GAO

Report to the Ranking Minority Member, Subcommittee on Energy and Water Development, Committee on Appropriations United States Senate

April 1986

NUCLEAR SCIENCE

Information on DOE Accelerators Should Be Better Disclosed in the Budget

Released

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Resources, Community, and
Economic Development Division

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April 9, 1986

The Honorable J. Bennett Johnston
Ranking Minority Member
Subcommittee on Energy and Water
Development
Committee on Appropriations
United States Senate

Dear Senator Johnston:

On May 3, 1985, you requested us to review certain issues concerning (1) the size and nature of the Department of Energy's (DOE's) investment in new high-energy and nuclear physics accelerator facilities--or major upgrades--prior to congressional approval of their construction and (2) the events and procedures leading to DOE's review and approval for building a new nuclear physics accelerator known as the Continuous Electron Beam Accelerator Facility. Information concerning the new electron accelerator facility was recently provided in a separate report. This report responds to your first area of interest concerning the extent to which DOE incurs preconstruction costs on large accelerator projects that are not clearly identified for congressional approval. In addition, and as subsequently agreed to with your office, the report provides information on the total costs and technical uncertainties of accelerator facilities and upgrades.

The report covers DOE's six largest high-energy and nuclear physics accelerator projects. Generally, our review showed that the DOE budgets submitted to the Congress contained only fragmented and incomplete information related to these projects, with respect to preconstruction costs as well as total estimated project costs. In addition, the status of technical uncertainties related to the projects has not been adequately disclosed.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 14 days from the date of this letter. At that time, we will send copies to interested parties and make copies available to others upon request.

Sincerely yours,

J. Dexter Peach
Director

Executive Summary

Accelerators are machines used by physicists to "see" the inner structure of the atom and study its components. Modern accelerators can cost billions of dollars and take several years to build. Concerned over accelerators' increasing costs, the Ranking Minority Member, Subcommittee on Energy and Water Development, Senate Committee on Appropriations, asked GAO to examine the total costs, including preconstruction costs, that the Department of Energy (DOE) has incurred or plans to incur on major high-energy and nuclear physics accelerator upgrades and new facilities.

Background

The high cost of accelerators makes it important that DOE follow its established operating procedures aimed at (1) fully estimating project costs and (2) identifying projects to Congress prior to investing large resources. Complying with these procedures would allow DOE to provide complete cost information so that the Congress can assess and make timely decisions on the need, affordability, and priority of the projects.

Results in Brief

DOE incurs substantial costs for accelerator projects that are not identified in the budget as project-specific costs. GAO estimated the total cost of six of the largest accelerator projects to be about $6.9 billion. DOE, however, has identified only about $0.6 billion of these project-specific costs in the budget. (All amounts are in fiscal year 1985 dollars.) This has occurred because the DOE Office of Energy Research definition of a project relates only to construction, which excludes certain project-specific components and preconstruction research and development. In addition, DOE funds a project in stages over a number of years and does not, when the first stage is authorized, identify for the Congress the total cost of completing the project.

GAO also noted that DOE does not fully disclose in its budget technical uncertainties, which have been identified in peer reviews, associated with the performance of certain accelerator components. These uncertainties could result in cost overruns or increased operating costs but were not disclosed because DOE's internal operating procedures do not require such disclosure.

Principal Findings

Disclosing Total Project Costs

Although DOE has provided some information on the total cost of the projects in congressional hearings, DOE's practice of incrementally funding projects and the omission of project technical uncertainties in the budget makes it difficult for the Congress to assess the affordability of such projects. Past DOE requests to upgrade an existing accelerator or build a new one were often based on incomplete information.

DOE defines a project as a unique undertaking with a firmly scheduled beginning and end. DOE's definition lacks specific criteria on when a project starts and ends and what components should be included. Given this flexibility, the DOE physics program offices have defined an accelerator project as primarily the effort during construction. Using this interpretation, DOE has incrementally funded accelerator projects without informing the Congress of the total cost in annual budget submissions. For example, DOE is considering building an accelerator called the Superconducting Super Collider. A DOE-funded estimate shows this project will cost about $4.1 billion over the next 8 years. DOE budgets through fiscal year 1987 have identified $57.9 million in research costs for the project but have not identified the project's total cost.

In addition, DOE's budget frequently does not include costs for equipment and other project-specific components that planning documents indicate are needed to make an upgrade and/or new facility complete and operational. For example, DOE is upgrading its accelerator at the Fermi National Accelerator Laboratory, but the budget requests for this upgrade did not include the cost of a computer facility and other items that are required for and dedicated to the operation of the accelerator. Including these omitted costs would increase DOE's estimated cost of the total upgrade from about $212 million to about $579 million. GAO believes DOE's definition of a project should be clarified to require all costs of dedicated components for an upgrade or new facility to be clearly shown in DOE's budget submissions. (See ch. 3.)

Accelerator projects incur substantial costs before construction is approved by the Congress that are not disclosed as project-related expenses. For example, included in GAO's total cost estimates for the projects is about $440 million in preconstruction costs, of which about $352 million has not been identified as project-specific costs in DOE's

budget. These costs, which were primarily for research and development, conceptual design studies, and components of the overall upgrade, have been included in DOE's budget as separate projects, or as generic research.

These preconstruction costs were not identified in its budget because the program office generally does not recognize a project until it requests construction funds. This allows DOE to make large investments that have not been considered by the Congress as part of DOE's projects. GAO believes that DOE should identify projects to the Congress before committing large resources. For the projects GAO reviewed, DOE has this type of information available in proposals submitted by its accelerator facilities.

Disclosing Project Technical Uncertainties

DOE's budget also does not disclose technical uncertainties which could affect a project's meeting its performance objectives. For example, DOE records show that technical uncertainties with magnets, a cooling system, and other components in the Fermilab upgrade have resulted in schedule delays and cost overruns amounting to more than $70 million. Also, if the operating lifetimes of components associated with the Stanford Linear Collider are not resolved, the annual operating cost of that project could increase by as much as $20 million. In neither case did DOE adequately disclose in the budget these uncertainties. GAO believes this information is important in deciding whether a project should proceed and, therefore, should be provided to the Congress along with complete cost information as part of DOE's budget submission. (See ch. 3.)

Recommendations

GAO makes recommendations to the Secretary of Energy aimed at identifying and disclosing, in DOE's annual budget submissions, preconstruction costs, total project costs, and technical uncertainties associated with major accelerator projects before committing large resources to those projects. Since DOE strongly disagreed with this report (see below), GAO is also recommending that the Appropriations Committees direct DOE to implement these recommendations. (See chs. 2 and 3.)

Agency Comments

DOE disagreed with the report's findings, conclusions, and recommendations. Much of DOE's disagreement revolved around the question of when it should use the budget to notify the Congress of total estimated project costs. DOE's comments indicated that it believes estimates are properly included only when firm project plans are submitted to the Congress for

construction funding. GAO believes that when the Congress is asked to make the first "downpayment" on an accelerator that has a preliminary design, with specific objectives, and with specific technical and operating parameters, the Congress should be informed of the project and provided with the best available estimate for the entire cost of the project. This is particularly important since the costs amount to hundreds of millions, or billions, of dollars. DOE's practice of providing piecemeal information about these costs in the budget and through congressional hearings only serves to frustrate the need for a complete picture of present and anticipated project costs. (See chs. 2 and 3 and app. III for DOE's comments and GAO's responses.)

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Abbreviations

AFMD	Accounting and Financial Management Division (GAO)
CEBAF	Continuous Electron Beam Accelerator Facility
DOE	Department of Energy
EMD	Energy and Minerals Division (GAO)
GAO	General Accounting Office
GeV	billion electron volts
HEPAP	High Energy Physics Advisory Panel
KeV	thousand electron volts
LAMPF II	Los Alamos National Laboratory's Meson Physics Facility II
MeV	million electron volts
NSAC	Nuclear Science Advisory Committee
NSF	National Science Foundation
OMB	Office of Management and Budget
PSAD	Procurement and Systems Acquisition Division (GAO)
RCED	Resources, Community, and Economic Development Division (GAO)
TeV	trillion electron volts

Introduction

Physics is a science that deals with matter and energy, their structure, properties, and interactions. Physicists who are studying the atom's nucleus use machines called accelerators (sometimes called "atom smashers") to discover and analyze the basic constituents of the nucleus, the forces that bind those constituents together, and the interactions between them. Discovering and/or analyzing recessively smaller or more elementary particles has historically involved the use of larger, more powerful, and more expensive accelerators.

In a request dated May 3, 1985, Senator J. Bennett Johnston, Ranking Minority Member, Subcommittee on Energy and Water Development, Senate Committee on Appropriations, expressed concern about the Department of Energy's (DOE's) activities and plans aimed at upgrading existing accelerators or building new ones (see app. I).[1] In response to his request, we examined the extent to which DOE incurs preconstruction costs on major accelerator upgrades and new facilities that are not clearly identified for congressional approval (see ch. 2). We also obtained information on the total cost of the upgrades and new facilities and compared them to the amounts DOE reported in its budget submissions to the Congress (see ch. 3).

This chapter provides an overall perspective of (1) high-energy and nuclear physics (two of the fields of science in which accelerators are used), (2) the DOE programs that support research in these fields, (3) the trend toward more powerful and expensive accelerators and equipment, and (4) the importance of timely and complete cost information.

Nature of High-Energy and Nuclear Physics

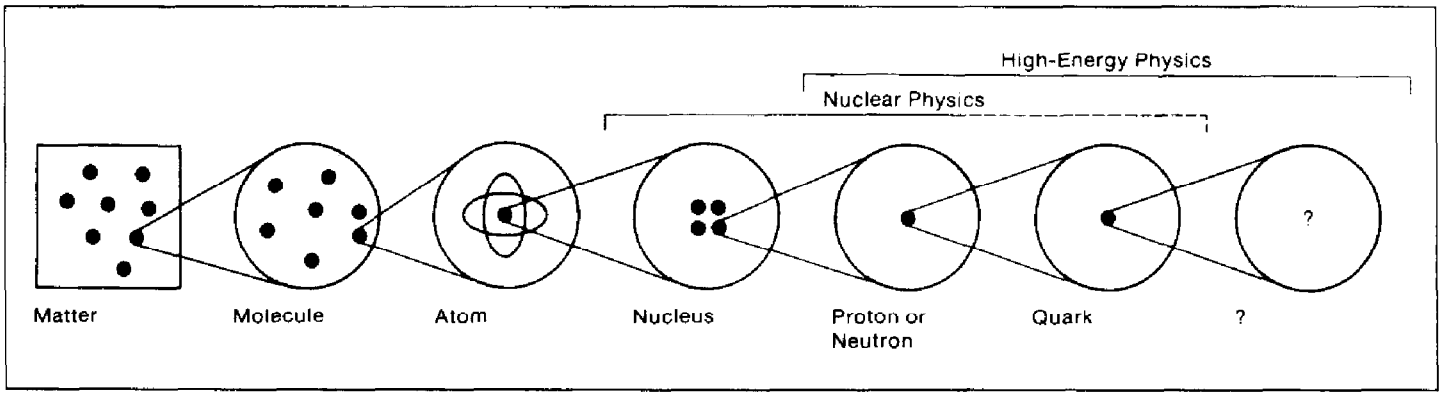
High-energy and nuclear physics are extensions of humanity's continuing desire to understand the universe. The primary objective of both sciences is to better understand the fundamental components of matter and the laws that underlie all physical processes in the universe. Generally, high-energy physics is aimed at (1) determining what ultimately constitutes energy and matter, (2) ascertaining how the components (or particles) of matter interact with each other, and (3) understanding the interrelationships between the most basic forces of nature[2] and the effects of those forces on matter. Nuclear physics concentrates on the interactions, structure, and other characteristics of the atom's nucleus.

[1]In the same letter, Senator Johnston requested information related to the selection and approval of the Continuous Electron Beam Accelerator Facility (CEBAF) project. That information is being obtained as part of a separate audit effort.

[2]These forces are known as the strong force, the electromagnetic force, the weak force, and gravity.

Figure 1.1 shows the basic components of matter and the areas of interest to high-energy and nuclear physicists. As shown in figure 1.1, the areas of interest to high-energy and nuclear physicists overlap. In addition, the dashed line indicates the growing interest of nuclear physicists in understanding the atom's nucleus through the study of more basic components of the nucleus.

Figure 1.1: Components of Matter



Experiments in high-energy and nuclear physics use accelerators to probe into the structure of matter. Accelerators produce and accelerate beams of particles such as electrons or protons which are made to collide with stationary targets or head-on with particles in another accelerated beam. Examination of the collision may reveal information concerning the structure of the particles and the forces acting on them. In this sense, the accelerator provides a "light" for physicists to see the inner structure of the atom's nucleus and is analogous to a super microscope that can study subnuclear particles billions of times smaller than the objects visible through an optical microscope.

Accelerators for high-energy and nuclear physics experiments are generally comprised of four components—a beam injector, an accelerator, detectors, and computers. The beam injector is used to inject the particles into a linear or circular accelerator, which, in turn, increases the particles' speed and energy. After the particles collide, detectors and computers record and analyze the results.

Injectors, accelerators, detectors, and computers operate as part of an overall accelerator system. Whereas the roles of injectors and accelerators are to create, accelerate, and collide particles at specified energy

levels, detectors and computers are necessary to observe, record, and analyze the particle collisions.

DOE's Role in High-Energy and Nuclear Physics

DOE has no specific mandate to support high-energy physics or nuclear physics other than that which is obtained through the annual appropriations process. DOE does, however, have general authority to perform "physical" research.[3] DOE's policy is to support scientific and technical research that advances the frontiers of scientific and engineering knowledge. In fiscal year 1985, this support amounted to $545.6 million for high-energy physics and $182.9 million for nuclear physics. The benefits of high-energy and nuclear physics research are discussed in two of our prior reports entitled Increasing Costs, Competition May Hinder U.S. Position of Leadership in High Energy Physics (EMD-80-58, Sept. 16, 1980) and DOE's Physics Accelerators: Their Costs and Benefits (GAO/RCED-85-96, Apr. 1, 1985).

Both the high-energy and nuclear physics programs are administered by the Office of High Energy and Nuclear Physics within DOE's Office of Energy Research. The Office of High Energy and Nuclear Physics has cognizant responsibility for resolving technical issues, such as the type of machine to be constructed and site selection. It also has primary responsibility for administration, including preparing the planning and budget documents.

In addition, several other organizations within DOE have responsibility for managing accelerator projects. They include

- the Office of Energy Research's Division of Construction, Environment, and Safety, which reviews and monitors construction activities through semiannual reviews;
- DOE's field operations offices, which perform day-to-day oversight of the projects; and
- the Office of Management and Administration, which identifies, monitors, and verifies the cost of major systems and projects under which some accelerator projects are categorized.

[3]This general authority is contained in Section 31(a) of the Atomic Energy Act of 1954, as amended (Public Law 83-703), Sections 103 and 107(a) of the Energy Reorganization Act of 1974 (Public Law 93-438), and Section 209(b)(1) of the DOE Organization Act (Public Law 95-91).

Characteristics of the High-Energy Physics Program

The high-energy physics program's specific objectives are

- searching for and discovering new physical phenomena, such as new particles, using high-energy subnuclear particle interactions;
- pursuing advanced concepts and technology development; and
- maintaining the U.S. program in a world leadership position.

DOE supports three high-energy physics accelerator facilities: the Brookhaven National Laboratory, Upton, New York; the Fermi National Accelerator Laboratory (Fermilab), Batavia, Illinois; and the Stanford Linear Accelerator Center, Palo Alto, California. The facilities are government owned and are operated for DOE by contractors. The accelerators located at these facilities vary in terms of the configuration (e.g., linear or circular), the type of beam (e.g., protons or electrons), and the energy level. Figures 1.2 and 1.3 are aerial views of the circular accelerator at Fermilab and the linear accelerator at Stanford, respectively.

Figure 1.2: Aerial View of Fermilab

Photo Courtesy of DOE

Figure 1.3: Aerial View of the Stanford Linear Accelerator Center

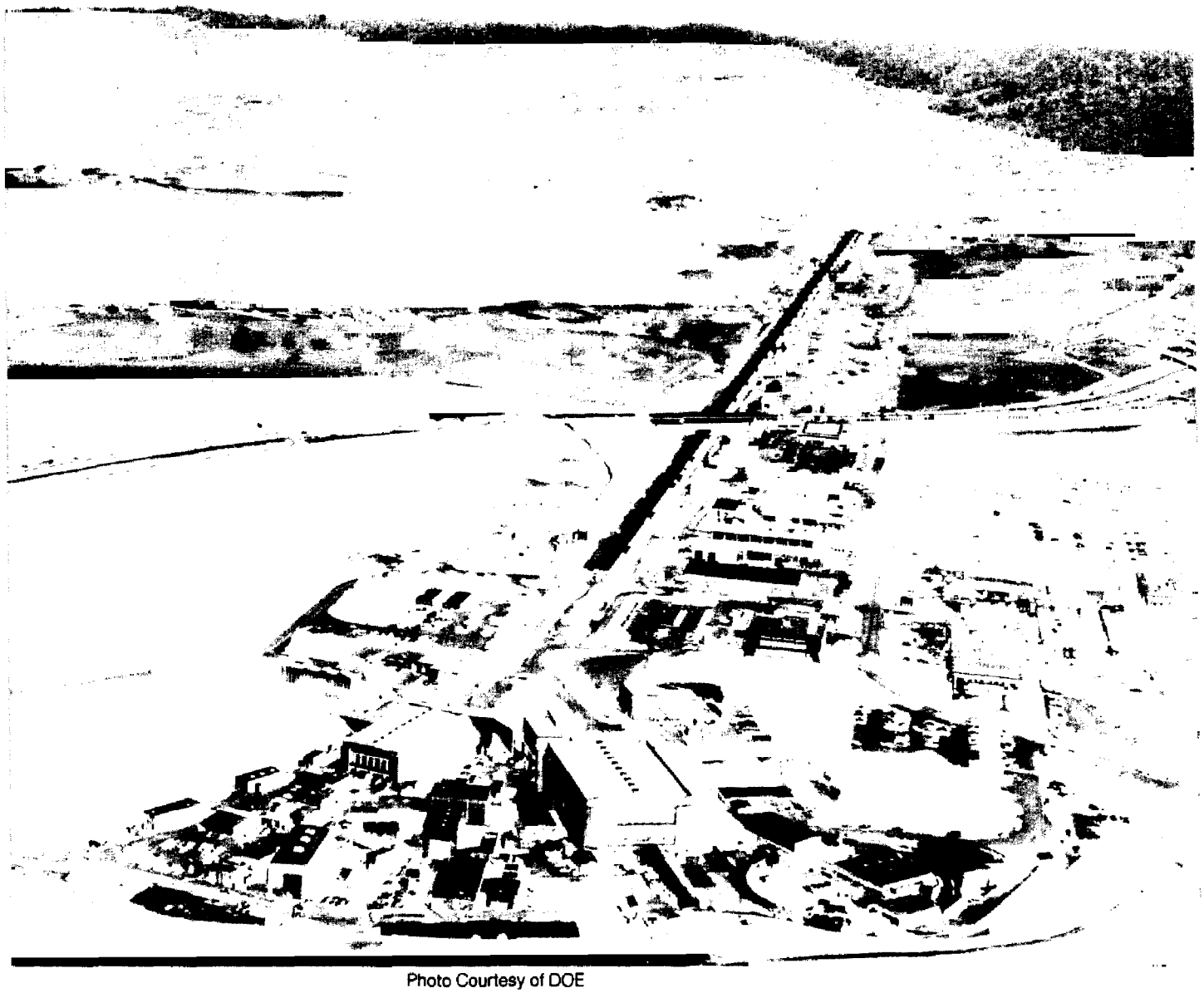


Photo Courtesy of DOE

To aid in directing the high-energy physics program, in 1967 DOE established the High Energy Physics Advisory Panel (HEPAP) to review the

program and provide advice on overall program balance, scientific priorities, and special problems. A subpanel for long-range planning was formed in 1981 to review the status and prospects of DOE's and the National Science Foundation's respective high-energy physics programs.[4] Appointed by the Secretary of Energy, HEPAP members are usually prominent physicists affiliated with universities and national laboratories that have DOE sponsored high-energy physics programs. These physicists provide peer review advice and can channel to DOE the concerns and ideas of the U.S. high-energy physics community.

Characteristics of the Nuclear Physics Program

DOE's nuclear physics program has objectives which, in part, overlap some of the high-energy physics objectives. The nuclear physics program's objectives are to

- describe quantitatively the behavior and structure of nuclei in terms of fundamental interactions,
- use nuclei as a laboratory for the study of the fundamental forces of nature,
- advance research capability by developing new facilities and improving particle beams and ancillary equipment at existing facilities, and
- maintain a position of leadership in nuclear physics research.

DOE's nuclear physics program supports 11 nuclear physics facilities and, like the high-energy physics program, sponsors both theoretical studies and experiments. Seven of these are national facilities and four are university based. The accelerators at the national facilities, along with one university-based facility (Yale), are government owned. The others are owned by the universities. These 11 facilities are contractor operated and include a wide variety of accelerator types, energy levels, and beam types. (See app. II for the list of DOE's nuclear physics accelerator facilities.)

In 1977, the Nuclear Science Advisory Committee (NSAC) was established to provide advice to DOE and the NSF regarding the scientific priorities within the field of nuclear physics research. NSAC has members from national laboratories and universities that are affiliated with DOE/NSF nuclear physics programs. Similar to the HEPAP panel, these members reflect the views of the general nuclear physics community.

[4]The National Science Foundation (NSF) and DOE are the two federal agencies responsible for funding high-energy physics and nuclear physics research. DOE provides about 90 percent and 80 percent, respectively, of the federal dollars for high-energy and nuclear physics. NSF provides the rest.

Trend Toward More Powerful, Expensive Accelerators and Equipment

Increases in accelerator energy levels have been important to physics discoveries because as scientists probe deeper into the atom's nucleus, the particles being studied are smaller and more tightly bound together. Thus, more energy is required to separate them. To further explore the atom's nucleus, physicists are now requesting even more powerful, and consequently more expensive, accelerators.

In the history of high-energy and nuclear physics, frequently a key element in making new discoveries has been the use of particle beams with increasingly higher energy levels. In the mid-nineteenth century, experiments at energies of several electron volts[5] led to the realization that the atom is composed of smaller structures. In the early 1900's, experiments in the range of about 1,000 electron volts (KeV) revealed electrons, protons, and neutrons. By increasing the power of accelerators to the billion electron volt (GeV) range, physicists were able to explore the subnuclear world and discover antiprotons[6] in 1955. Twenty-two years later, in 1977, physicists at Fermilab discovered the fifth quark[7] at an energy level of about 27.5 GeV. More recently, in 1983, physicists at a European accelerator facility discovered particles known as the W and Z bosons[8] at energies of about 600 GeV.

In the high-energy physics program, Brookhaven, Fermilab, and the Stanford Linear Accelerator Center have been working on increasing the energy of their respective existing accelerators. At Brookhaven, DOE has started funding a booster project that would improve the performance and capabilities of the existing accelerator. This Brookhaven upgrade is discussed in greater detail in chapter 2 as part of the Relativistic Heavy Ion Collider. Fermilab hopes to increase the energy of its accelerator with two separately funded projects called Tevatron I and Tevatron II. Tevatron I is intended to enable proton-antiproton collisions at a combined energy level of 2 trillion electron volts (TeV),[9] and Tevatron II is to upgrade the existing fixed target experimental areas. When this overall upgrade is completed in September 1987, Fermilab is expected to

[5]One electron volt is the amount of energy gained by a particle (such as an electron or proton) as it moves across an electric potential of 1 volt.

[6]Each particle has, in effect, a partner, called an antiparticle, which is identical except that all charge-like properties are opposite to those of the particle.

[7]One of two classes of particles believed by physicists to be truly elementary.

[8]These particles are thought to be carriers of the weak force.

[9]An earlier project known as the "Energy Saver" laid the groundwork for Fermilab's accelerator to eventually achieve the 2 TeV goal.

be the highest energy proton accelerator in the world. At Stanford, DOE is supporting a project known as the Stanford Linear Collider, which is intended to increase the energy level of the existing accelerator from 32 GeV to 100 GeV by colliding electrons with positrons (the antiparticle "partners" of electrons). When operations begin in fiscal year 1987, the Stanford Linear Collider will attempt to address some of the same scientific questions as those being addressed by proton accelerators. According to HEPAP, electron/positron colliders have one inherent advantage over proton machines and that is the ability to produce "clean" experiments (i.e., those without large background radiation), which makes it easier to observe the aftermath of particle collisions.[10]

Beyond these ongoing upgrades, the high-energy physics program's highest priority over the next several years is to build a new colliding beam accelerator—the Superconducting Super Collider—to collide proton beams at combined energies of 40 TeV (or 20 TeV in each beam). As shown in table 1.1, the total cost of high-energy physics planned facilities and upgrades, as estimated by the DOE program office in briefings and various documents, is nearly $4.5 billion.[11]

Table 1.1: High-Energy Physics Projects as of December 1985

Dollars in millions

Project	Location	Status	Total project cost proposed by DOE
Booster	Brookhaven National Laboratory	Under construction	$ 22.6
Tevatron I & II	Fermilab	Under construction	211.8
Stanford Linear Collider	Stanford Linear Accelerator Center	Under construction	139.3
Superconducting Super Collider	To be determined	Research prior to construction	4,100.0[a]
Total			**$4,473.7**

[a]Preliminary cost estimate. A more precise estimate is currently being developed by DOE.

In addition to the projects shown above, each of the nuclear physics facilities are planning to upgrade or increase, or are in the process of upgrading or increasing, the energy level of their respective accelerators. The cost of the largest upgrades (those exceeding $10 million)

[10]Report of the HEPAP Subpanel on Advanced Accelerator R&D and the SSC (DOE/ER-0255, Dec. 1985).

[11]All amounts are in fiscal year 1985 dollars except in the case of the Isabelle project discussed in ch. 3.

range from $11 million at Yale and Argonne to $16.8 million at the Brookhaven National Laboratory. In addition, DOE is considering two large projects recommended by NSAC.

NSAC and DOE nuclear physics program officials say their highest priority is to build a new accelerator called the CEBAF at Newport News, Virginia. At an energy level of 4 GeV, CEBAF would be the highest energy nuclear physics electron accelerator in the United States.

DOE has not indicated its priorities for building new facilities or upgrading existing ones beyond CEBAF. However, NSAC, in its December 1983 report entitled A Long Range Plan for Nuclear Science, has recommended building a Relativistic Heavy Ion[12] Collider as the program's second priority after CEBAF. In August 1984, the Brookhaven National Laboratory submitted a proposal to build a Relativistic Heavy Ion Collider that would use the facilities of a previously canceled project known as the Intersecting Storage Accelerator, or Isabelle. If approved by DOE, Brookhaven would build a colliding beam accelerator with an energy level of 100 GeV in each beam.

Following CEBAF and the Relativistic Heavy Ion Collider, and if financial resources are available, NSAC's third priority is to build a 10- to 30-GeV proton accelerator. Responding to the NSAC third priority, the Los Alamos National Laboratory, in December 1984, proposed upgrading its existing facility with a project called the Los Alamos Meson Physics Facility II (LAMPF II), which it had been working on prior to December 1983. If approved by DOE, LAMPF II would increase the energy of the existing accelerator from 800 million electron volts (MeV) to 45 GeV. As shown in table 1.2, the total cost of these ongoing and planned projects as proposed by DOE and the accelerator facilities is about $1 billion.

[12]Heavy ions are particles made up of three or more protons and enough neutrons to make the ion stable.

Table 1.2: Nuclear Physics Projects as of December 1985

Dollars in millions

Project	Location	Status	Total proposed cost[a]
LAMPF II	Los Alamos National Laboratory	Research prior to construction	$452.0
Argonne Tandem/ Linac Accelerator System	Argonne National Laboratory	Completed Sept. 1985	11.0
Brookhaven: Transfer Line	Brookhaven National Laboratory	Under construction	16.8
Relativistic Heavy Ion Collider		Research prior to construction	268.5
Yale University Upgrade	Yale University	Under construction	11.0
CEBAF	Newport News, Va.	Research prior to construction	217.6
Total			**$976.9**

[a]Includes amounts proposed by DOE and/or a DOE facility.

Importance of Timely and Complete Cost Information

Government policy-makers and managers are facing formidable financial management challenges in today's complex economic, political, and social environment. Demands to fund current programs, as well as provide for new investments in national defense and other needs, in a resource-scarce financial environment make allocating limited federal dollars increasingly difficult. Faced with implementing recently passed legislation aimed at eliminating the budget deficit, federal decision-makers will require, more than at any other time in the past, timely and complete knowledge of the cost of government services and projects.

The Balanced Budget and Emergency Deficit Control Act (Public Law 99-177, commonly known as the Gramm-Rudman-Hollings Act) requires the federal government to reduce and eventually eliminate the federal budget deficit. To achieve this end, the act provides a timetable and deficit ceilings that must be met by the federal government, starting in fiscal year 1986 and lasting until fiscal year 1991 when a balanced budget is supposed to be achieved.

To help manage and control government expenditures, the Congress and decision-makers in the executive branch require complete and timely cost information to assess the need, affordability, and priority of the projects proposed for funding. The Office of Management and Budget (OMB) has stressed the importance of providing accurate and timely cost

information to federal decision-makers for this purpose. For example, OMB's budget guidance to federal agencies recommends that requests for major procurement and construction programs provide for "full funding" of their entire cost. OMB also recommends that federal agencies avoid a premature commitment of funds to projects by communicating the need for the projects in their budget submissions to the Congress at the earliest possible date.[13]

We have recognized the need to improve the government's cost information to help control the cost of government. In a report entitled Managing the Cost of Government—Building an Effective Financial Management Structure (GAO/AFMD-85-35, Feb. 1985), we noted a number of problem areas in the federal financial management system, including the lack of reliable cost information on government activities in general, as well as the lack of consistent and complete information on the cost of projects. As noted in our report, all too often the government's cost information is incomplete, inconsistent, and unreliable. To help federal decision-makers better manage federal resources, we stressed the importance of complete, reliable, and consistent cost information.

Objectives, Scope, and Methodology

As requested by Senator Johnston in his May 3, 1985, letter, and as subsequently agreed to with his office, the objectives of our audit were to provide information on the

- extent to which DOE incurs preconstruction costs on major accelerator upgrades and new facilities that are not clearly identified for congressional approval and
- total cost of the upgrades and/or new facilities in comparison to the amounts DOE reported in its budget submissions to the Congress.

To fulfill these objectives, we obtained internal DOE regulations and guidelines regarding the use of research and development; operating, plant, and capital equipment; and construction funds. We discussed these regulations and guidelines with DOE officials to determine their application to high-energy and nuclear physics accelerator projects.

To determine what costs should be included in the total cost of an accelerator project, we reviewed criteria available in OMB and DOE internal

[13]Preparation and Submission of Budget Estimates (OMB Circular A-11, June 1985); Major System Acquisitions (OMB Circular A-109, Apr. 1976); and OMB's implementing Office of Federal Procurement Policy Pamphlet No. 1 (Aug. 1976).

regulations and budget guidance documents. These regulations and documents did not provide detail on the types of costs that should be associated with an accelerator project; however, they did state that, for budgetary purposes, a project should include all the necessary elements, together with their associated costs, to achieve a specific, identifiable upgrade or new facility. For accelerator projects, we interpreted "necessary elements" to include project-related research and development prior to and during construction, preoperating and start-up costs, design and construction costs, and equipment necessary to make the upgrade or new facility complete and operational at the higher energy level. Excluded from total costs are generic research and development costs for components that have not specifically been identified for use with a specific upgrade or new facility.

To obtain information on the total cost of DOE high-energy and nuclear physics accelerator projects, we initially obtained, from DOE headquarters in Germantown, Maryland, background and financial information on projects—ongoing, planned, and proposed—that were identified in our April 1, 1985, report. Those projects are: the Superconducting Super Collider; the Fermilab upgrade (Tevatron I and Tevatron II); the Stanford Linear Collider; Los Alamos National Laboratory's LAMPF II; Brookhaven's Relativistic Heavy Ion Collider, Transfer Line, and Booster; the Argonne Tandem/Linac Accelerator System; Yale University's upgrade; and CEBAF.

To obtain information on the amount of funding and the scope and purpose of each project, we visited sites for all the listed projects, held discussions with project officials, and obtained supporting documentation. CEBAF was visited as part of a separate, concurrent audit effort, and the detailed information on CEBAF contained in this report was obtained from that effort.

For the projects having total costs estimated by DOE and/or its facilities to be $50 million[14] or more (the Superconducting Super Collider, Stanford Linear Collider, Fermilab upgrade, CEBAF, Relativistic Heavy Ion Collider, and LAMPF II), we obtained information on the amount of funds used for specific components. This information was obtained to enable us to calculate the total estimated cost of these projects. Verification of the cost data at each site was limited to identifying what is included in the cost estimate and assuring that all applicable components are included in the projects' total estimated cost. We accomplished this at

[14]This amount, along with other criteria, represents DOE's threshold for identifying a major project.

each project location by reviewing project proposals, project planning documents, independent cost estimates where available, cost reports, and budget data and by discussing the material contained in these documents with facility officials. We also interviewed officials at DOE's Office of Management and Administration to determine their involvement and responsibility in overseeing the projects.

All cost data in this report are in fiscal year 1985 dollars with the exception of the Isabelle project, which is presented in actual (year of expenditure) dollars. Consequently, the amounts shown may not be the same as in the DOE documents from which they were derived. Conversion of prior years' cost data to fiscal year 1985 dollars was accomplished by using the gross national product implicit price deflator for the United States as compiled by Chase Econometrics from U.S. Department of Commerce data. Planned or future expenditures that were stated in actual dollars were converted to fiscal year 1985 dollars using DOE's August 1985 cost-inflation index. This index is used by DOE's facilities to derive planned project cost estimates beyond fiscal year 1986.

We performed our review from May to December 1985. Our review was performed in accordance with generally accepted government auditing standards.

Need for More Complete Disclosure of Costs Being Incurred on Accelerator Projects Prior to Congressional Approval

Using primarily operating funds, DOE begins funding research and development for high-energy and nuclear physics accelerator projects several years before construction is authorized by the Congress. This research and development is expected to cost about $440 million for upgrades and planned new accelerators, like the Superconducting Super Collider, covered in our review. DOE's budget to the Congress has not identified most of that amount—about $352 million—as preconstruction costs. Because preconstruction costs are not fully disclosed, the Congress is not directly informed of the nature and extent of such costs. Such costs could become substantial for one or more projects that the Congress may not wish to fund or approve for construction. The need to disclose the preconstruction cost is even more pressing today in light of the recently passed Public Law 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985, (commonly referred to as the Gramm-Rudman-Hollings Act), which intends to eliminate the federal budget deficit by 1991.

This chapter discusses (1) how accelerator projects are approved and funded, (2) the cost and nature of DOE's investment prior to construction, and (3) the importance of DOE identifying the projects promptly to the Congress prior to incurring large costs.

Expenditures for Accelerator Projects Begin Before Project Approval

Progress in physics research is often linked to advances in accelerator and detector technology. To ensure optimal future experimental capabilities, DOE encourages its accelerator facilities to perform generic research aimed at (1) improving their existing accelerators and (2) developing new accelerators. This research is directed at a broad range of areas, including developing new and improved concepts, techniques, and devices to accelerate, store, and transport particle beams; and to detect and measure the results of colliding beam and fixed target particle collisions. In addition, DOE facilities perform research and development in response to a specific need or opportunity identified by the physics community or by the facility itself. Such research has been initiated without specific DOE or congressional approval by using operating and/or laboratory discretionary funds. The processes generally followed for funding and initiating such research and development, and obtaining DOE and congressional approval of construction funds, are discussed below.

Both the high-energy and nuclear physics programs provide funds for generic research purposes. DOE's high-energy physics program provides funds specifically for such research under the high-energy technology portion of the operating budget. The nuclear physics program does not

provide its facilities with specific funding for accelerator research. However, the Director of the Office of Nuclear Physics informed us that DOE allows the facility directors to allocate a portion of the physics research budget for this purpose. In addition, the high-energy and nuclear physics facilities have available exploratory research and development funds or discretionary overhead funds[1] that, if approved by the laboratory/facility director, can be used for research on accelerator development.

Research needed to upgrade an existing facility or to build a new facility is initiated in either of two ways. Research on a project can be initiated when one of DOE's physics advisory committees identifies a need for a certain accelerator capability. (The proposed CEBAF is an example of this method.) Research on a project can also be started when the accelerator facility director identifies the need to upgrade the existing facility or when research at a facility results in a technological breakthrough. At times, research is initiated without the approval of the applicable DOE physics advisory committee. (The LAMPF II project at the Los Alamos National Laboratory is an example of this method.)

While research and development of a specific accelerator upgrade or a new accelerator project is underway, the facilities submit project proposals to DOE. Acting on the priorities recommended by the advisory committee, DOE submits the highest priority projects for approval by the Congress through the budget process. Of the three nuclear physics projects we reviewed in detail, DOE has submitted only the CEBAF project to the Congress for construction funding. For the high-energy physics program, DOE has not yet requested construction funds for the Superconducting Super Collider, but it is considering construction of that project to begin in fiscal year 1988.

Over the life of a project, starting from the time project-related research and development is initiated, or a specific upgrade is identified, to when all the necessary equipment is installed and the accelerator begins operation, facilities may have as many as five different types of funds available. Initially, the facilities may use operating funds either provided directly by DOE or obtained from laboratory discretionary amounts for research and development of accelerator component prototypes and for

[1]Discretionary overhead funds are those obtained by assessing a charge to the budgets of various programs funded by DOE at that facility. Such funds are disbursed at the discretion of the facility director and are used for research on new accelerator technology or for other purposes. Our Office of the General Counsel is examining whether the facilities' use of discretionary overhead funds for accelerator research purposes represents a proper application of appropriated funds.

conceptual design studies. When ready for construction, DOE submits (1) a budget request to the Congress asking for construction funds and (2) a construction project data sheet, which describes, justifies, and estimates the cost of the project.

Once construction is approved by the Congress, a second source, line-item construction funds, may be used for the accelerator, to construct buildings, tunnels, and related facilities. Concurrent with the construction effort, operating funds may continue to be used to perform research and development to optimize the design of components and systems for cost effectiveness, performance enhancement, and operating ease and reliability. Also, the facilities often use a third type of funding, capital equipment funds, to build detectors and purchase computer equipment. Finally, DOE facilities use two additional funding types—accelerator improvement project funds and general plant project funds—to support their accelerator projects. These latter funding types are usually intended to maintain the facility and enhance its operation.

The remainder of this chapter discusses preconstruction costs. Costs incurred for accelerator projects during and after construction are discussed in chapter 3.

Preconstruction Costs of Accelerator Projects

Costs for research and development incurred before congressional approval of an accelerator project's construction can be substantial. For most DOE accelerator projects, the total amount of preconstruction research and development costs is not readily identifiable in the DOE budgets sent to the Congress. For the projects we analyzed, we determined that DOE has spent or plans to spend about $440 million prior to construction. About $352 million of this amount has yet to be appropriately identified as preconstruction project costs in DOE's annual budgets to the Congress.

High-Energy Physics Projects

The actual and planned preconstruction costs of the high-energy physics projects we reviewed amount to $360 million. About $283 million of this cost has not been identified by DOE as project-related preconstruction costs in its budget submissions to the Congress. These costs are shown in table 2.1.

Table 2.1: Estimated Preconstruction Costs of High-Energy Physics Projects as of December 1985

Dollars in millions

Project	Total preconstruction cost	Preconstruction cost reported	Amounts not identified
Superconducting Super Collider	$120.1	$ 57.9[a]	$ 62.2
Tevatron I & II (Fermilab Upgrade)	197.6	16.4	181.2
Stanford Linear Collider	42.3	2.7	39.6
Total	**$360.0**	**$ 77.0**	**$283.0**

[a]Includes $18.6 million from reprogrammed funds for the Isabelle project in fiscal year 1984.

Source: Compiled by GAO from data furnished by DOE and its facilities.

Superconducting Super Collider

For the Superconducting Super Collider, DOE has not identified in its budget $62.2 million that includes (1) $35.3 million requested by the Central Design Group[2] for fiscal year 1987 specifically for the project, (2) about $23.7 million in planned expenditures by the DOE facilities for project-related research through fiscal year 1987 that are covered in agreements with the Central Design Group, and (3) $3.2 million in costs planned by the DOE facilities through fiscal year 1986, which were identified in the budget as capital equipment and generic research. According to the Director of Operations for the Office of High Energy Physics, no estimate was provided in the fiscal year 1987 budget because DOE has not completed its technical review of the project. When this review is completed in the summer of 1986, DOE will be better able to determine the direction and emphasis of the necessary research, including its associated cost. Regarding the $23.7 million for research covered in agreements with the Central Design Group, the Acting Associate Director for the Office of High Energy and Nuclear Physics said that the expenditures will benefit the proposed collider but will not be charged to the project because the research may benefit other future accelerators and would have been conducted regardless of the project.

Other preconstruction costs also associated with the Superconducting Super Collider are more difficult to quantify and are not included in DOE's budget estimate for the project. They include the salaries, travel, and other expenses of scientists from numerous universities and DOE laboratories who were involved in studies, workshops, panels, and task forces related to the Collider project during 1984 and 1985. These costs

[2]The Central Design Group was established by the Universities Research Association to supervise and coordinate the research and development efforts carried out by certain DOE laboratories, universities, and private industry on the Superconducting Super Collider. The Association is a consortium of 56 universities that operates Fermilab under a contract with DOE.

were paid by the scientists' home institutions, some of which were from funds provided by DOE for the physics research programs conducted at these institutions. Neither DOE nor the Central Design Group could estimate the amount of these costs.

In addition, DOE facilities, such as the Brookhaven and Lawrence Berkeley Laboratories, perform research that supports the Collider project but that is not included as part of the project's overall cost. These facilities charge costs to the Superconducting Super Collider only if the Central Design Group recommends and DOE allocates funds specifically for the project. If the research has potential application to accelerators besides the Superconducting Super Collider or is performed as part of a facility's advanced accelerator development program, the costs are not charged to the project.

At Brookhaven, for example, about $14.8 million was budgeted for magnet and refrigeration research and development in fiscal year 1985. Brookhaven allocated about $7 million of this research specifically to the Superconducting Super Collider and related research benefiting the project. The remaining $7.8 million for magnet tooling and other expenditures was allocated to generic research and not to the cost of the project, even though the expenditures, according to the Brookhaven National Laboratory, may benefit the Superconducting Super Collider. Brookhaven officials advised us that these costs have not been charged to the project because the tooling and other research can also be used for other superconducting magnets and could benefit the development of other, as yet unforeseen advanced accelerators.

Tevatron I and II

For the Tevatron I and II projects, DOE identified about $16.4 million in preconstruction costs in the construction project data sheets that it submitted to the Congress.[3] In addition, an earlier project called the "Energy Saver" was authorized by the Congress for fiscal year 1979 to install superconducting magnets in the Fermilab accelerator. These magnets were designed to (1) reduce the power consumption of the accelerator and (2) lay the groundwork for ultimately increasing the beam energy from 400 GeV to 1 TeV. DOE and Fermilab officials recognize the Energy Saver project as the first step toward developing the Tevatron projects and reaching the combined 2 TeV objective for the overall Fermilab

[3]DOE started constructing the Tevatron I project in fiscal year 1981. DOE's budgets through fiscal year 1983 showed $10.5 million in preconstruction costs incurred for the project. DOE did not disclose any preconstruction costs in its subsequent fiscal year budgets.

upgrade. The proposed conversion to a 1 TeV accelerator was identified in DOE's fiscal year 1979 construction project data sheets for the Energy Saver, but it was not discussed in subsequent budget documents for the Tevatron projects. Counting the cost of the Energy Saver, the preconstruction costs of the Tevatron projects are $197.6 million, as compared to the $16.4 million that DOE identified to the Congress.

A DOE official in the Division of Construction, Environment, and Safety stated that the Energy Saver project was not included as part of the Tevatron projects because the risks associated with superconducting magnets made a step-by-step approach prudent. When the Energy Saver project was approved, building superconducting magnets was considered to be high risk. To minimize the risk, DOE decided to fund the overall Fermilab upgrade in phases, starting with the Energy Saver. Only when the uncertainties associated with the superconducting magnets were resolved did DOE decide to proceed with the remaining phases of the project.

Stanford Linear Collider

The Stanford Linear Collider's preconstruction cost is $39.6 million more than DOE identified in the construction project data sheets that it submitted to the Congress. DOE began funding research related to developing components for the new collider concept in 1980. According to Stanford records, about $29.8 million in operating funds was spent on the project prior to construction. In addition, we noted that between 1980 and 1983, approximately $9.8 million was spent for upgrading existing laboratory facilities and beginning research and construction on detectors for the project. These costs have not been allocated to the project because, according to the Acting Associate Director of the Office of High Energy and Nuclear Physics, the Stanford Linear Collider was not officially a project until construction was authorized by the Congress.

Nuclear Physics Projects

The three proposed nuclear physics projects are expected to incur substantial preconstruction costs before DOE requests construction funds. The preconstruction costs associated with upgrades at Brookhaven and Los Alamos, as well as with building the new CEBAF facility at Newport News, Virginia, are expected to amount to $80.2 million. DOE has reported $11.2 million in preconstruction costs for CEBAF and the Relativistic Heavy Ion Collider, but it has not identified any of the remaining $69 million in preconstruction costs. The Acting Associate Director for the Office of High Energy and Nuclear Physics told us that his office did not specifically identify these costs in the budget because DOE has not

yet approved their construction. Table 2.2 shows the amounts DOE has specifically identified and total estimated preconstruction costs for these three projects.

Table 2.2: Estimated Preconstruction Costs of Nuclear Physics Projects as of December 1985

Dollars in millions

Project	Total preconstruction cost	Preconstruction cost reported	Amounts no identifie
CEBAF	$ 9.4	$ 9.4	$
Relativistic Heavy Ion Collider	16.8	1.8	15.
LAMPF II	54.0	.0	54.
Total	**$80.2**	**$11.2**	**$69.**

Source: Compiled by GAO from data furnished by DOE and its facilities.

CEBAF

For the CEBAF project, DOE has fully identified project-related costs in the budget. In its fiscal year 1987 budget, DOE disclosed all the preconstruction costs it provided to the Southeastern Universities Research Association[4] for project-related research.

Relativistic Heavy Ion Collider

DOE has not yet decided to build the Relativistic Heavy Ion Collider project. Consequently, it has not submitted a construction project data shee for the project. In total, Brookhaven expects to incur about $16.8 million[5] in preconstruction costs for research directly related to the Collider, of which $1.8 million was disclosed in the fiscal year 1987 budget. In addition, Brookhaven has underway two projects to upgrade the existing facility at a cost of $39.4 million. DOE is currently funding both a beam transfer line project and a booster project to start accelerating heavy ions. These two projects are essential for the Relativistic Heavy Ion Collider but are being separately justified to upgrade the existing Brookhaven facility to enable physicists to perform experiments at higher energies. DOE and Brookhaven officials acknowledge that the Brookhaven proposal assumes both of the separately funded projects are underway or completed prior to starting construction of the Relativistic Heavy Ion Collider. If these projects are not built, the Collider's scope and cost would have to be expanded to include these projects.

[4]The Southeastern Universities Research Association is expected to be the operating contractor for CEBAF.

[5]Of this amount, $2.6 million has already been incurred through fiscal year 1985, leaving a balance o $14.2 million to be used.

LAMPF II

DOE has not approved or requested funds specifically for LAMPF II, but $6 million in DOE-provided funds has been spent on the project through fiscal year 1985. Los Alamos National Laboratory officials have developed two scenarios for funding further research prior to construction. Under these scenarios, the Los Alamos National Laboratory plans to spend either $16.3 million or $54 million on LAMPF II before DOE and the Congress approve the project. These officials believe that construction of the LAMPF II upgrade could begin in fiscal year 1988 but acknowledge that a delay in building the CEBAF project may force a similar delay of LAMPF II because funds may not be available to build both facilities at the same time. Consequently, Los Alamos has developed a fallback scenario for building LAMPF II.

Under the first scenario, which assumes that construction begins in fiscal year 1988, about $16.3 million would be spent on research and development before construction. If construction is delayed until fiscal year 1992, because of the time required to construct CEBAF starting in fiscal year 1988 and the possibility of starting the Relativistic Heavy Ion Collider in fiscal year 1989, Los Alamos' fallback scenario is based on performing a greater portion of the necessary research prior to construction. Under this scenario, Los Alamos plans to spend about $54 million for research and a new detector that although ultimately intended for use on LAMPF II, would be used initially on the existing accelerator.

DOE Needs to Inform the Congress of Major Systems and Major Projects Before Committing Large Resources

To assure that the Congress is provided with complete information on the investments being made in accelerator projects prior to construction, DOE should promptly identify such projects in its budget submissions. Present internal DOE regulations contain requirements for prompt project identification, but the regulations have not been strictly complied with by the Office of Energy Research for the accelerator projects we reviewed. In some cases, DOE has not promptly identified accelerator projects costing over $50 million. We noted that up to 5 years may elapse from the time research is initiated on a specific upgrade or new facility until the time the project is identified in DOE's budget submission to the Congress.

The internal DOE regulations requiring prompt identification of a project are contained in Major System Acquisition Procedures (DOE Order 5700.3B). This order states that to avoid making a major commitment of funds, offices are required to perform a continuing analysis of the agency's mission and its ability to meet that mission. As soon as that

analysis identifies a deficiency or opportunity in existing agency capabilities, a document called the mission need statement should be prepared for approval by the acquisition executive.[6] This document is required to be prepared before large resources are committed to the project and before solutions to meeting the mission need have been identified. Once approved, this document along with the DOE budget, serves as the primary vehicle for identifying a project to DOE management and to the Congress.

Internal DOE regulations also require identifying large undertakings as either major systems or major projects. The primary distinction between a major system and a major project is the level of decision-making within DOE on matters pertaining to the undertaking, such as whether it should be allowed to proceed or be modified in terms of scope and performance specifications. DOE Order 4240.1E, Designation of Major System Acquisitions and Major Projects (May 14, 1985), requires that a project be designated as a major system if the total estimated government share of the research cost leading to a specific upgrade exceeds $50 million in the advanced research and development phase[7] or if the total estimated project cost exceeds $200 million. A project can also be designated as a major system on the basis of its national urgency, importance, size, complexity, or recommendation by a program office. A major project, on the other hand, should be identified as such if its estimated total cost is between $50 million and $200 million and/or it has high visibility and potential adverse environmental impacts.

Decisions regarding major systems are made by the acquisition executive, whereas decisions on major projects are usually made by the cognizant program assistant secretary. For the nuclear and high-energy physics programs, major project decisions are made by the Director, Office of Energy Research, who reports directly to the Secretary of Energy.

Although some projects we reviewed have been designated by DOE's Office of Management and Administration as either major systems or projects, our review showed that such a designation was not always prompt. In one instance, as shown in table 2.3, this designation was

[6]The acquisition executive is currently the Assistant Secretary, Office of Management and Administration.

[7]The advanced research and development phase is defined as the effort that should ultimately lead a particular application or product.

made after more than 5 years of research had been conducted on the project, with related expenditures.

Table 2.3: Accelerator Project Designation Dates

Project	Project-related research start date	Major project or system designation date
Tevatron I and II	1975	Mar. 26, 1981
Stanford Linear Collider	1980	May 6, 1983
LAMPF II	1983	Pending
CEBAF	1984	Apr. 26, 1984
Relativistic Heavy Ion Collider	1984	Pending
Superconducting Super Collider	1984	Mar. 14, 1985

Source: Compiled by GAO from DOE facility and Office of Management and Administration data.

DOE's Office of Energy Research has not prepared mission need statements—the formal mechanism for triggering major system or project designations—for any of these projects. The Fermilab Tevatron projects and the Stanford Linear Collider were designated as major projects by DOE's Office of Management and Administration shortly before the Office of Energy Research started construction. Both the Superconducting Super Collider and CEBAF were designated as major systems by the Office of Management and Administration because the program office estimated that the projects—if approved—would exceed $200 million. The program office, however, has disagreed. The Director, Division of Construction, Environment, and Safety, does not recognize specific upgrades or a new facility as major systems until DOE seeks construction authorization. In this respect, this official believes designation is premature until the Congress approves construction funding.

Conclusion

In view of the importance of timely and complete cost information to controlling the cost of government, DOE needs to provide better preconstruction cost information to the Congress. Actual and planned preconstruction costs of the accelerator projects we reviewed are substantially larger than the amounts DOE has identified to date in its budgets to the Congress. By not promptly identifying these project expenditures prior to construction or by funding portions of an overall upgrade in a piecemeal fashion, DOE allows large investments to be made in a project that has not been approved by the Congress. Thus, we are concerned that large investments may be made in accelerator projects that ultimately may not be approved by the Congress for construction. While we did not

identify examples where the Congress disapproved a major accelerator upgrade or new facility after a significant investment had been made ir preconstruction activities, we believe the Office of Energy Research's failure to promptly identify large projects to the Congress makes a deci sion of this type more likely. In this connection, the Congress, as well a: the executive branch, is faced with implementing recently passed legis- lation aimed at controlling, reducing, and ultimately eliminating federa budget deficits.

To assist in carrying out its oversight and legislative responsibilities, tl Congress needs accurate, up-to-date information concerning the ongoin and planned expenditures for those programs supported by federal dol lars, particularly in light of the tight federal budget and efforts to reduce the federal spending deficit. For DOE's high-energy and nuclear physics programs, this should include prompt identification of actual and planned investments in major accelerator projects prior to construction.

Although internal DOE regulations require prompt identification of maj undertakings, they are not strictly adhered to by the Office of Energy Research. Such identification should take place no later than when the criteria in the DOE regulations are met. Earlier identification is prefer- able, such as when research is started on a specific identifiable upgrad or new accelerator or when projects reach a stage when they are speci enough to be proposed to and/or recommended by the applicable scien advisory committees.

Recommendations

We recommend that the Secretary of Energy require that the Office of Energy Research identify and clearly disclose the preconstruction costs of major accelerator projects in DOE's annual budget submission to the Congress before committing large resources to these projects. To achie this end, the Secretary should direct the Office of Energy Research to follow applicable internal DOE regulations under which major undertak ings should be identified as projects. The Secretary may also want to consider requiring earlier identification, such as at the time research is started or when projects reach the stage at which they are specific enough to be proposed to or recommended by applicable advisory committees.

As discussed in the following section, DOE strongly disagrees with this report and is therefore unlikely to implement our recommendations without further direction. Consequently, we further recommend that t

House and Senate Appropriations Committees include a directive in the DOE appropriations legislation requiring disclosure of accelerator project information in accordance with these recommendations.

Agency Comments and Our Evaluation

We provided draft copies of this report to DOE for comment. DOE disagreed with our findings, conclusions, and recommendations. DOE's specific comments and our responses appear as appendix III. We have summarized DOE's comments relating to the material contained in this chapter:

1. The total estimated costs associated with accelerator projects such as the Superconducting Super Collider, the Relativistic Heavy Ion Collider, and LAMPF II should not be identified in the budget because construction has not been approved by DOE. Until they are approved by DOE, their cost estimates may be inaccurate; and in any event, the estimated costs of some projects have been included in testimony at congressional hearings.

2. Preconstruction research and development costs are included in the budget in the Operating Expenses section. Much accelerator research and development is generic in nature and difficult to identify with a specific project.

3. GAO has included the cost of the separately justified and funded upgrades as preconstruction costs of the Fermilab upgrade, the Stanford Linear Collider, and the Relativistic Heavy Ion Collider.

We support full disclosure of project cost estimates in the budget when projects are first initiated. It is incongruous that DOE does not recognize the inconsistencies in its practice of partial disclosure in the federal budget on the one hand, and on the other, the selective announcements of project cost estimates in congressional testimony. We are recommending a consistent approach to budget reporting. The budget is the place where Congress should be able to find the expected cost of federal undertakings. Partial and piecemeal disclosures in other forums does not, over time, reveal a consistent picture of resource requirements.

Regarding the disclosure in the budget of the total estimated costs of the Superconducting Super Collider, the Relativistic Heavy Ion Collider, and LAMPF II, specific technical and operating parameters have been determined and federal funds have been requested (and expended) for research and development directly related to those projects. Thus, DOE

should have informed the Congress of the total potential cost of these projects. This view is consistent with DOE's internal regulations and, in the current budget environment, is especially important to avoid sizable investments in projects that the Congress ultimately may not wish to fund for construction.

LAMPF II serves as an illustration of the need to promptly identify a project and provide the Congress with complete cost information. About $6 million has already been spent on this project through fiscal year 1985. DOE's comments, however, state that it does not intend to construct LAMPF II. Had DOE specifically provided in the budget pertinent details concerning LAMPF II, the Congress would have been in a better position to evaluate the merits of this project along with the merits of other competing projects, and possibly stop its progress prior to incurring the full $6 million already invested.

It is true that identification of total project costs involves the use of estimates that are gradually improved as more information becomes available. However, the fact that estimates can be improved is not a good reason for providing no estimate at all. The provision of available estimates—or a range of estimates—with appropriate qualifiers or caveats is needed to help the Congress make informed decisions on whether the initial funding for an accelerator project is reasonable.

DOE itself acknowledges the importance of disclosing such information by providing some project cost estimates during congressional hearings. Thus, it is evident that DOE has estimates it considers suitable for presentation to the Congress. Such disclosure, however, is limited in that only certain congressional committees and subcommittees are provided with appropriate project cost information. Presenting such information in the budget submission is needed for comparing various requests for funding and allocating limited financial resources accordingly.

Further, we agree that DOE has included preconstruction research and development expenditures in the Operating Expenses portion of the budget. However, these expenditures are generally not identified as being related to specific accelerators. Thus, the budget submissions do not adequately inform which project is to be provided with preliminary funds.

We disagree with DOE's characterization of preconstruction costs identified in the report as generic and difficult to associate with a particular project. Preconstruction costs included in this report were provided by

DOE's accelerator facilities and were characterized by these facilities as being directly related to the project, which as we noted previously are well-defined, and specific.

In regard to the separately justified, separately funded projects, the circumstances in each case are different and warrant separate discussion. We believe that the Energy Saver's costs are an integral part of the costs for the overall Fermilab upgrade. HEPAP, in an untitled July 1980 report (DOE/ER-0066) stated that "although the Energy Saver-Tevatron I-Tevatron II projects have been defined as three separate construction projects, they represent one integrated program to be accomplished in three phases. . .". In addition, although construction was completed on the Energy Saver in 1982, a Fermilab official informed us it has never operated as a 500 GeV stand-alone accelerator for physics experiments.

The inclusion of the costs associated with a separately funded upgrade as preconstruction costs for the Stanford Linear Collider was based on information provided by Stanford Linear Accelerator Center officials. Officials at the Center identified this project as a preconstruction cost of the Stanford Linear Collider.

With regard to the Relativistic Heavy Ion Collider, we note that the Tranfer Line and the Booster are prerequisites for the operation of the Collider. In the proposal for the Collider, which was submitted to DOE, Brookhaven has assumed completion of these separately funded projects. If they are not carried out, the cost of the Collider project would have to be increased and the scope expanded to provide similar capability. The cover letter to the proposal identified these upgrades as essential to the Collider project. Given their importance to the Collider project, in our draft report we included them as preconstruction costs for the Collider. However, since the Transfer Line and the Booster may be used to conduct experiments separate from the Collider, as noted in DOE comments, we have revised our cost estimate for the Collider project to exclude the cost of these two upgrades.

The Congress Needs Better Information on Total Accelerator Project Cost and Associated Technical Uncertainties

The total cost of accelerator projects and the risks associated with their construction and use are important elements in determining whether such projects should proceed. The Congress and the executive branch rely on information provided to them on costs and technical uncertainties to make timely decisions on a project's need, affordability, and priority. Our review showed, however, that information provided to the Congress in DOE's budget on the total costs and technical uncertainties involved in accelerator projects is fragmented, incomplete, and untimely. DOE's budget does not clearly identify, in one place, the full cost of a project and technical uncertainties of the necessary components before DOE commits resources to the project. The total cost of the accelerator projects we reviewed is about $6.3 billion more than DOE and its facilities reported because the preconstruction costs for the projects (discussed in ch. 2) and other essential components, such as detectors and computer equipment necessary to conduct experiments, are separately funded. Also, information provided to the Congress often did not fully disclose the existence or significance of technical uncertainties that could affect the project's success.

Full Cost of Accelerator Projects

For the high-energy and nuclear physics projects we reviewed, DOE's budget reported a cost of about $0.6 billion for the projects. Other DOE data, however, showed that the total cost of these same projects could be as much as $6.9 billion, or about $6.3 billion more than the costs reported by DOE in the budget.

High-Energy Physics Projects

For the high-energy physics projects, the estimated cost of ongoing and planned projects may be almost $5.4 billion more than DOE reported in the budgets furnished to the Congress. A summary of the projects' costs is shown in table 3.1.

Table 3.1: Total Estimated Costs of High-Energy Physics Accelerator Projects as of December 1985

Dollars in millions

Project	Total amount	Amounts reported in budget	Amounts n identifie
Superconducting Super Collider	$4,961.6	$ 57.9	$4,903
Tevatron I and II	579.0	211.8	367
Stanford Linear Collider	264.4	139.3	125
Total	**$5,805.0**	**$409.0**	**$5,396**

Source: Compiled by GAO from data furnished by DOE and its facilities.

Superconducting Super Collider

For the Superconducting Super Collider, DOE's budgets through fiscal year 1987 have yet to show the project's total cost.[1] In August 1984, DOE's Office of Management and Administration issued a report on the cost of the Superconducting Super Collider at the Secretary of Energy's request. In that report, the Office of Management and Administration estimated the cost of three design options for the project. For the design option that most closely approximates the design DOE is currently considering, the DOE Office of Management and Administration estimated the construction cost of the project to be $3.5 billion.[2]

The Office of Management and Administration staff noted that their estimate was based on the project's design assumptions being met by the research program. If some or all of the assumptions prove to be unrealistic, the Office of Management and Administration cautioned that the project's cost estimate would be higher. For example, in comparing the proposed magnets with what is currently available, the Office of Management and Administration noted that (1) the accelerator's beam size must be reduced by one-half (if it has to be larger, magnet cost will increase), (2) cooling systems must be improved to reduce refrigeration costs, (3) wires used in the magnets must be developed to carry 30 percent more current (if not, more wire, which is very expensive, will be required), and (4) cost of magnets in general must be reduced by one-half.

In addition, other costs for the Superconducting Super Collider were not included in the Office of Management and Administration's cost estimate. The Superconducting Super Collider is being designed with provisions for six experimental areas. As such, as many as six detectors and computing equipment costing as much as $0.8 billion will be added. In addition, the Superconducting Super Collider, if approved, will require

[1]DOE and its contractors have, on several occasions, discussed the total cost of the Superconducting Super Collider in congressional hearings. For example, on Feb. 28, 1985, hearings before the Subcommittee on Energy Development and Applications, House Committee on Science and Technology, the Director of the Central Design Group estimated the cost of the project at about $4.1 billion, including construction, preoperating costs, research, and the initial complement of detectors and computers.

[2]On Apr. 30, 1985, in hearings before Subcommittee on Energy Research and Development, Senate Committee on Natural Resources, the Office of Energy Research estimated the construction cost of the Superconducting Super Collider at $3 billion. The major cause for the cost difference was less optimistic assumptions on the construction costs of the project, including the fabrication and installation of the superconducting magnets and contingencies. While the program office has not responded to the Office of Management and Administration report, a representative from the Division of Construction, Environment, and Safety advised us that the differences between the two estimates is not unusual for a project as large as the Superconducting Super Collider, especially considering the project site had not yet been selected. According to this DOE official, unique characteristics of the site selected and in manufacturing the superconducting magnets may affect the cost of the project, the extent of which cannot be precisely predicted.

$.47 billion in research and preoperating expenses after construction is initiated. Counting these and the $120.1 million in preconstruction cost (as discussed in ch. 2), the total estimated cost of the Superconducting Super Collider is about $4.9 billion.

Tevatron I and II (Fermilab Upgrade)

The estimated cost of the Tevatron projects is $367 million more than DOE estimated in the most recent budget submission for the projects.[3] The costs not reported include separately funded projects that are projected to cost about $127.7 million for two detectors and $180.6 million for the Energy Saver. In addition to $37.4 million in other project-related costs, DOE's fiscal year 1986 budget includes a request for a $21.5 million computer upgrade for Fermilab to record and analyze the data obtained from conducting experiments using the higher energy Tevatron upgrades.

Stanford Linear Collider

With respect to the Stanford Linear Collider, our review showed that this project will cost $125.1 million more than the amount DOE reported in its budget request to the Congress. Not included in DOE's reported total cost for the project are detectors and other associated costs to make the project complete and operational. DOE must add a new detector—the Stanford Large Detector—and upgrade an existing detector—the Mark II—to allow physicists to record the experimental results at the higher energy level. Stanford officials estimate the costs of upgrading the Mark II and building the new detector to be $74 million. In addition, DOE incurred $39.6 million in preconstruction costs, about $0.7 million in other project-related costs to upgrade the facility, and plans to incur $10.8 million in preoperating and start-up costs that were not included.

Nuclear Physics Projects

For the three proposed nuclear physics projects, DOE reported in its budget about $219.4 million in costs for the projects. Our work showed the total cost of the same projects to be about $1,128.9 million, or about $910 million more, as shown in table 3.2.

[3]DOE's most recent construction project data sheets for the Tevatron I and II projects are in the fiscal years 1986 and 1985 budgets, respectively.

Table 3.2: Total Estimated Costs of Nuclear Physics Accelerator Projects as of December 1985

Dollars in millions

Project	Total amount	Amounts reported in budget	Amounts not identified
CEBAF	$ 247.6	$217.6	$ 30.0
Relativistic Heavy Ion Collider	273.3	1.8	271.5
LAMPF II	608.0	-0-	608.0
Total	**$1,128.9**	**$219.4**	**$909.5**

Source: Compiled by GAO from data furnished by DOE and its facilities and discussions with facility officials.

As noted in chapter 2, DOE has committed resources to all these projects but has approved only the CEBAF project for construction. We estimated the cost of CEBAF at about $247.6 million using DOE's fiscal year 1987 budget request and a subsequent study. DOE's cost for CEBAF includes all the necessary preconstruction research and equipment but excludes about $30 million in preoperating start-up costs for the project.

Brookhaven's proposal to build a Relativistic Heavy Ion Collider is based on using the tunnel, cooling equipment, and other facilities of the canceled Isabelle project.[4] Not counting the cost of using these facilities and equipment, and the two separately funded and justified projects (discussed in ch. 2), the total estimated cost of building the Relativistic Heavy Ion Collider is $273.3 million. DOE has identified $1.8 million in costs associated with the Relativistic Heavy Ion Collider in its budget.

The LAMPF II project's total cost may be $608 million if construction is started in 1992. According to the Project Director for the LAMPF II, the Los Alamos National Laboratory estimates LAMPF II will cost $452 million for construction,[5] $60 million for preoperating and start-up costs, $54 million in research and detector costs prior to construction (discussed in ch. 2), $40 million for detectors to be added after construction, and $2 million for computer costs. DOE has yet to identify any costs for LAMPF II in its budget.

[4]Because of problems associated with superconducting magnets, two new facilities that were coming on-line that could meet the capability of Isabelle, and the need to provide funds for the Superconducting Super Collider, DOE canceled the project in October 1983 after more than $200 million (in year of expenditure dollars) had been invested.

[5]LAMPF II's construction cost was discussed in hearings before the Subcommittee on Energy and Water Development, Senate Committee on Appropriations, on Apr. 19, 1985.

Need to Disclose the Full Cost of Accelerator Projects

New accelerator projects could cost as much as several billion dollars to build. In deciding whether to fund a new accelerator project, the Congress and executive branch must assess (1) the need, (2) the most cost effective alternative, and (3) what trade-offs affecting other programs are necessary, considering overall national priorities. Such assessments depend on complete project cost estimates to a far greater extent than in the past as the Congress and executive branch explore ways to eliminate the federal budget deficit.

DOE's budget guidance (Internal Review Budget Process, October 31, 1984) provides that the total cost of the project be shown by including all the costs necessary to make the project complete and operable, such as research, start-up, and training costs. If funds are used to build equipment that is related to the programmatic effort—in this case, to perform experimental physics research—the DOE guidance requires reporting an annual estimate of the capital equipment needs. The DOE guidance also states that if a project is deemed to be an intermediate phase of a long-range project, the relationship between the project and the foreseeable planned capacity should be identified. In addition, DOE's Accounting Practices and Procedures Handbook (DOE/CR-0009) states that construction project data sheets—which describe, justify, and estimate the cost of projects—shall include all improvements and equipment required to make the completed facility operable.

Based on our interviews with DOE officials, we believe the reason why the full cost of accelerator projects is not being reported is that DOE lacks a clear definition of a project. As defined in its internal regulations,[6] a project is:

". . . a unique major effort within a program which has a firmly scheduled beginning, intermediate, and ending date milestones, prescribed performance requirements, prescribed costs, and close management, planning, and control. A project is a basic building block in relation to a program. It is individually planned, approved, and managed but is not constrained to any specific element of the budget structure; e.g., operating expense or plant and capital equipment. Construction, if required, is part of the total project. Authorized and at least partially appropriated projects, will be divided into three categories, major systems acquisitions, major projects, and other projects."

The definition lacks specific criteria as to when a project starts and ends and what components should be included. DOE's physics program offices have defined an accelerator project to include only the costs incurred

[6]Major System Acquisitions, DOE Order 5700.1C, Sept. 6, 1983.

during accelerator construction. By excluding detectors and other dedicated equipment, DOE's project cost estimates in the construction project data sheets submitted to the Congress have been considerably less than the total cost of accelerator projects. This enables a new facility or an upgrade to appear more affordable in the budget than if the costs for all of the dedicated and necessary components are added to the project total.

While some cost information is disclosed in congressional hearings and other public documents, DOE should also disclose the total cost of a project in its budgets to the Congress before committing resources to the project. DOE's budgets, however, do not disclose the total cost of projects prior to incurring costs. This was evident for the Superconducting Super Collider, the Relativistic Heavy Ion Collider, and the LAMPF II projects we reviewed. Promptly disclosing the total cost of the project in the budget is necessary to make the project visible so that the Congress can make timely decisions on the project's need, affordability, and priority. According to the Acting Associate Director of the Office of High Energy and Nuclear Physics, the total costs of projects are not included in the budget when expenditures begin because a project's cost cannot be precisely determined until the necessary research is completed. While we recognize it may be difficult to estimate precisely the cost of a project in advance, we noted that preliminary cost estimates for projects are available in the project proposals submitted by the accelerator facilities and from information provided by peer reviewers.

Given the availability of this information, we believe DOE should provide the Congress with timely information on the total estimated cost of projects, including all the necessary components. Such information would help the Congress better assess the affordability of the project. As far back as 1978, we expressed concern about the cost of government-wide projects that exceed the amounts for which they were approved.[7] We reported that the cause for this situation was the economic and technical uncertainties surrounding the projects at the time they were first approved. To help deal with this problem, we proposed that federal programs identify the risks associated with projects and then quantify the costs associated with these risks. By providing the Congress with an estimate of a project's cost as well as the project's potential cost range (taking into account the uncertainties), we concluded that information would be available to better assess the project.

[7]See A Range of Cost Measuring Risk and Uncertainty in Major Programs—An Aid to Decisionmaking (PSAD-78-12, Feb. 2, 1978).

A discussion of project technical uncertainties and their implications for project costs is contained in the following section.

Need to Better Inform the Congress of Project Technical Uncertainties

Building new accelerators and upgrading existing ones requires highly technical, state-of-the-art components that must be designed and manufactured to strict specifications so that these machines can operate reliably at their intended energy level. When the necessary research is not completed before construction begins, technical uncertainties increase the probability that their projected performance may not be met and that their estimated costs and time frames may be overrun.

Present internal DOE regulations require program offices to use a step-by-step approach when proceeding from generic research to full-scale development of a project.[8] Outside of the procedure outlined in its regulations, DOE does not have a formal policy that requires completing all the necessary research on accelerator components before starting construction or disclosing the technical uncertainties in the construction project data sheets sent to the Congress.

DOE appears to endorse minimizing the time to develop and then build a new accelerator or upgrade an existing accelerator. According to facility officials for the projects in our review, the highly competitive environment in which the high-energy and nuclear physics programs operate requires bringing new projects or upgrades on-line as soon as possible. In meeting this objective, the DOE facilities perform research before and during the project's construction. As DOE noted in hearings before the Congress,[9] prior to construction, the research is aimed at (1) developing concepts and technology, (2) determining technical feasibility, (3) reducing construction and operating costs, (4) establishing reasonable cost estimates, and (5) assuring that minimum conceptual design performance specifications can be met.

DOE also noted in the same hearings that after construction is started, the research and development effort is continued to optimize the design of components and systems in terms of effectiveness, improved performance, operating ease, and reliability. For the larger projects, some of the components and systems are manufactured on a phased schedule

[8]DOE regulations are provided in Major System Acquisition Procedures, DOE Order 5700.3B, Sept. 8, 1983.

[9]Hearings before the Subcommittee on Energy and Water Development, Senate Committee on Appropriations, Apr. 19, 1985.

after construction is started, and much of the research during construction is related to these components and systems. We believe some of this research during construction is intended to minimize the time to develop and then build the project.

The concurrent manner in which research and construction is conducted makes building accelerator projects risky. The importance of adequately disclosing such technical uncertainties is illustrated by DOE's October 1983 cancelation of the Isabelle Project after more than $200 million (in year of expenditure dollars) had been spent. DOE started construction on the project even though the required superconducting magnets had not been fully demonstrated. DOE did not formally inform the Congress of the uncertainties associated with that project even though drafts of the project plan as far back as March 1980 identified the project as very risky. Up to the time DOE canceled the project, DOE had not approved the project plan even though the plan is required by internal regulation.[10]

Both the Stanford Linear Collider and Tevatron projects are examples of projects for which DOE could have provided better information to the Congress before starting construction. As discussed below, technical problems associated with the development of these projects may cause these machines to operate at less than their full design capacity or require substantial additional investments by DOE.

Technical Uncertainties Associated With the Stanford Linear Collider

DOE performed a substantial amount of the research and development on components before initiating construction of the Stanford Linear Collider. However, DOE technical consultants have reported to DOE that not all the research on components had been completed when the project was approved for construction. DOE's fiscal year 1984 construction project data sheet stated that

"Since the SLC [Stanford Linear Collider] is a new type of colliding beam device, there are some uncertainties in the final performance level of the machine. The HEPAP subpanel notes some of the factors which could lead to lower than design reaction rate, as well as some possibilities for higher than design performance. Many of these factors are such that tests with the full facility are required for their evaluation. We have, therefore, restricted the conventional facilities for the project and the scope of the initial physics detector facilities to the minimum required to develop the linear collider technique and to explore the physics potential."

[10]Requirements for a Project Plan are contained in Major System Acquisition Procedures, DOE Order 5700.3B, Sept. 8, 1983. Prior to this regulation, DOE Order 5700.3A, Major System Acquisition Procedures, Aug. 6, 1982, also required that a project plan be prepared for major projects and systems.

Although the Congress was notified of uncertainties in the performance of the project, DOE did not include the potential implications for operating costs.

After construction was started in October 1983, DOE encountered difficulty in building highly complex components called klystron tubes.[11] The Stanford Linear Accelerator Center encountered difficulty in getting the klystron tubes to withstand the high voltages necessary to operate the accelerator at the required energy level. If the klystron operating problems could not be resolved, DOE had a fallback plan to substitute two klystrons of the type used in the existing Stanford Linear Accelerator for each one originally planned for the upgrade. In a November 9, 1983, letter to DOE, Stanford officials estimated that it would cost an additional $6 million to use the fallback option. Additionally, Stanford officials informed us that the fallback option would substantially increase the operating costs of the facility (an estimate of the increase was not available).

Although internal DOE management reports show that Stanford has since been able to design a klystron tube that will work, DOE is now concerned about the operating lifetimes of the tubes. The operating goal is 10,000 hours for the tubes built in fiscal years 1985 and 1986 and 20,000 hours for the tubes to be built in fiscal year 1987. In an October 1984 letter to the Office of High Energy Physics, the DOE Stanford Site Office expressed concern over the klystron tubes' operating lifetimes. As of May 1985, Stanford had tested only eight tubes. At that time, data to accurately predict the tubes' lifetimes were insufficient. The longest any tube had run at that time was 1,440 hours. Stanford is continuing to test these tubes and plans to have sufficient data by the end of 1985 to calculate their lifetimes. With the cost of rebuilding the klystron tubes estimated at $15,000 per tube, the DOE Stanford Site Office estimated that an additional $20 million annually would be required to operate the Stanford Linear Collider if the operating lifetime of the tubes is only 1,000 hours (the worst case scenario). About 2 years will have elapsed after Congress approved the project before the tubes' lifetimes can be verified.

[11]Klystron tubes are high-frequency power tubes that are programmed to deliver microwave radiation into the accelerator pipe. This action increases the energy of the particles to the desired power level.

Technical Uncertainties Associated With the Fermilab Upgrade

The Tevatron projects require superconducting magnets and antiproton cooling systems that had not been fully demonstrated and were relatively new processes when the Congress approved construction. As a result of technical problems and modified spending schedules, Fermilab has encountered delays in completing the projects. For example, the Energy Saver project, originally scheduled for completion in June 1982, was not completed until May 1983. Similarly, the Tevatron I and II projects were scheduled to be completed in September 1986 and November 1985, respectively. Fermilab officials later estimated the completion dates for these projects to be September 1987 and July 1986, respectively. The delays have been accompanied by substantial increases in the costs for two of these projects, as shown in table 3.3.

Table 3.3: Estimated Cost Increase of Fermilab Upgrade as of December 1985

Dollars in millions

	Energy Saver	Tevatron I	Tevatron II
Revised budget estimate			
Construction	$58.1	$86.3	$52.3
Other related costs	93.6	53.3	19.9
Total project costs	**151.7**	**139.6**	**72.2**
Original budget estimate			
Construction	51.2	43.7	52.2
Other related costs	54.2	24.0	19.7
Total project costs	**105.4**	**67.7**	**71.9**
Cost increase			
Construction	6.9	42.6	0.1
Other Related Costs	39.4	29.3	0.2
Total cost increase	**$46.3**	**$71.9**	**$0.3**

Source: Compiled by GAO from DOE data in construction project data sheets.

Fermilab officials attributed the cost increases to more extensive research and development, costlier construction than originally budgeted, a change to a more expensive beam-narrowing technology, and expanded experimental areas.

In October 1985, Tevatron achieved its first proton-antiproton collision, although the beam energy level was 800 GeV compared with the 1-TeV level for which the upgrade was designed. Beam intensity (the rate of particles reaching the target) for some experiments is also below the level needed for Tevatron II's fixed target experiments. Fermilab plans

to spend $2.5 million in accelerator improvement project funds between fiscal year 1985 and 1988 for magnet replacements, cooling system, and other improvements to achieve the 1-TeV and beam intensity goals. According to a Fermilab official, a $19.3 million fiscal year 1988 line item project to construct an accelerator prebooster may be necessary to achieve the beam intensity goal.

DOE was aware of the technical uncertainties associated with the Fermilab upgrade at least as far back as 1980. A HEPAP report to DOE for that year identified a number of uncertainties related to the superconducting magnets and the antiproton cooling systems. The report recognized that additional research and development support may be required and that the risk of schedule delays in the project was high. Despite these concerns, none of these uncertainties were disclosed in the construction project data sheets provided to the Congress.

Conclusion

Complete and timely information on the total costs of accelerator projects and relevant information on both the technical and financial risks are critical inputs in assessing a project's affordability, need, and priority. The DOE budget, however, is not providing this information to the Congress in a timely manner. As our work indicated, DOE's definition of a project does not include adequate criteria for determining when a project starts and ends and what components must be included. Lacking these criteria, the scope, and hence the cost of a project, can be shown to be more affordable than is actually the case. Also, DOE's budget did not disclose the total cost of projects prior to DOE committing resources to the project and the technical uncertainties with regard to the projects' meeting their financial and technical objectives. Recognizing the high cost of new acclerator projects and their technical complexity, the Congress should be provided more timely and complete disclosure of the full costs and the major technical uncertainties of future accelerator projects. This would allow the Congress to make timely decisions regarding the authorization and appropriation of funds for proceeding with such projects.

Recommendations

We recommend that the Secretary of Energy require the Office of Energy Research to

- clarify the definition of an accelerator project to ensure that specific identifiable upgrades or new facilities include all the necessary components to make the projects complete and operational and

- report complete costs of projects along with their technical uncertainties in the budgets furnished to the Congress so that the projects' need, affordability, and priority can be appropriately evaluated prior to committing resources to the projects.

As discussed below, DOE strongly disagreed with material in this chapter and is therefore unlikely to implement these recommendations without further direction. Consequently, we further recommend that the House and Senate Appropriations Committees include a directive in DOE's appropriations legislation requiring disclosure of accelerator project information in accordance with the above recommendations.

Agency Comments and Our Evaluation

DOE disagreed with the findings, conclusions, and recommendations contained in this chapter. Specific DOE comments and our responses are contained in appendix III. In general, DOE objected to our inclusion of detectors and computer facilities as part of the total cost of accelerator projects. DOE states that such items are disclosed in other sections of the budget. Further, DOE disputes our conclusion that it has not disclosed the technical uncertainties of certain accelerator projects. DOE states that it is not always possible to predict technical problems and that contingency allowances are included in project cost estimates to allow for problems that may arise.

Regarding the inclusion of detectors and computer facilities as a part of total project cost estimates, we found that DOE did not always disclose such costs in the budget. For example, only $4 million—one year's funding—of the cost of detectors for the Stanford Linear Collider was included in the budget. The detectors' actual cost are estimated to be about $74 million. Detectors and computer equipment should be included in the budget as part of the accelerator project's total cost estimate because experiments cannot be conducted using the accelerator unless detectors and computer equipment exist to analyze the experiments. To exclude detectors from the cost estimate understates the cost of the project.

The technical uncertainties discussed in this chapter should not be characterized as unpredictable. Based on the evidence we obtained, all items discussed were known or should have been known early in the development of the project and should have been disclosed to the Congress at an early date. They are of such significant importance that even though contingency allowances were included in the cost estimates, substantial cost overruns still occurred. By disclosing technical uncertainties in its

budget submission at an early date, DOE could provide the Congress much better information with which to determine the advisability of funding the projects. With such disclosure, the Congress would be in a better position to make informed decisions on the merits of project proposals.

Request Letter From the Ranking Minority Member, Subcommittee on Energy and Water Development, Senate Committee on Appropriations

United States Senate

COMMITTEE ON APPROPRIATIONS
WASHINGTON, DC 20510

May 3, 1985

Honorable Charles A. Bowsher
Comptroller General of the United States
General Accounting Office
Washington, D.C. 20548

Dear Mr. Bowsher:

The Department of Energy is currently planning for and/or conducting research and development toward ultimately constructing several large, expensive, high-energy physics and nuclear physics accelerators. Your recent report to me identified these new accelerators to include CEBAF, RHIC, the SSC, and LAMPF II. Your report also identified the planned physical and financial parameters of the accelerators.

The Subcommittee on Energy and Water Development, Senate Committee on Appropriations, is becoming increasingly concerned about these facilities and the manner in which they come to be proposed and approved by the Department. In view of the likelihood of the Department's requesting construction funds for CEBAF as part of the fiscal year 1987 budget request, I am asking that the General Accounting Office provide me with a report describing the events and procedures which led to the CEBAF proposal and DOE's endorsement. Please include a description of the review and selection process for CEBAF and considerations given by the Department and others to cost-effective alternatives.

In addition, I am also aware that millions of dollars are being spent on these accelerators--usually in the form of research and development or operating funds--before they are approved by the Congress as a line-item construction project. I am, therefore, requesting that the General Accounting Office also provide me with a separate report describing the size and nature of the investment in such new facilities--or major upgrades--prior to approval of construction.

Because the Subcommittee is concerned about these matters in relation to future requests for funding, the Subcommittee will need information regarding both of these areas in time for use during deliberations on the Department's fiscal year 1987 budget request--probably around April 1, 1986.

Hon. Charles A. Bowsher, p. 2
May 3, 1985

If you have any questions concerning these matters, please contact Mr. Proctor Jones of the Subcommittee staff on 224-0335.

Sincerely,

J. Bennett Johnston
Ranking Minority Member
Subcommittee on Energy and Water
Development

JBJ/Jt

DOE Nuclear Physics Accelerator Facilities

National Facilities

- Argonne Tandem/Linac Accelerator System, Argonne National Laboratory, Argonne, Ill.
- Bates Linear Accelerator Center, Massachusetts Institute of Technology, Middleton, Mass.
- Clinton P. Anderson Meson Physics Facility (LAMPF), Los Alamos National Laboratory, Los Alamos, N.M.
- Holifield Heavy Ion Research Facility, Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Superhilac/Bevalac, Lawrence Berkeley Laboratory, Berkeley, Calif.
- 88-inch Cyclotron, Lawrence Berkeley Laboratory, Berkeley Calif.
- Tandem/AGS Heavy Ion Facility, Brookhaven National Laboratory, Upton, N.Y.

University-Based Facilities

- A.W. Wright Nuclear Structure Laboratory, Yale University, New Haven, Conn.
- Cyclotron Institute, Texas A&M University, College Station, Tex.
- Nuclear Physics Laboratory, University of Washington, Seattle, Wash.
- Triangle Universities Nuclear Laboratory, Duke University, Durham, N.C.

Advance Comments From the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

Department of Energy
Washington, DC 20585

MAR 10 1986

Mr. J. Dexter Peach
Director, Resources, Community and
Economic Development Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Peach:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled "DOE Accelerators: Their Costs and Technical Uncertainties Should Be Better Disclosed."

See general comment.

The report contains numerous, substantial misstatements; errors of fact and interpretation; and misrepresentations that render the conclusions invalid. The report makes two erroneous fundamental assertions that are repeated throughout. These are (1) that DOE incurs substantial costs for accelerator projects that are not identified in the budget as project-specific costs; and (2) that DOE does not fully disclose in its budget technical uncertainties which could result in cost overruns or increased operating costs. Both of these assertions are incorrect. The cost estimates that GAO used in various instances are not substantiated, and we are not able to verify their source or accuracy. The report contains gross misconceptions on the practice used to identify and request potential new projects. Thus it misleads the reader to conclude that DOE misrepresents to the Congress the estimated costs of its accelerator projects by enormous amounts; in one case by a factor of approximately 90. This is simply unfounded. While this letter addresses briefly our major concerns, detailed substantive comments and corrections are enclosed.

See comment 2.

See comment 1a.

DOE is criticized for not disclosing the full costs of accelerator projects before it commits resources to the project. The report states on page 2 that "GAO estimated the total cost of six of the largest accelerator projects to be about $6.9 billion. DOE, however, has identified only $600 million of these project-specific costs in the budget through fiscal year 1987." This implication that the Department is failing to disclose $6.3 billion of project-specific costs is a gross misrepresentation. The $6.3 billion figure includes: (1) $5.65 billion as the GAO estimate of total project-related costs after construction begins for the Superconducting Super Collider (SSC), the Relativistic Heavy Ion Collider (RHIC), and the

See comments 1b, 1c, and 24.

Los Alamos Meson Physics Facility (LAMPF) II--the Department has not made a decision to request construction authorization for these projects; (2) $0.23 billion for prior projects (Energy Saver, AGS Booster, BNL Tandem/AGS Beam Transfer Line, and SLAC Linac Improvements) which have already been separately justified and approved through the Congressional budget process--GAO appears to believe that their costs should be added also into the cost estimate for follow-on projects (Tevatron, Stanford Linear

See comments 1a and 1e.

Accelerator (SLC), and RHIC); (3) $0.13 billion which includes laboratory requests and proposals for future R&D to which the Department has made no specific commitment, as well as an apparent double-counting of $23.7 million of SSC R&D funds; and (4) $0.21 billion as GAO's estimate for the cost of Tevatron and SLC detectors which were separately justified and approved in the Department's Capital Equipment request. The DOE strongly

See comment 5.

disagrees with reporting the first three items in the budget as project-specific costs.

See comment 1a.

The largest element of costs which GAO contends have not been identified to the Congress is $4.9 billion of their cost estimate for the SSC project. This misrepresents both the status of SSC and the substantial amount of information already reported to Congress. SSC is not a project; it is currently an R&D activity to better define a potential project, its costs, schedules, and uncertainties. No decision has yet been made within DOE to propose that SSC be a project. It is, therefore, totally inappropriate for GAO to imply that DOE is hiding from the Congress the true cost of the project by a factor of approximately 90; $4.96 billion vs. the $58 million identified for preconstruction R&D contained in the budget. Further, SSC has been discussed at many Congressional hearings and during Congressional staff briefings. Based upon the information on SSC that has been presented to Congress (and GAO), we cannot believe that Congress thinks SSC will cost only $58 million, as the GAO report implies.

See comment 1a.

The report also claims that the costs of two projects (RHIC and LAMPF II) are $921 million more than what DOE reported. The $921 million represents GAO's estimates for proposals from contractors to build the RHIC and LAMPF II facilities. The reason that DOE has not yet identified in the budget any construction costs associated with these projects is that DOE has not made a decision on whether to request construction funds for them. In the case of RHIC, $2 million in preconstruction R&D is specifically included in the FY 1987 nuclear physics Congressional budget submission for studies to define the parameters of such a facility. We fail to understand GAO's criticism of DOE for not reporting in its budgets contractors' estimated costs for facilities for which DOE has not yet decided to request funding.

Certain line item construction projects, particularly the Energy Saver, the AGS Booster, and the AGS/Tandem Transfer Line, have been mislabeled as preconstruction components of other follow-on projects. The report states that the Tevatron I and II projects cost $367 million more than the DOE reported (Table 3.1 and related discussion). The $367 million includes

See comment 1b.

GAO's estimates for the separately funded detectors ($128 million), the earlier Energy Saver project ($181 million), "other project related costs" ($37.4 million), and $21.5 million for a new computer facility. The detectors, Energy Saver and the computer facility were separately identified in Congressional budgets and were fully justified--GAO does not disagree with that. The detectors were not included in the Construction Project Data Sheets as a matter of practice. Rather they were included in the budget requests as Capital Equipment items and, thus, fully disclosed,

See comment 6.

although in another section of the budget. The Energy Saver was a complete stand-alone project, justified on its own merits. It was usable and valuable when completed, irrespective of whether Tevatron I and II would ever be built. We believe that this approach of building upon past investments by upgrading existing facilities provides a very cost-effective way of achieving new capabilities. The computer facility at Fermilab is also a stand-alone project, justified on its own merits and not an undisclosed element of Tevatron I and II as implied in the report.

See comment 1c.

The report also distorts the situation with respect to RHIC (see Table 3.2). The GAO included in their estimate of the cost of RHIC two previous line-item construction projects at Brookhaven National Laboratory: the Alternating Gradient Synchrotron Accumulator Booster and the Tandem/AGS Heavy Ion Transfer Line. While these projects would benefit a Relativistic Heavy Ion Collider if it were to be constructed, these two projects were undertaken as separate line-items to increase the existing capabilities of the Alternating Gradient Synchrotron and not as preconstruction for RHIC.

See comment 1f.

The report charges that DOE does not appropriately identify preconstruction R&D costs to specific projects. The Department supports a variety of R&D studies which are generic in nature and not project specific. Although some of this R&D leads to proposals that eventually are submitted to Congress, the proper definition of projects and identification of total project costs early in the R&D period is very difficult and contains great uncertainty. It is very difficult to identify closely what fraction of the R&D efforts which lead up to a project are actually directly related to the project as

See comment 1g.

proposed. Extensive preconstruction R&D activities are required to examine alternatives and to determine feasibility and costs. These results are required before we can define project scopes, develop reliable cost estimates and schedules, and examine technical uncertainties. Preconstruction R&D thus provides a data base necessary for DOE's decisions on whether to proceed with proposed projects. These R&D expenditures are reported to Congress in the Operating Expenses sections of the budget and have been extensively discussed in briefings with Congressional staff,

See comment 1a.

during Congressional hearings, and in response to questions from Congress. It is, therefore, incorrect that "DOE... make(s) large investments that have not been considered by the Congress...." as the report states on page 4. It would be premature and misleading to present incomplete information on the total cost of a potential project at these early stages in the

review process prior to a DOE decision to request funding. Thus, the appropriate time to specify total project cost is when the Department has solid information and has made a decision to seek authorization of construction.

See comment 9.

We also disagree with statements in the report regarding technical uncertainties for accelerator projects. The nature of these projects is such that they are at the very forefront of scientific and technological advancements. This inevitably means high risk. These projects are subjected to a wide variety of reviews from many diverse and independent sources to, in part, identify uncertainties, minimize them, and provide adequate financial contingencies for problems that inevitably arise. The Department's construction requests include a carefully evaluated contingency allowance to cover technical uncertainties. The process of determining this allowance looks at each component and assigns a contingency allowance based on estimated risk. Despite all of our reviews and analyses, it is not possible to always predict just where a technical problem might arise or what its implications might be. However, through the use of this contingency allowance and careful project management, High Energy and Nuclear Physics has historically had an excellent record of its authorized construction projects being completed close to the requested cost. We provide accurate accounts of project status to the Congress. We disagree with the report and maintain that DOE does adequately disclose technical uncertainties to Congress.

With respect to technical uncertainties at the SLC, the report does acknowledge that DOE notified Congress concerning uncertainties but criticizes DOE for not discussing the potential implications on operating costs once SLC is completed (pp. 60-62). We believe that GAO's discussion of the issue of klystron lifetime does not reflect the latest information on that subject. Original lifetime estimates were based on rational assumptions from experience with similar tubes and this gave us confidence about the nature of the uncertainty. Operating data to date on the new high power tubes developed by SLAC demonstrate a lifetime substantially longer than 1000 hours. The GAO discussion of klystron lifetimes is, therefore, unduly pessimistic.

Now on pp. 43-44.

See comment 9.

Table 3.3 and the accompanying discussion leads to a number of misstatements and erroneous conclusions about technical difficulties with the Tevatron projects. The GAO report fails to acknowledge that Congress was fully advised of the decision to change the technology needed to produce anti-proton beams and about the attendant change in project scope and increase in cost. Our original presentations to Congress included our best estimates of technological uncertainty as we knew them at the time. The project was rescoped after a thorough technical review and an analysis of CERN's technical successes. It was concluded that a revised cooling scheme would significantly improve the luminosity and physics capability of the collider. We simply could not foresee the eventual difficulties that

See comments 9 and 38.

surfaced. But when problems did arise and a redesign was completed, we were quick and forthright in disclosure to Congress. There are a number of other misunderstandings relating to technological uncertainties at Fermilab that are discussed in the enclosure to this letter and which should be factored into a final report.

Now on p. 46.

See comment 40.

One significant additional incorrect statement on page 64 concerning Tevatron should be corrected. GAO states that a $19.3 million upgrade at Fermilab will be required to achieve the beam intensity goal. This statement is not supported by any information we know of from the laboratory. It is true that Fermilab staff are considering proposing the construction of a prebooster, among other possibilities, to enhance the intensity and luminosity of the beams. These would potentially be upgrades to the laboratory, rather than changes necessary to meet original project specifications.

See comment 10.

A major misstatement appears on page 13, where the report states: "DOE has no specific mandate to support high-energy physics or nuclear physics other than that which is obtained through the annual appropriations process." That statement is incorrect. DOE, through its own Organization Act and authority derived from its predecessor agencies, the Energy Research and Development Administration and the Atomic Energy Commission, has broad and long-standing statutory authority to support high energy and nuclear physics programs. For example, section 31a. of the Atomic Energy Act of 1954, as amended (Public Law 83-703), provides in part: "The Commission is directed to exercise its powers in such manner as to insure the continued conduct of research and development... in... nuclear processes... the theory and production of atomic energy, including processes, materials, and devices related to such production...." High energy and nuclear physics fit the Act's definition of "research and development" rather precisely. In addition, sections 103 and 107(a) of the Energy Reorganization Act of 1974 (Public Law 93-438) include authority to engage in and support research, including physical research, related to the development of energy sources.

See comment 10.

When the research and development functions of the Atomic Energy Commission were transferred from the Commission to the Energy Research and Development Administration, all necessary statutory authority which was available to the Commission was also transferred and made available to the Administration (section 301(h) of the Energy Reorganization Act of 1974); and similarly, when the functions of the Energy Research and Development Administration were transferred to DOE, all statutory authority available to the Administration to perform the transferred functions was also transferred and made available to DOE (section 641 of the DOE Act, Public Law 95-91).

See comment 10.

In the DOE Organization Act itself, there is specific recognition of DOE's authority to conduct a physical research program. See, for example, section 209(b)(1) of the DOE Organization Act which requires that the

Director of the Office of Energy Research advise the Secretary "with respect to the physical research program transferred to the Department from the Energy Research and Development Administration."

Finally, the Department objects to the title of the report which reflects the GAO's conclusions that we strongly challenge. We believe that the title should more objectively identify the subject being investigated.

DOE hopes that these comments will be helpful to GAO in their preparation of the final report.

Sincerely,

Martha O. Hesse
Assistant Secretary
Management and Administration

Enclosure

Detailed Substantive Comments and Corrections
on the General Accounting Office Draft Report Entitled
"DOE Accelerators: Their Costs and Technical Uncertainties
Should Be Better Disclosed"

1. Page 2: "DOE incurs substantial costs for accelerator projects that are not identified in the budget as project-specific costs. GAO estimated the total cost of six of the largest accelerator projects to be about $6.9 billion. DOE, however, has identified only $600 million of these project-specific costs in the budget through fiscal year 1987."

   DOE Response: This is a very misleading statement which grossly distorts the facts. The $6.9 billion cost quoted by GAO for the six largest accelerator projects includes the GAO's estimate of $5.65 billion for the total project costs after beginning of construction of SSC ($4.84 billion), RHIC ($256 million), and LAMPF II ($554 million). This is hardly appropriate since the Agency has not yet decided to proceed with construction of any of these efforts. We are now performing research directed toward assisting the decision making process of whether or not to proceed. In addition, the GAO has added into its estimate $230 million for prior projects which have already been justified and approved as separate projects. This includes in the GAO's estimate for the Tevatron, $181 million for the Energy Saver; and for RHIC, $39 million for the Tandem/AGS Beam Transfer Line and the AGS Booster. Also included are $54 million of laboratory projected costs for LAMPF II which the Department does not intend to construct, $35.3 million for SSC which is the contractor's request to which DOE is not committed, and $23.7 million of SSC R&D costs which are apparently double-counted. We strongly disagree with including these costs as part of the total project cost for subsequent upgrades.

   The GAO charge that DOE has not informed Congress of these costs is a misrepresentation of the facts. The distortion has to do with a failure of GAO to understand when the Department is committed to pursue something as a project. Until the Department is willing to commit to and seek support for construction of a project, it is premature and counterproductive to approach elements outside the Department, including the Congress, in a formal manner with plans and estimates that are not firm. As the GAO admits later in their report, Congress has been apprised of the rough cost estimates through the hearing mechanism. The DOE approves funds for research in many speculative areas and some small fraction of these research areas will lead to a project at some point. At the outset of any of these research efforts it is impossible to accurately predict which specific effort will become a major project. To identify all such efforts as potential projects would be totally misleading.

2. Page 2: "This has occurred because DOE's definition of a project relates only to the cost of construction, which excludes the cost of certain project-specific components and preconstruction research and development."

See comment 1.

See comment 2.

DOE Response: The TEC (Total Estimated Cost) presented in a construction project request relates specifically to the cost of construction of the project which has a well identified beginning, scope, and end. However, the project data sheet accompanying the request for authorization and funding also includes cost estimates of the accompanying R&D costs and preoperating costs during the construction period and an estimate of the assumed annual costs associated with its operation following completion of construction. An estimate is also usually provided for the costs of the initial complement of experimental equipment to be used at the accelerator facility, both in the text of the Construction Project Data Sheet and in the hearing presentations. Preconstruction R&D costs are generally not included except for special major projects such as SSC and CEBAF for several reasons: (1) The nature of R&D for the very advanced facilities is such that it is difficult to estimate a priori its full extent and full costs. (2) It is difficult to determine, even after the fact, which R&D costs are project-specific and which are generic in the early stages of project conception. (One needs to recognize that these facilities which are themselves at the forefront of research require some of the most advanced technologies and are largely one-of-a-kind devices.) (3) The preconstruction R&D costs are relatively modest.

3. Page 2: "In addition, DOE funds a project in various stages over a number of years and does not, when the first stage is authorized, identify for the Congress, the total cost of completing the project."

See comment 3.

DOE Response: This presumably refers to the Fermilab Energy Saver, Tevatron I, and Tevatron II construction projects and to the BNL Transfer Line, AGS Booster, and RHIC projects. The implication that either of these groups of projects was all one project is both incorrect and misleading. Each of these six projects was or may be justified in the future on its own merits. Certainly, the Tevatron I and Tevatron II projects required the success of the earlier Energy Saver project, however, the reverse is not true. All, of course, also required the existence of the base Fermilab facility. Likewise, at BNL, RHIC, if constructed, would build upon the success of the Transfer Line and AGS Booster. However both the Transfer Line and AGS Booster provide new stand-alone physics capabilities which do not require RHIC.

4. Page 3: "Although DOE has provided some information on the total cost of the projects in congressional hearings and other documents, DOE's practice of incrementally funding projects and the omission of project technical uncertainties in the budget makes it difficult for the Congress to assess the affordability of such projects. Since DOE's budget does not disclose the total cost of projects, proposals for upgrading an existing accelerator or building a new one are incomplete."

See comment 4.

DOE Response: The Department does not incrementally fund projects in the sense that GAO implies. Each project presented to the Congress provides a stand-alone capability. We do try, for reasons of cost effectiveness, to build upon prior investments where appropriate. As indicated in comment 2, DOE's cost estimates and budget presentation and testimony at the time of the construction, do address complete costs during the construction request period.

5. Page 3: "...DOE has obtained incremental funding for accelerator projects without informing the Congress of the total cost of the project in its annual budget submissions. For example, DOE is considering building a new accelerator called the Superconducting Super Collider which it estimated will cost about $4.1 billion over the next 8 years. DOE budgets through fiscal year 1987 have identified $57.9 million in initial research costs for the project, but have not identified the project's total cost."

See comments 1a and 1g.

DOE Response: The Department has not yet made a decision on whether to proceed with construction of the SSC. In the absence of such a commitment, there is, according to well established procedures, no project for which to present cost estimates. GAO evidently believes that it is possible to define total project costs before carrying out preconstruction R&D. It is, in fact, one of the most important tasks of preconstruction R&D efforts to determine, as accurately as possible, the cost of construction and total project cost both of which are then included in construction project data sheets submitted to Congress. The Department's budget submissions for FY 1985-FY 1987 have not addressed the total cost estimate for SSC because the Department has not yet decided on whether to proceed with SSC. Furthermore, a reliable estimate of these costs, including technical uncertainties, is still in preparation and then must be thoroughly reviewed. The DOE has not withheld information from the Congress about a potential SSC project. When the decision was made to initiate R&D directed toward an SSC, all four pertinent Congressional committees were notified by letter of October 18, 1983, and special hearings were held on October 19, 1983, and October 25, 1985, by the House Science & Technology Committee. DOE has been fully responsive to Congressional requests for information about SSC, much of which has been incorporated in records of budget and other hearings.

6. Page 3: "In addition, DOE's budget frequently does not include costs for certain equipment and other project-specific components that planning documents indicate are needed to make an upgrade and/or new facility complete and operational."

See comments 5 and 32.

DOE Response: As required by the Congress, DOE's budgets do specify costs for capital equipment for detectors and secondary beam components for new facilities in the Capital Equipment section of the budget. In the case of Tevatron I and SLC, the need for detectors was specifically

referenced in the Construction Project Data Sheets even though related costs were not included in the total project cost estimate. These costs are not included because detector needs are less well defined at the time of project authorization and, in part, to properly compete them against other equipment needs of the program. Frequently, detectors are developed in a phased manner to provide a set of initial detectors to be available for initial operation, with detectors developed later for fuller utilization based on the latest physics and technology.

7. Pages 3-4: "For example, DOE is building a large upgrade called Tevatron, but the budget requests for this upgrade did not include the cost of a computer facility and other project-related items which are required for and dedicated to the operation of the accelerator. Including these omitted costs would increase DOE's estimated cost of the total upgrade by $367 million, from $212 million to $579 million."

DOE Response: The GAO estimate of omitted costs includes $21.5 million for the Fermilab computing upgrade. The need for the computing upgrade at Fermilab is not totally related to Tevatron I and II. Much of the existing computer hardware at Fermilab is antiquated and in need of replacement, independent of the Tevatron I and II projects. This obsolesence has been a concern of GSA based upon a 1980 GAO report.

See comment 6.

The GAO cost data for Tevatron erroneously includes, in addition to the computer facility, other items, such as $181 million for the stand-alone Energy Saver project, $128 million for detectors which are accounted for elsewhere in the budget request, and $37.4 million of "other project-related costs" which we do not agree are proper.

See comments 1b, 34, and 1a.

8. Page 4: "Accelerator projects incur substantial costs before construction is approved by the Congress that are not disclosed as project-related expenses. For example, included in GAO's total cost estimates for the projects is about $480 million in preconstruction costs. About $395 million of this amount has not been identified as project-specific costs in DOE's budget to the Congress."

"DOE did not identify these preconstruction costs in its budget because DOE generally does not recognize a project until it requests construction funds from the Congress. This allows DOE to make large investments that have not been considered by the Congress as part of DOE's projects."

DOE Response: DOE does indeed define a project as beginning when the Department makes a request to the Congress for construction funding. Most of the items which GAO indicates as preconstruction costs are not properly preconstruction costs. The $395 million which GAO claims are not identified as project specific preconstruction costs includes: $181 million for the Energy Saver and $39 million for the AGS Booster

See comment 7.

and Transfer Line which are not appropriate preconstruction costs (see comment #3); $35 million laboratory request for SSC R&D for FY 1987 which the Department may not fully include in its budget; $54 million laboratory estimate for LAMPF II R&D through FY 1991, which the Department does not intend to fund; and an apparent double counting of $23.7 million of SSC R&D funds. The remaining $62 million is the GAO's estimate for preconstruction R&D which we have not included as described below.

It is our practice not to include R&D costs which preceded this time. We have not done so because these are prior commitments, and it is impossible to identify closely what fraction of the R&D efforts which lead up to a project are actually directly related to the project as proposed. As noted in the body of the report, funds are spent in research areas which tend to be generic in nature and not project specific. These are forefront technology endeavors and it is not known beforehand how much R&D is required to resolve technical problems. It becomes difficult in later years to go back and break down this funding by project. Once the project is being planned for submission to the Congress, the R&D funds associated with the construction are identified in the Construction Project Data Sheet. Early R&D funding for projects is normally identified in the narrative, Operating Expenses section of the budget. The proper identification of total project costs early during the R&D period is very difficult and contains a lot of uncertainty. During this period many of the required supporting facilities have not been sufficiently identified for functional requirements.

9. Page 4: "This allows DOE to make large investments that have not been considered by the Congress as part of DOE's projects. To avoid this situation, GAO believes that DOE should identify projects to the Congress before committing large resources."

See comment 8.

DOE Response: Most of what GAO is presenting as not identified preconstruction costs are the costs of earlier projects separately justified and approved by the Congress (see comments #1 and #8). The true preconstruction R&D costs are usually not substantial relative to project construction cost.

Now on p. 4.

10. Page 5: "DOE's budget also does not disclose technical uncertainties which could impact on whether a given project can meet its performance objectives....In neither case did DOE disclose in the budget these uncertainties and their potential implications on costs."

DOE Response: The projects involved are very high technology endeavors employing and developing the most advanced technologies. While it is recognized that difficulties may arise in such endeavors, it is not possible to pinpoint precise trouble areas in advance and to

identify cost impacts. We point out that all project cost estimates do include allowance for contingency funds to cover precisely these unforeseen technical problems of the type referred to by GAO.

See comment 9.

Through the use of the contingency allowance and careful project management, HENP has had an excellent record of its authorized construction projects being completed close to the requested cost. To put this statement in perspective, HENP completed several large projects started in the sixties and seventies on schedule and within cost while meeting the performance specifications. Cost overruns have been experienced on some recent HENP projects including the Tevatron I and ISABELLE/CBA as noted in the draft GAO report. However, "worst case" cost overruns experienced on recent HENP projects have been less than the average for DOE projects. Furthermore, DOE had the best project cost performance record of six government agencies with more than $10 billion of construction according to the GAO Report NSIAD 83-32, "Status of Major Acquisitions as of September 30, 1982." Sampling of project performance on large complex projects conducted in the private sector also indicated the HENP performance is quite good in comparison.

Also, it is worth noting that most of the overrun alluded to by GAO at Fermilab was in the Tevatron I project which was significantly rescoped after thorough technical review and reports of CERN technical successes indicated that a revised cooling scheme would enhance the probability of meeting project goals and greatly increase the physics capability of the collider. The Congress was informed promptly of our revised plans and the associated costs by letter of June 16, 1982, before proceeding. The question of klystron lifetimes raised in regard to SLC is in the realm of conjecture. As of now, sufficient information has been accumulated to clearly show that the pessimistic lifetime estimate used by the GAO is without basis. The way to determine klystron lifetime is to operate them and evaluate the lifetime as a result of the operating data. Although we haven't had enough operating time to demonstrate that the long lifetime goal has been achieved, there is a sound basis to anticipate that klystron lifetime will not be a serious problem. The implied impact on annual operating budgets is only possible under the most catastrophic circumstances which no one at SLAC, at DOE, nor any members of technical review panels believe will occur. Such an increase in operating costs on an annual basis for any project would be intolerable, and if such problems were to occur, they would be resolved by a one time modification program.

11. Page 13: "DOE has no specific mandate to support high-energy physics or nuclear physics other than that which is obtained through the annual appropriations process."

DOE Response: That statement is incorrect. DOE, through its own Organization Act and authority derived from its predecessor agencies, the Energy Research and Development Administration and the Atomic Energy Commission, has broad and long-standing statutory authority to support high energy and nuclear physics programs. For example, section 31a. of the Atomic Energy Act of 1954, as amended, (Public Law 83-703), provides in part: "The Commission is directed to exercise its powers in such manner as to insure the continued conduct of research and development... in... nuclear processes... the theory and production of atomic energy, including processes, materials, and devices related to such production...." In addition, sections 103 and 107(a) of the Energy Reorganization Act of 1974 (Public Law 93-438) include authority to engage in and support research, including physical research, related to the development of energy sources.

See comment 10.

When the research and development functions of the Atomic Energy Commission were transferred from the Commission to the Energy Research and Development Administration, all necessary statutory authority which was available to the Commission was also transferred and made available to the Administration (section 301(h) of the Energy Reorganization Act of 1974); and similarly, when the functions of the Energy Research and Development Administration were transferred to DOE, all statutory authority available to the Administration to perform the transferred functions was also transferred and made available to DOE (section 641 of the DOE Organization Act, Public Law 95-91).

Finally, in the DOE Organization Act itself, there is specific recognition of DOE's authority to conduct a physical research program. See, for example, section 209(b)(1) of the DOE Organization Act which requires that the Director of the Office of Energy Research advise the Secretary "with respect to the physical research program transferred to the Department from the Energy Research and Development Administration."

Now on p. 14 and app. II.

12. Page 19 and Appendix III: "DOE's nuclear physics program operates 11 nuclear physics facilities and, like the high-energy physics program, sponsors both theoretical studies and experiments. Seven of the facilities are at national laboratories and four are university based."

DOE Response: The Bates Linear Accelerator Center is a government-owned university-based facility, not a national laboratory. The count should be rectified to 6 national laboratories and 5 university facilities.

See comment 11.

13. Page 21: "When this overall upgrade is completed in September 1987, Fermilab is expected to be the highest energy proton accelerator in the world."

See comment 12.

DOE Response: Fermilab is already the world's highest energy fixed target facility. It will become the highest energy collider in the fall of 1986.

14. Page 21: "When completed in fiscal year 1987, the Stanford Linear Collider project will attempt to address some of the same scientific questions as those being addressed by proton accelerators."

See comment 13.

DOE Response: SLC will provide a world unique research capability. It will permit study of Z^0 production via the electron-positron annihilation process and will permit observation of decays of very short lived objects. It will address questions which cannot be studied with proton accelerators, and in areas accessible to both, it will probe in a different and complementary way than the proton accelerators.

15. Page 22: Table 1.1 identifies DOE proposed cost of SSC as $4.1 Billion.

See comment 14.

DOE Response: As already indicated, the Department has made no decision to proceed with SSC and has not proposed the project or a cost estimate to the Congress. The Central Design Group (CDG), in its Reference Designs Report, did develop a preliminary cost estimate which was reviewed by DOE. DOE has used this preliminary estimate in a number of public statements. DOE does not have a specific proposal for the SSC and a supporting detailed cost estimate is not yet completed. This is what is being done by CDG at the present time.

16. Page 22: Table 1.1 Footnote (a)

See comment 15.

DOE Response: This footnote is incorrect. The Department still considers the Alternating Gradient Synchrotron (AGS) as a high energy physics facility although it will have unique capabilities for the nuclear physics program in the heavy ion area. The AGS program is expected to remain largely high energy physics in the near future. If RHIC is built, the AGS subsequently would be devoted predominantly to providing heavy ion beams for injection into RHIC.

17. Pages 22-23: Text between Table 1.1 and Table 1.2.

See comment 16.

DOE Response: This text appears to belong on page 24 after Table 1.2.

18. Page 23: "Following CEBAF and the Relativistic Heavy Ion Collider, and if financial resources are available, NSAC's third priority is to build a 10 to 30-GeV proton accelerator. Responding to the NSAC third priority, the Los Alamos National Laboratory, in December 1984, proposed upgrading its existing facility with a project called the Los Alamos Meson Physics Facility II (LAMPF II), which it had been working on prior to December 1983."

See comment 17.

DOE Response: The Nuclear Science Advisory Committee (NSAC) Long Range Plan for Nuclear Science of 1983 stated in regard to LAMPF II, "regarding a 10-30 GeV accelerator, the financial assumptions of this report preclude a major additional facility." The "Review of the Long Range Plan for Nuclear Science" of 1984 stated, "Meanwhile we should discuss strategies for the high-energy hadron physics necessary for a balanced program of nuclear research into the 21st century..." Neither of these reports identified the proton facility as "third priority." Although DOE respects NSAC's scientific judgment in identifying an advanced proton facility as being of potentially high physics interest, no plans are being presently considered to construct such a facility. DOE activities specifying the scientific emphasis and scope of such a project have not been carried out, so that concomitant costs cannot even be estimated. DOE has not provided any direct funding for development of such a project at LANL or at any other institution. In order to responsibly carry out the goals of the nuclear physics program plan, DOE does provide some funding to LANL, as well as other institutions, for generic research in the area of accelerator physics.

Footnote 9. Add the words -- plus enough neutrons needed to make the ion stable.

19. Page 24: Table 1.2

See comment 18.

DOE Response: See previous discussion of LAMPF II (comment #18). The Booster at BNL is a high energy physics project. It is justified primarily on the enhanced proton and polarized proton capability. The transfer line is a nuclear physics project. Not included in the GAO table is the University of Washington Upgrade (a superconducting LINAC booster) at $8.0 million. In fact, the Yale and Washington projects were authorized together at $19.0 million.

20. Page 26: "As noted in our report, all too often, the government's cost information is incomplete, inconsistent, and unreliable. To help federal decisionmakers better manage federal resources, we stressed the importance of complete, reliable, and consistent cost information."

See comment 19.

DOE Response: We believe that the DOE's present procedures achieve this objective. The GAO criticism of the Department for not identifying project-related costs when a new concept first emerges and enters into the study phase seems to be inconsistent with their own statement here. At the time we go forward with a construction request to Congress we have a well reviewed design and cost estimate.

21. Page 30: "Using primarily operating funds, DOE begins funding research and development for high-energy and nuclear physics accelerator projects several years before construction is authorized by the Congress. This research and development is expected to cost about $480 million for upgrades and planned new accelerators, like the

Superconducting Super Collider, covered in our review. DOE's budget to the Congress has not identified most of that amount--about $395 million--as preconstruction costs. Because preconstruction costs are not fully disclosed, the Congress is not directly informed of the nature and extent of such costs."

DOE Response: Congress has been directly informed of all program costs. Most of the items which make up GAO's $395 million of "preconstruction costs not fully disclosed" are not properly preconstruction costs. See comment #8.

See comments 7 and 20.

22. Page 31: "In addition, the high-energy and nuclear physics facilities have available discretionary overhead funds that, if approved by the laboratory/facility director, can be used for research on accelerator development."

Now on p. 23.

DOE Response: The reference here to "discretionary overhead funds" should be changed to "exploratory R&D funds," and also corrected in the footnote on page 32.

See comment 21.

23. Page 32: "While research and development of a specific accelerator upgrade or a new accelerator project are underway, the facilities submit project proposals to the appropriate science advisory committee, which prioritizes the various proposals. Acting on the priorities recommended by the advisory committee, DOE submits its highest priority projects for approval by the Congress through the budget process."

DOE Response: Project proposals are submitted to the Department not to advisory committees. DOE may refer proposals to advisory committees such as High Energy Physics Advisory Panel (HEPAP) or NSAC for review and advice and/or use some other form of peer review to assist in evaluation of the project proposals.

See comment 22.

24. Page 33: "Finally, DOE facilities use two additional funding types--accelerator improvement project and general plant project funds--to support their accelerator projects."

DOE Response: The High Energy and Nuclear Physics programs do not use Accelerator Improvement Projects (AIP) and General Plant Projects (GPP) funds to support construction projects. These valuable resources are properly used to maintain and improve effectiveness of existing facilities.

See comment 23.

25. Page 34: "For the projects we analyzed, we determined that DOE has spent or plans to spend almost $480 million prior to construction. About $395 million of this amount has yet to be appropriately identified as preconstruction project costs in DOE's annual budgets to the Congress."

See comments 1a and 7.

DOE Response: As discussed before, this is misleading and incorrect. (See comment #8).

26. Page 34: "The actual and planned preconstruction costs of the high energy physics projects we reviewed amount to $360 million through fiscal year 1987. About $283 million of this cost has not been identified by DOE as project-related preconstruction costs in its budget submissions to the Congress."

See comments 1a, 3, and 7.

DOE Response: This is misleading and incorrect as addressed earlier (see comments #3 and #8).

27. Page 35: Table 2.1 lists unidentified preconstruction costs of SSC as $62.2 million, Tevatron I and II as $181.2 million, and SLC as $39.6 million.

DOE Response: These numbers are wrong and misleading. For the SSC GAO has included FY 1987 contractor requests which the Department may not necessarily support and apparently double counts the $23.7 million referenced later on page 35. GAO has included the full cost of the Energy Saver as a "preconstruction" cost of Tevatron I and II (see last sentence of the first paragraph page 38). This is most inappropriate, since the Energy Saver was a separately justified, Congressionally approved construction project. It is true that Tevatron I and II build upon the superconducting accelerator provided by the Energy Saver project, but Energy Saver was a stand-alone project justified on its own merits, approved by the Congress, and funded as a separate construction project. It has been our policy to build upon past investments in order to obtain essential new capabilities in the most cost-effective manner. It is highly misleading to include costs of these prior investments in the cost estimates for the upgrades. The Construction Project Data Sheet and testimony to Congress clearly identified these budget items as upgrades building upon the prior investments in Energy Saver.

See comments 1c and 1e.

With regard to Stanford Linear Collider, the comments about the $9.8 million are misleading. The upgrade of linac energy, while subsequently important for SLC, was initiated and justified to achieve new physics capability with the linac.

See comment 24.

28. Page 36: "Regarding the $23.7 million for research covered in agreements with the Central Design Group, the Acting Associate Director for the Office of High Energy and Nuclear Physics said that the expenditures will benefit the proposed collider, but will not be charged to the project because the research may benefit other future accelerators and would have been conducted regardless of the project."

DOE Response: This statement by the GAO is not true, includes an incorrect attribution, and represents a substantial misunderstanding. The funding for R&D covered by the Central Design Group agreements with the laboratories ($23.7 million) is: (a) for R&D conducted specifically for the SSC, (b) charged as R&D for the SSC, and (c) not in addition to, but part of what GAO calls "Preconstruction cost reported" ($57.9 million) in Table 2.1. The Acting Associate Director for High Energy and Nuclear Physics notes there is some long-term generic R&D being carried out in the high energy program which has side benefits for the SSC. Since this generic R&D is a continuation of earlier efforts, is not SSC specific, and would be conducted regardless of the SSC, it is not considered part of the specific SSC R&D effort. On the other hand, the R&D carried out under the CDG/Laboratory agreements is SSC specific and is so charged.

See comment 1e and 1f.

29. Page 36: "Other preconstruction costs are also associated with the Superconducting Super Collider that are more difficult to quantify and are not included in DOE's budget estimate for the project. They include the salaries, travel, and other expenses of scientists from numerous universities and DOE laboratories that were involved in studies, workshops, panels, and task forces related to the Collider project during 1984 and 1985. These costs were paid by the scientists' home institutions, some of which were from funds provided by DOE for the physics research programs conducted at these institutions. Neither DOE nor the Central Design Group could give an estimate of the amount of these costs."

DOE Response: Participation in studies, workshops, and task forces of relevance to high energy physics is considered part of the normal professional duties of a scientist and no separate accounting is required of these activities. We see no reason to treat SSC-related activities of this type in any special way. In a similar manner, no costs are ever assigned to the time most scientists contribute to the peer review process, which is considerable and which is also taken as a normal professional responsibility.

See comment 25.

30. Page 37: "...an earlier project called the "Energy Saver" was authorized by the Congress for fiscal year 1979 to install superconducting magnets in the Fermilab accelerator. These magnets were designed to (1) reduce the power consumption of the accelerator and (2) lay the groundwork for ultimately increasing the beam energy from 400 GeV to 1 TeV."

DOE Response: The Energy Saver project provided a complete accelerator facility, not just superconducting magnets. The project, in addition to the magnets, provided beam injection, cryogenics, vacuum, and beam instrumentation. Energy Saver raised the useable beam energy at Fermilab to 500 GeV for fixed-target experiments.

See comment 1b.

31. Page 38: "Counting the cost of the Energy Saver, the preconstruction costs of the Tevatron projects are $197.6 million, as opposed to $16.4 million."

See comment 1b.

DOE Response: As noted earlier, inclusion of the Energy Saver cost as a preconstruction cost of Tevatron I and II is a gross misrepresentation. While the Tevatron does require the Energy Saver, the reverse is not true. Energy Saver is a stand-alone project justified on its own merits.

Now on p. 27.

32. Page 38: "According to Stanford records, about $29.8 million in operating funds was spent on the project prior to construction. In addition, we noted that between 1980 and 1983, approximately $9.8 million was spent for upgrading existing laboratory facilities and beginning research and construction on detectors for use on the project. These costs have not been allocated to the project because, according to the Associate Director of the Office of High Energy and Nuclear Physics, the Stanford Linear Collider was not officially a project until construction was authorized by Congress."

See comment 24.

DOE Response: Assignment of the full $9.8 million to SLC related activities is an arbitrary judgment and does not have basis in fact. All upgrades of laboratory facilities and detectors during this period were justified and carried out for the purpose of specific upgrades of the physics capabilities of the existing facilities, not for the purpose of some potential future projects.

33. Page 39: "DOE has reported $8.3 million in preconstruction costs for CEBAF in the fiscal year 1985 and 1986 budgets, but has not identified any of the remaining $111.6 million in preconstruction costs for the other proposed projects. The Acting Associate Director for the Office of High Energy and Nuclear Physics told us that they did not specifically identify these costs in the budget because DOE has not yet approved their construction."

See comment 1a.

DOE Response: This must be a gross misunderstanding by the GAO since the Acting Associate Director does not agree that the quoted $111.6 million are all appropriately preconstruction costs or even all DOE planned costs of any kind. See comments #1, #8, and #18.

34. Page 40: "For the CEBAF project, DOE did not begin identifying project-related costs in the budget until fiscal year 1985. By that time, about $1.4 million in funds provided by DOE had already been spent by the Southeastern Universities Research Association for project-related research."

DOE Response: The statement about CEBAF funding is misleading. The CEBAF project had been developed using State of Virginia and local funds. FY 1984 funds ($1.0 million) were not committed until action on the FY 1985 appropriation bill was passed in July 1984, and DOE received full Congressional approval for reprogramming funds. The first DOE funding of CEBAF occurred on August 3, 1984, upon notification of those Congressional actions. This funding, and all other funding for the CEBAF project have subsequently been fully identified in the Construction Project Data Sheets.

See comment 26.

35. Page 41: "Of the total amount planned through fiscal year 1987, $16.8 million will be for research directly related to the Relativistic Heavy Ion Collider...DOE is presently funding both a beam transfer line project and a booster project to start accelerating heavy ions. These two projects are being separately justified to upgrade the existing Brookhaven facility to enable nuclear physicists to perform experiments at higher energies. DOE and Brookhaven officials also acknowledge that the Brookhaven proposal assumes both of the projects are underway or completed prior to starting construction of the Relativistic Heavy Ion Collider. However, the projects have not been identified as being directly related to the collider project."

Now on p. 28.

DOE Response: The beam transfer line project enables heavy ions to be accelerated by the AGS for experiments at 14 GeV per nucleon. The booster project is a high energy physics project and provides increased intensities for protons, polarized protons, and higher mass heavy ions for the AGS program. Each project is a stand-alone project approved on its own merits. Their existence, as well as the entire existing BNL AGS and Tandem facility complex, are assumed in the planning for the Relativistic Heavy Ion Collider activities but are not directly related to the colliders.

See comment 1c.

36. Page 41: "In the meantime, Brookhaven expects to incur $56.2 million in preconstruction costs through fiscal year 1987."

DOE Response: In fiscal years 1984 through 1987, BNL has provided or expects to provide $5.4 million in laboratory R&D exploratory funds for research relating to the collider proposal. In FY 1986, DOE provided $0.08 million for collider R&D, and in FY 1987 DOE is requesting $2.0 million for Brookhaven to perform research relating to a Relativistic Heavy Ion Collider. No other funds have been provided for this purpose.

See comment 1c.

37. Page 42: "Present internal DOE regulations contain requirements for prompt project identification, but the regulations have not been strictly complied with by the Office of Energy Research for the accelerator projects we reviewed. DOE has not promptly identified

accelerator projects costing over $50 million. We noted that up to 5 years may elapse from the time research is initiated on a specific upgrade or a new facility until the time the project is identified in DOE's budget submission to the Congress."

DOE Response: DOE does identify projects promptly to the Congress when the Department decides to proceed with a project. As stated earlier, it is neither possible nor appropriate to attempt to precisely define a project when we first begin R&D which may or may not later lead to a project. The Department does identify the R&D and its purpose in the Operating Expenses section of the budget.

See comment 27.

38. Pages 43-45: GAO makes references to the Director, Office of Management and Administration, Assistant Secretary for Management and Administration (ASMA), and the Office of Management and Administration respectively, relating to Major System Acquisitions.

DOE Response: All three should be retitled to the Acquisition Executive. The role of Acquisition Executive is currently performed by the ASMA; however, the titles are not synonymous. Previous Secretaries have designated Under Secretaries or Deputy Secretaries in the role of Acquisition Executive.

See comment 28.

39. Page 44: "Although some projects we reviewed have been designated by DOE's Office of Mangement and Administration as either major systems or projects, our review showed that such a designation was not always prompt. In one instance, as shown in table 2.3, this designation was made after more than 5 years of research and related expenditures had been conducted on the project."

DOE Response: The GAO assertion is false. GAO is defining the starting date of R&D which eventually led to the Energy Saver as the starting point for Tevatron I and Tevatron II. As we have indicated previously, this is inappropriate. Energy Saver is a stand-alone project that does not require either Tevatron I or Tevatron II.

See comment 1b.

40. Page 44: Table 2.3: Project designation dates

DOE Response: As indicated in our previous responses, the table is misleading with respect to Tevatron I and II in that the start date of 1975 can only be arrived at by including the Energy Saver which, as discussed above, is not appropriate.

See comment 1b.

41. Page 44: "DOE's Office of Energy Research has not prepared mission need statements--the formal mechanism for triggering major system or project designations--for any of these projects. (Refers to projects listed in Table 2.3; namely, Tevatron I and II, Stanford Linear Collider (SLC), LAMPF II, Superconducting Super Collider (SSC), CEBAF, and Relativistic Heavy Ion Collider.) The Fermilab Tevatron projects

Now on p. 31.

and the Stanford Linear Collider were designated as major projects by DOE's Office of Management and Administration only after the Office of Energy Research requested construction funds. Both CEBAF and the Superconducting Super Collider were designated as major systems by the Office of Management and Administration because the program office estimated that the projects--if approved--would exceed $200 million."

DOE Response: The statement that the Office of Energy Research has not prepared a Mission Need Statement is incorrect in the case of the SSC. The statement in regard to the other projects may mistakenly leave the reader with the impression that the Office of Energy Research does not comply with the project documentation requirements of the Department. This is not true.

First, the Office of Energy Research prepared a draft SSC project plan and provided it on January 10, 1984, to then Secretary Hodel. According to the version of DOE Order 5700.4, in effect at that time, a Mission Need Statement was defined as the first version of a project plan, to be brief in nature. The rather complete draft project plan exceeded the requirement of preparing a Mission Need Statement. The draft plan was submitted to Secretary Hodel as part of the response to his special direction to conduct a detailed feasibility study for building the SSC and to identify the R&D which would be required for the Department to responsibly consider committing to construction. Senior level Departmental management determined that designating the SSC a Major Systems Acquisition (MSA) and invoking the formal ESAAB (Energy Systems Acquisition Advisory Board) process as outlined in DOE Order 5700.4 was premature at that time. As noted in the GAO report, SSC was formally designated a MSA in 1985. Preparations are under way within DOE to consider construction of the SSC. As part of this consideration, an ESAAB meeting has been scheduled and a Justification for New Start (JNS) is being prepared (the JNS was formerly designated as a Mission Need Statement). Thus, documentation for the SSC beyond the level of a Mission Need Statement was prepared by the Office of Energy Research in January 1984.

See comment 29.

Second, a draft project plan for CEBAF was distributed for DOE staff comment in the summer of 1985. DOE was at that time seriously considering an FY 1987 construction authorization request for CEBAF, so the timing of the preparation of the draft project plan was entirely appropriate. Revisions to the draft have been held in abeyance pending the decision to incorporate superconducting radiofrequency cavity technology into the CEBAF design. This decision has now been made, and a revised project plan reflecting the decision will be prepared. Third, although Mission Need Statements were not prepared for SLC and Tevatron I and II, project plans were prepared and approved for all three projects. Fourth, the GAO report states that Mission Need Statements are the formal mechanism for triggering major system or project designations. While this may be a conclusion which could be

drawn from the DOE Order, it is not the sole means by which the Department identifies and designates projects as major system acquisitions or major projects. Management may make these designations at any time depending upon the project's cost, National urgency, importance of the project to program objectives, and its size and complexity. Also, it should be noted that, on occasion, mission need statements may not be required due to Congressional legislative actions that formally establish the mission need. Thus, the Office of Energy Research has not generally prepared separate Mission Need Statements, but has prepared project plans for its projects. An exception was made for the SSC for the reason mentioned above. Fifth, the Office of Energy Research believes that it is premature at this time to develop a project plan for RHIC and that the budget process obviates the need for a Mission Need Statement for the purpose of designating RHIC a MSA or Major Project. Since there is no Departmental consideration at this time regarding LAMPF II, it is totally inappropriate to prepare either a project plan or Mission Need Statement.

Now on p. 31.

42. Pages 44-45: "Both CEBAF and the Superconducting Super Collider were designated as major systems by the Office of Management and Administration because the program office estimated that the projects--if approved--would exceed $200 million. The program office, however, has disagreed. The Director, Division of Construction, Environment, and Safety, does not recognize the Superconducting Super Collider and CEBAF as major systems because he stated such a designation is premature until the Congress approves construction funding."

See comment 30.

DOE Response: The statement on not treating the Superconducting Super Collider and CEBAF as Major Systems Acquisitions (MSAs), because to do so would be premature prior to Congressional approval, needs clarification. Both are presently designated MSAs. The Director, Division of Construction, Environment, and Safety, may have said that generally speaking such a designation prior to an Agency decision to seek Congressional authorization was premature.

Now on p. 31.

43. Pages 44-45: GAO states that Mission Need Statements, currently Justifications for New Start (JNS), are not accomplished until funds are requested.

See comment 29.

DOE Response: The JNS for the Superconducting Super Collider is currently being updated. The JNS and project plan for CEBAF were scheduled to be completed in August 1985 and are delayed for the reasons stated on comment 41.

44. Page 45: "Actual and planned preconstruction costs of the accelerator projects we reviewed are substantially larger than the amounts DOE has identified to date in its budgets to the Congress."

See comments 1a, 1b, 1c, and 5.

DOE Response: This statement is false and misleading. As indicated in numerous earlier comments, GAO has included in its analysis preconstruction costs which are inappropriate because they include the costs of prior, approved construction projects and separately justified and approved capital equipment costs.

45. Page 45: "By not promptly identifying these project expenditures prior to construction or by funding portions of an overall upgrade in a piecemeal fashion, DOE allows large investments to be made in a project that has not been approved by the Congress."

See comments 20 and 27.

DOE Response: We strongly disagree. Money is not spent on a construction project without Congressional approval. As discussed in comment #20, R&D studies are done prior to project definition which, although it is not, and frequently cannot be, project associated, is discussed in the narrative portion of the Operating Expenses sections of the high energy and nuclear physics budgets.

46. Page 46: "For DOE's high-energy and nuclear physics programs, this should include prompt identification of actual and planned investments in major accelerator projects prior to construction."

See comment 1a.

DOE Response: As indicated previously, the Office of Energy Research does promptly identify planned investments in major projects as soon as adequate information is available and the decision is made to request authorization for a project.

47. Page 46: "Although internal DOE regulations require prompt identification of major undertakings, they are not strictly adhered to by the Office of Energy Research. Such identification should take place no later than when the criteria in the DOE regulations are met. Earlier identification is preferable such as when research is started on a specific identifiable upgrade or new accelerator, or when projects are proposed to and/or recommended by the applicable science advisory committees."

Now on p. 36.
See comments 19, 22, and 27.

DOE Response: See our comment #37 on compliance with DOE regulations. The GAO observation that "early identification is preferable" contradicts their charge on page 48 that DOE's budget information to Congress is fragmented and incomplete. Earlier identification, when there is less sound information on which to base cost estimates, would lead to poor estimates. Finally, DOE does not request a project just because it is recommended by an advisory committee.

Now on p. 36.

48. Page 48: "Our review showed, however, that information provided to the Congress in DOE's budget on the total costs and technical uncertainties involved in accelerator projects is fragmented, incomplete, and untimely. DOE's budget does not clearly identify--in one place--the full cost of a project and technical uncertainties of

the necessary components before DOE commits resources to the project. The total cost of the accelerator projects we reviewed is $6.3 billion more than what DOE and its facilities reported because the preconstruction costs for the projects (discussed in ch. 2) and other essential components such as detectors and computer equipment necessary to conduct experiments are separately funded. Also, information provided to the Congress often did not fully disclose the existence or significance of technical uncertainties that could affect the project's success."

See comments 1 and 5.

DOE Response: See comments #1 and #44 with regard to the $6.3 billion of identified costs.

See comment 9.

Technical uncertainties are very frequently unforeseeable. However, high risk areas of DOE advanced technology projects are clearly identified in the required project plan documentation. A clear and best estimate of the costs associated with known and estimated risk areas is handled through contingency estimates. These are always clearly identified.

Now on p. 36.

49. Page 49: "For the high-energy physics projects, the estimated cost of ongoing and planned projects may be almost $5.4 billion more than DOE reported in the budgets furnished to the Congress. A summary of the projects' costs is shown in table 3.1."

See comment 1.

DOE Response: The GAO statement is incorrect and misleading. The table is incomplete and misleads the reader. See comment #1.

Now on p. 38.

50. Pages 51-52: "The estimated cost of the Tevatron projects is $367 million more than DOE estimated in the most recent budget submission for the projects. The costs not reported include separately funded projects that are projected to cost about $127.7 million for two detectors and $180.6 million for the Energy Saver. In addition to $37.4 million in other project-related costs, DOE's fiscal year 1986 budget includes a request for a $21.5 million computer upgrade for Fermilab to record and analyze the data obtained from conducting experiments using the higher energy Tevatron upgrades."

See comment 16.

DOE Response: We strongly disagree with including costs of prior, separately funded activities such as Energy Saver and detectors as part of Tevatron I and II costs.

See comment 6.

The computer facility at Fermilab was submitted as a separate line item for approximately $22 million. While it will be used extensively for analysis of data obtained from the operation of the Tevatron projects, it is not exclusive to those projects and its use is generic to the overall laboratory functions and should not be attributed to the Tevatron projects alone.

See comments 31 and 5.

The accelerator is considered a basic tool which can be used in many ways to obtain expected or unforeseen results. Detectors and computers for data collection are generally designed for specific experiments which will use the accelerator tool. In some cases, the cost of detectors is funded by organizations (including international cooperation) that will be setting up specific experiments. Therefore, not all costs are necessarily borne by DOE and, hence, are not identified up front. The costs projected in the GAO report are higher than DOE is planning and presumably include contributions by international collaborators.

Now on p. 38.

51. Page 52: "With respect to the Stanford Linear Collider, our review showed that this project will cost $117.1 million more than the amount DOE reported in its budget request to the Congress. Not included in DOE's reported total cost for the project are detectors and other associated costs to make the project complete and operational. DOE must add a new detector--the Stanford Large Detector--and upgrade an existing detector--the Mark II--to allow physicists to record the experimental results at the higher energy level. Stanford officials estimate the costs of upgrading the Mark II and building the new detector to be $76.8 million. In addition, DOE incurred $39.6 million in preconstruction costs and $.7 million in other project-related costs to upgrade the facility that were not included."

See comments 32 and 5.

DOE Response: Although the costs of detectors were not included in the tabulation of total project cost, the need for them was identified in the narrative section of the Construction Project Data Sheet and in the Capital Equipment section of appropriate budgets. It must be noted that the detector plan for SLC has two components. An immediate upgrade of an existing detector (Mark II) for initial use in FY 1987 when SLC turns on, and a second, full-size detector to be available about 3 years later. Initiation of the second detector was specifically delayed to take advantage of latest physics and detector technology developments. This detector could not be precisely defined and costed when SLC construction was requested. Further, we again note that GAO detector cost estimates apparently include international cost-sharing contributions as well as U.S. funding.

Now on p. 39.

52. Page 53: Table 3.2 and related discussion.

See comments 1b, 1c, and 7.

DOE Response: We believe that the GAO is using a complicated and confusing definition of Total Project Cost (TPC) in place of Total Estimated Cost (TEC) throughout chapter 3. For example, certain line-item construction projects have been labeled as preconstruction components of other follow-on projects. In determining the TPC for the Relativistic Heavy Ion Collider, for example, the GAO included two previous line-item construction projects at Brookhaven National Laboratory: the Alternating Gradient Synchrotron Accumulator Booster

and the Tandem/AGS Heavy Ion Transfer Line. While these projects would benefit RHIC, if it is constructed, they were undertaken as separate line-item projects to increase the existing capabilities of the Alternating Gradient Synchrotron and not as preconstruction for a Relativistic Heavy Ion Collider. For other DOE comments on the "amounts not identified" column which DOE disagrees with, see comments #1 and #8.

Now on p. 39.

53. Page 53: "DOE is presently considering a new accelerator design for CEBAF that is intended to improve upon the design envisioned by DOE in its fiscal year 1985 budget request. The cost of the accelerator, based on the design DOE is now considering, has not yet been determined."

See comment 26.

DOE Response: The costs of the CEBAF project have been fully reviewed and are compiled in the data sheets submitted to Congress in the FY 1987 budget submission. The current total costs of CEBAF have been identified as $236.3 million facility costs and $26.25 million in R&D costs for a total of $262.55 million in current year dollars. Using the DOE Independent Cost Estimate price change indices of August 1985, the total costs in FY 1985 dollars are $217.4 million.

Now on p. 39.

54. Page 54: "DOE has yet to identify any costs associated with the Relativistic Heavy Ion Collider in its budgets."

See comment 1a.

DOE Response: This is correct, except for the $2 million R&D funds requested in FY 1987. The Department has not yet decided to proceed with construction of RHIC. See comments #1, #8, and #41.

Now on p. 39.

55. Page 54: "DOE has yet to identify any costs for LAMPF II in its budget."

See comment 1d.

DOE Response: This is indeed true. The Department presently has no plans to proceed with LAMPF II and, therefore, there is no reason to identify costs.

Now on p. 39.

56. Page 54, footnote 4: "Because of problems associated with superconducting magnets and two new facilities that were coming on-line that could meet the capability of Isabelle, DOE cancelled the project in October 1983, after more than $200 million (in year of expenditure dollars) had been invested."

See comment 33.

DOE Response: This statement is false. While it is true that technical difficulties with superconducting magnets were encountered during the ISABELLE [later called Colliding Beam Accelerator (CBA)] effort, these technical problems had been solved by October 1983. While the CERN $\bar{p}p$ collider and Tevatron I could access some of the physics areas to be covered by CBA, both have low luminosities and do not come close to fully replacing CBA. The Department decided not to continue CBA construction because changes in the status of

physics indicated that high priority should be given to exploring the TeV mass region, which CBA could not penetrate and the limited resources expected to be available would be most effectively used by concentrating on moving to the higher energy.

Now on p. 41.

57. Page 56: "By excluding detectors and other dedicated equipment, DOE's project cost estimates in the construction project data sheets submitted to the Congress have been considerably less than the total cost of accelerator projects. This enables a new facility or an upgrade to appear more affordable in the budget than if the costs for all of the dedicated and necessary components are added to the project total."

DOE Response: DOE does not usually include the cost of detectors in the total project cost indicated in the Construction Project Data Sheets because these are often not well known at the time project authorization is requested. Also, the detectors frequently evolve in stages. For example, at SLC an upgraded Mark II is planned for initial research to be followed 3 years later by the Stanford Linear Detector, fabrication of which just recently began. Likewise at Tevatron I. The costs of detectors are clearly spelled out in the Capital Equipment section of the budget, and the need for them also is indicated in the narrative of the Construction Project Data Sheets and in Congressional testimony.

See comment 34.

Now on p. 41.

58. Page 56: "While some cost information is disclosed in congressional hearings and other public documents, DOE should also disclose the total cost of a project in its budgets to the Congress before committing resources to the project. While the cost of new facilities and upgrades are disclosed in congressional hearings and other public documents furnished to the Congress, DOE's budgets do not disclose the total cost of projects prior to incurring costs."

DOE Response: As discussed in previous comments, it is neither possible nor appropriate to responsibly identify project costs at the time preconstruction R&D, which may lead to a project, is initiated. DOE does disclose project costs before committing resources to construction. It also discloses project-related costs for detectors in the Capital Equipment budget. Early generic R&D studies are pursued prior to project definition. These costs necessarily must occur prior to presenting a project for construction approval by the Congress.

See comment 1a and 1f.

Now on p. 41.

59. Page 57: "According to the Acting Associate Director of the Office of High Energy and Nuclear Physics, the total cost of projects are not included in the budget when expenditures begin because the project's costs cannot be precisely determined until the necessary research is completed. While we recognize it may be difficult to

estimate precisely the cost of a project in advance, we noted that preliminary cost estimates for projects are available in the project proposals submitted by the accelerator facilities and from information provided by peer reviewers."

DOE Response: The preliminary cost estimates and comments of peer reviewers GAO refers to are not considered substantive and are likely to be misleading. The project at such an early time is usually incompletely defined and early estimates are uncertain. There is no real basis for a good cost estimate until after preparation or completion of a thorough conceptual design and a careful DOE review. It is at this point that DOE feels it can best make a decision on whether to request authorization for construction of a project. With this procedure, the Office of High Energy and Nuclear Physics has an excellent record of its authorized construction projects being completed close to the requested cost.

See comment 1g.

60. Page 58: "DOE appears to endorse minimizing the time to develop and then build a new accelerator or upgrade an existing accelerator. According to the Acting Associate Director of DOE's Office of High Energy and Nuclear Physics, the highly competitive environment in which the high-energy and nuclear physics programs operate requires bringing new projects or upgrades on-line as soon as possible. In meeting this objective, the DOE facilities perform research before and during the project's construction."

Now on p. 42.

DOE Response: The Acting Associate Director does not recall making any such statement, does not agree with it, and believes it over emphasizes the competitive environment. What DOE/HENP endorses is to develop and construct new projects in an optimum fashion, technically, economically, and scientifically. It has been the Acting Associate Director's observation and experience that construction of advanced technology devices such as accelerators, once started, is most effectively and most economically carried out if the construction is able to follow a natural construction pace rather than be strung out by too limited a funding rate. The point of doing R&D before and during construction is of a different nature and is related to the need for very advanced technology to provide the most forefront experimental capabilities at the lowest cost for the needs of these basic research fields.

See comment 35.

61. Page 59: "Some of this research during construction is intended to minimize the time to develop and then build the project."

Now on p. 43.

DOE Response: The purpose of R&D concurrent with construction is to optimize the performance and cost effectiveness of technical systems. Minimizing the time to build a project is not its purpose.

See comment 35.

Now on pp. 43.

62. Pages 59-60: "Up to the time DOE canceled the project, DOE had not approved the project plan even though the plan is required by internal regulation."

See comment 36.
Now on p. 43.

DOE Response: We note that the effective date of the DOE Order referenced by GAO on page 60 is September 8, 1983, only 6 weeks before DOE formally announced its decision not to continue with the ISABELLE/CBA program.

Now on p. 43-44.

63. Pages 61-62: Discussion on technical uncertainties at SLC.

Now on pp. 43-44.

DOE Response: The GAO discussion on pages 61 and 62 is misleading as to the technical problems encountered during 50 MW klystron development.

Now on pp. 43-44.

The statements attributed to the Stanford Site Office on page 62 are out of context and misleading. The objective was an exercise in a worse case scenario to point out DOE's "need to carefully observe the current 50 MW lifetime tests on the LINAC" because of its potential impact on operating costs. The example given clearly states that "There is no basis for this low lifetime (ie, 1000 hr.) assumption."

See comment 9.

There is not now, nor has there ever been, any technical basis for the pessimistic assumption of 1000 hour lifetime. The 10,000 to 20,000 hour lifetime expectations used in modeling replacement scenarios for klystrons are based on an extrapolation from the large data base accumulated on the older 35 MW tubes. Intense review by a number of microwave tube experts throughout the lifetime of the project has established these extrapolations as sensible and the only known, reliable approach to estimating klystron lifetimes a priori. Operating data accumulated to date is reinforcing strongly these early extrapolations, and lifetime has been clearly demonstrated to be well in excess of 1,000 hours.

Now on p. 45.

64. Page 62: "The Tevatron projects require superconducting magnets and antiproton cooling systems that had not been fully demonstrated and were relatively new processes when the Congress approved construction. As a result of technical problems in this area, Fermilab has encountered schedule delays. For example, the Energy Saver project was originally scheduled for completion in June 1982 but was not completed until May 1983. Similarly, the Tevatron I and II projects were scheduled to be completed in September 1986 and November 1985, respectively. Fermilab officials now estimate the completion dates for these projects to be September 1987 and July 1986, respectively. The delays have been accompanied by substantial increases in the costs for two of these projects as shown below in Table 3.3."

See comment 37.

DOE Response: The completion delays were not, in fact, due solely to technical problems. The modified spending profiles, resulting from the budget process also contributed. Also, when considering upgrades to

existing facilities, the interaction of the upgrade with the total laboratory program must be considered. The increases in the costs that are indicated in the report are primarily generated by technological changes and are only secondarily due to delays; and the delays cited are largely independent of the technological changes discussed in comments #10 and #63.

Now on p. 45.

65. Page 63: "Table 3.3: Estimated Cost Increase of Fermilab Upgrades as of December 1985."

DOE Response: The table and discussion relative to Tevatron I present a massive distortion of the facts in this case. Specifically, the report does not point out that the increase in the construction budget estimate is due to a major project rescoping. The Congress was promptly and fully informed of the decision to change the technology used to produce antiproton beams and the revised cost estimate. No construction funds had been expended for beam cooling components or even authorized by DOE when the R&D at Fermilab and developments at CERN indicated a different approach. This is another indication that DOE does keep the Congress informed about technological risks. The table also points out a methodological problem with the approach that GAO took in reporting project costs by converting everything to 1985 dollars, namely the original construction estimate for Tevatron II was $49 million in actual year funds and it has never changed in any document. The problem has to do with the changes in the actual expenditure rate and the conversion to 1985 dollars. Another misinterpretation on this page is the assertion that DOE is using other fund types (AIP) to allow projects to meet their goals, thus "really overrunning" the Congressionally authorized ceiling. This is simply not supported by the facts, e.g. the data sheet approved by Congress for the Tevatron I only says near 1 TeV. Further, the data sheets do not specify an intensity goal. The AIP projects that are alluded to are aimed at reliability improvements and, as a bonus, they will provide for increased energy, improved beam cooling, or increased luminosity depending on the specific project.

See comment 38.

Now on p. 45.

66. Page 63: "Beam intensity (the rate of particles reaching the target) is also below the level needed for Tevatron II's fixed target experiments."

DOE Response: The statement is incorrect. Tevatron II experiments cover a wide range of beam intensity requirements. In some cases, a very high intensity is needed for optimal performance of experiments; however, the experiments still produce useful physics at lower intensities. In some cases an experiment cannot handle the full intensity, if available, and consequently cause the intensity to be "turned down" for optimum performance.

See comment 39.

Now on p. 46.

67. Page 64: "According to Fermilab officials responsible for the project, a $19.3 million fiscal year 1988 line item project to construct an accelerator prebooster may be necessary to achieve the beam intensity goal."

See comment 40.

DOE Response: We know of no Fermilab official who said that a prebooster would be necessary to meet intensity goals for the projects. It is true that the staff at Fermilab is considering a prebooster, among other possibilities, to improve both the intensity and luminosity of the beams. We feel that project goals can be met without such additional projects.

The following are GAO's comments on the Department of Energy's letter dated March 10, 1986.

GAO Comments

General: After our review of DOE's comments, we concluded that our views on these budgetary issues are balanced, fair, objective, and consistent with the need for the disclosure of pertinent budget information to facilitate the making of sound budgetary decisions. We find that DOE's position on the report is inconsistent with the documentary evidence we obtained and the interviews we conducted with officials at DOE and its accelerator facilities. We made only two revisions to our description of project status and related costs as a result of our consideration of DOE's comments. These changes relate to the costs we reported for the Relativistic Heavy Ion Collider (due to our inclusion of the booster and transfer line projects) and the Stanford Linear Collider (due to our inclusion of minor amounts borne by others through international cost sharing). In total, the changes decreased by only $42.2 million, our $6.9 billion estimate of costs for the six projects we reviewed. Our comments on the key underlying issues in response to DOE's comments are contained at the end of chapters 2 and 3. Our specific comments follow.

1.a. The DOE comments contain a number of objections to our report and give explanations for not disclosing full cost estimates in the budget. DOE objects to the draft report's citation of costs associated with accelerator projects for which DOE has not yet decided whether to proceed with construction. DOE also states that it is premature and counterproductive to provide the Congress with preliminary information on a project until DOE is ready to request construction funds. When a project has been proposed to DOE by a DOE accelerator facility, specific design and operating parameters and objectives have been determined. Once federal funds of any type (operating, research and development, etc.) are requested by DOE for a specific DOE physics accelerator project, the Congress should be informed of that project's total potential cost. This view is consistent with DOE's internal regulations and, in the current budget environment, is especially important to avoid sizable investments in projects that the Congress ultimately may not wish to fund for construction. We acknowledge that DOE has provided total cost estimates on several of the projects we reviewed as part of congressional hearings. While this provides certain committees and subcommittees of the Congress with more complete cost information, inclusion of the best available total cost information in the budget request itself is essential to allow the Congress as a whole to compare various competing requests for funding from DOE and other

federal departments and agencies, and to make equitable allocations of limited financial resources accordingly.

1.b. In regard to the Energy Saver project, we continue to believe that it costs are an integral part of the costs for the overall Fermilab upgrade. HEPAP, in an untitled July 1980 report (DOE/ER-0066) stated "although the Energy Saver-Tevatron I-Tevatron II projects have been defined as three separate construction projects, they represent one integrated program to be accomplished in three phases . . .". Our September 16, 1980, report entitled Increasing Costs, Competition May Hinder U.S. Position of Leadership in High-Energy Physics, EMD-80-58, also identified the Energy Saver as the first phase of Tevatron. Both DOE and Fermilab pro vided formal comments on that 1980 report, but neither challenged our characterization of the Energy Saver as the first step toward Tevatron. Further, we were told by a Fermilab official that the Energy Saver has never operated as a stand-alone 500 GeV accelerator for the purposes o conducting physics experiments.

1.c. With regard to the Relativistic Heavy Ion Collider, we note that the Transfer Line and Booster are prerequisites for the operation of the Col lider. In the proposal for the Collider, which was submitted to DOE, Brookhaven has assumed completion of these separately funded projects. If they are not completed, the cost of the Collider project woul have to be increased and the scope expanded to provide similar capability. Given their importance to the Collider project, we included them in our draft report as preconstruction costs for the Collider. However, recognizing that the Transfer Line and Booster could be used to conduct experiments separate from the Collider, we have revised our cost estimates for the Collider to exclude the $39.4 million for these two projects. The remaining preconstruction costs—after exclusion of the Transfer Line and the Booster—represent preconstruction costs that ar directly related only to the Collider project.

1.d. Regarding the LAMPF II project, we continue to believe that the Congress should be provided, in the annual budget requests, complete technical and cost information for any specific accelerator project for which funds are to be spent. LAMPF II illustrates why such disclosure is needed As noted in our report, about $6 million has already been spent on this project through fiscal year 1985. DOE states, however, that it does not intend to construct LAMPF II. Had DOE specifically provided in the budget pertinent details concerning LAMPF II, the Congress would have been in a better position to evaluate the merits of this project, along with the

merits of other competing projects, and possibly stop it before the full $6 million was invested.

1.e. DOE's contention that $23.7 million of preconstruction costs for the Superconducting Super Collider is "double-counted" is not correct. Although this amount may benefit other accelerator projects, we note that it represents expenditures requested by the Central Design Group for preconstruction research on the Collider. This amount has not been identified in the budget as an estimated preconstruction cost associated with this project, and, therefore, not double counted.

1.f. In chapter 2 of the report we noted that DOE conducts generic research, and DOE is correct in pointing out that it is impossible to accurately predict which effort will become a project. However, none of the cost figures or analyses contained in the report involve generic research. All cost data—obtained from DOE's accelerator facilities—pertain to specific, well-defined upgrades or projects that have specific objectives and well-developed technical designs and operating parameters.

1.g. Finally, regarding the ability to provide the Congress with firm cost estimates, we note that proposals for upgrades or new facilities which DOE receives contain project cost estimates. Generally, DOE uses these estimates when it reviews the proposal. Therefore, it would appear that these estimates are considered accurate enough for DOE to use in its decision-making process. The report does not state that the Congress has to be informed of the exact final cost of a project when project-specific funds are first requested, only that the best available estimate or range of estimates of total project costs be provided to the Congress for use in its budgetary process. Any qualifications or caveats concerning such estimates, of course, could and should be provided.

2. DOE provides no evidence to support its contention that research and development costs during construction, preoperating costs, operating costs, and equipment costs are included in the project data sheets. The project data sheets for the Stanford Linear Collider included construction costs, research costs during construction, and project engineering and design costs. Preoperating and start-up costs and about $74 million in costs for detectors (equipment required to conduct experiments) were not included. The capital equipment section of the budget did show $4 million for the detectors—this amount represents one year's funding—without disclosing the total costs.

For the Tevatron projects, DOE disclosed the cost of detectors (about $128 million) in the budget only after the Congress approved construction funds. Even in the budget request for the CEBAF project, which we found came close to identifying the full cost of a project, DOE did not identify about $30 million for preoperating and start-up costs.

We disagree with DOE's contention that it is difficult to estimate preconstruction costs or to separate generic from project-specific research costs. All preconstruction costs included in our report were specifically identifiable to a project and were provided by DOE's accelerator facilities or obtained from DOE or accelerator facility documents. Even if such costs were difficult to identify, an estimate or range of estimates could provide the Congress with better information to assist in its decision-making process and would be preferable to not providing any cost estimates at all.

We also disagree that preconstruction costs are "relatively modest." The preconstruction costs for the Superconducting Super Collider are currently estimated to be about $120 million. Preconstruction costs for the Stanford Linear Collider are estimated to be about $42.3 million, or about 30 percent of the $139.3 million total project cost proposed by DOE. In the nuclear physics program, estimated preconstruction costs for LAMPF II are about $54 million, or about 12 percent of DOE's total estimated project cost of about $452 million.

3. Our conclusion that DOE funds a project incrementally is not limited strictly to separately funded projects. The separately funded projects—the Energy Saver and the Brookhaven Transfer Line and Booster—are discussed in our comments numbered 1b and 1c. Our report points out that DOE generally funds a single upgrade or new project using various types of funds over a period of years. First, preconstruction work is funded using operating or research and development funds. Then, after congressional approval, one or more phases of construction follows. Finally, additional funds, often plant and capital equipment funds, are used to purchase detectors and computer equipment necessary to operate the accelerator. In most cases, only the construction effort is identified as project costs.

4. Our position regarding incremental funding of accelerator projects is discussed in our comment number 3. DOE also states that its budget presentation and testimony address complete costs during the construction request period. Our report does not take issue with many of the costs reported during the construction period. Rather, the report stresses the

need for (1) earlier disclosure to the Congress of a project and its estimated costs and (2) informing the Congress, when the first project-specific funds of any type are requested, of the preconstruction, preoperating, detector, and computer costs in addition to the construction costs.

5. DOE's rationale for not including the cost of the detectors was based on incomplete designs and the possibility that a portion of the cost may be borne through international cost-sharing (see DOE's comments numbered 50 and 51). This rationale is not sufficient to warrant their exclusion from a project's total cost. Present detectors are costing about $50 million or more to build. We believe DOE could provide—at a minimum—a range of estimated costs (including disclosure of anticipated cost-sharing arrangements) for detectors as part of a project's overall cost estimate. Such disclosure, in our opinion, would be preferable considering (1) the fact that detectors represent critical components necessary for conducting experiments on the accelerator and (2) their large costs.

6. The planned acquisition of the computer facility for Fermilab should be included as part of the overall Tevatron upgrade's total cost. Although DOE does not include the computer facility in the budget as part of the total cost of Tevatron, DOE's fiscal years 1986 and 1987 budget requests for the computer facility specifically states that it is being justified primarily for the additional data analysis requirements of Tevatron I. The point of our report is that as long as a DOE effort is directed toward a specific goal—no matter how many individually funded projects and subprojects it is divided into—the Congress should be provided with information on total estimated costs to facilitate informed decision-making regarding the overall goal's affordability.

The basis for DOE's disputing the Tevatron-related costs appears to be its narrow definition that project costs are only those costs occurring during construction. The Energy Saver, detectors, and other project-related items costing $37.4 million are integral components of the overall Fermilab upgrade. Without these components, experiments could not be conducted on the upgraded facility. Further discussion of the Energy Saver is included in our comment number 1b. More detail relating to the inclusion of estimated detector costs is contained in our comment number 5.

7. Overall, DOE's comment relates to a basic difference of opinion concerning project costs and, specifically in this case, preconstruction costs. Our interpretation, which is supported by DOE internal regulations and

the need to provide the Congress with early identification of accelerator projects and their estimated total costs, is detailed in chapter 2 and in our comment number 1a. While DOE elaborates on its definition of accelerator project costs, it offers no support or source for that definition. We continue to believe that the costs for the Energy Saver represent preconstruction costs for the Fermilab upgrade (Tevatron) and that preconstruction costs for the Superconducting Super Collider and LAMPF II should be identified as a part of the total estimated costs for these projects. These costs are specifically discussed in our comments numbered 1a, 1b, 1e, and 1d, respectively. A discussion of the Booster and Transfer Line costs is contained in our comment number 1c. Discussion of generic versus project-specific research appears in our comment number 1f. Our comment number 1g discusses DOE's comment that estimating project costs prior to construction is difficult.

We also disagree that projects are specifically identified in the operating expense portion of DOE's budget. For example, DOE's budget, through fiscal year 1987, does not identify the LAMPF II project, even though about $6 million has been spent on the project. In addition, DOE's 1983 budget does not specifically refer to the Stanford Linear Collider even though costs were incurred on the project. Similarly, in the 1987 budget $2 million to be used to "define the parameters of a facility dedicated to production and examination of quark-gluon plasma" was requested. Although not mentioned, this was a reference to funds related to the Relativistic Heavy Ion Collider.

8. While the cost of earlier separately funded projects, such as Energy Saver, do comprise a large part of the preconstruction costs identified, we disagree that the remaining preconstruction costs are "not substantial" relative to the construction effort. Preconstruction costs for the Stanford Linear Collider and LAMPF II total about 30 percent and 12 percent, respectively, of DOE's estimate of those projects' total costs. Although Superconducting Super Collider preconstruction costs of abou $120 million total only about 3 percent of DOE's estimate of that project' total costs, we do not agree with DOE's contention that such an amount i "not substantial."

9. DOE's statement that accelerator projects involve very high technolog is sufficient reason to disclose to the Congress known technical uncertainties before beginning construction of an accelerator project. While we agree that it may not be entirely possible to pinpoint precise trouble areas in advance, the problem areas which we identified were known prior to construction. They are so important that they are basic to the

successful operation of the facility in terms of cost and level of performance. If DOE is not assured that the accelerator's anticipated performance level will be met or is aware of technical uncertainties, it should disclose the uncertainties in the budget so that the Congress will have all information available to assess the affordability of the project. To that end, the inclusion of a contingency allowance is not a substitute for disclosing a project's technical uncertainties. Contingency allowances are of limited use, depending on the severity of the problem. For example, the Isabelle, Energy Saver, and Tevatron I projects included contingency allowances that proved to be insufficient to resolve the problems associated with these projects. Despite contingency allowances, substantial cost overruns and delays still occurred.

In addition, DOE's notification to the Congress of the risks associated with the Tevatron projects should not be characterized as prompt. Although DOE was aware of the technical uncertainties of the planned Tevatron cooling technology in 1980, they were not disclosed to the Congress until 1982, after the Congress had approved construction of the project. In this regard, the report states that DOE should provide the Congress with the most complete, relevant information on a project before, rather than after, it is approved for construction.

Concerning the technical uncertainties related to the klystron tubes for the Stanford Linear Collider, notably missing from DOE's comment is information on the expected lifetimes of tubes based on the testing performed to date and the cost of a modification that may be necessary. Our use of a 1,000-hour tube lifetime was based on the fact that DOE had achieved only 1,440 hours of performance at the time of our review. While this may have been pessimistic, there is also no basis for a more optimistic position. DOE's optimism is based on the extrapolation of lifetimes using older technology (35 megawatt) tubes rather than a more advanced tube (50 megawatt) variety. Our review showed that Stanford encountered difficulties just developing the more advanced 50 megawatt tube. Thus, any prediction of the more advanced tubes' lifetime using extrapolations of older technology tubes is inherently risky and as such could prove unreliable. The critical need to test the advanced tubes' lifetimes by operating them in the existing accelerator, has also been cited by DOE's Stanford Site Office. Since this was not done before DOE started constructing the project, we do not believe there is a sound basis for DOE's optimism on the operating lifetimes of the advanced tubes. In addition, we do not believe there was a sound basis for not disclosing this potential problem to the Congress prior to construction authorization.

10. The difference between our statement and DOE's comment appears to be based on different interpretations of the term "physical research." The DOE comment describes authority to conduct a physical research program but contains no specific mandate for it to perform high-energy and nuclear physics research. To recognize DOE's views on this point, we revised our report to show that DOE believes it has general authority to support physical research.

11. Our categorization of the Bates Linear Accelerator Center as a national facility is based on a DOE/NSF Nuclear Science Advisory Committee report, A Long Range Plan for Nuclear Science (December 1983). In that report, NSAC categorizes the Bates Electron Accelerator Center at the Massachusetts Institute of Technology as a major "national", as opposed to a dedicated university facility. Our categorization is also based on the fact that the Bates accelerator is used for experimental purposes by many groups supported by institutions other than the Massachusetts Institute of Technology.

12. Our statement on Fermilab is correct. To avoid detailed, complex explanations of the technical differences between fixed target and colliding beam accelerators, we simply stated that Fermilab will be the highest energy proton accelerator in the world. We believe such a statement is sufficiently broad to encompass both configurations of proton accelerators.

13. DOE's comment does not refute the statement in the report. Both the Stanford Linear Collider and Fermilab will address some of the same scientific questions. DOE's comment supports that statement and explains further that the same questions will be addressed, but in a "different and complementary way."

14. We acknowledge that DOE has made no decision to proceed with constructing the Superconducting Super Collider. However, DOE is spending considerable funds on the project and, as stated in its comment, has not submitted a cost estimate to the Congress. We believe the Congress should be provided with the best available estimate of this project's total cost. Even if the estimate is tentative and subject to change, it is important that the Congress know that the incremental preconstruction expenditures which DOE is currently making represent a "downpayment" on an accelerator which could cost between $4.1 billion and $4.9 billion.

15. The table was formulated in anticipation of the Relativistic Heavy Ion Collider. In response to DOE's comment, we have removed the data related to the Booster from the nuclear physics table (table 1.2) and included those data in the high-energy physics table (table 1.1).

16. The text describing high-energy physics projects appeared on pages 20 and 21 of the draft, followed by the table showing the high-energy physics projects. The text describing nuclear physics projects appeared next on pages 22 and 23, followed by a table showing the nuclear physics projects. This is a logical order and we see no need to restructure this section as suggested in the DOE comment.

17. The difference between DOE's comment and our interpretation of NSAC's 1983 report is semantical. The NSAC report did not specifically refer to LAMPF II as a "third priority." After naming CEBAF the first priority and the Relativistic Heavy Ion Collider as second priority, the NSAC report stated that in case financial resources become available, LAMPF II should be kept readily available because it represents many unique opportunities. Only CEBAF, the Relativistic Heavy Ion Collider, and LAMPF II were mentioned. We therefore believe that "third priority" continues to be an appropriate characterization of LAMPF II.

Regarding DOE's statement that it has no plan to build LAMPF II and has provided no direct funding, we believe LAMPF II is correctly included as a DOE project because about $6 million has been spent on research and development activities for this project. DOE's statement that no "direct" funding has been provided is correct in the sense that the funds budgeted were not specifically earmarked for LAMPF II. However, as we stated in the report, these funds have been provided from physics research and discretionary overhead funds, and therefore, have not been identified in the budget to the Congress as expenditures for a specific accelerator project.

Finally, we added DOE's suggested language to the footnote on heavy ions.

18. As noted in our comment number 15, we have removed data related to the Booster from the nuclear physics table (table 1.2) and have included those data in the high-energy physics table (table 1.1). We excluded the University of Washington upgrade from our list of nuclear physics projects because the scope of our review was to identify the 10 largest planned and ongoing projects and select 6 for in-depth review. We treated Yale and the University of Washington as separate, distinct

projects because they are at different locations, even though they were justified by DOE as one project.

19. We agree with DOE's comment that, if accurate cost information is available, it is preferable to a rough estimate. We disagree, however, with DOE's practice of not providing the Congress with cost information in the budget if highly accurate cost data is not available. For example, the Congress has not been provided, in the budget, with a total cost estimate for the Superconducting Super Collider, even though a DOE-funded estimate of about $4 billion exists. We believe that when DOE first requested funds to be used for preconstruction expenditures for this project, it would have been far more useful for the Congress to be provided with the best available estimate at that time rather than no estimate at all. When the Congress is asked to make the first "downpayment" on an accelerator, it should at least be informed of the approximate total cost of the project, particularly when that cost is expected to amount to hundreds of millions or billions of dollars.

20. The expenditures we identified as preconstruction costs are costs preceding construction that are specifically for an identifiable upgrade or new facility. While some of these costs are included in the construction project data sheets, they are disclosed after the fact or after the cost has already been incurred. Our report states that DOE should disclose these costs as estimates before they are incurred rather than when construction funds are requested.

21. We labelled what DOE calls "exploratory research and development funds" as discretionary overhead funds because these funds are disbursed at the discretion of a national laboratory or accelerator facility. We included DOE's term in the report (to acknowledge its formal designation of these funds) in addition to the term discretionary overhead funds, which we believe accurately characterizes the funds.

22. We have amended the report to show that project proposals are submitted to DOE rather than the applicable advisory committee. We note, however, that all proposals covering projects included in our detailed review were evaluated by HEPAP or NSAC.

23. DOE provided no evidence to support its statement that accelerator improvements projects' and general plant projects' funds have not been used on the projects we reviewed. To determine the cost of accelerator projects, we requested accelerator laboratory officials to provide their estimate of the costs of the projects as well as the sources of the funds.

For both the Stanford Linear Collider and the Tevatron projects, Stanford and Fermilab officials specifically identified the use of these funding types.

24. The characterization of $9.8 million as a cost directly associated with the Stanford Linear Collider was made by officials at the Stanford Linear Accelerator Center. They supplied us with a listing of costs directly related to the Collider which noted that the $9.8 million was such a cost. Our review did not disclose documentary support for DOE's contradictory view.

25. The statement in the report did not advocate including these amounts as preconstruction costs, but was merely included to disclose that, above and beyond the preconstruction costs noted, additional costs have been incurred that are associated with the project.

26. The report has been updated to show that DOE included $217.6 million in costs for the CEBAF project, in its budget submissions for fiscal year 1987. However, still excluded from DOE's total cost estimate for CEBAF is about $30 million in preoperating and start-up costs that are necessary to the successful operation of the accelerator and that we believe should be added to the project's total cost.

27. As stated in the report, DOE's practice of not identifying a project until construction funds are requested is inconsistent with DOE's regulations and allows large investments to be made in accelerators that have not been approved by the Congress. Further, DOE misrepresents our position. The report advocates identifying projects to the Congress only after it is out of the generic research phase. All projects included in the report had specific objectives, design and operation parameters, and estimated costs. Finally, DOE's statement that research and development is identified in the operating expenses section of the budget is misleading and only partially correct. DOE does include research and development costs in that section of the budget; however, as noted in our comment number 7, the costs are not identified with the project to which they are directly related.

28. The report has been revised to retitle the Director of Office of Management and Administration as the acquisition executive.

29. DOE provides no support to refute our conclusion that it does not prepare the necessary documents to promptly identify a project. For the Superconducting Super Collider, we do not believe a draft, unapproved

version of the project plan is a substitute for the required document. Neither our audit work nor DOE provided any evidence that DOE prepared an approved mission need statement or a substitute document in a timely fashion.

With CEBAF, DOE also assumed that a draft project plan, as opposed to a final version of the project plan, is a viable substitute for an approved mission need statement. Further, DOE stated that the draft project plan was circulated in the summer of 1985 for a project that was to begin construction in fiscal year 1987. This account of the CEBAF project is misleading. DOE first requested construction funds for the CEBAF project as part of its fiscal year 1985 budget submission, but the Congress declined to fund the project. In fiscal year 1986, OMB deferred the project's construction. Given these points of clarification, we do not believe CEBAF is a viable example to support DOE's position that the necessary documents for identifying a project have been prepared in a timely manner.

The situation is the same for the other projects in our review. For example, DOE approved the project plan for the Tevatron I and II projects in February 1983 and January 1982, respectively, after requesting construction funds for fiscal years 1981 and 1982. In the case of the Stanford Linear Collider, Stanford had prepared a project plan which has not been approved, even though construction started in fiscal year 1984. We also believe a mission need statement should have been prepared for LAMPF II because DOE incurred costs on the project starting in 1983.

30. We clarified our report to more closely characterize DOE's position on designating a project prior to a decision seeking congressional authorization of the project.

31. In estimating detector costs in chapter 3, we excluded from our estimate about $2.8 million in detector contributions from Canada and Italy. These costs were not excluded in our previous draft report because contributions from foreign participants at the time of our review were not firm and were expected to be relatively insignificant.

32. Disclosing, in the narrative section of the construction project data sheet, that the Stanford Linear Collider needs a detector does not provide the Congress with sufficient information. Nearly all accelerator upgrades or new accelerators require new or upgraded detectors. The Congress should be provided with the most complete cost information

available to enable it to compare and contrast competing federal projects; DOE's budget submissions disclosed only $4 million, one-year's funding, for the Stanford Linear Collider detectors.

International cost-sharing contributions for detectors are discussed in our comments numbered 5 and 31.

33. Our statement pertaining to the cancelation of the Isabelle project is supported by an Office of Energy Research memorandum to the Secretary of Energy dated October 5, 1983. The memorandum discussed the Isabelle project's cancelation and specifically cited technical problems with superconducting magnets, which delayed the project at least 2 years. This same memorandum also stated that a 1983 HEPAP subpanel acknowledged that an existing European accelerator and Tevatron I would explore "much of the physics" accessible to the Isabelle project. We amended the report, however, to incorporate DOE's view that providing resources to the Superconducting Super Collider project (for exploring the "TeV mass region") was also a reason for canceling Isabelle.

34. See our comment number 5 for a discussion dealing with the inclusion of the cost of detectors as a part of a project's total estimated cost. In addition, showing detectors' costs in the Capital Equipment section of subsequent budget submissions is not a substitute for their disclosure as a part of a project's total cost estimate. The Congress needs the most complete total cost information available in making funding decisions on these expensive projects.

35. DOE's comment contradicts an earlier statement attributed to DOE and referred to in the report that research and development is conducted concurrent with construction to bring accelerators on-line as soon as possible. Neither statement, however, addresses the real issue—why research and development cannot be completed prior to construction. As we pointed out in our report, DOE's cancelation of the Isabelle project was in part caused by problems in developing the necessary superconducting magnets. Had adequate research been conducted prior to construction, and assuming—as DOE states—that international competition was not an overwhelming criterion, cancelation of Isabelle may have been avoided. However, in order to avoid a conflict with what DOE officials are now stating, we have changed the report to attribute the statement only to DOE accelerator laboratory officials, who also made the statement.

36. DOE programs were required, under DOE Order 5700.3A (dated Aug. 6, 1982) to prepare a project plan for large projects. As such, the requirement was in effect more than a year before Isabelle was canceled. The report has been revised to show the requirement for a project plan existed before September 1983.

37. The report has been modified to reflect that, in DOE's opinion, the modified spending profiles also contributed to schedule delays.

38. We do not agree with DOE's contention that the report's presentation of data on the cost overrun at Fermilab distorts the facts. The information contained in table 3.3 is taken directly from DOE's budget requests as submitted to the Congress.

We did not alter the cost information except to restate it in fiscal year 1985 dollars. The methodology we used to convert the Tevatron I and II costs into fiscal year 1985 dollars is contained in chapter 1 of this report. The reason for slightly different amounts shown for the project is related to when the expenditures were made. If a large portion of the $49 million is expended at an early phase of the project, conversion to 1985 dollars will show that cost to be larger than if these same expenditures were made during the latter phase. In terms of constant 1985 dollars, the cost of a project will vary depending on when the expenditures take place.

DOE's statement that Tevatron I's cost overruns were due to rescoping is not relevant. The point of our report is that DOE should have disclosed the technical risks and the potential need to rescope the project. DOE's statement that research and development funds were being used for the projects reinforces our point that DOE was aware of the technical risks involved but did not disclose these risks until after the project was approved by the Congress for construction.

39. The report has been amended to state that beam intensity is not adequate for some experiments that require a higher intensity level

40. Fermilab officials informed us that, to meet the original design specifications, a prebooster may be necessary. This is the statement that appears in the report. We agree that the prebooster may be able to increase accelerator performance beyond the original specifications—thus enabling attainment of original objectives and providing a performance bonus.

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