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FEDERAL RESEARCH
Concerns About Developing and Producing Magnets for the Superconducting Super Collider

Statement of
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Before the
Subcommittee on Investigations and Oversight
Committee on Science, Space, and Technology
House of Representatives

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Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the status of the Department of Energy's (DOE) Superconducting Super Collider (SSC). My testimony today will focus on the approach DOE and the SSC Laboratory are using to develop and industrially produce the superconducting magnets for the SSC. My remarks are based on two recently issued GAO reports on the SSC. The first report, Federal Research: Super Collider Estimates and Germany's Industrially Produced Magnets, (GAO/RCED-91-94FS), was issued on February 12, 1991; the second report, Federal Research: Status of DOE's Superconducting Super Collider, (GAO/RCED-91-116), was issued on April 15, 1991.

My remarks about the magnets include the following points:

-- Although superconducting magnets for an accelerator have been industrially produced once, whether the DOE and the SSC Laboratory will be similarly successful is uncertain because they are taking a different approach to develop and produce the magnets for a substantially larger accelerator.

-- Full-size superconducting collider dipole magnets for the SSC's current design have not yet been built or tested, and a significant risk remains that the magnets may not work as intended.

-- The development schedule for these magnets is compressed and, as such, increases the risk that the magnets will not work as intended because little time has been allowed to resolve any problems that may be encountered.

Before I discuss these points in detail, let me provide some background information on the SSC and on Germany's accelerator, the Hadron Electron Ring Accelerator or HERA.

BACKGROUND

The SSC, which will be located about 30 miles south of Dallas, Texas, will be the world's largest high energy particle accelerator. A particle accelerator is a research tool used by physicists to seek fundamental knowledge about energy and matter. The SSC will collide two beams of protons at an energy of 40 trillion electron volts (TeV). A principal feature of the SSC is two rings of superconducting magnets located in an underground tunnel 54 miles in circumference. The two rings of magnets will steer and focus the proton beams in opposite directions until they collide at various interaction regions where large detectors will record the collisions for analysis by physicists. DOE recently estimated that the SSC will cost $8.2 billion (in current year dollars).

Our February 1991 report described Germany's experience producing superconducting magnets industrially for its high energy physics accelerator, HERA -- located at the Deutsches Elektronen-Synchrotron (DESY) laboratory in Hamburg, Germany. HERA, which will collide protons with electrons in a 3.9-mile ring, is substantially smaller than the SSC. HERA uses conventional magnets for its electron beam and superconducting magnets for its proton beam. HERA is one of only two accelerators built to date that use superconducting magnets. It is the only accelerator whose superconducting magnets have been industrially produced. Authorized in April 1984, HERA was completed after about 6-1/2 years of construction in November 1990. HERA was completed within 1 month of its original estimated scheduled date and within its original estimated cost of about 1.01 billion deutsche marks (about $673 million).

DOE'S APPROACH DIFFERS FROM GERMANY'S

Germany's experience with building the HERA accelerator shows that superconducting magnets can be industrially produced. Numerous minor problems were encountered and resolved during the development and production of the magnets, but German officials told us that such problems should be expected when new technologies are involved. Germany's cost to produce the magnets industrially increased by less than 7 percent (from about $29.5 million to about

$31.5 million) over the 3-year life of the contract, and the magnets were delivered on schedule.

German officials attributed their success in having industry produce the superconducting magnets to four factors:

-- One person at DESY had the authority and the knowledge needed to make all decisions concerning the technology, budget, and schedule for the magnets.

-- The laboratory clearly identified the specifications for the industrially produced magnets before bids were requested.

-- The laboratory retained the flexibility to negotiate with the contractor by maintaining ownership of the tooling and the technology.

-- DESY fully measured and tested each magnet before accepting and installing it into the accelerator ring.

The SSC Laboratory has approached these factors differently in developing and producing superconducting magnets.

-- The SSC Laboratory relies primarily on other DOE laboratories' technical expertise with superconducting magnets.

-- The laboratory requested bids from industry to build magnets before building or testing a prototype magnet.

-- The laboratory retains ownership of the tooling and technology, but is allowing one contractor to take the lead in the design and development of tooling and techniques for producing magnets.

-- Finally, the SSC Laboratory plans to rely on the contractor to measure the magnets at the plant and to cold test about 19 percent of the magnets before they are installed in the collider's tunnel.

The most obvious difference between the HERA and SSC projects is that the HERA project was built at an existing accelerator facility while the SSC project is starting at a new location where no pre-existing accelerator exists. In designing and constructing HERA, DESY made extensive use of existing accelerators. For example, the injection energy level for protons was determined by the capability of the magnets in the existing accelerators at the site to accelerate protons. Therefore, Germany was able to focus most of its accelerator construction efforts on the additional requirements for HERA. In comparison, DOE and the SSC Laboratory have had to concern themselves with constructing the entire SSC accelerator, as well as establishing and building the laboratory itself.

COLLIDER DIPOLE MAGNETS ARE UNTESTED

The SSC Laboratory has not yet built or tested full-size 50-millimeter collider dipole magnets. Because of the December 1989 change in design from a 40-millimeter to a 50-millimeter aperture, the tooling for building these magnets only recently became available. Although testing continues on the 40-millimeter magnet, much of the needed data on the magnets' mechanics and performance will not be available until the 50-millimeter magnets are built and tested. To develop the superconducting magnets, the SSC Laboratory will build and test both model (1.8 meters in length) and full-size (15 meters in length) 50-millimeter magnets. Model magnets are used to test tooling and magnet design features for incorporation into the design and production tooling for full-size magnets. Under this approach, the design is to be subsequently detailed in a series of process and performance specifications for use by industry in producing full-size magnets.

Fermilab, which has a lead role in developing the magnets, has continued to build collider dipole magnets of the original 40-millimeter design. It has done so in order to test various components, such as insulation and the superconducting wire.

However, the 40-millimeter magnet program was reduced for fiscal year 1990. According to Fermilab officials, this was because the design was changed to the 50-millimeter magnet and because budget constraints limited the amount of superconducting wire bought for 1990. As a result, only four out of six proposed full-size 40-millimeter magnets were built in 1990. According to the Magnet Systems Division Director at the SSC Laboratory, because fewer 40-millimeter magnets were built, less test information was available. However, he considered that the impact on the program will be minimal because development planned for the 40-millimeter magnets will take place using the 50-millimeter magnets.

Fermilab received the tooling for the model 50-millimeter magnets in October 1990. It completed and began testing the first of these model magnets in December 1990. Due to the lead time for purchasing the tooling following the design change to a 50-millimeter aperture, it did not receive the tooling for the full-size 50-millimeter magnets until April 1991. Therefore, Fermilab has only recently begun to build the first full-size 50-millimeter magnet.

COLLIDER DIPOLE MAGNET DEVELOPMENT SCHEDULE IS COMPRESSED

The magnet development schedule is compressed, with overlapping development stages and little or no time available between stages for resolving problems. According to an SSC Laboratory official, when problems arise in one development stage they will be resolved in the next stage. However, such an approach increases the risks that the magnets will not work as intended.

A Subpanel of DOE's High Energy Physics Advisory Panel (HEPAP) noted that the magnets are costly (about $2 billion), require additional development to achieve a proven design for a 50-millimeter aperture, need tooling and assembly methods for mass production, and must be thoroughly tested before the SSC Laboratory commits to production. The subpanel concluded that the schedule was "not realistic" and recommended adding 6 to 12 months to the early part of the schedule. Among other things, this rescheduling would provide more time to reduce risk for the magnets. In response to the HEPAP recommendation, the SSC Laboratory added 5 months to the time planned for industry delivery of the first production magnets -- from February 1994 to July 1994.

Despite the time extension, the magnet development schedule is still compressed. For example, in July 1990 the SSC Laboratory issued a Request for Proposals for collider dipole magnets. In October 1990 the SSC Laboratory announced that General Dynamics and Westinghouse were selected to enter into negotiations for the contract. Thus, the SSC Laboratory solicited offers even before Fermilab began building the first model 50-millimeter magnet in October 1990.

In addition, each subsequent phase of development overlaps the preceding phase. For example, before Fermilab completes building and testing its first full-size 50-millimeter dipole magnet in November 1991, industry is scheduled to begin building its first full-size demonstration magnet at Fermilab in June 1991.

The SSC Laboratory will test the first group of industry-built demonstration magnets in an above-ground string test scheduled to be completed in the fourth quarter of fiscal year 1992. According to SSC Laboratory officials, this above-ground string test will determine whether the 50-millimeter dipole magnets will work together and with the other SSC components, including the electrical power supply and cooling systems. If the magnets do not work, the success of the SSC project will be jeopardized. For example, after the project was authorized in 1978, DOE had constructed about one-third of the tunnel for a collider called ISABELLE in 1980, when it encountered unexpected problems with its superconducting magnets. DOE made a considerable effort to address the magnet problems, but in 1983 DOE terminated the project. When terminated, over $200 million had been spent and 75 percent of the project's conventional construction had been completed.

Following successful completion of the string test for the SSC's magnets, the magnets are to be installed in the first sector of the underground tunnel to further demonstrate the installation and performance of the magnets when integrated with the cooling systems. Construction of the first tunnel sector, about 8 miles in length, is scheduled to begin in the fourth quarter of fiscal year 1992.

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In summary, Mr. Chairman, of the uncertainties and risks associated with the construction of the SSC, the major technical risk concerns the collider dipole magnets. Although Germany has demonstrated that superconducting magnets can be industrially produced, their magnets were made for a substantially smaller accelerator and involved different management approaches. Whether the SSC's magnets will work as intended is uncertain because no full-size magnet of the current design has been built and tested.

Although DOE has taken some action to reduce the risk, such as delaying the start of magnet production, uncertainties and risks remain. The schedule for developing the magnets is still compressed and the overall risks for the magnets are high because little time will be available to resolve any problems that may be encountered.

A critical test in determining whether the magnets will work as intended is the above-ground string test scheduled for the fourth quarter of fiscal year 1992. Tunnel construction is also scheduled to start in the fourth quarter of fiscal year 1992. In our April 1991 report, we suggested that the Congress could limit the government's financial risk by not funding that tunnel construction until after the string test shows that the magnets work as intended. Such contingent funding would ensure that a tunnel is not constructed before the SSC Laboratory has demonstrated that industry can successfully produce the magnets.

Mr. Chairman, this concludes my prepared remarks. We will be happy to respond to any questions you may have.