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Report to the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives

May 2008

DEPARTMENT OF ENERGY

Office of Science Has Kept Majority of Projects within Budget and on Schedule, but Funding and Other Challenges May Grow

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GAO-08-641

Highlights of GAO-08-641, a report to the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives

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Why GAO Did This Study

The Department of Energy (DOE) has long suffered from contract and management oversight weaknesses. Since 1990 DOE contract management has been on GAO's list of programs at high risk for fraud, waste, abuse, and mismanagement. In 2003 DOE's Office of Science (Science) unveiled its 20-year plan to acquire and upgrade potentially costly research facilities. In light of DOE's history and the potential cost of this ambitious plan, GAO was asked to examine Science's project management performance. GAO determined (1) the extent to which Science has managed its projects within cost and schedule targets, (2) the factors affecting project management performance, and (3) challenges that may affect Science's future performance. GAO reviewed DOE and Science's project management guidance and 42 selected Science projects and also interviewed DOE and laboratory officials.

What GAO Recommends

GAO recommends that DOE (1) consider adopting, department-wide, selected practices from Science's independent project reviews and (2) review and strengthen, as appropriate, DOE's departmentwide project management guidance to ensure that each project's technical goals are clearly defined.

DOE generally agreed with these recommendations.

To view the full product, including the scope and methodology, click on GAO-08-641. For more information, contact Gene Aloise at (202) 512-3841 or aloisee@gao.gov.

What GAO Found

Of the 42 projects GAO reviewed that were completed by Science or under way from fiscal years 2003 through 2007, more than two-thirds were completed or being carried out according to original cost and schedule targets. Of the 27 projects that were completed during this period, 24 were completed within the original committed cost. Science also largely succeeded in achieving its original committed schedules, with 21 of the 27 projects completed on or ahead of time. Two of Science's completed projects were both over cost and late. Fifteen of the 42 projects reviewed were still under way in February 2008. Nine of these 15 projects appeared to be on track to meet their cost and schedule targets; the rest were likely to be completed over cost, late, or both.

Science's ability to generally achieve projects' original cost and schedule targets is due in part to factors often considered fundamental to effective project management: leadership commitment to meeting cost and schedule targets; appropriate management and technical expertise; and disciplined, rigorous implementation of project management policies. Science's frequent independent reviews, in particular, were cited by DOE officials as a key reason for Science's project management performance. To achieve cost or schedule targets, Science also trimmed selected components from some projects, a practice that has sometimes raised concerns. Specifically, DOE's Office of Engineering and Construction Management, which develops DOE's project management policy, and DOE's Inspector General have expressed the concern that changes in scope may not always preserve a project's technical goals. Construction Management officials told GAO that if a project's technical goals are not detailed enough, it can be difficult to determine the effects of changes in scope. They are therefore considering clarifying project management guidance regarding this issue, perhaps by 2009.

Given forecasts of increasingly constrained discretionary spending, plus a workforce fast approaching retirement, Science is likely to face two primary challenges to maintaining future performance: budgetary and market uncertainties, and a shrinking pool of qualified project management and technical expertise. First, achieving targets could become more difficult for Science as future federal budget constraints interrupt anticipated flows of funding to projects already under way or labor and commodity prices rise unexpectedly. Several projects GAO reviewed exceeded or will exceed their cost targets because expected funding did not materialize or prices increased after cost and schedule targets had been established. Second, finding knowledgeable staff to lead and carry out projects may become harder, since an estimated 21 percent to 43 percent of Science's engineers, scientists, and contract specialists will become eligible for retirement within the next 5 years. Similar large-scale retirements are expected at Science's contractor laboratories. Science will need to remain diligent to ensure future success in the face of these potentially intensifying challenges.

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Abbreviations

CERN	European Organization for Nuclear Research
DOE	Department of Energy
GLAST	Gamma-Ray Large Area Space Telescope

United States Government Accountability Office
Washington, DC 20548

May 30, 2008

The Honorable Brad Miller
Chairman
The Honorable F. James Sensenbrenner, Jr.
Ranking Member
Subcommittee on Investigations and Oversight
Committee on Science and Technology
House of Representatives

The Department of Energy's (DOE) Office of Science (Science) and its predecessor agency[1] have long served the nation in the quest for scientific knowledge and innovation. From the construction of long tunnels where subatomic particles collide with targets at nearly the speed of light to the design and launch of a satellite telescope that reveals stellar explosions in the deepest parts of space, projects overseen by the Office of Science have broadened our understanding of the cosmos and of the fundamental components of life on Earth. With a $4 billion annual budget, Science has historically been the nation's single largest funding source for basic research in the physical sciences, energy sciences, advanced scientific computing, and other fields, most of which is carried out at 10 national laboratories and 42 research and development facilities nationwide. Contractors to DOE—primarily research consortia or nonprofit institutions—perform the day-to-day operations at each of these laboratories and facilities. DOE site offices, located at or near the laboratories and facilities, are responsible for overseeing the laboratory and facility contractors, including monitoring the progress of scientific projects and the maintenance and upgrade of buildings.

In 2003, Science unveiled an ambitious 20-year plan to upgrade its existing portfolio of research facilities and to pioneer the design and construction of potentially costly new scientific instruments and facilities. These projects include the Linac Coherent Light Source, an advanced, laser-based X-ray light source that will illuminate the structure of molecules never previously visible, and the International Thermonuclear Experimental Reactor, a facility to test the feasibility of fusion, a process

[1]The predecessor agency to the Office of Science was the Office of Energy Research within DOE.

in which nuclei are combined to generate energy like that produced naturally by the sun. Science's contractor laboratories and facilities will ultimately be charged with executing Science's 20-year plan, which, if carried out in its entirety, could cost many billions of dollars.

Since 1990, we have reported that the Department of Energy as a whole has suffered from substantial and continual weaknesses in overseeing contractors and managing large, expensive, and technically complex projects effectively. Some projects, such as DOE's planned waste treatment and immobilization plant at its Hanford site in Washington State, have been fraught with problems that caused project expenses to soar beyond estimated costs and project schedules to exceed completion dates, sometimes by many years. DOE's environmental cleanup and construction projects, in particular, have significantly and consistently overrun both cost and schedule targets, occasionally requiring cutbacks so severe that facilities do not function as intended or, worse, delaying projects so long that, upon completion, they no longer serve the intended purpose. Because of problems like these, GAO in 1990 included DOE's contracting and project management on the list of federal programs and functions at high risk of fraud, waste, abuse, and mismanagement. While DOE has since implemented various management improvements, including a 2000 policy directive outlining the steps required for project planning and execution, some of the department's projects continue to experience major cost overruns and delays. As of May 30, 2008, DOE contracting and project management remain on GAO's high-risk list.

Although our recent work has focused on DOE projects experiencing cost and schedule difficulties at program offices other than the Office of Science—particularly the Office of Environmental Management and the National Nuclear Security Administration—in light of Science's plan to invest billions of dollars in the coming years to acquire or upgrade facilities and equipment at its sites, we are reporting on (1) the extent to which Science manages its projects within cost and schedule commitments, (2) the key factors affecting Science's project management performance, and (3) the main challenges that could affect Science's ability to maintain project management performance in the future.

In conducting our work, we reviewed DOE project management policies and guidance and interviewed headquarters officials at DOE's Office of Engineering and Construction Management, which provides project management policy and oversight departmentwide, and at Science's Office of Project Assessment, which provides guidance and oversight for Science's projects. We also obtained performance information on the 42

Science projects at 10 national laboratories that, from fiscal year 2003 through fiscal year 2007, were either completed (27 projects) or still under way at the time of our study and for which Science had committed to cost and schedule targets (15 projects). Because we did not consider as fully reliable DOE's Project Assessment Reporting System, the database DOE uses to track project performance, we obtained project cost and schedule data and other information directly from the laboratories responsible for the projects.[2] From these 42 Science projects, we selected for more detailed review a nongeneralizable sample of 12 projects overseen by four laboratories with diverse scientific missions: Argonne National Laboratory and Fermi National Accelerator Laboratory in Illinois, Oak Ridge National Laboratory in Tennessee, and the Stanford Linear Accelerator Center in California. We selected these 12 projects to ensure that our sample included completed and ongoing projects, scientific projects and infrastructure improvement projects, and a wide range of project costs. Together, the 12 projects represent about $2.9 billion, or 75 percent, of the total value of the 42 projects. To understand how these projects were managed and the reasons that projects did or did not meet their cost and schedule commitments, we visited the four laboratories, reviewed project data and documentation for the selected projects, and interviewed the contract laboratories' project managers and Science's on-site federal project directors.[3] For each of the 30 projects we did not review in depth, we obtained and analyzed project performance documentation from the responsible laboratories. In assessing whether projects had achieved their cost and schedule targets, we followed Office of Management and Budget guidance and DOE performance goals, which regard projects completed at less than 10 percent above their original cost targets as achieving satisfactory performance. Because Office of Management and Budget guidance includes performance standards for project schedule, we considered projects to be on time if they were or are expected to be completed at less than 10 percent past their original target completion date. DOE's performance goals, developed in coordination with the Office of Management and Budget, do not address project schedule. To

[2]GAO, *Department of Energy: Further Actions Are Needed to Strengthen Project Management for Major Projects*, GAO-05-123 (Washington, D.C.: Mar. 18, 2005).

[3]Results from nongeneralizable samples, including the sample of 12 projects we selected for in-depth review, cannot be used to make inferences about Science's project performance overall. Our interest was in gathering information on the selected Science projects to identify material factors that may not exist across all projects but can help expand our understanding of Science's organizational strengths and potential future challenges.

determine Science's main future challenges, we interviewed officials at the four laboratories, DOE regional site offices, and DOE headquarters. We reviewed relevant studies on human capital planning by GAO, DOE's Inspector General, and the National Science Foundation. We also reviewed recent GAO studies on federal budgetary constraints. Appendix I describes our scope and methodology in more detail, and appendix II summarizes the 42 projects we reviewed. We conducted this performance audit from June 2007 through May 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Results in Brief

Of the 42 projects we reviewed that were completed by Science or under way from fiscal year 2003 through fiscal year 2007, more than two-thirds were completed or being carried out in accordance with original cost and schedule targets. Of the 27 projects that were completed during this period, 24 (89 percent) were completed within the original committed cost. For purposes of this analysis, given DOE's performance goals and Office of Management and Budget guidance, we considered any Science project completed at less than 10 percent beyond its original cost or schedule baseline as completed within the committed cost and schedule targets. These completed projects represented a wide range of efforts—from conventional construction projects costing a few million dollars, such as improvements to heating and air-conditioning systems, to the design and construction of sophisticated scientific equipment costing more than a billion dollars. Science also largely succeeded in achieving its original committed schedules, with 21 (78 percent) of the 27 projects completed on or ahead of time. Two (7 percent) of Science's completed projects, however, were both over budget and late. These projects included one to construct a device to measure the activity of subatomic particles called neutrinos and another to upgrade the performance of an existing particle accelerator. Fifteen of the 42 projects we reviewed were still under way as of the end of February 2008. Nine of these 15 projects appear to be on track to meet both their cost and schedule commitments, whereas 4 of them are expected to finish late, and 2 are expected to miss both their cost and schedule commitments.

Science's ability to manage a majority of projects within original cost and schedule commitments is due in part to factors generally considered fundamental to effective project management: leadership commitment to meeting cost and schedule targets; appropriate management and technical expertise; and disciplined, rigorous implementation of project management policies through processes that focus on results. Science's practice of trimming selected technical or other components from projects also sometimes played a role in achieving cost and schedule commitments, although this practice has raised some concerns.

- *Strong leadership commitment to meeting cost and schedule targets:* Science's leadership is strongly committed to holding projects to their original cost and schedule baselines and has made it clear to the rank and file at its laboratories that they are accountable for staying within these limits. Officials we spoke with said that requesting additional funding was normally not an option if problems arose.

- *Appropriate project management and technical expertise:* Science and laboratory officials said that finding experienced staff to manage and carry out projects can be challenging, but they have generally succeeded by implementing recruitment and retention incentives, collaborating with other Science laboratories to secure the expertise and management skills lacking on the project team, and training skilled scientists in effective project management techniques. For example, Oak Ridge Laboratory officials said they initially had problems attracting people with the right skill mix to work on the Spallation Neutron Source, including finding a capable management team. As a result, the laboratory developed a "human resources tool kit," which provided recruiting and retention incentives that allowed the lab to efficiently hire needed personnel. Furthermore, both the Oak Ridge and Fermi laboratories have obtained additional scientific expertise by partnering with other Science laboratories and arranging for knowledgeable staff to work from their home laboratories rather than relocate.

- *Disciplined, more-rigorous application of DOE policies:* Science has developed more-rigorous project oversight policies and processes than required under a DOE project management directive issued in 2000.[4] This rigor enhanced Science's ability to identify potential problems and to take timely corrective actions to help keep projects on track. DOE's directive requires independent internal reviews at key decision points—all told, one or two reviews during a project's life span. Science, however, conducts

[4]DOE Order 413.3, *Program and Project Management for the Acquisition of Capital Assets* (Oct. 13, 2000), and the update, Order 413.3A (July 28, 2006), establish a framework for managing projects costing over $5 million.

reviews much more often, with some projects receiving as many as 17 reviews each, depending on the project's nature and complexity. Science's independent review panels consist of as many as 30 technical and management experts from other Science field sites, including contractor laboratories external to the project. The review panels rigorously assess management, cost, schedule, technical, and safety issues. Lessons that panel members have learned from experience on prior projects often lead to specific actions to address emerging problems, such as potentially difficult procurements and technical design issues or overly optimistic initial cost estimates.

In addition, Science's practice of occasionally trimming away selected components from a project's scope (the sum total of a project's requirements and features) when facing budgetary constraints also helped to achieve cost or schedule targets. Such reductions to scope are permitted, with the proper DOE or laboratory approval, as long as the changes do not adversely affect Science's key technical goals for a project. But concerns have been raised by DOE's Office of Engineering and Construction Management and its Inspector General that changes in scope may not always preserve a project's technical goals. For example, the Spallation Neutron Source project team cut a number of items from the project's scope—including 5 scientific instruments—to achieve its cost baseline. The Inspector General and the Office of Science disagreed over the effect these changes had on the project's technical goals, in part because those technical goals were so broadly defined that it was unclear how acquiring the 5 instruments, rather than the 10 described in the project baseline, may have affected the facility's performance, if at all. Although we did not find other projects where concerns about scope reductions appeared, we did find differences in the level of detail spelled out in projects' technical goals, even among similar projects. Office of Engineering and Construction Management officials we spoke with are concerned enough about this vulnerability departmentwide that they are considering clarifying project management guidance on defining projects' technical goals, perhaps by 2009.

Given continued budgetary pressures, which have been forecast to increasingly constrain the nation's discretionary spending, plus an aging workforce nearing retirement, Science is likely to face two primary challenges to its project performance in the future: heightened funding and market uncertainties and a shrinking pool of qualified people to manage projects.

- *Uncertainties in funding and market forces:* Achieving cost and schedule targets could become more difficult for Science in the future if growing federal budgetary constraints further interrupt anticipated flows of funding to projects already under way. Some projects we reviewed experienced interruptions in funding for two primary reasons: tightened federal budgets reduced discretionary funding available to support the projects, or an international partner failed to provide support as planned. Given that federal budgets are likely to remain tight, Science can expect to face continued funding difficulties. Science's fiscal year 2008 appropriations, for example, totaled less than the amount required to support the year's anticipated expenditures for ongoing projects. A number of Science's projects already under way could be delayed as a result, possibly raising total costs. Since a sudden increase in prices can render well-considered cost estimates obsolete, uncertainties in prices for labor and manufactured goods, which have sometimes fluctuated widely, may make it still more difficult to achieve cost and schedule targets. A project to implement seismic and utility upgrades at the Stanford Linear Accelerator, for example, has faced unanticipated labor price increases in the San Francisco Bay Area, which, according to federal officials, has threatened the project's ability to achieve its original cost and schedule targets.

- *Shrinking pool of experienced and knowledgeable staff:* Although Science and laboratory officials said that to date they have generally been able to find experienced and knowledgeable staff to lead and carry out projects, doing so may become increasingly difficult in the future, as an estimated 21 percent to 43 percent of Science's workforce becomes eligible for retirement by 2011. Similar large-scale retirements are expected at Science's contractor laboratories. Of the 12 projects we reviewed in depth, Science officials reported that for 2 of them, contractors initially had trouble securing adequately experienced project managers, although only 1 breached its cost and schedule baseline as a result. Experienced management personnel were unavailable for this project—to create and study the behavior of subatomic particles called neutrinos—because they had been assigned to other, higher-priority projects. This issue is of substantial concern to DOE's Inspector General, who in 2007 identified human capital as a "significant management challenge" requiring priority long-term attention.

We are recommending that the Secretary of Energy consider whether other program offices would benefit from adopting selected practices from Science's independent project reviews, such as the frequency and focus of reviews for technically complex projects. We are also recommending that DOE review and strengthen, as appropriate, its project management guidance to help better ensure each project's technical goals, including the project's expected scientific performance and functionality of its facilities and infrastructure.

We provided a draft of this report to DOE for its review and comment. DOE generally agreed with our findings and stated that it would consider incorporating recommendations as part of its *Root Cause Analysis: Corrective Action Plan* to improve contract and project management. DOE also provided a number of general and project-specific comments that we incorporated throughout this report as appropriate.

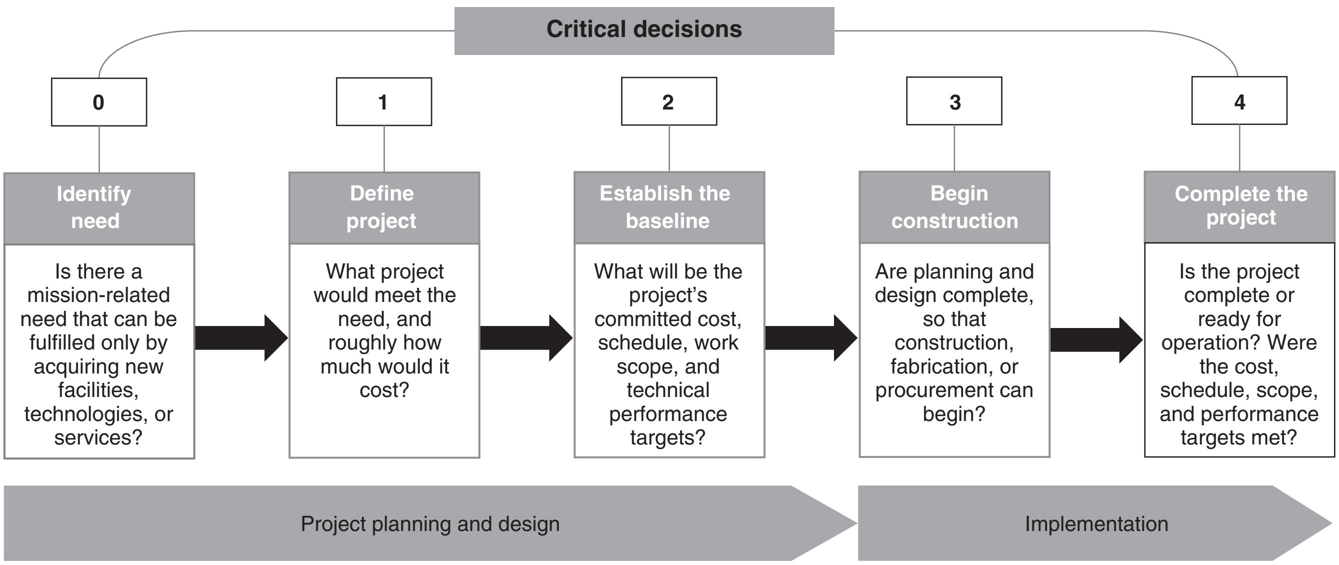
Background

Created in 1977 from diverse agencies, DOE manages the nation's nuclear weapons production complex, cleans up the environmental legacy of nuclear weapons development, and conducts research in both energy and basic sciences. DOE carries out its work at numerous sites and facilities around the country, primarily through private entities that manage the facilities and implement program and project activities under contract to DOE. About 90 percent of DOE's annual budget of $24 billion goes into contracts. The department has established an extensive network of site offices to directly oversee the work of these contractors.

DOE's Office of Science is one of several program offices within the department. It is the third largest in annual funding, after the Office of Environmental Management, which leads the national effort to clean up toxic and nuclear waste sites left by nuclear weapons manufacture, and the National Nuclear Security Administration, which conducts nuclear weapons research and manages the nation's nuclear weapons stockpile. Science's $4 billion in annual funding is used primarily to support scientific research conducted under contract with private entities, many of which are educational or other nonprofit institutions. For example, UT-Battelle—a limited-liability partnership formed by the University of Tennessee and Battelle Memorial Institute—manages and operates the Oak Ridge National Laboratory in Tennessee. In addition to managing research, contractors are responsible for carrying out major repairs or upgrades to existing facilities, equipment, and site infrastructure; fabricating or procuring needed technological components; and designing and constructing additions to the facilities. The vast majority of the scientists, engineers, and others who manage research funded by the Office of Science work directly for the facility contractors.

DOE has a consistent record of poorly estimating costs and managing projects. We reported in 1997 that over a 16-year period, 80 DOE projects costing over $100 million were started, but only 15 were completed, with most of these experiencing cost overruns and delays. Thirty-one of the 80 projects were terminated before completion. For example, we reported that the Office of Environmental Management's efforts to clean up a disposal area for hazardous waste at the Idaho National Laboratory were running 2 years behind schedule and that estimated costs had nearly doubled to $400 million. Problems were so severe that DOE eventually terminated all work on this project. The cleanup effort has recently been renewed—more than 10 years after we first reported problems—as the state of Idaho enforces DOE agreements to mitigate hazardous wastes buried at the site. DOE's Office of Engineering and Construction Management was established in 1999 mainly to implement project management reforms that would address such problems. The Construction Management office is responsible for providing consistent guidance on project management policy and processes and for facilitating oversight of the department's project management efforts. As part of these responsibilities, the office in 2000 issued DOE Order 413.3, *Program and Project Management for the Acquisition of Capital Assets*, which was updated in 2006. All DOE program offices must comply with the updated order if their projects involve acquisitions totaling $20 million or more, although the principles set forth in the order apply to projects costing $5 million or more. This directive defines DOE's project management and oversight principles, including requirements for both external project reviews led by the Construction Management office and internal project reviews led by DOE program offices; these internal and external reviews assess each project's costs, schedule, and technical issues. The order also prescribes a series of DOE management reviews and approvals, called critical decision points, required to move a project forward (see fig. 1). In general, DOE management reviews and approvals at these decision points are to ensure that the project requirements are met.

Figure 1: The Five Critical Decision Points in DOE's Project Management Process



Sources: GAO and DOE.

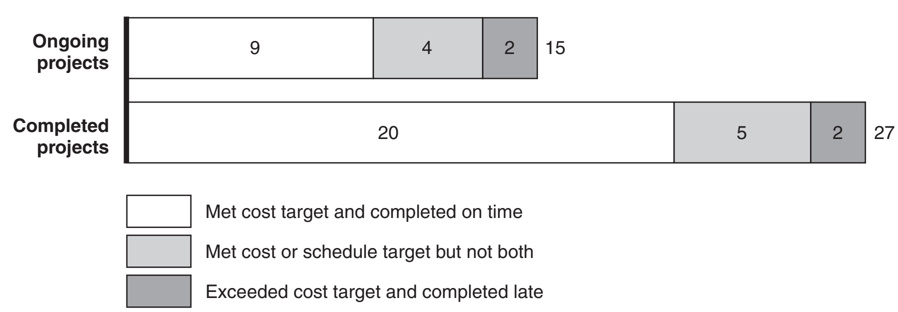
Before a project may begin construction, the sponsoring DOE program office must develop and obtain departmental approval for the project's "performance baseline." This baseline represents the organization's commitment to completing a project at a certain cost and by a specific date. Also included as part of the performance baseline are the project's technical goals, which define the scope of work and the project's expected performance at completion. The scope and performance standards define in general terms what facilities and equipment will be purchased or upgraded within the agreed cost and schedule targets, as well as the project's minimum capability to perform the desired function at completion, such as a research facility's ability to accommodate people and equipment or a particle accelerator's minimum energy level.

Sometimes problems arise during a project's implementation that prevent the project from achieving its original cost, schedule, or technical baselines. If so, the project generally must be "rebaselined" to reflect needed changes. In essence, a revised baseline allows a project that is running over budget or late, or requires a change in scope, to establish new performance targets. The performance baseline may be changed only with Science or DOE management review and approval. In rare instances, DOE may decide to terminate the project rather than approve a change, particularly if the project's technical goals cannot be achieved without spending substantially more money.

Office of Science Managed Majority of Projects within Committed Cost and Schedule Targets

Of the 42 projects we reviewed that were completed by Science or under way from fiscal year 2003 through fiscal year 2007, around 70 percent adhered to their original cost and schedule targets (see fig. 2). Twenty-seven of the projects we reviewed were completed during this period, and 15 were still under way. Our analysis found that 24 (89 percent) of these 27 projects met their original cost targets and 21 (78 percent) were completed on or ahead of schedule. Similarly, as of the end of February 2008, 9 (60 percent) of the 15 projects that were still under way were on track to meet their original cost and schedule targets. For purposes of this analysis, in accordance with Office of Management and Budget guidance and DOE performance goals, we considered as within budget any Science project that exceeded or will exceed its original cost baseline by less than 10 percent. Although DOE performance goals do not address project schedule, the Office of Management and Budget's guidance addresses both cost and schedule; we therefore also evaluated Science's performance in meeting its schedule baseline, considering as on time the projects that exceeded or will exceed the original completion date by less than 10 percent.

Figure 2: Expected or Actual Performance of 42 Reviewed Office of Science Projects, Fiscal Year 2003 through Fiscal Year 2007



Source: GAO analysis of Office of Science data.

Among the completed projects, the 20 that successfully met their original cost targets and were on time ranged in nature from construction jobs costing a few million dollars to cutting-edge scientific facilities and equipment costing more than a billion dollars. While a few of these projects finished well below their original cost and schedule targets, most were at or near the targets, including the following:

- *Run IIb CDF Detector, Fermi National Accelerator Laboratory, Illinois:* In July 2006, scientists and engineers successfully completed a 3.5-year effort[5] to upgrade a highly complex device used for detecting the presence of subatomic particles at the laboratory's main particle accelerator. The project was completed for around $10.9 million—64 percent less than the $30.4 million cost target—and 4 months ahead of schedule. The upgraded device was capable of supplying critical evidence of certain particles thought to exist but undetectable by current particle detectors; confirmation of these particles could help resolve fundamental questions about the nature of energy and matter. A concurrent project to upgrade a similar detector at the Fermi Laboratory's main accelerator, the Run IIb D-Zero Detector, was also completed well below (39 percent) its original $29 million target; it was also completed on schedule.

- *Nanoscale Science Research Centers at Argonne National Laboratory, Illinois; Brookhaven National Laboratory, New York; Lawrence Berkeley National Laboratory, California; Oak Ridge National Laboratory, Tennessee; and Sandia and Los Alamos national laboratories, New Mexico:* All five of the nanoscale science research center construction projects included in our review came in at or below their original cost and schedule targets or are on track to do so.[6] The Center for Nanoscale Materials at the Argonne National Laboratory, finished in September 2007, for example, took 47 months to complete. The project was completed on schedule and within its original committed cost target of $72 million.[7] The 88,000-square-foot facility, used for researching and developing materials at the molecular or atomic level (such as those found within computer microchips), houses wet and dry laboratories and sterile "clean rooms" outfitted with $36 million of specialized research instruments and equipment, as well as a computing center, offices, meeting rooms, and other supporting infrastructure.

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[5]Unless otherwise noted, for ease of discussion in this report, project length has been measured from DOE's critical decision point 2, when the cost and schedule baselines are established for a project, to critical decision point 4, when DOE certifies that the project is complete.

[6]Construction of the nanoscience research facility with components at the Sandia and Los Alamos national laboratories, New Mexico, was carried out as a single project. Additionally, the project to construct the facility at the Brookhaven National Laboratory, New York, was the only project of the five that was still under way as of the end of February 2008.

[7]The state of Illinois provided half of this project's funding.

- *Laboratory facilities HVAC upgrades, Oak Ridge National Laboratory, Tennessee:* A project to upgrade heating, ventilation, and air-conditioning systems was finished in November 2003 (4 months ahead of schedule) for about $150,000 less than the project's original target cost of $7.2 million. The project, which took 23 months to complete, involved upgrading and replacing deteriorated equipment and piping serving 13 buildings in the central research complex.

In addition, 5 of the 27 completed projects (19 percent) met either their cost or schedule target but not both. Those that missed their schedule targets finished 3 to 15 months late. The projects in this group included lower-cost infrastructure improvement projects and higher-cost projects to acquire advanced research equipment. The following projects met their cost targets but missed their schedule targets:

- *Electrical systems upgrade, Oak Ridge National Laboratory, Tennessee:* This $5.9 million project was completed in April 2003 slightly under budget but took about 26 months to complete, 3 months longer than scheduled. The project included replacing damaged electrical poles and about 3 miles of feeder lines around the laboratory complex, installing a computer-based electrical metering system, and replacing or installing additional breakers and substations throughout the laboratory complex.

- *Central supply facility, Argonne National Laboratory, Illinois:* This $5.9 million project met its original cost target when it was completed in October 2002. Design began around June 1999,[8] and construction was completed in 40 months, about 15 months later than originally scheduled. The focus of this project was to expand a storage facility and make other improvements to site infrastructure.

Finally, only 2 of the 27 completed projects (7 percent) were both over cost and late. These 2 projects finished 18 percent and 23 percent over cost and over 1 year late. With costs ranging from $58 million to $168 million, they were among the more costly of the projects we reviewed and generally had longer lead times, taking up to 6 years to complete after their original cost and schedule estimates were established. Both projects aimed to expand Science's research capabilities, rather than to improve site infrastructure. The projects that were both over cost and late follow:

[8]Argonne National Laboratory could not document the date of critical decision point 2 because this project's cost and schedule targets were set before DOE's project management order 413.3 was issued.

- *Neutrinos at the Main Injector, Fermi National Accelerator Laboratory, Illinois:* The neutrinos project included designing and constructing two particle detectors—one sited at Fermi Laboratory in Batavia, Illinois, and the other in Soudan, Minnesota—and a tunnel in which a proton beam instrument could be aimed through solid earth at the Soudan detector, more than 450 miles away. This $168 million project took 72 months and was completed 17 months late at more than 23 percent over its committed cost.

- *Stanford Positron-Electron Asymmetric Ring (SPEAR 3 Upgrade), Stanford Linear Accelerator Center, California:* This project, to upgrade the scientific capability of the SPEAR 3 device, was completed in 2003 for $58 million—14 months late and nearly 18 percent over its original cost target of $49 million. The upgrade project, which lasted over 5 years, increased the device's ability to produce x-rays useful for research in a variety of disciplines, including biology and medicine. Science partnered with the National Institutes of Health, which provided half of the project's funding.

For Science's 15 projects still under way as of the end of February 2008, Science or laboratory officials reported that they expected to complete 9 (60 percent) within their cost and schedule targets. In contrast, managers of 4 of the 15 projects (27 percent) told us that as of the end of February 2008, they expected to meet their cost targets but not their target completion dates. And 2 (13 percent) of these projects—specifically, the National Compact Stellarator Experiment at the Princeton Plasma Physics Laboratory, New Jersey, and the Linac Coherent Light Source project at the Stanford Linear Accelerator Center—are expected to miss both their cost and schedule targets.

Several Factors Contributed to Science's Cost and Schedule Performance

That Science has been able to deliver most projects within their committed cost and scheduled targets is due in part to practicing sound management principles: leadership commitment to achieving these targets, ensuring that each project has the necessary management and technical expertise, and approaching project management with discipline and rigor so that processes focus on results. Science's practice of trimming selected technical or other components from some projects helped in achieving cost and schedule commitments, although this practice has sometimes raised concerns.

Leadership Commitment to Achieving Cost and Schedule Targets Played a Key Role

In our prior work reviewing practices that promote effective project management, we identified committed leadership as an important contributing factor.[9] An organization's leaders play a pivotal role because they serve as the primary proponents of the organization's values and culture, including commitment to consistently achieving project cost and schedule targets. When the top tier of an organization embraces a particular performance goal, the rest of the organization is more likely to follow suit. Shortly after assuming office in 2002, the Under Secretary of Science issued a memorandum to Science staff articulating his commitment to achieving project cost and schedule targets, stating that "the Office of Science expectation is that all projects be completed on schedule and within budget" and that senior-level managers and project staff would be held accountable for doing so. Most recently, in a March 2007 testimony before Congress, the Under Secretary emphasized Science's continued commitment to "a careful process" of preparing project cost and schedule targets to ensure that they are realistic.[10] Science leadership's consistent emphasis on achieving cost and schedule goals appears to have been adopted by Science and contractor laboratory management and staff, many of whom told us they believed that requesting more money or more time to complete a project was typically not an option, as the following examples illustrate:

- *National Compact Stellarator Experiment, Princeton Plasma Physics Laboratory, New Jersey:* This experiment to develop an alternative method for harnessing fusion energy is facing design problems that are likely to increase the cost by 91 percent and delay completion by 4.5 years. In an August 2007 letter to the Fusion Energy Sciences Advisory Committee, which advises the Office of Science on fusion energy research, the Under Secretary requested that the committee evaluate the feasibility of continuing the project. "These overruns are large enough to add new burdens on the limited resources of the U.S. fusion energy sciences program, as well as undermine confidence of the Administration and Congress in the ability of the Office of Fusion Energy Sciences and the Office of Science to manage large and technically challenging construction

[9] GAO, *Department of Energy: Consistent Application of Requirements Needed to Improve Project Management*, GAO-07-518 (Washington, D.C.: May 11, 2007), and GAO, *Framework for Assessing the Acquisition Function at Federal Agencies*, GAO-05-218G (Washington, D.C.: Sept. 1, 2005).

[10] House Committee on Appropriations, Subcommittee on Energy and Water Development, *Hearing on the Fiscal Year 2008 Budget for the Department of Energy's Office of Science*, March 14, 2007.

projects. Given the magnitude of the increases projected for the NCSX (National Compact Stellarator Experiment), all options, including termination of the project, must be considered," the Under Secretary wrote. As of November 2007, the project team had requested to increase the cost target and extend the completion schedule, but the Under Secretary had not approved the request.

- *Center for Nanoscale Materials, Argonne National Laboratory, Illinois:* The Argonne National Laboratory project staff managing the construction of this $72 million office and laboratory facility said that the Director of Basic Energy Sciences, who was responsible for project oversight, repeatedly made it clear that the team could not exceed its cost target. According to the laboratory project manager for construction, basic energy sciences officials were "breathing down our necks" to ensure that the project would be completed on time and within cost; it was.

- *Neutrinos at the Main Injector, Fermi National Accelerator Laboratory, Illinois:* The federal project director said that the project team felt pressured to maintain a fixed budget target even before a firm baseline was established. The project included designing and constructing two particle detectors and a tunnel. He pointed out that an early Fermi Laboratory plan to construct three modules for the Neutrinos at the Main Injector project was trimmed back to two modules to save on costs, even though the project had not yet committed to a cost target. According to the federal project director, suggesting that the project's budget expand for the modules was not an option.

Management and Technical Expertise Was Generally Available to Lead and Carry Out Projects

Another factor important to effective project management is having people in the right numbers with the right skills to accomplish an agency's goals. Science and laboratory officials said that finding experienced staff to manage and carry out projects can be challenging, but they have generally succeeded by supporting and implementing recruitment and retention incentives, collaborating with other Science laboratories to secure expertise and management skills lacking on the project team, and training skilled scientists in effective project management techniques. For example:

- *Spallation Neutron Source, Oak Ridge National Laboratory, Tennessee:* Oak Ridge Laboratory officials said problems assigning people with the right skills to support construction of the Spallation Neutron Source, the world's most powerful neutron-scattering device, were significant. Not only did the project face problems hiring a project manager, but it also faced problems securing other needed staff. When initial work on the spallation project did not progress adequately, threatening cost and schedule targets, the project manager was replaced. The laboratory, which had developed a "human resources tool kit" to assist in recruiting and retaining staff, was eventually able to secure needed personnel. According to officials, they offered key personnel pay incentives, including recruiting bonuses and employment service credit for employees transferring from other DOE laboratories.

- *U.S. components of the Large Hadron Collider, Fermi National Accelerator Laboratory, Illinois:* Science officials said that many laboratories have been able to secure scientific expertise they lacked by partnering with other Science laboratories, so that experienced staff could lend their knowledge and expertise to a project without having to relocate themselves and their families. The hadron collider project is a collaboration among the member states of the European Organization for Nuclear Research,[11] the United States, and others to construct a new high-energy physics facility outside Geneva, Switzerland. The United States is contributing components to an accelerator and two very large general-purpose detectors. Because the project's complexity and size required a wide range of technical expertise not readily available at the Fermi site alone, the laboratory collaborated with two additional laboratories, Lawrence Berkeley and Brookhaven national laboratories. Fermi Laboratory, with experience constructing and operating particle detectors, was given responsibility for overseeing U.S. contributions to one of the two detectors and the accelerator; Brookhaven took responsibility for the other detector.

- *Center for Nanoscale Materials, Argonne National Laboratory, Illinois:* Science officials said that laboratories generally assign a project leader with science background and a project manager with project management background to manage projects jointly. In one instance, they assigned a scientist as project manager. For the nanoscience research facility at Argonne Laboratory, the project manager was a trained physicist. He said that although his interest and expertise lay in scientific research, the laboratory assigned him to spearhead construction of the nanoscience facility. To successfully do so, he said, he received sufficient training in project management skills to be certified by the Project Management Institute, a national organization that sets professional project management standards. Similarly, according to Oak Ridge officials, 12 federal and laboratory staff completed project management training and

[11]The organization is known by its acronym, CERN.

were professionally certified by the Project Management Institute during construction of the Spallation Neutron Source.

Rigorous Project Oversight Policies and Processes Helped Identify Potential Problems

Another factor fundamental to effective project management is the quality of project monitoring and oversight. Office of Science project monitoring and oversight practices are more frequent, focused, and rigorous than those required under DOE project management guidance.[12]

DOE requires that, at selected stages, projects receive independent peer reviews, called independent project reviews, directed by each responsible program office.[13] Generally, DOE guidance states that independent peer reviews are to be done by individuals with no vested interest in a project's outcome. Depending on the total project scope, cost and schedule estimates, and other factors, such internal reviews may be required to validate the mission need for the project (at critical decision point 0), the project's costs and schedule estimates (at critical decision point 2), and the project's readiness to be executed or begin construction (at critical decision point 3). For projects involving high-risk or high-hazard nuclear facilities, a technical review at critical decision point 1 may also be required to validate the safety of the project's design. Guidance regarding independent peer review suggests only when and why reviews should occur; it does not provide specific requirements for how the reviews should be conducted or how each project should be evaluated.

Science not only follows this overall guidance but has developed more explicit guidelines, laid out in its *Independent Review Handbook*. For each Science project, a review panel is convened, consisting of up to 30 technical and management experts from Science field sites and contractor laboratories other than the project site; more-complex projects have larger review panels, and less-complex projects have smaller panels. The handbook lays out the documentation each project team should provide reviewers, expected areas of reviewer expertise and their respective responsibilities, and follow-up procedures for addressing any problems

[12] DOE Order 413.3 and Order 413.3A.

[13] Other reviews are also required, including those conducted by organizations within and outside of Science, such as external independent reviews by DOE's Office of Engineering and Construction Management, peer reviews of project designs, "earned-value management systems" reviews, and quarterly project reviews. These reviews were outside the scope of our report.

identified during review. For example, the handbook calls for assessing, among other things:

- how a project conforms to Science's mission needs;
- cost estimates, including the estimates' basis and level of detail, associated risks, and contingency planning in the event of unexpected events, such as changes to labor market rates;
- planned schedules and how schedules could affect cost estimates;
- the proposed strategy for procuring goods and services to support the project;
- the project's business management, including organization, project controls, staffing, risk mitigation, quality issues, and environmental and safety compliance issues; and
- how problems or recommendations identified in previous reviews were or are being addressed.

For most of the Science projects we reviewed, DOE guidance required only one or two independent peer reviews. Nevertheless, Science reviewed many of these projects more than the requisite once or twice and issued review reports that appeared to be comprehensive. Many officials we spoke with, including DOE Construction Management officials, federal project directors, and laboratory officials, said that Science's peer reviews are thorough; often improve cost and schedule estimates; and lead to corrective measures that address procurement, design, and other problems. In fact, a number of these officials pointed to these reviews as key to Science's strong performance relative to that of other DOE offices.

DOE and laboratory officials told us that the technical expertise provided by Science's internal review panels was key to providing effective review and oversight, particularly since the Office of Engineering and Construction Management, which develops guidance on project management policy and processes, depends on internal reviews to evaluate technical issues that lie beyond its own capabilities. DOE Construction Management and other officials explained that Science's internal reviews are valuable because the panel members' experience and expertise help to identify and resolve potential difficulties before they become problems affecting cost, schedule, or technical goals. The following examples illustrate the effectiveness of internal reviews:

- *The Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, Tennessee:* Under DOE guidance, this $65 million project to construct a four-story office and laboratory complex to study materials on the nanoscale should have received two independent internal reviews, one at the stage in which cost and schedule targets and work scope were validated and another when the project was nearly ready to begin construction. Science, however, conducted four reviews—on average, one each year. Among the concerns identified during these internal reviews were questions about whether a planned "clean room" would adequately limit the number and size of airborne environmental pollutants, such as dust, microbes, and vapors, and whether the costs of achieving industry standards for a sterile laboratory environment had been accurately projected. The review panel for this project suggested hiring a private consultant to evaluate the laboratory's construction plans, and numerous changes were ultimately implemented. In addition, the review panel validated cost estimates that had been revised on the basis of an earlier review. Ultimately, this project averted cost overruns and was completed 1 month early.

- *U.S. contributions to the Large Hadron Collider, Fermi National Accelerator Laboratory, Illinois:* Under DOE guidance, the three projects (components of two particle detectors and an accelerator)[14] comprising the $531 million U.S. contribution to the international Large Hadron Collider would have required only one internal review each to validate readiness for construction at critical decision point 3. Instead, Science conducted 17 reviews of each component. According to project managers for the detector components, the first internal independent review found that the estimated cost allowance to cover unexpected occurrences was deficient, given the project's complexity. The review panel directed the project teams to develop a higher cost estimate to better account for unexpected problems. Ultimately, each of these projects was or will be completed within 2 percent of its committed cost (the two detector projects are still under way), although our analysis suggests that all three were or will be completed late, in part because of installation delays resulting from problems with tunnel construction, which was a responsibility of the European consortium.

[14] U.S. funding for the Large Hadron Collider project was provided by both the National Science Foundation and DOE. U.S. funding supported three primary components: two particle detectors and an accelerator. Funding for the accelerator included $90 million paid to CERN to purchase U.S. manufactured parts for that instrument. The total combined DOE and National Science Foundation commitment to the project was $531 million. DOE regards the U.S. contributions to the collider as one project. For purposes of analysis, we have characterized these contributions in this report as three separate projects because they had separate budgets and schedules and were tracked separately under DOE's Project Assessment Reporting System.

Science Modified Project Scope to Meet Cost and Schedule Targets, but This Practice Sometimes Raised Concerns

Some of the projects we reviewed were able to achieve original cost or schedule targets, in part because they trimmed away selected components from the project's scope. DOE's project management order 413.3 and associated guidance allow revisions in project scope to control costs and stay on schedule, as long as the project will still meet its technical goals and the proper laboratory or DOE officials approve the changes. DOE guidance defines technical goals to include the minimum level of performance that a project must attain—the essential capabilities, design features, functions, and other characteristics present at the project's completion—to fulfill the mission need motivating DOE to pursue the project.[15]

The scope of several projects we reviewed was revised to help meet cost or schedule targets, without apparent adverse effect on technical goals, including:[16]

- Argonne National Laboratory trimmed scope from a project to expand its central supply facility when it decided not to remove aboveground pipes from the laboratory grounds. The funds saved by this decision offset the unexpected additional costs resulting from higher-than-expected construction bids. Removing the pipes was considered the project's lowest priority.
- Similarly, Oak Ridge National Laboratory eliminated a planned upgrade of the electrical connections between two laboratory buildings, in part because electricity use had declined and the upgrade was no longer essential. Eliminating this work helped offset increased costs associated with other components of the project.[17]
- At the Stanford Linear Accelerator Center, a plan to construct an administrative office building was deleted from the Linac Coherent Light Source project and replaced by a plan to renovate existing space to help offset costs associated with high construction bids resulting from labor market pressures in the San Francisco Bay Area.

[15]Although technical goals may exist for a project's various components and subcomponents, we are referring here to the technical goals of a project as a whole, as defined in the project baseline.

[16]Each of the changes in scope we report here was approved by the appropriate DOE or laboratory officials.

[17]Although this project met its original committed cost target, it was completed 3 months late for reasons unrelated to the described change in scope.

DOE policies and guidance, as well as other organizations' guidance related to effective project management, emphasize the importance of clearly defining a project's performance or technical goals. Specifically, DOE guidance requires that minimum performance goals clearly define what new facilities or functions a project will consist of. These goals are then used as a measure for evaluating project performance. Our own cost assessment guide and studies of DOE's project management by the National Research Council also discuss the importance of defining a project's technical goals appropriately to enable adequate oversight.[18] The underlying rationale is that if technical goals are too broad or vaguely stated, it can be difficult to assess whether or to what extent trimming certain aspects of project scope undermines the project's ability to accomplish its mission.

In fact, concerns have been raised within DOE that projects' goals may not always be adequately defined. An April 2008 DOE report—which cited the findings of a recent workshop to identify systemic challenges in planning and managing DOE projects—found that DOE often fails to plan thoroughly before committing to project costs, schedules, scope, and technical goals. This shortcoming was identified as the primary root cause for long-standing project management problems.[19] Project management oversight officials at DOE's Office of Engineering and Construction Management said that projects, including Science's, sometimes include overly broad technical goals, making it difficult to determine the effects of a change in project scope. According to DOE, descriptions of project scope do not always articulate technical goals in terms of required facilities, whose costs generally make up a significant share of overall expenditures. Facility requirements, as well as technical goals, must be well defined in project scope to establish reliable cost and schedule targets. Officials added that they believe that DOE guidance could be clarified to help ensure that project technical goals are sufficiently detailed to permit effective oversight.

[18]GAO, *Cost Assessment Guide: Best Practices for Estimating and Managing Program Costs*, GAO-07-1134SP (Washington, D.C.: July 2, 2007), and National Research Council, *Progress in Improving Project Management in the Department of Energy: 2003 Assessment* (Washington, D.C.: National Academies Press, 2004).

[19]Department of Energy, *Root-Cause Analysis: Contract and Project Management* (Washington, D.C., April 2008).

DOE's Inspector General has also raised concerns about project scope. Specifically, changes in the scope of the Spallation Neutron Source project led the Inspector General to conclude that Science had compromised the project's scientific mission and technical goals to achieve cost and schedule commitments and avoid requesting more funding from Congress. In its November 2001 report, the Inspector General found that, among other scope reductions, Science had trimmed both the range of capabilities and the number of planned scientific instruments it had committed to in the original baseline.[20] Science countered that it had never committed to procuring the 10 instruments described in the project's performance goals and was clear in its intention to delay selecting instruments until later in the project. Science officials explained that the 5 instruments ultimately selected were chosen on scientific, rather than budgetary, grounds and were technically superior to the 10 "proxy" instruments in the original performance goals. Science and the Inspector General disagreed over the effect these changes may have had on the project's technical goals, in part because those goals were so broadly defined that it was unclear how acquiring the 5 instruments, rather than the original 10, may have affected the facility's performance.

We did not find such concerns in the other projects we reviewed, although we did find differences in the level of detail spelled out in technical goals, such as the goals listed for five similar nanoscience research centers in five states. For example, the center in Illinois defined "completion" as a completed laboratory building approved for occupancy, with all scientific instruments delivered, installed, verified, and tested. The technical goals for the centers in California and New York went so far as to specify the number of users their facilities would accommodate. All of these facilities were or are on track to successful completion, but if any of them found it necessary to reduce scope to stay on track, it might be difficult to discern the effect of any reductions on the overarching technical goals unless those goals were explicitly detailed. The effect of a midproject reduction in how many researchers and staff a facility could accommodate, for example, might only be apparent for the centers whose technical goals spelled out how many users were originally envisioned for the facility. An Office of Engineering and Construction Management official explained that a scope description clearly laying out a building's expected functionality, not just its square footage, can make it easier for interested

[20]Department of Energy, Office of the Inspector General, *Progress of the Spallation Neutron Source Project*, DOE-IG/0532 (Washington, D.C., November 2001).

parties to understand key project goals and the effects of any modifications in scope. Engineering and Construction Management officials we spoke with are concerned enough about this vulnerability departmentwide that they are considering developing and issuing additional guidance on defining projects' technical goals, perhaps by 2009.

Maintaining Successful Project Performance in the Future Will Require Continued Attention to Challenges Affecting Funding and Human Resources

Science is likely to face two primary challenges to maintaining its project performance in the future: heightened funding and market uncertainties, and a shrinking pool of qualified people to manage projects. Interruptions in expected funding that in the past have increased project costs or caused schedule delays will doubtless continue, given the ongoing decline in federal funding available for discretionary projects, including Science's programs. Meanwhile, as the nation's population ages and both federal and laboratory staff retire in increasing numbers, the pool of experienced scientists and project managers available to carry out Science's program of work is likely to shrink, and difficulties replacing them are likely to continue.

Heightened Funding and Market Uncertainties Could Make Cost and Schedule Targets More Difficult to Achieve in the Future

Achieving cost and schedule targets could become more difficult for Science in the future, as growing federal budgetary constraints potentially exacerbate interruptions in anticipated flows of funding to projects already under way and volatile market conditions in some areas of the country unexpectedly drive up the costs of the labor and commodities needed to complete those projects. When projects do not receive funding as anticipated, officials said, projects take longer to complete. Labor expenses accumulate over the longer period, and prices for commodities may increase, driving total project costs upward. The experiences of the following projects at the Stanford Linear Accelerator Center in California help illustrate how these forces have affected Science's ability to meet cost and schedule targets:

- *Stanford Positron-Electron Asymmetric Ring (SPEAR 3 Upgrade):* This project experienced a slowdown in the expected stream of funding during the years when a large share of the project's costs were to be allocated for major aspects of the work, such as fabricating components. As a result, Science had to extend its schedule and revise its cost estimates to ensure sufficient funding and staff to carry out the remaining work. Total project costs increased 9 percent—from $53 million to $58 million—and instead of 4 years, the project took over 5 years to complete. This followed an earlier but unrelated cost increase from the project's original $49 million target cost, resulting from a decision by Science and the National Institutes of Health, which funded half of the project's costs, to further boost the scientific capability of the upgraded device beyond the level planned in the baseline.

- *Large Area Telescope:* This telescope is the primary scientific instrument to be flown on the Gamma-Ray Large Area Space Telescope (GLAST), which is due to launch in May 2008. The telescope, DOE's contribution to GLAST and a joint effort of the National Aeronautics and Space Administration and a host of other U.S. and foreign institutions, was completed in March 2006.[21] Once in orbit, the telescope will be used to explore the dynamics of extreme environments in space and could lead to major discoveries about the universe. When the cost and schedule targets were first established, this project included an in-kind contribution by the French space agency to design and fabricate the telescope's calorimeter—a device for measuring the energy picked up by the telescope's sensors. When the French government withdrew its participation, the project managers at the Stanford Linear Accelerator Center had to procure the component elsewhere and pay for it out of the project's budget. That procurement contributed to the overall increase in costs from $121 million to $188 million, and DOE's direct financial contribution to the project increased from $37 million to $45 million.

- *Safety and operational reliability improvements:* This $15.7 million project will upgrade utilities and improve the aging Stanford laboratory's ability to withstand earthquakes. When construction prices in the San Francisco Bay Area rose dramatically and unexpectedly between approval of the project's cost baseline and DOE's authorization to begin construction, Stanford postponed some planned improvements until other, higher-priority work was completed. If sufficient funding is unavailable to complete those improvements, they will be cut from the project. Officials told us they do not plan to request additional funding. If, near the end of construction, residual project funding is available, Stanford will then contract for the postponed work, adding at least 3 months to this 3.5-year project.

Although the future cannot be predicted with certainty, it seems that current federal fiscal constraints on discretionary funding will likely make

[21] Although Science managed the large-area telescope project, DOE's direct financial contribution totaled $45 million of the $188 million project cost.

Science's ability to meet its future cost and schedule targets increasingly more challenging. Lower-than-expected appropriations for fiscal year 2008 are already forcing Science to end or slow progress on several projects and curtail operation or use of a number of scientific facilities and items of equipment obtained earlier. According to Science's assessment, for example, shortfalls in funding for one of the ongoing projects in our review—a $33 million effort to construct additional space at the Lawrence Berkeley National Laboratory, California, to accommodate the growing number of researchers using the Advanced Light Source facility—could delay this 3.5-year project by more than 1 year beyond the original committed schedule. For the U.S. contribution to the International Thermonuclear Energy Reactor—an internationally led fusion energy demonstration project currently in planning and design and the subject of our prior work[22]—$10.7 million in funding for fiscal year 2008 was provided, rather than the $160 million requested.

Over the long term, fiscal constraints on discretionary funding are also likely to affect Science's 20-year plan to acquire new research equipment and facilities. In our work assessing the nation's long-term fiscal outlook, we have reported that continued budget deficits—exacerbated by the aging of the American population and rising related Social Security and health care costs—could soon lead to a protracted decline in the availability of federal funding for discretionary programs, including scientific research.[23] The Director of Science's Office of Project Assessment said that interruptions in project funding arising from federal fiscal constraints represent the primary challenge Science faces in meeting cost and schedule targets in the future. In a February 2008 presentation to the High Energy Physics Advisory Panel, the Under Secretary for Science echoed this concern. He said he expected that recent flat and declining budgets for the agency would continue unless Science and its advocates successfully convinced Congress of the need for long-term high-energy physics research.

[22]GAO, *Fusion Energy: Definitive Cost Estimates for U.S. Contributions to an International Experimental Reactor and Better Coordinated DOE Research Are Needed*, GAO-08-30 (Washington, D.C.: Oct. 26, 2007).

[23]GAO, *A Call for Stewardship: Enhancing the Federal Government's Ability to Address Key Fiscal and Other 21st-Century Challenges*, GAO-08-93SP (Washington, D.C.: Dec. 17, 2007), and GAO, *The Nation's Long-Term Fiscal Outlook: January 2008 Update*, GAO-08-591R (Washington, D.C.: Mar. 21, 2008).

Finally, recent sustained increases in the prices for crude oil, steel, and other commodities and a weakening dollar could have inflationary effects on the nation, leading to higher prices for many things—from manufactured goods to facility construction.[24] Unexpected increases in prices add continued uncertainty to the cost of Science's planned long-term research and facility construction programs, raising questions about Science's ability to meet cost and schedule targets in the future.

Forthcoming Retirements Could Deplete Scientific, Technical, and Management Expertise Available for Future Projects

Large-scale retirements as the nation's workforce ages are likely to continue challenging Science's ability to staff future projects effectively and, ultimately, achieve cost and schedule goals. Two of the 12 projects we reviewed in depth have faced difficulties securing adequately experienced project managers, although only 1 breached its cost and schedule baseline as a result. This 72-month project, Neutrinos at the Main Injector, was completed 17 months late and 23 percent over its committed cost, in large part because expertise in two areas was not available in a timely manner. First, the management team overseeing the project had little experience in tunneling, which was needed to house an underground proton-beam device. Staff qualified to oversee tunneling work were not brought on board the project until after the contractor encountered technical and safety problems. Second, the project's cost target had been established before engineering was completed, and the design did not fully account for the underground environment. Other factors, including higher-than-expected construction prices, also contributed to the cost increase and delay.

Such problems securing adequate management and technical expertise will doubtless continue, given expected retirements within Science and its contractor laboratories and growing competition for scientific expertise, as these examples demonstrate:

- *Office of Science:* According to the most recent analysis from the Office of Science, about 21 percent of the agency's workforce was eligible for retirement in 2005, and that number is expected to increase to 43 percent by 2011. Technical occupations are expected to be most seriously affected, although Science also is facing the imminent departure of much of its senior executive staff. Science has reported that almost all of its nuclear,

[24]Congressional Research Service, *Weak Dollar, Strong Dollar: Causes and Consequences* (Washington, D.C., Oct. 18, 2007).

chemical, and mechanical engineers will be eligible for retirement by 2011, as well as one-third or more of its technical specialists, such as physical scientists, health physicists, and chemists. In addition, more than half of Science's senior management staff is already eligible to retire. These people include senior project management officials, as well as Science's most senior leadership in basic energy sciences, fusion energy sciences, high-energy physics, and nuclear physics. Looming retirements are of substantial concern to DOE's Inspector General, which has identified human capital as a "significant management challenge" requiring priority long-term attention.[25] The Inspector General reported in 2007 that recent reductions in overall staffing at the department—staffing levels at Science have declined by almost 15 percent since 1999—combined with an aging workforce approaching retirement will create difficulties ensuring that the department has sufficient skills and knowledge in place to carry out its future responsibilities.

- *Contractor laboratories:* Officials at three of the four laboratories we visited—Fermi, Oak Ridge, and Argonne—said that, like the federal government, they also anticipate large-scale retirements in the near future, although budget reductions have already caused layoffs of many staff with management and technical expertise.[26] The vast majority of staff working on Science projects (about 23,000 people) are employed by DOE's 10 contractor laboratories and facilities across the country. In anticipation of future retirements, workforce-planning officials at the laboratories we visited said they had recently begun succession planning. None, however, had yet estimated the resulting shortfall in project management and scientific expertise because they have not completed comprehensive analyses comparing their expected capabilities with their future workforce needs.

  Nevertheless, laboratory officials said that replacing retiring staff will present a challenge because the labor market demand for expertise in key science and engineering fields currently exceeds the supply. Colleges and universities are not generating enough graduates to replace staff who are retiring. An Argonne National Laboratory preliminary analysis of its

[25]Department of Energy, Office of Inspector General, *Special Report: Management Challenges at the Department of Energy*, DOE/IG-0782 (Washington, D.C., December 2007).

[26]The Stanford Linear Accelerator Center is undergoing a change in mission that has caused it to encourage early retirements and voluntary separations. The center's director of human resources said he anticipates that retirements will not present a near-term challenge.

workforce needs, for example, recently identified a shortage of expertise in the computational sciences, superconducting technology, nanoscience, nuclear engineering, and health physics. Argonne's experience underscores the findings of a 2008 National Science Foundation report, which revealed that science and engineering occupations grew at an average annual rate of 3.6 percent between 1990 and 2000—more than triple the growth rate of other occupations.[27] According to the foundation, growth in the science and engineering labor force in the past has been supported by an influx of foreign-born graduates. But global competition for such expertise is rising, and fewer immigrants can be expected to fill those skill gaps in the future. The director of Fermi Laboratory's human resources organization said that the laboratory has already faced problems retaining its foreign-born scientists, many of whom have returned to their home countries for higher pay and better professional opportunities. In addition, laboratory officials said they often face stiff competition for new graduates with for-profit private sector firms, where salaries can be substantially higher and hiring incentives, such as relocation packages, are often better. The combined effects of retirements and a labor market in which demand for experienced and knowledgeable scientists and technicians far outstrips the supply will be a formidable challenge for Science in the future as it seeks not only to implement its future plan of work, but also to do so within budget and on time.

Conclusions

The ability of DOE's Office of Science to deliver a majority of its projects since 2003 within their original committed cost targets and on time stands in clear contrast to the struggle of other DOE program offices, in particular, the Office of Environmental Management. Science has encountered challenges common to many large federal projects, including unexpected interruptions in funding and difficulties in securing appropriately qualified staff. Yet the office has addressed such challenges, in large part by instilling a strong organizational commitment to meeting cost and schedule targets, implementing a rigorous approach to project oversight, and appropriately addressing staffing problems it has encountered. Some of Science's practices—in particular, the frequency and focus of its independent reviews—may offer practical lessons for DOE's Office of Engineering and Construction Management, which this office could consider implementing in other DOE program offices. The

[27] National Science Foundation, *Science and Engineering Indicators 2008* (Arlington, Va., January 2008).

wide range of expertise that internal review panels are able to supply—from pointing out design flaws and potential procurement obstacles to professional skepticism of overly optimistic cost and schedule estimates—appears to be especially effective in helping projects stay on track to meet their performance targets. Still, Science will need to remain diligent to ensure future success despite continuing, and potentially intensifying, challenges in funding and the impending retirement of large numbers of experienced technical and project management staff. These growing pressures might lead Science to more often consider trimming selected components from a project's planned scope of work to achieve cost and schedule targets—a practice that has the potential, without due diligence, of eventually weakening some of a project's technical goals. In our view, concerns about scope reduction expressed by DOE's Inspector General, differences we found in the level of detail describing technical goals for similar projects, and DOE's own concerns about inadequate project definition could, when taken together, indicate potential vulnerabilities associated with trimming project scope. To help ensure that vulnerabilities do not materialize as problems, Science and other DOE offices could benefit from DOE project management guidance to ensure that a project's scientific mission and technical goals are clearly defined, so that before reducing scope, organizations have fully weighed the scientific and technical effects of the reductions and have ensured that scope-altering trade-offs are clear to key interested parties, including Congress.

Recommendations for Executive Action

To help improve the potential for projects throughout DOE to achieve their cost and schedule targets, we recommend that the Secretary of Energy direct the Director of the Office of Engineering and Construction Management, which develops DOE's project management policy and facilitates project management oversight, to consider whether other DOE program offices would benefit from adopting selected practices from Science's independent project reviews, such as the frequency and focus of reviews for technically complex projects.

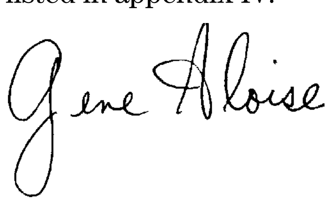
In addition, to lessen the possibility that changes in work scope could undermine some projects' ability to meet their mission need, we recommend that the Secretary of Energy direct the Office of Engineering and Construction Management to review DOE's project management guidance and consider whether it could be strengthened to help ensure that each project's technical goals, including the project's expected scientific performance and corresponding facility requirements, are clearly and sufficiently defined.

Agency Comments and Our Evaluation

We provided copies of our draft report to DOE for comment. The department generally concurred with our findings and stated that it would consider incorporating our recommendations into its *Root Cause Analysis: Corrective Action Plan*. DOE also wished to clarify the utility of trimming project scope, stating that our report appeared to imply that trimming project scope was an inappropriate practice. On the contrary, we believe that trimming scope can be a useful tool to help keep projects on schedule and within cost targets when internal or external events affect a project's cost or progress. We described several projects in the report where scope was trimmed without apparent adverse effect on the projects' overall technical goals. Officials within DOE, however, have raised concerns that projects' goals may not always be adequately defined, which can make it more difficult to assess the effects of a change in project scope. In addition, officials within the Office of Engineering and Construction Management said they believed that DOE guidance could be clarified to help ensure that project technical goals are sufficiently detailed to facilitate effective oversight. We agree, and we believe that if and when difficult choices must be made, the effect of those choices should be clear to all interested parties, including Congress. The department also provided numerous technical clarifications, which we incorporated as appropriate. Appendix III contains DOE's comment letter.

As agreed with your offices, unless you publicly release the contents of the report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees, the Secretary of Energy, and the Director of the Office of Management and Budget. We will also make copies available to others upon request. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or aloisee@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix IV.



Gene Aloise
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

To determine the extent to which the Department of Energy's (DOE) Office of Science (Science) manages its projects within cost and schedule commitments, we obtained performance information on the 42 Science projects at 10 national laboratories that, from fiscal year 2003 through fiscal year 2007, were either completed (27 projects) or still under way at the time of our study and for which Science had committed to cost and schedule targets (15 projects). The 42 projects excluded information technology acquisitions and projects that met our selection criteria but were suspended at the time we selected projects for review in October 2007. Because we did not consider DOE's Project Assessment Reporting System a fully reliable source for performance information on individual projects, we obtained project cost and schedule data and other information directly from the responsible laboratories.[1]

For the 42 Science projects, we reviewed selected documents providing information about the projects' scope and purpose, estimated and actual costs, and proposed and actual time frames. We compared the cost or schedule commitments in the original project baselines with the actual performance of the 27 completed projects and the expected performance—as of February 29, 2008—for the 15 projects still under way. For most of the 27 completed projects, we compared the cost targets in the documents establishing the project baseline (at critical decision point 2, or CD-2) with the actual costs, as provided in the documents certifying project completion (at critical decision point 4, or CD-4). We then compared the proposed time frames in the CD-2 documents with the CD-4 document approval dates.[2] In a few cases, these documents were not available, and alternative documents were used instead. For the 15 projects still under way, we compared the cost and schedule targets in the CD-2 documents with project performance reports as of February 29, 2008, provided by the responsible laboratories. In recognition of Office of Management and Budget guidance and DOE's recent project performance goals, we characterized projects that met or exceeded (or are expected to meet or exceed) their original cost or schedule goals by less than 10 percent as completed within budget or on time, whereas we considered projects that exceeded (or will exceed) their goals by 10 percent

[1]GAO, *Department of Energy: Consistent Application of Requirements Needed to Improve Project Management*, GAO-07-518 (Washington, D.C.: May 11, 2007), and GAO, *Department of Energy: Further Actions are Needed to Strengthen Project Management for Major Projects*, GAO-05-123 (Washington, D.C.: Mar. 18, 2005).

[2]For some projects baselined before the implementation of DOE's project management directive, DOE Order 413.3, approved in October 2000, the committed cost and schedule targets were established early in project development, typically, at conceptual design.

or more to be over cost or late.[3] The Office of Management and Budget requires that federal agencies monitor the performance of capital acquisitions and that agency heads review major acquisitions that exceed their cost, schedule, and performance goals by 10 percent or more.[4] In coordination with the Office of Management and Budget, DOE in 2008 adopted a goal of completing individual projects within 10 percent of the original cost baseline, with certain exceptions that were beyond the scope of this report.[5] DOE did not adopt a performance goal for projects' schedule baselines.

To evaluate the key factors affecting Science's project management performance, we selected a nongeneralizable sample of 12 out of the 42 projects overseen by four laboratories with diverse scientific missions—Argonne National Laboratory and Fermi National Accelerator Laboratory in Illinois, Oak Ridge National Laboratory in Tennessee, and the Stanford Linear Accelerator Center in California—for more detailed review. The projects were the Center for Nanoscale Materials; Neutrinos at the Main Injector; U.S. ATLAS; U.S. Compact Muon Solenoid; U.S. Large Hadron Collider Accelerator; Center for Nanophase Material Sciences; SNS Instruments: Next Generation; Spallation Neutron Source; Large Area Telescope; Linac Coherent Light Source; safety and operational reliability improvements at the Stanford Linear Accelerator; and Stanford Positron-Electron Asymmetric Ring (SPEAR 3) upgrade. Results from nongeneralizable samples, including our sample of 12 projects, cannot be used to make inferences about Science's overall project performance. Our interest was in gathering information on the selected Science projects to identify material factors that may not exist across all projects but could help us understand Science's organizational strengths and potential future challenges. We selected these 12 projects to ensure that our sample included completed and ongoing projects, scientific projects and infrastructure improvement projects, and a wide range of project costs. Together, the 12 projects represented about $2.9 billion, or 75 percent, of the total value of the 42 projects.

[3] In a prior GAO report, *Department of Energy: Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays*, GAO-07-336 (Washington, D.C.: Mar. 27, 2007), the Spallation Neutron Source was characterized as exceeding its original baseline. At the time of our 2007 report, the project was 2 percent over its original cost target.

[4] Office of Management and Budget, *Planning, Budgeting, Acquisition, and Management of Capital Assets*, circular A-11, part 7 (Washington, D.C., July 2007).

[5] Department of Energy, *Root-Cause Analysis: Contract and Project Management* (Washington, D.C., April 2008).

For these 12 projects, we visited the responsible laboratory and reviewed selected documents providing information about the project's scope and purpose, estimated and actual costs, and proposed and actual time frames. We also examined reviews of the 12 projects conducted by Science's Office of Project Assessment, which provides guidance and oversight for Science's projects.[6] We interviewed federal project directors, laboratory project managers, and other knowledgeable staff to gather their perspectives on their projects' performance and reasons for it. We also discussed key factors affecting Science's project management performance with headquarters officials at DOE's Office of Engineering and Construction Management, which provides project management policy and oversight departmentwide; at Science's Office of Project Assessment; and Science's principal subprogram offices. In addition, to evaluate projects' technical goals, we reviewed the project execution plans for projects within and outside our nongeneralizable sample.

To determine the main challenges that could affect Science's ability to maintain project management performance in the future, we interviewed federal and laboratory officials at the four laboratories we visited, as well as officials at DOE's Office of Engineering and Construction Management and Science's Office of Project Assessment. We interviewed workforce-planning officials at the four laboratories, Science's headquarters, and regional administrative offices in Illinois and Tennessee. We also reviewed relevant studies by GAO, DOE's Inspector General, and the National Science Foundation about fiscal challenges facing the United States and challenges to maintaining a skilled federal workforce and to securing technical expertise across a variety of scientific fields.

We conducted this performance audit from June 2007 through May 2008, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[6]Although many different types of reviews of Science's projects were conducted by organizations within or outside of DOE, we limited our assessment to Science's independent project reviews and, to a lesser extent, external independent reviews conducted by DOE's Office of Engineering and Construction Management.

Appendix II: Summary of Office of Science Projects Reviewed

We obtained and reviewed performance information on 42 Science projects at 10 national laboratories, summarized in table 1.

Table 1: Projects Under Way or Completed from Fiscal Year 2003 through Fiscal Year 2007

Site and project	Project type	Status	Original target completion date[a]	Actual completion date[b]	Percentage over (under) completion date[c]	Original target cost (dollars in millions)[a]	Final cost (dollars in millions)[b]	Percentage over (under) target cost[c]
ARGONNE NATIONAL LABORATORY								
Center for Nanoscale Materials[d]	Scientific	Completed	9/1/2007	9/1/2007	0%	$72.00	$72.00	0%
Central supply facility	Infrastructure	Completed	7/1/2001	10/1/2002	60.00	5.90	5.90	0
Fire safety improvements	Infrastructure	Completed	6/1/2003	11/1/2003	16.13	8.43	8.38	(0.59)
Mechanical and control systems upgrade	Infrastructure	Completed	6/1/2005	6/1/2005	0	9.00	8.96	(0.44)
BROOKHAVEN NATIONAL LABORATORY								
Center for Functional Nanomaterials	Scientific	Under way	4/1/2008	3/1/2008	(2.08)	81.00	81.00	0
Electrical system modifications: phase II	Infrastructure	Completed	9/1/2003	11/1/2003	7.41	6.77	6.73	(0.59)
Electron Beam Ion Source	Scientific	Under way	3/1/2010	9/1/2010	14.29	14.80	14.80	0
Ground and surface water protection upgrade	Infrastructure	Completed	12/1/2003	11/1/2003	(3.33)	6.05	6.03	(0.33)
Research support building	Infrastructure	Completed	3/1/2007	2/1/2007	(2.94)	18.27	18.27	0
STAR Electromagnetic Calorimeter	Scientific	Completed	9/1/2003	9/1/2003	0	8.60	8.60	0
FERMI NATIONAL ACCELERATOR LABORATORY								
MINERvA	Scientific	Under way	4/1/2010	9/1/2010	13.51	16.80	16.80	0
Neutrinos at the Main Injector[d]	Scientific	Completed	9/1/2003	2/1/2005	30.91	136.10	167.97	23.42

Site and project	Project type	Status	Original target completion date[a]	Actual completion date[b]	Percentage over (under) completion date[c]	Original target cost (dollars in millions)[a]	Final cost (dollars in millions)[b]	Percentage over (under) target cost[c]
Run IIb CDF Detector	Scientific	Completed	11/1/2006	7/1/2006	(8.89)	30.40	10.90	(64.14)
Run IIb D-Zero Detector	Scientific	Completed	11/1/2006	11/1/2006	0	28.60	17.40	(39.16)
U.S. ATLAS[d]	Scientific	Under way	9/1/2005	9/1/2008[e]	40.45	163.75	163.75	0
U.S. Compact Muon Solenoid[d]	Scientific	Under way	9/1/2005	9/1/2008[e]	40.91	167.25	167.25	0
U.S. Large Hadron Collider Accelerator[d]	Scientific	Completed	9/1/2005	7/1/2006	12.05	200.00[f]	200.00	0
LAWRENCE BERKELEY NATIONAL LABORATORY								
Advanced Light Source molecular environmental science facility	Scientific	Completed	10/1/2002	12/1/2002	5.26	6.75	6	(11.11)
Advanced Light Source user support building	Infrastructure	Under way	5/1/2010	5/1/2010	0	32.80	32.80	0
Building 77 rehabilitation: phase II	Infrastructure	Under way	11/1/2009	11/1/2009	0	13.61	13.61	0
Gamma-Ray Energy-Tracking Array	Scientific	Under way	3/1/2011	3/1/2011	0	18.80	18.80	0
The Molecular Foundry	Scientific	Completed	12/1/2006	12/1/2006	0	85.00	84.90	(0.12)
Transmission Electron Aberration-Corrected Microscope	Scientific	Under way	9/1/2009	9/1/2009	0	27.09	27.09	0
Sitewide water distribution upgrade: phase I	Infrastructure	Completed	12/1/2003	12/1/2003	0	8.26	8.26	0
OAK RIDGE NATIONAL LABORATORY								
Center for Nanophase Materials Sciences[d]	Scientific	Completed	9/1/2006	8/1/2006	(2.08)	65.00	64.74	(0.40)
Electrical system upgrade	Infrastructure	Completed	1/1/2003	4/1/2003	13.04	5.99	5.90	(1.50)

Site and project	Project type	Status	Original target completion date[a]	Actual completion date[b]	Percentage over (under) completion date[c]	Original target cost (dollars in millions)[a]	Final cost (dollars in millions)[b]	Percentage over (under) target cost[c]
Facilities heating, ventilation, and air-conditioning upgrade	Infrastructure	Completed	3/1/2004	11/1/2003	(14.81)	7.20	7.05	(2.08)
Fire protection system upgrade	Infrastructure	Completed	9/1/2004	5/1/2004[g]	(12.50)	6.02	5.89	(2.16)
Fundamental neutron physics beamline	Scientific	Under way	6/1/2010	4/1/2010	(2.56)	9.20	9.20	0
Laboratory for Comparative and Functional Genomics	Scientific	Completed	9/1/2003	10/1/2003	4	13.90	13.86	(0.29)
Research support center	Infrastructure	Completed	8/1/2004	10/1/2004	9.52	16.26	16.04	(1.35)
SNS instruments: next generation (SING I)[d]	Scientific	Under way	9/1/2011	8/1/2010	(15.66)	68.50	68.50	0
Spallation Neturon Source[d]	Scientific	Completed	9/1/2005	5/1/2006	8.60	1332.80	1405.00	5.92
PACIFIC NORTHWEST NATIONAL LABORATORY								
Physical sciences facility	Infrastructure	Under way	2/1/2011	2/1/2011	0	224.00	224.00	0
PRINCETON PLASMA PHYSICS LABORATORY								
Alcator C-Mod lower drive upgrade	Scientific	Completed	3/1/2003	4/1/2003	5.26	5.20	5.14	(1.15)
National Compact Stellarator Experiment	Scientific	Under way	5/1/2008	12/1/2012	107.84	86.30	165.00	91.19
SANDIA AND LOS ALAMOS NATIONAL LABORATORIES								
Center for Integrated Nanotechnologies	Scientific	Completed	5/1/2007	5/1/2007	0	75.80	75.75	(0.07)
STANFORD LINEAR ACCELERATOR CENTER								
Large Area Telescope[d]	Scientific	Completed	3/1/2006	2/1/2006	(2.5)	121.20	188.06[h]	55.17
Linac Coherent Light Source[d]	Scientific	Under way	3/1/2009	7/1/2010	34.04	379.00	420.00	10.82

Site and project	Project type	Status	Original target completion date[a]	Actual completion date[b]	Percentage over (under) completion date[c]	Original target cost (dollars in millions)[a]	Final cost (dollars in millions)[b]	Percentage over (under) target cost[c]
Safety and operational reliability improvements[d]	Infrastructure	Under way	9/1/2009	12/1/2009	7.32	15.72	15.72	0
SPEAR 3 upgrade[d]	Scientific	Completed	9/1/2002	11/1/2003	29.17	49.20	58.00	9.23
THOMAS JEFFERSON NATIONAL ACCELERATOR LABORATORY								
CEBAF center addition: phase I	Scientific	Completed	6/1/2006	4/1/2006	(6.25)	10.94	10.94	0

Source: GAO analysis of Office of Science data.

Note: DOE data typically expressed target completion dates as month and year; for consistency, we recorded and calculated target and actual completion dates from the first of the month.

[a]Original completion date and cost targets were committed to at critical decision point 2, when cost and schedule targets are set. For projects baselined before DOE's project management order 413.3 was fully implemented, we used an equivalent project milestone or, if such a milestone was not available, we instead used estimates at conceptual design. Estimates made at conceptual design lack the precision possible when design has progressed further.

[b]For projects under way, the actual completion date and final cost reflect Science's projections as of February 29, 2008.

[c]To determine the extent to which each project finished before or exceeded its original target completion date, we computed percentage change from the planned project length (the period between DOE's approval of critical decision point 2, which is not shown in the table, and the original target completion date) to the actual project length (the period between critical decision point 2 approval and critical decision point 4, when DOE certifies that a project is complete). To determine the extent to which each project finished under or exceeded its original target cost, we computed the percentage change from the original target cost to the final cost.

[d]Part of our nongeneralizable sample of 12 projects selected for in-depth review.

[e]DOE completed 97 percent of this project on time. The remaining 3 percent will not be completed until September 2008 because of tunneling problems at the European Organization for Nuclear Research (CERN) site in Switzerland.

[f]DOE funding included $90 million paid to CERN to purchase parts made in the United States.

[g]Date corresponds to date of project's critical decision point 4 memorandum, our criterion for project completion. Documentation for this project, however, indicates that the upgrades were completed in March 2004, 2 months earlier.

[h]DOE's direct financial contribution to this project amounted to $45 million.

Appendix III: Comments from the Department of Energy

Department of Energy
Washington, DC 20585

May 21, 2008

Mr. Gene Aloise
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20584

Dear Mr. Aloise:

Thank you for the opportunity to comment on the draft Government Accountability Office (GAO) report, entitled Office of Science Has Kept Majority of Projects on Schedule and within Budget, but Funding and Other Challenges May Grow (GAO-08-641). Generally, the Department of Energy agrees with your findings and recommendations. The recommendations will be considered as part of the agency's Root Cause Analysis Corrective Action Plan to improve contract and project management.

The Office of Science (SC) has a culture of effective project management that stems from a shared belief in delivering the maximum science capability in each of its projects. SC appreciates that GAO has recognized elements of its culture (leadership, expertise, and rigorous oversight) contributing to successful project outcomes. This is helpful in communicating SC's commitment to scientific excellence throughout the science communities, DOE laboratory complex, and other stakeholders – especially SC oversight organizations.

SC understands that its large projects use precious, limited public resources and must always be appropriately prioritized, well defined, and effectively managed from concept formulation to operations. This is a legacy that has been built by SC and its predecessors over many decades. Today, SC managers and staff take pride in passing this legacy on by promoting effective project management as a signature SC experience that gives meaning to daily project work.

SC also agrees with GAO's description of challenges (availability of funding and talent) confronting the organization that may impact future project outcomes.

Finally, we would like to clarify the utility of "trimming" of project scope as a means of meeting project cost and schedule targets. Although GAO accurately reports that DOE's project management directives allow reductions in scope, the implication appears to be that this approach is inappropriate. DOE considers this practice to be in keeping with the principles of responsible project management. We are often required to make difficult choices in the face of internal and external events that affect project costs. These choices can result in reductions to scope in order to ensure meeting the primary technical goals within cost and schedule constraints. Further, when a change of this type is proposed a rigorous review is done to ensure that the change is appropriately defined, justified, and approved.

Please find two attachments to this letter which provide additional general and project-specific comments on the draft report. Many of these comments were provided to GAO in response to their initial Statement of Facts, but were not reflected in the draft report.

Sincerely,

Daniel R. Lehman
Director
Office of Project Assessment
Office of Science

Enclosure

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Gene Aloise, (202) 512-3841 or aloisee@gao.gov

Staff Acknowledgments

In addition to the individual named above, Janet Frisch, Assistant Director; Ellen W. Chu; Elizabeth Deyo; Kevin Jackson; Omari Norman; Jeff Rueckhaus; and Ginny Vanderlinde made key contributions to this report.

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