve as a champion and source of expertise for project management in DOE. The office should be on a level equal to or higher than that of the assistant secretaries. The director should be a career professional project manager who has successfully managed a progression of projects in the public or private sector.

The project management office would provide professional project management, project managers, owners' representatives, and project management standards, procedures, and support services to the program offices. The project management executive would relieve assistant secretaries and program office directors of the need to maintain their own project management capabilities thereby allowing them to focus on their central responsibilities.

The project management executive would provide consistent project management systems for all programs and DOE projects as well as the following functions:

- standardized reporting and a centralized database on projects to support the secretary, deputy secretary, and program offices
- project trend forecasting and early warning of potential problems
- management of an independent review process
- recommendations for proactive corrective actions
- a focal point for responsibility and accountability for projects within DOE and an interface to external organizations on project management issues
- a champion for excellence in project management in DOE

The proposed project management office would provide functional management but not line management; it would manage the project managers, not the projects. The office of project management would develop and maintain a cadre of professional certified project managers who would be assigned to manage DOE projects for all program offices. Program and field offices could identify their requirements and preferences, and the designated manager would be seconded to the field for the duration of the project.

A cadre maintained by a central organization would have many advantages. First, it would be a reliable source of project management expertise with personnel trained and coordinated by the central office and would transfer lessons learned from project to project. Second, this arrangement would enable DOE to attract, motivate, and retain highly skilled and dedicated professional project managers critical to project management success. Third, each program office would choose qualified personnel from the project management pool, and the program office would maintain direct control over the project. Fourth, program assistant secretaries would continue to be responsible for the funding and successful performance of projects. And fifth, program offices would continue to be responsible for project staffing and support. All program offices that are responsible for projects would be included in this initiative.

To be effective, the proposed project management office must have sufficient staff, including assistant project managers, procurement personnel, contract specialists, cost engineers, planners, schedulers, cost accountants, controllers, systems analysts, and others. The project management office would provide consistent methods and systems to be used for cost estimation, risk analysis, contracting, incentives, change control, progress reports, and earned value management. The committee expects that the designated project management executive would immediately prepare an organizational plan for staffing procurement, project controls, finance and administration, contracts, and other support functions to support project managers. The support personnel, like the project managers, would rely on the project management executive for management doctrine, training, accountability, promotions, and rewards but would be administratively assigned to projects in the field, where they would be responsible to the project manager. The support staff would not require that new positions be created but could be filled by existing personnel in FM, the program offices, and the field operations offices. By incorporating the support staff within the proposed project management office, these functions would be performed more consistently and efficiently than they are now.

The committee believes that DOE must take decisive action now to correct its documented performance deficiencies. If it does not do so, Congress could very well take further control of DOE projects as it has done through previous legislation. The committee believes, however, that DOE can and should change its project management culture and solve its project management problems internally. By creating the proposed project management executive, DOE could improve its performance in all of its mission areas (and save taxpayers billions of dollars). This major organizational and management initiative would demonstrate that DOE is addressing one of its most difficult challenges. It would free the secretary, deputy secretary, and under secretary to focus on policy issues and other national and international concerns, rather than having to defend project budgets and explain project deficiencies.

As a result, more projects would be completed, more sites would be cleaned up, and fewer problems would have to be explained to DOE headquarters, the media, and Congress. An agency-wide project management executive could bring to bear lessons learned nationwide to ensure that DOE projects fulfill their objectives, meet the needs of stakeholders and the government, and are completed on time and on budget. It would clarify lines of responsibility and improve accountability. The proposed office of project management would be a professional response to an urgent problem. All of DOE's stakeholders would benefit from greater certainty and consistency in DOE's management of projects.

FUNCTIONS AND RESPONSIBILITIES

The main functions and responsibilities of the office of project management would include the project management oversight functions that are currently assigned to FM, as well as the following functions:

- Develop and maintain a corps of professional, trained, and certified project managers.
- Train and certify project managers and manage the career path for project managers.
- Select project managers for specific projects in consultation with program assistant secretaries.
- Develop department-wide policies, procedures, and reporting systems for the management of projects.
- Develop and deploy standard project management systems and contractor reporting requirements for progress reports, financial reports, and other reports to determine the viability of each project consistently throughout DOE.
- Set standards and monitor the execution of project management plans.
- Mandate and assess compliance with required policies and procedures using a graded approach based on the size, complexity, and sensitivity of projects.
- Compile lessons learned and best practices, and disseminate this information to all projects throughout DOE.
- Manage the processes for independent cost estimates and independent project reviews.
- Ensure that the appropriate level and types of risk assessments are performed using consistent risk assessment methodology.

- Conduct quarterly or annual reviews, depending on the type of project.
- Develop and maintain a database of DOE-wide project information for current and historical purposes.
- Make recommendations to the program assistant secretaries with regard to project status and corrective actions.
- Ensure the use of project management tools, such as systems engineering, value engineering, and earned value monitoring.
- Benchmark proposed project costs and schedules annually against projects of other federal agencies and the private sector, throughout the life of the project.
- Prepare and issue annual forecasts of project cash flow, cost to complete, and time to complete, as well as assessments of the likelihood of achieving approved baselines for strategic and major systems and line-item projects.
- Obtain and maintain ISO 9000 certification.

CONCLUSION

In the committee's judgment, the alternative to the establishment of the proposed office of project management is to continue DOE's poor project performance with a steady loss of credibility with Congress, regulators, other stakeholders, and the American public. That path—and almost all evidence indicates that DOE is on that path—leads in the direction of reduced budgets, increased pressure from outside influences, and much more micromanagement than DOE has experienced to date.

According to the provisions of the 1993 Government Performance and Results Act, in addition to other financial and management legislation, DOE is required to meet mission and project challenges. To meet these challenges and those that will arise from the current and future portfolio of DOE projects, DOE must move beyond the legislatively mandated minimum performance. Accepting and implementing the recommendations of this committee for improved project management could result in a process in which projects receive strong support and stable funding and would be managed by professionals whose focus would be cost, schedule, and performance.

The committee realizes that following their recommendations would require cultural as well as organizational changes for DOE. As the Phase I report of this study concluded, success is affected more by culture, attitude, and organizational commitment to quality and service than by procedures (NRC, 1998). Consequently, to be successful, the proposed office of project management must have the full and continuing support of the secretary, the under secretary, the deputy secretary, and all of the program offices and field offices as a top-down management initiative.

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Appendices

A

Evidence of Problems with DOE Project Performance

A variety of organizations have documented the cost and schedule problems associated with U.S. Department of Energy (DOE) projects and programs. A few have provided solid evidence to validate the existence of these problems, and some have offered recommendations for solutions. The committee reviewed documents produced by a variety of organizations:

- reports by the General Accounting Office (GAO)
- reports by the DOE Office of Inspector General
- independent external reviews of DOE projects
- statistical analyses by Independent Project Analysis, Inc., for DOE
- project histories

REPORTS BY THE GENERAL ACCOUNTING OFFICE

GAO, which examines matters relating to the receipt and disbursement of public funds, has performed numerous audits and evaluations related to DOE construction, procurement, and contracting practices. Many of these reports have been focused on contractor performance and the appropriateness of contractor costs. In its Performance and Accountability Series, GAO recently summarized more than 15 reports that found problems in the following areas: the completion of large projects; modifications of DOE's organizational structure to correct problems; DOE contracting practices; and technical and managerial skills (GAO, 1999). The reports note the challenges facing DOE in carrying out its mission, DOE's performance, and efforts to meet these challenges and implement reform.

A few of the reports are directly related to project performance, but most are indirectly related, focusing more on organization and management. The most relevant are described below.

In 1996, GAO reported on DOE's difficulties in delivering major projects in keeping with baseline costs, schedules, and scope (GAO, 1996a). Of the 80 major systems projects initiated between 1980 and 1996, only 15 were completed, many of them behind schedule and over cost; 31 were terminated before completion. GAO concluded that there were four causes of failure:

- a poor system of incentives for contractors
- insufficient DOE personnel with the skills to oversee contractor operations
- DOE's poorly defined or changing missions
- the incremental funding of projects

GAO cited frequently deficiencies in DOE's contracting practices. In 1990, GAO concluded that DOE's contracting practices were at high risk for fraud, waste, and abuse (GAO, 1997a). Although GAO has commended DOE's efforts to reform its contracting since 1994, it continues to monitor contract management as a high-risk area and has encouraged DOE to do more to increase competition among bidders (GAO, 1996b), link contractor fees to performance (GAO, 1998a), and determine the best contracting type and strategy to use for each project (GAO, 1997b, 1998b, 1998c).

The effect of organizational structure on project performance has been another area of focus for GAO. The absence of clear lines of authority or defined roles and responsibilities throughout the department has made it difficult to demand accountability from contractors or staff (GAO, 1997c).

OFFICE OF INSPECTOR GENERAL

The mission of the DOE Office of Inspector General (OIG) is to promote effective, efficient, and economical operations of DOE programs through audits, inspections, investigations, and other reviews. The OIG has continually advised DOE headquarters and field office managers of the significant issues affecting project performance. The major areas where improvements in efficiency and effectiveness can be made are described in the following section.

Contract Management

DOE's contract administration has many weaknesses. Recent reports have noted problems in the development and use of performance measures in various management contracts. In one case, the Nevada Operations Office did not establish performance milestones until the contractor had completed the work

(DOE, 1997a). The OIG found that the Rocky Flats Field Office had approved a contractor's cost reduction proposals that did not meet DOE's basic criteria for reducing cost by using innovative practices. The OIG also found that this contract included performance measures that were not supported by objective data, were not structured to encourage and reward superior performance, and were often focused on the process rather than the results of the process (DOE, 1997b). In 1997 OIG reviewed the Cost-Reduction Incentive Program with Westinghouse Savannah River Company and found that most of the savings identified by the program could not be attributed to innovative changes in work methods or processes. The internal assessment team recommended that the Savannah River Operations Office either modify the program so that payments were made only for innovative ideas or cancel the program and initiate performance-based incentives that would reward cost savings above an established threshold. Although several options were available, OIG found that the operations office did not act on the suggestions in the internal assessment (DOE, 1998a).

Architecture and Engineering Costs

The OIG has issued several reports over the past few years criticizing the high cost DOE pays for architecture and engineering (A-E) services. The OIG concluded that the costs of A-E services at six locations averaged more than twice those of industry for comparable projects (DOE, 1990). In a report on 65 conventional construction projects at the Idaho National Engineering Laboratory (INEEL), the OIG found that the costs incurred were $5.8 million higher than comparable industry standards (DOE, 1996a). In a recent review of projects by Sandia (SNL) and Los Alamos National Laboratories (LANL), the OIG found that Sandia's A-E costs were reasonable in comparison to adjusted industry standards, but Los Alamos' costs were 65 percent, or $2.5 million, higher than the adjusted standards for the seven projects reviewed. The success at Sandia was attributed to cost-control measures and competition among firms for A-E procurement. Higher costs at Los Alamos were attributed to inadequate and ineffective cost controls and performance measures (DOE, 1998b).

Project Management

DOE has not established mechanisms for controlling changes in the costs, schedules, and scope of projects. Some projects were constructed without a full assessment of alternatives, changes to the mission, or realistic budgets (DOE, 1996b). An audit of renovation and new construction projects at Lawrence Livermore National Laboratory found that the laboratory could not demonstrate that it had selected the best alternatives for meeting the DOE's mission needs while minimizing costs (DOE, 1997c).

INDEPENDENT EXTERNAL REVIEWS OF DOE PROJECTS

DOE is currently contracting for independent reviews to assess the quality of the technical scope, cost estimates, schedules, and supporting data for DOE projects in accordance with congressional language and criteria provided by the National Research Council (NRC, 1998). The findings and recommendations of the initial reviews transmitted to Congress have documented deficiencies similar to those found by this committee and others. The results to date have indicated that DOE's problems with project performance continue. The findings range from project-specific deficiencies to overall issues and concerns with DOE policies and practices related to project delivery and management. The findings of the 10 independent project reviews that have been completed so far are summarized below.

- The Spent Nuclear Fuel Dry Storage Project, at INEEL, is a "privatization" project with a total project cost (TPC) of $105 million. The independent reviewer found many deficiencies in planning, execution, and contracting of this project, including the omission of a project execution plan and associated schedules. INEEL had not sent formal documentation to DOE headquarters to alert the department that the project was likely to exceed its TPC. INEEL had no formal procedures for selecting the privatization contract form, and the reviewers found no record of an analysis underlying that decision. Finally, INEEL did not have sufficient project staff because funding for project staff must come from operating budgets rather than project budgets for privatization projects (Lockwood-Greene Technologies, 1998).
- The Stockpile Management Restructuring Initiative Project at DOE's Pantex facility has many weaknesses in budgeting and planning. The schedules for some of the subprojects were "extremely conservative," and cost estimates for many of the more routine demolition and construction activities were "very high." Too many layers of management were involved in approving "small, straightforward projects." The reviewers found that 8 of the 12 subprojects lacked adequate justification for proceeding (questionable economic benefits, reduced operational flexibility, or failure to take account of changing circumstances) (Foster Wheeler Environmental Corporation, 1998a).
- An independent review of the Stockpile Management Restructuring Initiative at the Kansas City Plant called it "a well run, well managed project." The review, however, did identify that an independent review of the project's cost estimate found that level-of-effort estimating may have been used rather than an activity-based approach. The assessment also identified $3.2 million worth of start-up engineering that was not included in the original cost estimate (Foster Wheeler Environmental Corporation, 1998b).

- The Nuclear Materials Storage Facility Renovation project of LANL had a number of deficiencies in cost estimating and scheduling. At the time of the review, there was no baseline total cost estimate document, and the construction schedule needed to be revised to support the completion of the project cost estimate. The review team also found that the LANL did not have a comprehensive plan integrating all stockpile management projects and programs (CETROM, 1998a).
- CETROM Consulting Engineering, Inc., also reviewed the Rapid Reactivation Project initiated to protect the limited life component manufacturing capabilities of SNL, LANL, and the Kansas City Plant. The review found certain deficiencies although the project was generally successful. The schedule contingency allowances were too small management documents were not complete; LANL did not have a project execution plan (PEP); and the PEP for the Kansas City Plant needed to be updated (CENTROM, 1998b).
- The review of the Nuclear Materials Safeguards and Security Upgrades Project at LANL found that although a detailed schedule risk analysis was performed as part of the critical decision review process, risks such as construction performance and the potential impacts of ongoing changes to the project management process at LANL had not been taken into account. The reviewers also noted that although LANL was to be a subcontractor, there was no documentation to hold LANL accountable for the cost and schedule of its deliverables (CETROM, 1998c).
- The Jupiter Corporation reviewed the Pit Disassembly and Conversion Facility Project of the DOE Office of Fissile Material Disposition and found that the project managers had not adequately considered the applicability of Nuclear Regulatory Commission licensing standards and other regulatory requirements, although Congress requires that DOE submit to those standards. In addition, the project had failed to document the analysis supporting its choice of contract type (Jupiter Corporation, 1998a).
- An independent review of the Dual Axis Radiographic Hydrotest Facility Project found it to be generally successful and well managed. The reviewers suggested that a simpler project management process be adopted and that procurement documentation be better coordinated among the national laboratories involved with the project (Jupiter Corporation, 1998b).
- The independent review of the Chemistry and Metallurgy Research Facility Upgrades project of LANL (which was suspended in 1997 because of rapidly growing costs and scope and was partly resumed in 1998) found serious weaknesses. The reviewers found that the original cost, scope, and schedule baselines had not been changed to meet current DOE missions, and they recommended that new baselines be established. They also observed that DOE management at DOE headquarters, disregarding stated

policy, had inserted itself into the process for approving changes in the baseline (Jupiter Corporation, 1998c).

- An independent review of the Atlas Project to improve simulation of nuclear weapons performance at LANL found that the project was unlikely to be completed within the baseline cost estimate. The reviewers noted that up until very recently, DOE had focused on the technical challenges of the project and the design changes precipitated by the change in mission for the project. Consequently project management and cost had been given little attention. The emphasis is now on meeting the TPC of $48.9 million although no updated project-specific risk and uncertainty analysis has been conducted since the 100 percent draft CDR was issued (Cadmus Group and Project Performance Corporation, 1999).

STATISTICAL ANALYSES OF DOE PROJECTS

Three statistical analyses of DOE project performance in the areas of environmental remediation (ER) and waste management (WM) were performed by an outside contractor, Independent Project Analysis, Inc. (IPA): *Project Performance Study*, November 30, 1993 (IPA, 1993); *Project Performance Study, Waste Management Addendum*, December 1995 (IPA, 1995); and *Project Performance Study Update,* April 1996 (IPA, 1996). These studies involved statistical comparisons of DOE ER and WM projects with a database of comparable projects performed by private industry and other government agencies (primarily the U.S. Army Corps of Engineers), including multivariate regression models derived from these data. Although the committee was unable to inspect the models developed and used by IPA in these analyses, these Project Performance Studies are believed to be the only cross-sectional and longitudinal analyses of DOE project performance as a whole. The results of these analyses have not been challenged by DOE, and in fact were the basis for a two-day "stand-down" initiated by the secretary of energy and assistant secretary for environmental management on January 26 and 27, 1994 (*Improving Project Performance: A Federal Hands-on Initiative*) (IPA, 1994). The *Project Performance Study Update* in April 1996 was commissioned by the assistant secretary in an attempt to demonstrate progress made as a result of the EM stand-down.

Although the projects, sample sizes (76 projects in December 1990, 65 projects in November 1993, 22 projects in December 1995, and 48 projects in April 1996), statistical models, and database of industrial projects used for comparison all varied from study to study, some common themes emerged. The studies focused on four factors:

- cost performance, or the absolute cost of DOE projects compared to cost for projects by industry and other government agencies, normalized for comparability

- cost overruns, or the relative increase of DOE project costs compared to the original budgets
- schedule performance, or the absolute time duration of DOE projects compared to the duration of projects by industry and other government agencies, normalized for comparability
- schedule slippages, or the relative increase of DOE project durations compared to the original schedules

Project Costs and Cost Overruns

Combining the results of the *Project Performance Study* of November 30, 1993 (IPA, 1993), with the *Waste Management Addendum* of December 1995 (IPA, 1995), DOE WM projects cost an average of 48 percent more than comparable projects performed by industry and other government agencies; and DOE ER projects cost about 33 percent more. On the same basis, the average cost overruns for ER projects were about 48 percent and for WM project's about 42 percent compared to an average of about 3 percent for industry and other government agencies. Moreover, the variability in cost growth from project to project for DOE was much higher than industry. Thus, not only did DOE projects cost roughly 40 percent more than comparable industrial projects (the "DOE tax"), they also overran their initial cost estimates by about 45 percent, indicating that DOE either has a problem controlling costs or a problem estimating costs. The *Project Performance Study Update* in April 1996 (IPA, 1996) stated that "We expect that the DOE WM '96 project (sic) will average 33 to 43 percent more than the private sector. Additionally, we expect that cost overruns will be lower .... about 22 to 36 percent for the DOE WM '96 project set" (p. 80). For ER projects, the same report stated, "We expect DOE ER's average cost to go from 33 percent more than the private sector to 25 percent more" (p. 119). However, the ER cost overruns were not expected to change; "DOE ER projects are still likely to have 50 percent cost growth...." (p. 123).

Project Durations and Schedule Slippages

Combining the results of the *Project Performance Study* (IPA, 1993), with the *Waste Management Addendum* (IPA, 1995), DOE WM projects took an average of three times longer to complete them comparable projects by industry and other government agencies, and the original schedules slipped an average of "about 22 months, or 52 percent" (IPA, 1996, p. 80), compared to an average of 17 percent in industry. Thus, even though DOE WM initial project schedules were very long compared to similar projects done by others, they nevertheless slipped more. The *Project Performance Study Update* of April 1996, however, projected that "the average slip [was to be reduced] to about 15 months, or 35 to 43 percent. The reduced schedule slip should reduce the relative schedule duration of DOE WM projects from 300 percent of private sector norm (i.e., three times as long as the private sector) to 250 to 280 percent of the private sector norm. This is still too long..." (p. 80). The DOE ER project schedule performance was slightly better, with durations only about 18 percent longer than comparable projects, but the average schedule slippage was about 42 percent. In the 1996 *Update,* IPA expected "DOE ER schedules to speed up slightly, from 18 percent slower than the private sector to 15 percent slower" (p. 121). However, the average ER schedule slip of 42 percent was expected to "remain about the same" (p. 124).

Thus, the 1996 *Update* expected some improvements in costs and durations compared to the previous studies, but these were extrapolations because the projects in the study had not yet been completed. No follow-up study has been made since April 1996 to determine whether these expectations were realized, but even with these projected improvements, DOE project costs and schedules would be very much higher than for comparable projects in industry.

In addition to the outcomes or dependent variables (project costs, overruns, durations, and slippages), the IPA studies also identified some causal factors or independent variables that influenced these outcomes. According to the *DOE DP Project Cost Growth Study* of December 1990 (IPA, 1990):

> The cost growth of these projects is distorted by the frequent use of scope as a contingency. Of the 59 projects that could be analyzed for this, 11 (nearly 20 percent) used an average of 12 percent of their actual expenditures for items outside of the original intent of the projects. Seven of the projects (over 10 percent) decreased their actual costs by an average of 10 percent by reducing the scope from that which was authorized.... An example of the type of discretionary scope change would be if a laboratory project, which was to have included equipment purchases, met with a favorable bidding climate. The remaining money might be spent on equipment purchases beyond those initially planned (p. 19).

Even though these observations were made in 1990, there is no reason to believe that the situation had changed by 1998; according to a presentation made by Dr. David A. Gottschlich of IPA to this committee on August 3, 1998, "Scope reduction is a primary method for cost control." Moreover, the DOE Inspector General *(Audit Report: The U.S. Department of Energy's Value Engineering Program*, HQ-B-98-01, July 1998, [DOE, 1998c]) reported that the Chicago operations office reported as savings from value engineering "about $1.2 million ... from refining cost estimates and project scopes when contract bids exceeded available funding" (p. 2). Scope adjustments are likely to bias project costs upward, on the average, even if the original cost estimates were unbiased because its easier to add reasons to spend any underruns.

Project Definition

Project definition in DOE projects has been a continuing problem. According to the *Project Performance Study* of November 30, 1993, "The statistical analysis shows that project definition [at the completion of design] accounts for 50 percent ($r^2 = 0.50$) of the cost growth variance [in environmental remediation projects]. This relationship is statistically significant at the 0.0001 level" (IPA, 1993, p. 47). In other words, for these projects, the level of project definition explains more of the variance in cost growth than all other variables put together. IPA used a composite front end loading index (FEL) comprised of a combination of several parameters (Gottschlich, 1998). Based on the results of the *Project Performance Study* of November 30, 1993 (IPA, 1993) and the *Waste Management Addendum* of December 1995 (IPA, 1995), "DOE WM [waste management] project definition is poor [with] only 6 percent design complete at authorization vs. 15 percent design complete for industry." Moreover, "[the] FEL index of complex projects is worse than [the] FEL of routine projects," indicating an inversion: more complex projects are authorized with *less* design definition than routine projects.

The 1996 *Update* (IPA, 1996) showed some improvement: "At baseline, DOE WM process projects in the sample fell into the Screening Study [the lowest] category, substantially short of the Industry average; since the stand-down, their definition has improved from Screening Study to Poor" (p. 41). However, "the project definition improvement is about one-quarter of what is needed...." (p. 43). For WM projects, "site definition improved, but engineering status ... improved only slightly" (p. 47), and "there has been negligible improvement [in project execution planning] since the Stand-Down" (p. 49). For ER projects, the 1996 *Update* (IPA, 1996) found that "the level of front end loading attained by DOE's remediation projects is not improving" (p. 89), and there was no improvement in site definition, engineering definition, or project execution planning (p. 91). As noted above, project definition is highly correlated with cost growth. Of the DOE premium for "WM projects ... an average of 48 percent more than the same designs executed by the private sector," eleven percentage points of this 48 percent premium could be eliminated if the average DOE project definition index were equal to the average for the private sector. That is, a WM project that would cost $10 million in the private sector would cost DOE $14.8 million, but this could be reduced by $1.1 million if the DOE project definition were equal to the average project definition in the private sector. As the incremental engineering cost of improving this project definition would be far less than $1.1 million, this improvement would have substantial benefits to cost ratio. Nevertheless, as IPA summarized the situation after the 1996 *Update* (IPA, 1996), "we do not expect to see a significant change in these metrics: no significant improvement in FEL" (Gottschlich, 1998).

Value Engineering

The 1996 IPA *Update* indicates that "the estimated cost to conduct ... value engineering ... [is] about 0.5 percent of the accepted savings" (p. 53). In the DOE WM projects, "although value engineering was used on almost half of the projects, we expected more frequent usage...." The DOE Inspector General agreed with the benefits to cost ratio: "The Corps [of Engineers] has reported a $20 return for each $1 spent on the VE [value engineering] effort....[and] the General Accounting Office ... reported that VE usually produces a net savings of 3 to 5 percent of project costs" (DOE, 1998c, p. 1). Moreover, "Public law 104-106 and Office of Management and Budget (OMB) Circular A-131 require Federal agencies to use VE." Nevertheless, the DOE IG concluded, as of July 1998, that "The Department had not fully developed and implemented an effective VE program" (DOE, 1998c, p. 2), and documented savings from value engineering were less than 3 percent of project costs.

Project Team Turnover

> The DOE WM projects in the baseline sample experienced a high rate of project manager turnover (over 80 percent) during execution.... This is nearly twice the turnover levels experienced by Industry.... Nearly 70 percent of the projects in the DOE WM '96 project set have already [that is, in April 1996] experienced a change in their project managers; since only one of these projects was complete, we expect that the incidence of turnover in the current set of projects will exceed that of the baseline (IPA, 1996, p. 63).

In short, DOE project manager turnover was getting worse in 1996.

DOE Involvement at Project Level

> In the private sector, virtually every project is run by a project manager from the owner's organization. In those very rare cases—less than 2 percent—where the project manager is from the contractor's organization, the owner almost always has a strong presence in the project team. Those projects without good owner control perform distinctly worse as a class than those with strong owner control. DOE WM projects are usually led by a project manager from the contractor organization and often have little or no DOE/owner representation on the project team (IPA, 1996, p. 65).

Compared to the 1993 *Study* and the 1995 *Addendum*, the 1996 *Update* showed a significant increase in the involvement of DOE personnel at the project level for WM projects but still much less than the average for the private sector projects (IPA, 1996, p. 66). Since then, DOE has emphasized privatization; the effect of privatization on the involvement of DOE personnel at the project level is not known.

HISTORIES OF SPECIFIC PROJECTS

Various analyses of DOE projects were either part of the preconstruction planning process or, in some cases, as postconstruction evaluations. A preconstruction predictive project analysis can be used as a basis for decisions on the potential project outcomes based on the identified risks. Postconstruction assessments tend to evaluate results so that the lessons learned can be used for future projects. The following project performance assessments included statistical analyses that benchmarked performance against other projects with similar characteristics. The committee felt that these projects were representative of DOE's project portfolio.

Hanford Waste Vitrification Project

A Project Risk Analysis of the Hanford Waste Vitrification Plant (IPA, 1990), was prepared in June 1990 by IPA for the DOE Office of Program Management. On the basis of statistical analysis using the IPA project database for comparison, this report recommended that DOE make the following changes:

- Increase the contingency allowance in the capital cost estimate from 19 to 39 percent to allow an even chance of avoiding a cost overrun. The three factors for additional contingency include: (1) project is not yet fully defined; (2) new technology is approximately one-fifth of the project cost; and (3) nuclear materials processing facilities usually require higher contingencies.
- The current schedule, accelerated by two years over the original schedule, is somewhat optimistic.
- The cold start-up schedule of eight months is optimistic.
- Production performance for this project during the first year is expected to be only 25 percent of design attainment.

The statistical risk analysis of this project indicated that "the chances of meeting or underrunning the $965 million estimate are less than 15 percent. There is an even chance of overrunning the estimated cost of $965 million by $155 million. There is a 16 percent chance of overrunning the $965 million cost estimate by $335 million" (p. 13). The "$965 million cost estimate" included a "base estimate" of $806 million and a 20 percent contingency of $159 million. That is, the risk analysis showed a less than 15 percent chance of meeting DOE's estimate, even including DOE's contingency, and about one chance in six of an overrun of more than $335 million.

The Hanford Waste Vitrification Plant was canceled in August 1996 after an expenditure of $418 million. According to the IPA risk analysis, this project was clearly in trouble. Nevertheless, the project proceeded.

Rocky Flats 881 Hillside Project

A Post Analysis of the 881 Hillside Project was performed by IPA in September 1994 for EG&G Rocky Flats (IPA, 1994), the site maintenance and operating (M&O) contractor. The goal of this ER project was to stop the migration of a groundwater plume contaminated with trichloroethylene (TCE) and heavy metals. The proposed solution was the design and construction of a 1,500-foot French drain to intercept the groundwater migrating down the 881 hillside and the development of an associated treatment facility. The project was authorized in 1988, re-authorized in 1990, and completed in April 1992, at a total cost of $11.31 million. "The 1988 estimate included approximately 13 percent contingency; the 1990 estimate included 11 percent contingency" (p. 3). In fact, the actual cost growth was 443 percent compared to the 1988 estimate, and 91 percent compared to the 1990 estimate.

The *ex post* statistical analysis showed that "The 881 Hillside remedial action was 4.41 times more expensive than the industry average cost for comparable work… The project results included a faulty design, excessive cost overruns, and poor cost performance relative to comparable projects performed by other organizations…. In addition to the poor project coordination, the project team experienced a lot of turnover…. The project overrun was due to a poor understanding of the project at its authorization points and to poor project practices. In other words, the scope of work was very poorly understood and that scope was performed badly…. In 1988 the project was poorly defined, but the project was authorized anyway.... The project team consisted of numerous organizations that were poorly coordinated. Turnover was a constant problem, both with companies and individuals at companies.... The remedial design was flawed and resulted *in numerous change orders on fixed price contracts*…. The project's contractual strategy appears to have been to distribute the work to as many organizations as feasible" (emphasis added) (IPA, 1994, pp. ii–iv).

According to the results of this report, the following recommendations were made:

- Ensure that projects receive a minimum level of FEL (project definition) at key project milestones.
- Ensure rigorous design reviews.
- Do not use diverse contracting strategies for poorly defined projects.
- Set cost contingencies in line with project risks.

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B

Communication of Project Costs and Durations

The committee has observed that the U.S Department of Energy (DOE), Congress, and other stakeholders do not always use the same definitions for project terms, such as cost estimate, contingency, and risk. DOE documents talk a great deal about risk but offer no precise meaning of the term or how to compute it. Clarifications of terminology and frames of reference, including quantitative assessments of risk and uncertainties, could reduce misunderstandings about project estimates, contingencies, and commitments.

A *cost estimate* is a prediction about a future event, namely the final project cost, and because future events are uncertain, they ought to be described probabilistically. Cost estimates ought to reflect the uncertainties and risks inherent in the project at the time the estimates are made. Confidence factors or ranges should be included with all cost estimates at all stages of a project, to give proponents, participants, and sponsors a realistic idea of the risks and uncertainties related to cost and schedule overruns. Point estimates should be avoided because they give a misleading impression of precision, especially when the reliability of the estimate is low. The General Accounting Office (GAO) criticized "DOE's practice of presenting rough order of magnitude numbers as point estimates" (GAO, 1998, p. 11).

Allowances for cost uncertainties and unknown cost factors can be developed through risk assessments, scenario analyses, contingency assessments, sensitivity analyses, and related methods. Sensitivity analyses and independent external reviews of the assumptions used in the cost and duration estimates should be used to assure that cost and duration estimates are robust against changes in assumptions. "Studies show that the amount of contingency required in the estimate is directly related to how well the project is defined. Projects with poorly defined scopes require larger contingencies than projects with well-defined scopes…. [A] contingency is added to adjust for the estimator's incomplete or uncertain knowledge" (Diekmann, 1996, p. 12).

Two basic types of uncertainties may be identified. One type is internal to the project and the other external. The *internal uncertainties* or unknowns relate to such estimating factors as labor rates or productivity, unexpected foundation conditions, prices and quantities of commodities, such as concrete, steel, etc. Best estimates of these factors must be included in the initial estimated cost of the project, and allowances for changes to the estimated values should be included in the contingency.

External uncertainties are related to external influences and externally-mandated changes beyond the control of the project. They include the effects of political change, Congressional actions, changes in general DOE policies, local, state, or tribal influences, and all changes in cost or schedule originating outside the project for reasons unrelated to the project's purpose or objectives.

The different types of uncertainties have often been treated differently, and estimates often do not include external unknowns, uncertainties, or risks because cost estimators did not know how to estimate them and because they are externally controlled, hence deemed not to be the responsibility of the project. But not allowing for external risks is the same as estimating them to be zero. This practice may be acceptable in projects for which the external uncertainties are very small, but this is not usually the case for DOE projects. DOE cannot apply conventional thinking to unconventional situations. DOE should estimate both classes of uncertainty and include all uncertainties in the contingencies.

Objective, statistical evidence demonstrates that DOE's cost estimates are biased on the low side, as documented in Appendix A. The *Project Performance Study Update* by Independent Project Analysis, Inc., (IPA, 1996) also found that "contingencies of 20 to 25 percent [are assigned for waste management projects] regardless of the individual project risks" (pp. 69–70). When contingencies are based on flat percentages rather than on risk or uncertainty assessments, it is not surprising that costs frequently exceed the assigned contingencies.

The same study found that "DOE underestimates the contingency requirement for their ER [environmental restoration] projects.... DOE ER estimated contingencies are not in line with industry norms and are set too low" for the projects' risks (IPA, 1996, pp. 115–116). Contingencies averaged about 15 to 20 percent, but average cost growth was 48 percent. Obviously these costs were not covered by contingency allowances.

DOE's schedule duration estimates are also biased on the low side, as documented in Appendix A. There is no indication that DOE includes any contingency allowances for project durations when setting schedules.

PROJECT COSTS

Figure B-1, adapted from Figure 4.3 of the RAND study performed for DOE in 1981, shows the general trend in cost estimates over the life cycle of a project (Merrow et al., 1981). The figure shows that the average estimates are biased on the low side; they approach the true or final cost asymptotically from below; and the 67 percent confidence limits (+/- one standard deviation from the estimate) do not even cover the actual cost until late in the project.

General guidance for conducting benefit-cost and cost-effectiveness analyses was spelled out by the Office of Management and Budget (OMB) in 1992. OMB Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, states:

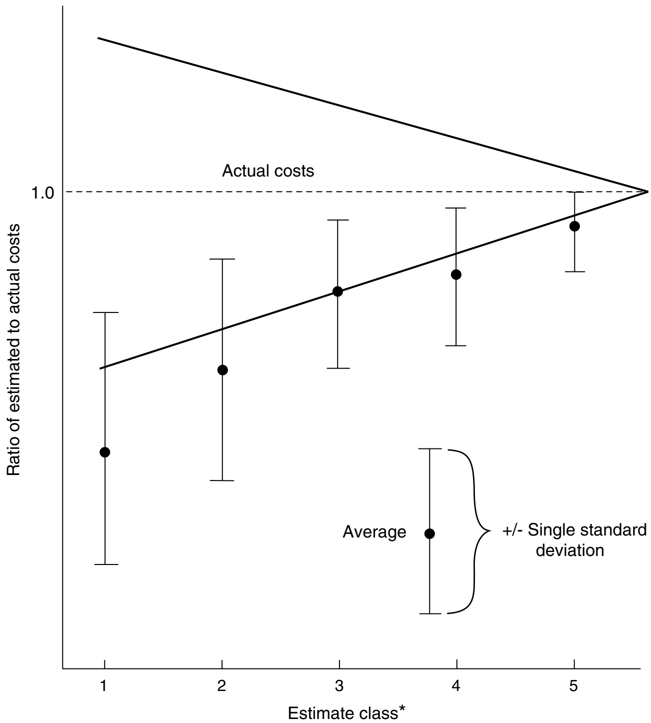

FIGURE B-1 Cost estimation accuracy over the life cycle of a project. Source: Merrow et al., 1981, p. 37. *Estimate class refers to the stage of a project's development: 1 = research and development; 2 = project definition; 3 = engineering (preliminary); 4 = engineering (definitive); 5 = construction.

9. Treatment of Uncertainty. Estimates of benefits and costs are typically uncertain because of imprecision in both underlying data and modeling assumptions. Because such uncertainty is basic to many analyses, its effects should be analyzed and reported. Useful information in such a report would include the key sources of uncertainty, expected value estimates of outcomes, the sensitivity of results to important sources of uncertainty, and where possible, the probability distributions of benefits, costs, and net benefits.

a. Characterizing Uncertainty. Analyses should attempt to characterize the sources of uncertainty. Ideally, probability distributions of potential benefits, costs, and net benefits should be presented. It should be recognized that many phenomena that are treated as deterministic or certain are, in fact, uncertain. In analyzing uncertain data, objective estimates of probabilities should be used whenever possible. Market data, such as private insurance payments or interest rate differentials, may be useful in identifying and estimating relevant risks. Stochastic simulation methods can be useful for analyzing such phenomena and developing insights into the relevant probability distributions. In any case, the basis for the probability distribution assumptions should be reported. Any limitations of the analysis because of uncertainty or biases surrounding data or assumptions should be discussed.

b. Expected Values. The expected values of the distributions of benefits, costs and net benefits can be obtained by weighing each outcome by its probability of occurrence, and then summing across all potential outcomes. If estimated benefits, costs and net benefits are characterized by point estimates rather than as probability distributions, the expected value (an unbiased estimate) is the appropriate estimate for use.

Estimates that differ from expected values (such as worst-case estimates) may be provided in addition to expected values, but the rationale for such estimates must be clearly presented. For any such estimate, the analysis should identify the nature and magnitude of any bias. For example, studies of past activities have documented tendencies for cost growth beyond initial expectations; analyses should consider whether past experience suggests that initial estimates of benefits or costs are optimistic.

DOE cost estimates violate OMB Circular No. A-94 in a number of ways:

- The effects of uncertainty are not analyzed.
- No probability distributions are given for costs.
- Past experience showing bias in cost estimates is not taken into account in new cost estimates.
- Sensitivity analyses are not performed.
- Cost estimates are not expected values.

If the probability distribution of costs were symmetrical (e.g., a normal distribution [Figure B-2]), the expected value, or mean, would correspond to the median, or 50 percent likelihood value. That is, for a symmetric probability distribution, 50 percent of all projects on the average would ultimately cost less than the expected value, and 50 percent would cost more.

If the probability distribution on costs is skewed to the left (Figure B-3), the mean (expected value) of the costs would be to the right of (higher than) the median. In this case, on the average, more than 50 percent of all projects would cost less than the estimated value, and fewer than 50 percent would ultimately cost more than the mean value. It is clear from the statistical analyses cited in Appendix A that DOE estimates do not fit this pattern. Therefore, the evidence is that the costs estimated for DOE projects are not the expected costs.

Communications between project participants and stakeholders could be improved if the definitions of estimated costs, budgets, and contingencies were clarified. This could be achieved if DOE adhered to the requirements of OMB Circular No. A-94 and included uncertainties in its estimates. Clarification could also be achieved by reporting the probability distribution (also required by OMB Circular No. A-94). However, the situation might be better conveyed by reporting the complement of the cumulative probability distribution, which is the probability that the cost will be exceeded for any value of cost, as shown in Figure B-4.

This format directly shows the likelihood of the cost overrunning any given amount. "An accurate project contingency will allow a project team to avoid a cost overrun by establishing a project budget large enough to absorb cost increases driven by project uncertainties." (Diekmann, 1996, p. 34) When presented in this format, the authorized budget (i.e., the sum of the estimate plus the contingency), can be assigned based on an acceptable probability that the actual costs will exceed the budget.

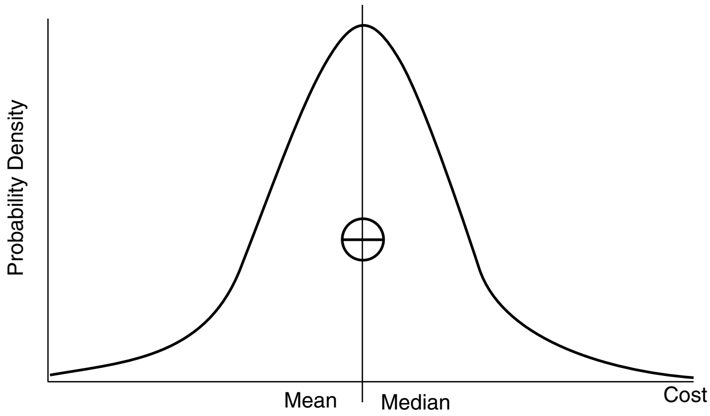

FIGURE B-2 Symmetrical probability distribution for cost.

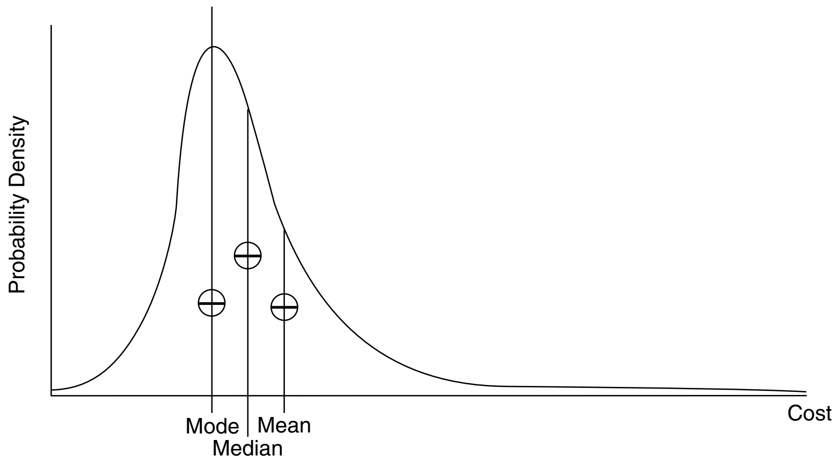

FIGURE B-3 Skewed probability distribution for cost.

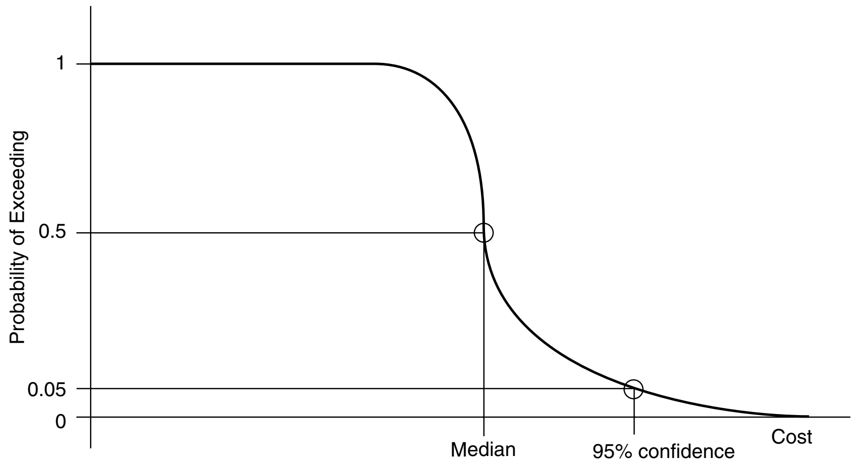

FIGURE B-4 Probability of final project cost exceeding any value.

PROJECT DURATION

A probability distribution for project durations, or the timing of significant project milestones, is shown in Figure B-5. An alternative would be to give the median duration (the duration that would, on the average, be exceeded 50 percent of the time) and the 90 or 95 percent confidence duration (the duration that would, on the average, be exceeded 5 percent of the time). In fact, the latter method of reporting uncertainties in project durations and milestone dates was used in the DOE *Report to Congress: Treatment and Immobilization of Hanford Radioactive Tank Waste* (DOE, 1998), in which "British Nuclear Fuel, Ltd. (BNFL) ...provided two sets of milestone dates that differ depending on BNFL's estimate of their likelihood of achievement (*i.e.*, either 50 percent confidence or 90 percent confidence."

OMB Circular No. A-94 outlines two methods for obtaining probability distributions or confidence factors: (1) by estimating probabilities objectively, and (2) by stochastic simulation methods.

- According to OMB, objective estimates should be used whenever possible. Objective estimates can be obtained through statistical models using multivariate regression on previous project data. This is the type of analysis used by IPA (under contract to DOE) in the *Project Performance Study Update* (IPA, 1996) and other studies (IPA, 1993, 1995). Regression coefficients are determined by an objective statistical analysis of previous costs; then specific project parameters are used as independent variables in these models to predict expected costs and establish confidence limits.

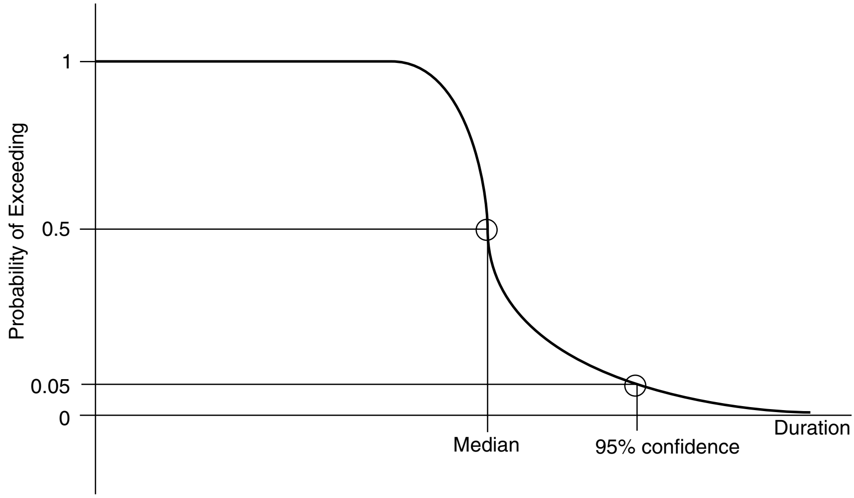

FIGURE B-5 Probability of project duration exceeding any value.

Similar regression models can be used to predict durations and the confidence limits on durations. (Typically, however, an assumption is made of normal distributions, so that the computed standard deviation of the estimate is used to give symmetric, rather than asymmetric, probability distributions and confidence intervals.)

- Stochastic simulations are commonly carried out through Monte Carlo computer simulations. A number of computer models have been developed for the type of stochastic simulation described in OMB Circular No. A-94. DOE has actually sponsored some for use on environmental restoration projects. Diekmann and Featherman (1998) discuss risk analysis simulation models developed with funding by EM-432 and the Center for Risk Management at Oak Ridge National Laboratory; and Diekmann developed a methodology for predicting cost and schedule growth "based on data from eight ER [environmental restoration] projects" (Diekmann, 1996).

DOE has also used uncertainty analysis and simulation to evaluate the effects of technological risk on life cycle costs (von Winderfeldt and Schweitzer, 1998). Although the analysis was program-related rather than project-related (the focus was on selecting a tritium supply alternative based on operability, productivity, and availability), analogous methods could be used for estimating the probability distributions for project costs and durations. The results were presented in figures similar to Figures B-4 and B-5. Other DOE-sponsored studies have focused on evaluations of technical risk, comparisons of alternative technologies, and the development of "decision analysis methodology [that] can analyze uncertainties about site characterization and remedial alternative effectiveness" (Parnell et al., 1997).

Although some individuals at DOE have supported the development and use of methods for risk analysis in keeping with OMB Circular No. A-94, their use is not DOE standard practice. "Modeling these risks and interpreting the results requires skills that are not common on a given ER [environmental restoration] project team. This means that if cost risk studies are to be commonplace some training will be needed" (Diekmann, 1996). Although some individuals in DOE have used these risk assessment tools, their general use, even when developed with DOE funds, has not been institutionalized in the DOE organization.

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C

Characteristics of Successful Megaprojects or Systems Acquisitions

INTRODUCTION AND USE

Experience has shown that more planning and skill are necessary to develop, sustain, and successfully deliver what can be deemed a "megaproject" than for a conventional construction project. The information in this appendix can be used by the U.S. Department of Energy (DOE) as a benchmark against generally accepted successful project characteristics. The characteristics described do not define a process. They are formatted as a checklist for comparing the characteristics of a DOE project with the characteristics of other successful projects.

Checklists are reminders for good managers. The following checklist can be used for all important projects—when the project is being prepared for the development of baseline parameters, as a post-mortem for identifying lessons to be shared with other project managers, or at any other time to check the health of the project and identify likely sources of problems.

The many characteristics of successful megaprojects are complex and are not well documented. Information is usually assembled to document what went wrong with a project rather than to document the circumstances of success. The list of characteristics of successful megaprojects that follows is based on the collective experience of more than a dozen highly knowledgeable professionals with experience in large-scale projects. Of course, not every item listed must be present in order for a megaproject, or any project for that matter, to succeed. If there is a good correlation, particularly if the characteristics listed as "essential to success" in each category are there, then the project should have a good chance for success. If there is little correlation and only a few of the essential characteristics are present, the parties responsible for the project should consider what can be done to improve the chances of success.

Although a sound, reliable project management system is very important to project success, the project management system alone does not guarantee success. Successful projects must be run by trained, skilled, talented, and experienced managers who can not only plan and manage the work well, but who can also handle external factors effectively. The organizational structure must also be designed for project success.

The conditions, qualities, and characteristics that follow will require sizing, shaping, and fitting for the wide range of DOE projects, which have very different scopes or purposes (e.g., environmental cleanup, retrofitting facilities, routine construction, one-of-a-kind science projects). But a standard is a good place to begin the process of fitting and adjusting and setting up the project in a way that increases its chances of success.

GENERAL CONDITIONS

The following general characteristics apply to the project setting, surroundings, and sponsor. These conditions are generally external to the project itself but are significant factors in its success or failure. These conditions are divided into three categories: conditions essential to success; conditions important to success; and conditions beneficial to success.

Conditions Essential to Success

1. Project sponsors know what they need and can afford, where they want to locate the project, and when it must be ready for use or otherwise completed. The project has a purpose, and the benefits are clearly defined and understood by all participants.
2. The project has a champion in the owner's organization whose position and influence enable him or her to affect behavior and performance in the owner's organization that would benefit the project.
3. The sponsor/owner/user is clearly focused on the successful completion of the project throughout the life of the project.
4. Open communications, mutual trust, and close coordination are maintained between owner/users and project management during planning, design, construction, start up, and turnover of the completed project to the owner.
5. Project managers (in owners' as well as contractors' organizations) are experienced professionals dedicated to the success of the project. Each demonstrates leadership, is a project team builder as well as a project builder, possesses the requisite technical, managerial, and communications skills, and is brought into the project early.

6. Regularly scheduled management review meetings with prepublished agendas are attended by all interested project participants to coordinate actions and focus on moving forward and to act on potential problems and issues as they arise.
7. Contracts are clear and unambiguous. The responsibilities of owners and contractors are clearly understood by all parties.
8. Contract incentives are clear and unambiguous, appropriate to the performance objectives, and adequately compensate the contractor for the use of resources, risks, and performance contribution to the owner's objectives.
9. Incentives, as applicable, may be provided so that each contracting party shares in the benefits of improvements in project performance.
10. Risks are borne by the parties most able to manage, control, or reduce them. Therefore, owners bear the risks related to site conditions, external factors, and overall scope of the work; contractors bear risks for their own efficiency and performance in fulfilling the terms of the contract; owners and contractors work together to minimize total project risks rather than shifting them from one to the other.
11. Accountability for project success or failure is understood to be the responsibility of named key individuals.
12. The half life of the political sponsors that decided to proceed with the project exceeds the half life of the project. Thus, there will be no change in the political will during the execution of the project.

Conditions Important to Success

1. Request for Proposals and bid documents clearly define the project and the owner's requirements and expectations.
2. Pre-bid meetings with prospective contractors and suppliers ensure that all parties understand the owner's requirements, limitations, conditions, and expectations.
3. Contracts are awarded on the basis of value, not just cost. Value includes demonstrated capability, experience, leadership, initiative, accepted projected schedule, and other factors directly related to the successful performance of the work.
4. Each party engaged in the project knows who that party's customer is, what that customer is buying in both quantity and quality, and when that customer expects delivery.
5. The project organization and mission are clearly defined and understood by everyone. The roles and responsibilities for each key person are published, and the chain of command is clearly defined.

6. The depth, stability, and time commitments by key personnel are appropriate for the project to ensure low turnover in management and key technical positions.
7. Key project personnel from all participating entities are trained in public affairs, public information, effective communications, and information management.
8. A partnering arrangement is used, in which owners, users, contractors, stakeholders, regulators, and public representatives are brought together at the outset to come to consensus on the tasks that must be accomplished and the roles and responsibilities of each.
9. The public and stakeholders understand and accept the purpose of the project, the types of technologies to be employed, the processes used to award contracts, and the past relationships of the contractors with the local labor force, suppliers, and vendors.
10. Acceptance, concurrence, and buy-in are obtained from all stakeholders based on their being well informed and involved in the decision-making process leading up to the start of the project. Stakeholder acceptance is high throughout the project maintained by proper control of the work, good communications, diplomacy, and consideration.
11. The project has a single information technology standard and agreed upon protocols that have been published and are understood and observed by all.
12. Contract types and terms are appropriate to the risks and to the allocation of risks between the parties.
13. Adversarial relations are avoided through good contracts, good communications, and teamwork, from the earliest stages of the project.
14. If appropriate to the scope and duration of a project, an owner-controlled insurance program provides wrap-around coverage for all parties engaged in the work.
15. Individual contractors, to mitigate their own project risk and based on the risks inherent in their work, may carry insurance separate from the owner-controlled program insurance.
16. The participation of individuals and contractors representing protected classes is a priority for project management; programs are in place that encourage participation through training and administrative assistance in obtaining prequalification or other requirements for participation.
17. Good labor relations and training programs ensure an adequate supply of skilled workers and lessen the chances of unjustified work stoppages, jurisdictional disputes, and other personnel issues.
18. Owners and contractors can explore methods and practices to improve project efficiency and effectiveness.

Conditions Beneficial to Success

1. The project is relatively immune to external factors that could affect the scope, mission, quality, cost, or duration of the project.
2. The project is open to the outside for receiving information, advice, improvements, technology, and independent assessment.

SPECIAL CONDITIONS

The following characteristics relate to a particular project and apply to the owner, the contractor, the contract, budgets and funding authorizations, project operations, and similar project-specific characteristics.

Conditions Essential to Success

1. Scope, cost, schedule, and quality are closely interrelated, and a change in one will probably cause a change in one or more of the others.
2. The benefit-to-cost ratio for the project is high enough that increases in costs within the preset confidence limits will not threaten the viability of the project.
3. Budgets include allowances for explicit contingencies.
4. Budgeted funds are planned and committed without interruption so that progress will not be delayed or halted at the end of the fiscal year or other interruptions in cash flow.
5. An integrated project control system is in place that reflects the budgets, work breakdown structure, and schedule of values to a level that relates tasks, budgets, and schedule.
6. Leading indicators of problems are identified and closely monitored for early signs of trouble so that corrective actions can be taken.
7. Actual cost and schedule performance are compared periodically with planned performance through an earned value method system and performance indicators that report trends in both current and projected costs and schedules. Reports are provided to participants at regular intervals for their information, corrective actions, and response.
8. A rigorous, formal configuration management/change control process is in place to deal with all configuration issues or changes in scope, schedule, or costs beyond a stated threshold.
9. All proposed scope or design changes are justified with regard to configuration and project objectives and are priced out and documented to include their effect on quality, scope, cost, and schedule, as well as their ripple (nonlinear) effects on reworking, schedule, and costs.
10. Decisions to proceed with changes in scope or schedule come through the change control process and through the chain of command after due, but

timely, consideration of their impact on project completion time, cost, and performance.

11. Issues involving the environment, safety, or health are handled directly and efficiently with the primary focus on avoiding harm and mitigating exposure.
12. Safety is a primary focus of every project participant, and job specific training and coordination are uniform and universal.
13. Permits, easements, rights of way, cooperative agreements and other evidence of unfettered access to the work site and its surroundings are in place and available.
14. Stakeholders, regulators, and other interested parties have been briefed on the scope, schedule, and cost estimates. Milestones significant to each interested party have been identified and explained.
15. Trade-offs between risk and technology opportunities are examined quickly, carefully, and definitively to determine the best available technology in a given context.
16. The owner, designers, and contractors understand the risks, uncertainties, and sources of risk in the project, and are prepared to take action to mitigate them.
17. Contractors are brought into the project early so they can participate in the design process, work planning, design and build specialized equipment, become familiar with the site and conditions, and become an integral part of the project delivery team.
18. Pre-existing labor agreements are consistent with the planned work, workers, materials, equipment, and processes planned by the contractors.

Conditions Important to Success

1. Planned rates of work are not constrained by the vagaries of annual appropriations or payment authorizations, which could increase contingencies in subcontract costs, disrupt the orderly flow of work, and generally increase costs.
2. Wherever possible, budgets are multiyear, updated, and extended annually.
3. Cost estimates and contingencies to account for margins of error or uncertainty include input from local and federal regulators, when appropriate.
4. The uncertainties in costs and schedules are estimated and include a range of impacts for public or political opposition to the project, as well as the lack of cooperation from local, state, and other regulators, especially if the project is unique and controversial.
5. Contractor safety records and statistics are available to the project manager and the owner. Problems are addressed immediately and constructively by the parties involved.
6. The roles and responsibilities of each party charged with quality control are

clear, understood, not overlapping, appropriate to the work, and accepted by all parties.

7. A records and documentation program is in place to ensure that a documented history of the life of the project will be available.
8. A specific project-wide, nonjudicial disputes resolution process is in place to resolve differences of opinion or interpretation of the contract or the work so the project team can continue to work as a team.
9. Systems are in place to track and report progress against the cost and schedule baselines at regular, planned intervals. All parties actively participate in a lessons learned program to improve productivity, safety, and overall performance.

Conditions Beneficial to Success

1. Design-to-budget methods are used to track changes in material quantities and other costs compared to the baseline estimate.
2. Actual and budgeted costs of work performed are tracked in the field.
3. Suppliers and vendors are involved during planning and design to ensure that supplies of required materials and the latest technology are available.
4. An active, quality improvement program addresses every level of staff and all processes, as well as work products.
5. The project and all of its participants and contractors are ISO 9000 qualified.
6. Political influence, extraneous political and social factors, and other factors not related to successful execution of the project in terms of time, cost, and quality are controlled to limit their influence on project performance.

TECHNICAL CONDITIONS: SCOPE

Essential to Success

1. The scope of work is clearly defined in terms relevant to the project team.
2. Wherever possible, scope performance is defined in terms of deliverables or numbers of units of planned work to be completed by a certain time.
3. The quality assurance/quality control program is tailored to meet project-specific requirements, and the scope reflects both requirements and expectations according to the contract.
4. The project plan is based on employing best available, state-of-the-art technology, but not experimental or unproven technology.
5. Site conditions are well known and have been thoroughly investigated. Accurate information is available on subsurface conditions (geology, groundwater, toxic or hazardous materials, and other factors), hydrology, and meteorology.

Conditions Important to Success

1. A published project quality control plan establishes the requirements for quality by all staff and parties at all levels.
2. When an environmental impact statement (EIS) and record of decision precede project initiation, each and every environmental action noted in the EIS is translated into specific mitigation plans attached to each work package to ensure compliance.

Condition Beneficial to Success

1. The project does not take so long to execute that the science or technology on which it is based is obsolete before the project is completed.

TECHNICAL CONDITIONS: COSTS

Conditions Essential to Success

1. Project baseline estimates include all identifiable cost elements and contingency sums to account for items not yet identifiable at the stage of design development that supported the estimates.
2. Cost estimates, at all stages, reflect the level of detail and explicit contingencies consistent with the stage of design development to limit the likelihood of significant cost increases through design development following authorization of the project.
3. Through the change control process, explicit contingency sums are converted to explicit item costs, as items are identified and accepted by change control; the contingency is reduced accordingly.
4. Allowances for cost growth and unknown cost factors are developed through risk analysis, contingency analysis, or scenario analysis and are included in the cost estimate.
5. Costs are distributed and tracked against the baseline cost estimates distributed to work elements through the work breakdown structure.

Conditions Important to Success

1. Biases in the cost estimates are addressed through independent reviews of the assumptions and their impacts on the cost estimates.
2. Cost estimates objectively account for risks, changes, hazards, user/owner culture and rules, and similar nonexplicit factors that are likely to influence costs.

Conditions Beneficial to Success

1. A cost estimate, which is a statement about a future event, should be probabilistic to reflect the risks inherent in the project.
2. Confidence factors, or the likelihood that a given cost will not be exceeded, are associated with cost estimates at all stages to give project sponsors a clear idea of the risks of cost variances and overruns.

TECHNICAL CONDITIONS: SCHEDULE

Conditions Essential to Success

1. Schedules and cost estimates are prepared together based on the work breakdown structure and production rates, crew size, physical constraints, and other time-impacting issues.
2. Schedules, like cost budgets, include contingencies, and the contingencies are known and continuously managed by the project manager.
3. The benefits of early completion of work are high, and schedules are aggressive and planned to complete the project as early as possible.
4. To minimize exposure to internal and external changes, the schedule is aggressive and is pursued vigorously.
5. Milestones, including owner actions, are clearly defined, listed, tracked for performance, and continuously monitored against performance.

Conditions Important to Success

1. Schedule contingencies decrease as the work progresses, and fewer unknowns remain to be resolved.
2. Risk analysis and probability techniques are applied to task durations.
3. Independent reviewers evaluate the assumptions used in making the schedules and determine how realistic the major milestones and completion date(s) are.

Conditions Beneficial to Success

1. Critical equipment and materials are available to support the schedule.
2. The reasons for completing the project by a given date are clear.

D

Biographies of Committee Members

Kenneth F. Reinschmidt (*chair*) retired from Stone and Webster, Inc., as senior vice president. He held various positions at Stone and Webster, including president and chief executive officer of Advanced Systems Development Services, Inc., and manager of the Consulting Group in the Engineering Department. Prior to his work at Stone and Webster, Dr. Reinschmidt was a senior research associate and associate professor in the Civil Engineering Department, Massachusetts Institute of Technology, where he was engaged in interdisciplinary research on power-plant engineering, design, construction, and project management. He is a former member of the Building Research Board of the National Research Council (NRC) and served or chaired several 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 Foundation review panels on construction automation, computer-integrated construction, and engineering research centers. Dr. Reinschmidt was elected to the National Academy of Engineering (NAE) in 1991. He obtained his B.S., M.S., and Ph.D. degrees from the Massachusetts Institute of Technology.

Philip R. Clark, Sr., recently retired as president, chief operating officer, and chief executive officer of GPU Nuclear Corporation, which operates and maintains the Three Mile Island Nuclear Power Plant in Pennsylvania and the Oyster Creek Nuclear Power Plant in New Jersey. He was elected to the NAE in 1993 and was a member of the NRC Committee on Decontamination and Decommissioning of Uranium Enrichment Facilities. After 25 years of service in the Naval

Reactors Program, he retired as associate director for reactors, Naval Reactors Division, U.S. Department of Energy (DOE) and chief, Reactor Engineering Division, Naval Sea Systems Command. Mr. Clark was responsible for the management and direction of all activities involved in the cleanup of the Three Mile Island 2 reactor accident. At various times, he was director of the Institute of Nuclear Power Operations, the American Nuclear Energy Council, the Advanced Reactor Corporation, and the Nuclear Energy Institute. He has won the Navy Distinguished Civilian Service Award and the U.S. Energy Research and Development Administration Special Achievement Award. He holds a B.C.E. from the Polytechnic Institute of Brooklyn.

Frank P. Crimi recently retired as vice president, Lockheed Martin Advanced Environmental Systems Company. He previously served as vice president of Nuclear Engineering Services, Waste Chem Corporation; manager of decommissioning services, General Electric Company; and manager of plant systems engineering, Advanced Reactor Systems at General Electric. He also held a number of key positions at the DOE Knolls Atomic Power Laboratory operated by General Electric. His experience includes the management of large, complex programs in the nuclear industry, including construction, operation, and maintenance of naval nuclear reactor plants. He also was the General Electric program manager for decommissioning DOE's Shippingport Atomic Power Station. Mr. Crimi has been a member of several NRC committees, including the Committee on Decommissioning of Uranium Enrichment Facilities, Committee on Peer Review in Environmental Technology Development Programs, and the Committee to Review DOE's Decontamination and Decommissioning Technology Development Program. He holds a B.S. in mechanical engineering from Ohio University.

Lloyd A. Duscha retired from the U.S. Army Corps of Engineers (USACE) in 1990 as the highest ranking civilian after serving as deputy director, Engineering and Construction Directorate, at USACE headquarters. Mr. Duscha was elected to the NAE in 1987. He was principal investigator for the recent NRC report, *Assessing the Need for Independent Project Reviews in the Department of Energy*, which was produced during Phase 1 of the current study. Mr. Duscha is currently an engineering consultant to national and foreign government agencies, the World Bank, and private sector clients. Mr. Duscha has served on numerous NRC committees including the Committee on the Outsourcing of the Management of Planning, Design, and Construction Related Services, and the Committee on Shore Installation Readiness and Management. He is a past member of the NRC Board on Infrastructure and the Constructed Environment, and was vice-chairman for the U.S. National Committee on Tunneling Technology. Other positions held include president, U.S. Committee on Large Dams; chair, Committee on Dam Safety, International Commission on Large Dams; member of Executive Committee, Construction Industry Institute; and member of the Board of Directors, American Consulting Engineers Council Research and Management Foundation. He has numerous professional affiliations, including fellow of the American Society of Civil Engineers, and the Society of American Military Engineers. He has a B.C.E. from the University of Minnesota, by which he was also awarded the Board of Regents Outstanding Achievement Award.

G. Brian Estes is the former director of construction projects, Westinghouse Hanford Company, where he directed project management for construction projects in support of operations and environmental cleanup of the Department of Energy Hanford Site. 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 commander of the Third Naval Construction Brigade, Pearl Harbor, Hawaii. He supervised more than 700 engineers, 8,000 Seabees, and 4,000 other employees in providing public works management, environmental support, family housing support, facility planning, and 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. As deputy commander for facilities acquisition and deputy commander for public works, Naval Facilities Engineering Command, he directed the execution of the $2 billion Military Construction Program, and the $3 billion Facilities Management Program. 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.

Paul H. Gilbert is senior vice president, principal professional associate and principal project manager of Parsons Brinckerhoff Quade & Douglas, Inc. He was elected to the NAE in 1997. Mr. Gilbert was the project director of the PB/MK Team for design, construction management, and construction of the conventional facilities of the Department of Energy's Superconducting Super Collider and has served as principal-in-charge for major civil engineering projects, such as the Stanford Linear Accelerator Positron-Electron Project, Basalt Waste Isolation Project at Hanford, Nuclear Power Plants in Mined Caverns Study, Downtown Seattle Transit Project, Long Beach Naval Fuel Pier, and the Boston and San Francisco Effluent Outfall Tunnels. Mr. Gilbert is a member in many organizations, including the American Society of Civil Engineers (ASCE), the Project Management Institute, the Society of American Military Engineers, and the Moles. He has won numerous awards in civil engineering and construction management including ASCE fellow, and the ASCE Rickey Medal and Construction Management Award. He holds a B.S. in civil engineering and an M.S. in structural mechanics from the University of California, Berkeley, and is a registered professional engineer in 17 states.

Alvin H. Mushkatel is professor in the School of Urban Planning and Landscape Architecture, Arizona State University. He has held positions in political science at the University of Denver, University of Missouri, and St. John's University in Minnesota. He has conducted numerous studies on risk perception, siting of hazardous facilities, and nuclear waste policy and was a member of a DOE Public Participation Seminar Series Panel on public trust and confidence. He has served as a member of the NRC Committee on Decontamination and Decommissioning of Uranium Enrichment Facilities, the Committee on Earthquake Engineering (and a number of its subpanels), and the Committee on the Review and Evaluation of the Army Chemical Stockpile Disposal Program. Dr. Mushkatel has published widely in the fields of hazards policy and risk perception. He holds a Ph.D. in political science from the University of Oregon.

Ray O. Sandberg recently retired as manager of special projects on the Superconducting Magnetic Energy Storage Project, Bechtel, Inc. He was planning manager on the Heavy Water–New Production Reactor construction project and managed the Bechtel design and cost-estimating team in support of the DOE Richland studies on conversion of the WNP-1 reactor to defense materials production; directed development of comparative advanced conceptual designs, construction techniques, cost estimates, and schedules for the $6 million DOE New Production Reactor Study; was manager of Nuclear Fuel Cycle Economics; was Bechtel's technical manager for post-accident planning for the recovery of Three Mile Island Unit 2, including the testing of proposed decontamination techniques and removal of the damaged fuel; and was project engineer for the preliminary design of the Alabama Enrichment Plant, a $3 billion gaseous diffusion enrichment complex. He was a member of the NRC Committee on Decontamination and Decommissioning of Uranium Enrichment Facilities and the Committee on Technology Development for Decontamination and Decommissioning. He has an M.S. in chemical engineering from Washington University and an M.B.A. from Golden Gate University.

Alan Schriesheim is director emeritus, Argonne National Laboratory, and recently retired as professor of chemistry, University of Chicago. He was elected to the NAE in 1989. Prior to his service for Argonne National Laboratory, he worked for the Exxon Corporation where he was the general manager in the Engineering Technology Department were he oversaw the development and commercialization of engineering technology for Exxon affiliates worldwide. Dr. Schriesheim has served on numerous NRC committees, including the Committee on Advanced Fossil Energy Technologies, Government-University-Industry Research Roundtable, Committee on Scientists and Engineers in the Federal Government, and the Committee on Environmental Research. Dr. Schriesheim has served on a variety of government panels and boards applicable to this study, including the DOE Energy Research Advisory Board, Magnetic Fusion Advisory

Committee to the DOE, Advisory Committee on Science and Technology, Presidential National Commission on Superconductivity, U.S. House of Representatives Subcommittee Science Advisory Group on Renewing U.S. Science Policy, and the Argonne National Laboratory Board of Governors. He has a B.S. in chemistry from the Polytechnic Institute of Brooklyn and a Ph.D. in physical organic chemistry from Pennsylvania State University.

Mark N. Silverman is the former manager of the DOE Rocky Flats Field Office and is currently a consultant providing services in a wide range of fields, including management and organizational improvements, energy, environmental protection and cleanup, communications, aerospace, and oceanography. He has broad expertise in administration and operations related to various aspects of DOE programs, including weapons production, environmental restoration, and nuclear waste management. Mr. Silverman oversaw the transition of Rocky Flats from a nuclear weapons production facility to an environmental restoration and nuclear-waste management site with a vision to closing the facility within 10 years. Previous to his assignment at Rocky Flats, he was deputy manager of the Savannah River Operations Office, where he successfully oversaw construction of the Defense Waste Processing Facility, a $3 billion vitrification facility to stabilize and safely store more than 10 million gallons of highly radioactive liquid waste. He has served as an area manager of the DOE's Western Area Power Administration, director of the Denver Oil Shale Project Office, and director of the Geothermal Loan Guaranty Program. He also served in a variety of government positions in the Environmental Protection Agency, the Federal Energy Administration, and the Energy Research and Development Administration. As a foreign affairs and congressional fellow, he served as a legislative assistant on energy policy, foreign affairs, and defense issues. He has a B.S. from the U.S. Military Academy at West Point and an M.A.C. from the University of Pennsylvania. He has completed postgraduate courses at Colorado State University and the University of Denver, where he is an adjunct professor.

Richard I. Smith retired as staff engineer in the Systems and Risk Management Department of Battelle Pacific Northwest Laboratories. He contributed to and managed extensive programs sponsored by the Nuclear Regulatory Commission on the decommissioning of licensed nuclear facilities and the development of criteria for the release of decontaminated sites. He has participated in the development of a number of Environmental Impact Statements for both DOE and the Nuclear Regulatory Commission related to nuclear facility decommissioning, spent fuel management, and radioisotope production. His studies on the decommissioning of power and test reactors, fuel cycle facilities, and nonfuel cycle nuclear facilities focus on estimating the costs and occupational radiation dose for the decontamination and decommissioning of nuclear facilities, are widely known and used throughout the world. He has been a consultant to the

International Atomic Energy Agency (IAEA) on the decommissioning of nuclear facilities and spent fuel management. In recent years, he has also participated in extended IAEA programs for the planning and management of decommissioning WWER-440 reactors throughout the former Eastern bloc countries. Mr. Smith was a member of the NRC Committee on Decontamination and Decommissioning of Uranium Enrichment Facilities and contributed to the NRC study that examined proposed plans for disposing of spent aluminum-uranium fuels from domestic and foreign research reactors. He is a registered professional engineer in nuclear engineering and has an M.S. in applied physics from the University of California, Los Angeles.

Rebecca Snow is a partner in the Washington law firm of Covington and Burling. Her specialization is environmental law with a concentration on Superfund matters, and her work has focused on identifying and controlling liabilities and costs in private and government enforcement actions involving the cleanup of hazardous-waste sites. Ms. Snow is a featured speaker on Superfund issues and the environmental aspects of real estate and business transactions. She co-authored a two-volume treatise addressing the major substantive and procedural issues that have arisen in Superfund cleanups. She is a member of the Bar in the District of Columbia, Nevada, and the United States District Court for the District of Columbia. She has a J.D. from Harvard Law School and a B.A. from Brigham Young University.

Clyde B. Tatum is professor of civil engineering at Stanford University and coordinator of the Construction Engineering and Management Program. His research interests and numerous publications include mechanisms and strategies for process and product innovation in construction, methodologies for design-construction integration, and decision-making in technology adoption. Before joining the Stanford faculty, he was involved with various engineering and construction tasks with Ebasco Services, Inc., and the USACE. His experience includes the planning, design, and management of complex projects in the energy production industry and other heavy industries. He is a registered professional engineer in Colorado and Washington. He has a B.S. in mechanical engineering from Virginia Polytechnic Institute, an M.S. in engineering from the University of Michigan, an M.B.A. from New York University, and a Ph.D. from Stanford University.

E

Committee Meetings and Activities

1. COMMITTEE MEETING, JUNE 22–23, 1998
NATIONAL RESEARCH COUNCIL, WASHINGTON, D.C.

Presentations

Department of Energy (DOE)

DOE Project Management Systems
Antonio Tavares, Director
Office of Project and Fixed Asset Management

Office of Energy Research Construction Project Management
Daniel Lehman, Director
Construction Management Support Division, Office of Energy Research

DOE Privatization and Contract Reform
Walter Howes, Director
Office of Privatization

Response to Committee Questions and Scheduling of Site Visits
Peter Devlin, Associate Director
Office of Fixed Asset Management

General Accounting Office

Policies and Practices of the DOE for Major Systems and Other Construction Projects
Victor Rezendes, Director, Energy, Resources, and Science Issues
Gary Jones, Associate Director, Energy, Resources, and Science Issues

Defense Nuclear Facilities Safety Board

Selected DNFSB Recommendations and Recent Activities Related to the Design and Construction of DOE Facilities
John T. Conway, Chairman
A.J. Eggenberger, Vice Chairman
Joseph DiNunno, Member
John Mansfield, Member
Steve Krahn, Deputy Technical Director

2. SITE VISIT, JULY 13, 1998
DOE HEADQUARTERS, WASHINGTON, D.C.

Presentations

Program Office Project Activities
Beverly Cook, Acting Principal Deputy Director
Office of Nuclear Energy

James Decker, Deputy Director
Office of Energy Research

Michael Knotek, Program Advisor For Science and Technology
Office of the Secretary

Stephen Mournighan, Director, Management Systems
Office of Procurement & Assistance Management

Ed Lazur, Director, Office of Construction and Capital Projects
Office of Defense Programs

Gregory H. Friedman, Acting Inspector General

James Owendoff, Acting Assistant Secretary
Office of Environmental Management

Howard Canter, Acting Director
Office of Fissile Material Disposition

3. SITE VISIT, JULY 20–21, 1998
ALBUQUERQUE OPERATIONS OFFICE AND
ROCKY FLATS FIELD OFFICE

Presentations at the Albuquerque Operations Office

Introduction and Overview
Bruce Twining, Manager
DOE Albuquerque Operations Office (DOE-AL), and

Earl Whiteman, Assistant Manager for Technology and Site Programs
DOE-AL

Project Management Roles and Responsibilities
John Themelis, Deputy Assistant Manager for Environment/Project Management
DOE-AL

Environmental Management Project Activities
George Rael, Director, Environmental Restoration Division Office
DOE-AL

Budget Formulation Activities in Support of the Acquisition Process and Project Management
Frank Baca, Chief Financial Officer
DOE-AL

Contract Activities in Support of the Acquisition Process and Project Management
Bill Meyers, Director, Contracts and Procurement Division
DOE-AL

Roles, Responsibilities and Processes for Facility Acquisition/Project Management at Los Alamos National Laboratory (LANL)
John Bretzke, Group Leader, Facilities Engineering
LANL

Roles, Responsibilities and Processes for Facility Acquisition/Project Management at Sandia National Laboratories (SNL)
Stan Harrison, Program Manager, Technical Services Program
SNL, and

Pamela McKeever, Manager, Corporate Programs
SNL

Presentations at the Rocky Flats Field Office

Lance Schlag, Team Leader, Budget Group
DOE Rocky Flats Field Office (DOE-RFFO)

Keith Klein, Deputy Manager
Technical Programs, DOE-RFFO

Paul Golan, Assistant Manager for Program Planning and Integration
DOE-RFFO

Frazer Lockhart, Assistant Manager for Closure Projects
DOE-RFFO

Jessie Roberson, Manager
DOE-RFFO

Len Martinez, Chief Financial Officer
Kaiser-Hill LLC

Bob Card, President/CEO
Kaiser-Hill LLC

Larry Burdge, Vice President Planning and Integration
Kaiser- Hill LLC

4. SITE VISIT, JULY 22–23, 1998
SAVANNAH RIVER OPERATIONS OFFICE AND
OAK RIDGE OPERATIONS OFFICE

Presentations at the Savannah River Operations Offices

Introduction and Overview
Greg Rudy, Manager
DOE Savannah River Operations Office (DOE-SR); and
Frank McCoy, Deputy Manager
DOE-SR

Program Focus and Overview
John Anderson, Acting Assistant Manager, Nuclear Materials and Facility
Stabilization, DOE-SR

In Tank Precipitation Project
Howard Gnann, Acting Assistant Manager, High Level Waste
DOE-SR

Overview of Projects and Operations
Ambrose Schwallie, President
Westinghouse Savannah River Company

Overview of Projects and Operations
John Oakland, Vice President, Projects Engineering and Construction
Bechtel Savannah River, Inc.

Overview of the Tritium Extraction Facility
Rich Viviano, Supervisory Engineer
DOE-SR

Presentations at the Oak Ridge Operations Office

Organizational Overview and Projects Discussion, Lockheed Martin Energy Research Corporation (LMER), and Lockheed Martin Energy Systems (LMES)
James C. Hall, Manager
Oak Ridge Operations Office (DOE-OR)

Spallation Neutron Source (SNS) Organization and Management Team, Technical Issues, Cost Estimate, and Baseline
David Wilfert, Deputy Project Manager SNS
DOE-OR

Transuranic Waste Project, the Foster-Wheeler Contract, and Disposal Cell Project
Rodney Nelson, Assistant Manager for Environmental Management
DOE-OR

DOE Internal Reviews (Office of Energy Research) and Lessons Learned from the Superconducting Super Collider
Edward G. Cumesty, Assistant Manager for Laboratories
DOE-OR

ORNL and Relationships with DOE Site Offices
Jerry H. Swanks, Deputy Director
Oak Ridge National Laboratory (ORNL), LMER

Engineering and Construction Funding, Staff, Contracting, and Project Management
Edward Krieg, Director, Engineering and Construction
ORNL, LMER

Bechtel Jacobs Organization and M&I Contract
James Thiesing, Vice Present and Deputy General Manager
Bechtel Jacobs Company L.L.C.

Organizational Overview and Infrastructure Needs
Todd Butz, Y-12 Plant Manager
LMES

5. SITE VISIT, JULY 28–29, 1998 RICHLAND OPERATIONS OFFICE AND IDAHO FALLS OPERATIONS OFFICE

Presentations at the Richland Operations Offices

Lloyd Piper, Deputy Manager
DOE Richland Operations Office (DOE-RL)

Michael Hughes, President
Bechtel Hanford, Inc.

William Madia, Director
Pacific Northwest National Laboratory

Ronald Hanson, Acting President
Fluor Daniel Hanford, Inc.

Peter Knollmeyer, Assistant Manager for Facility Transition
DOE-RL

David Evans, Program Manager
B Plant, DOE-RL

Merilyn Reeves, Member
Hanford Advisory Board

Presentations at the Idaho Operations Offices

Warren Bergholz, Deputy Manager
DOE Idaho Operations Office (DOE-ID)

Lee Williams, Project Manager
DOE-ID

Dave Herrin, Project Manager
DOE-ID

John Wilcynski, Manager
DOE-ID

Jeff Hoyles, Director Procurement Services Division
Office of the Chief Financial and Administrative Officer
DOE-ID

Bob Secondo, Special Technical Assistant/Project Manager
Office of Program Execution
DOE-ID

Mike Bonkoski, Program Director
Office of Program Execution
DOE-ID

Jerry Lyle, Assistant Manager
Office of Program Execution
DOE-ID

6. COMMITTEE MEETING, AUGUST 3–4, 1998
NATIONAL RESEARCH COUNCIL, WASHINGTON, D.C.

Presentations

Issues and Overview of Construction Project Management and Delivery
Charles McGinnis, Retired Associate Director
Construction Industry Institute, University of Texas–Austin

Project Management and Project Delivery—Issues and Concerns of DOE Contractors
Hank Hatch, Former President/CEO
Fluor Daniel Hanford, and COO Select, American Society of Civil Engineers

Discussion of House Report 105-271
Jeannie Wilson, Staff Assistant
House Subcommittee on Energy and Water Development

Discussion of Fiscal Year 1999 DOE Appropriations
Don McKinnon, Staff Assistant
House Subcommittee on Energy and Water Development

DOE Project Management Systems
Frank Peters, Deputy Director
Office of Field Management

DOE Project Management Policy and Practices
Tony Tavares, Director, Project and Fixed Asset Management
Office of Field Management

Project Performance Analysis Studies for DOE's Office of Environmental Restoration and Waste Management
David Gottschlich, Area Manager
Independent Project Analysis, Inc.

7. WRITING GROUP MEETING, OCTOBER 7–9, 1998
ARNOLD AND MABEL BECKMAN CENTER
NATIONAL ACADEMIES OF SCIENCES AND ENGINEERING
IRVINE, CALIFORNIA

8. COMMITTEE MEETING, OCTOBER 29–30, 1998
J. ERIK JONSSON WOODS HOLE CENTER OF THE NATIONAL ACADEMY OF SCIENCES
WOODS HOLE, MASSACHUSETTS

9. COMMITTEE MEETING, DECEMBER 1–2, 1998
NATIONAL RESEARCH COUNCIL, WASHINGTON, D.C.

Presentations

Department of Defense Project Control Systems
Wayne Abba, Senior Program Analyst
Office of the Under Secretary of Defense

DOE Environmental Management Independent Reviews
Thad Konopnicki, Special Assistant
Office of the Deputy Assistant Secretary for Environmental Management

DOE Project Management Reform Initiatives
Thomas Todd, Director
Office of Field Management

Glossary

Baseline. A quantitative expression of projected costs, schedule, and technical requirements; the established plan against which the status of resources and the progress of a project are measured.

Baseline change proposal. The instrument/document describing a proposed change and its impacts on project baselines.

Benchmarking. An improvement process in which an organization or agency or company measures its performance against that of best-in-class organizations or agencies or companies, determines how they achieved their performance levels, and uses the information to improve its own performance; benchmarking can be used to compare strategies, operations, processes, and procedures.

Characterization. The identification of the quality or delineation of properties. For DOE it is often the determination of waste composition and properties, whether by a review of processes, nondestructive examination or assay, or sampling and analysis, to determine appropriate storage, treatment, handling, transportation, and disposal requirements.

Conceptual design. The activities required to evaluate project design alternatives and to develop sufficient detail to establish a baseline scope, cost, and schedule for project authorization.

Construction manager. The individual or firm responsible to DOE or its contractor for the supervision and administration of a construction project.

Construction project. The full scope of activities required on a work site to fulfill the requirements of the construction acquisition documents; activities performed in support of, or as part of maintenance, manufacturing, decontamination and decommissioning, or environmental restoration or remediation.

Contingency. The amount budgeted to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties; the amount of the contingency depends on the status of design, procurement, and construction and the complexity and uncertainty of the component parts of the project; contingency does not eliminate the need for an accurate assessment of expected cost.

Critical Decision. A formal DOE determination at a specific point in a project (prior to commencement of conceptual design, commencement of execution, and prior to turnover) that allows the project to proceed.

Earned value. A management technique comparing the value of work performed to actual costs and relating resource planning to schedules and technical performance requirements; work is planned, budgeted, and scheduled using specific time increments to set measurable performance baselines; comparisons of planned values to actual performed (earned) values, provides an objective assessment of cost performance.

Facility. The buildings, utilities, structures, and other improvements associated with an operation or service and dedicated to a common function.

Graded approach. The depth of detail required and the magnitude of resources expended for a particular management element to be commensurate with the element's relative importance to safety, environmental compliance, safeguards and security, programmatic importance, magnitude of the hazard, financial impact, and/or other facility-specific requirements.

ISO 9000. A quality improvement methodology sanctioned by the International Standards Organization for assessing the quality of professional services; in its simplest application, the ISO 9000 process requires that an organization seeking certification, define what it does, how it will do it, what records will be kept, and who the responsible parties are for all operations; the organization must show that its policies and procedures, etc. are (1) consistent with its purpose; (2) universally applied, understood, and followed; and (3) continued as the basis of doing business.

Life cycle. The life of an asset from planning through acquisition, maintenance, operation, and disposition.

Life-cycle cost. The total price of a system, building, or other product, computed over its useful life, including all direct, indirect, recurring, nonrecurring, and other costs involved in acquiring, owning, operating, maintaining, and disposing of the system or product over a specified period of time, including environmental and energy costs; the net life-cycle costs savings is determined by subtracting the cost of performing the value function over the life of the activity or product from the value of total savings generated by the value function.

Line-item project. Separately identified project activities submitted for funding, reviewed, and approved or disapproved by Congress.

Management and operating contractor. A contractor conducting work pursuant to a management and operating contract.

Performance criteria. A condition or set of conditions that, when satisfied, indicate successful completion of the performance objective.

Performance measures. Any evaluation, comparison, or judgment toward meeting the performance objective.

Performance objective. A statement of wants, needs, and expectations of customers that sets the direction for the contract effort.

Preliminary design. A continuation of the conceptual design and the project design criteria as a basis for project development; preliminary design develops fiscal, engineering, and other information to determine the requirements and criteria that govern the definitive design; tasks include preparation of preliminary planning and engineering studies, preliminary drawings and outline specifications, life-cycle cost analysis, preliminary cost estimates, and scheduling for project completion; preliminary design identifies long lead procurement items and analyzes risks associated with continued project development.

Program office. A DOE headquarters organization responsible for program management and for assisting and supporting field elements in safety and health, administrative, management, and technical areas.

Project. A unique effort that supports a program mission with defined start-up and completion end points, undertaken to create a product, facility, or system with interdependent activities planned to meet a common objective/mission; projects include planning and execution of construction, renovation, modification, environmental restoration, or decontamination and decommissioning, and large capital equipment or technology development activities; tasks that do not include these elements, such as basic research, grants, and operations and maintenance of facilities, are not considered projects.

Project design criteria. Technical data and other project information developed during the project identification, conceptual design, and/or preliminary design phases, that define the project scope, construction features and requirements, and design parameters; applicable design codes, standards, and regulations; applicable health, safety, fire protection, safeguards, security, energy conservation, and quality assurance requirements, and other requirements.

Project manager. An official who has been assigned responsibility for closely related efforts to achieve stated or designated objectives, defined tasks, or other related activities on a schedule for performing the work funded as part of the project; the person responsible for planning, controlling, and reporting on a project.

Project risk. A factor, element, constraint, or course of action that introduces an uncertainty of outcome and the possibility of technical deficiencies, inadequate performance, schedule delays, or cost overruns that could impact a DOE mission; evaluation of project risk must include its potential impact and probability of occurrence.

Stovepipe. A system procured and developed to solve a specific problem characterized by a limited focus and functionality; a system that contains data that cannot be easily shared with other systems.

Strategic system. A special type of line-item project(s), a stand-alone system within a program mission area that is a primary means of advancing DOE's strategic goals; designation of a strategic system is determined by the secretary of energy based on cost, risk factors, international implications, stakeholder interest, and/or national security.

Total estimated cost. An estimate of the total cost of a task, demonstration, or program; unlike a planning estimate, total estimated cost is based on definitive information regarding technical scope, contracting methods, schedule, and resource requirements; once a task is approved, total estimated cost becomes a baseline figure and is subject to change control procedures.

Total project cost. All costs specific to a project incurred through the start-up of a facility but prior to the operation of a facility; total project cost includes, but is not limited to, design and construction activities, contingency, economic escalation, pre-engineering activities, feasibility and maintenance studies, one-time start-up costs, initial operator training, and commissioning costs.

Training. The process of providing for and making available to an employee(s) and placing or enrolling an employee(s) in a planned, prepared, and coordinated program, course, curriculum, system, or routine of instruction or education in fiscal, administrative, management, individual development, or other fields to improve individual and organizational performance and further the agency's mission and performance goals.

Value engineering. An organized effort directed by a person trained in techniques to analyze the functions of systems, equipment, facilities, services, and supplies to determine the essential functions at the lowest life-cycle cost consistent with performance, reliability, availability, quality, and safety requirements.

Waste management. The planning, coordination, and direction of functions related to the generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance.

Work breakdown structure. The result of project/program planning establishing the physical work packages or elements that completely define a project; the work breakdown structure organizes the physical work packages into levels that can be developed into a summary.

Acronyms

AEC	Atomic Energy Commission
AL	Albuquerque Operations Office
ANL	Argonne National Laboratory
BNFL	British Nuclear Fuels Ltd.
CD	Critical Decision
CDR	Critical Decision Review
CII	Construction Industry Institute
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DP	Office of Defense Programs
EE	Office of Energy Efficiency and Renewable Energy
EM	Office of Environmental Management
ER	Office of Energy Research (now known as the Office of Science)
ERDA	Energy Research and Development Administration
ESAAB	Energy Systems Acquisition Advisory Board
FE	Office of Fossil Energy
FM	Office of Field Management

GAO	General Accounting Office
GOCO	government-owned contractor-operated
ID	Idaho Operations Office
INEEL	Idaho National Engineering and Environmental Laboratory
IPA	Independent Project Analysis, Inc.
ISO	International Organization for Standardization
JPODPM	Joint Project Office Direction on Project Management
LANL	Los Alamos National Laboratory
LCAM	life-cycle asset management
LMER	Lockheed Martin Energy Research Corporation
LMES	Lockheed Martin Energy Systems Corporation
MAP	management access process
MD	Office of Fissile Material Disposition
M&I	management and integration contractor
M&O	management and operating contractor
NAE	National Academy of Engineering
NE	Office of Nuclear Energy Science and Technology
NN	Office of Nonproliferation and National Security
NRC	National Research Council
OIG	Office of Inspector General
OMB	Office of Management and Budget
OR	Oak Ridge Operations Office
ORNL	Oak Ridge National Laboratory
PEP	project execution plan
PMA	Power Marketing Administration
PMP	project management plan
PNNL	Pacific Northwest National Laboratory
RFFO	Rocky Flats Field Office
RFP	request for proposal
RIFS	remedial investigation/feasibility study
RL	Richland Operations Office
RW	Office of Civilian Radioactive Waste Management
SC	Office of Science (formerly Office of Energy Research)
SNL	Sandia National Laboratories

SNS	Spallation Neutron Source
SR	Savannah River Site
TEC	total estimated cost
TPC	total project cost
TWRS	Tank Waste Remediation System