

Cato Institute Briefing Paper No. 16: Super Boondoggle: Time to Pull the Plug on the Superconducting Super Collider

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Executive Summary

Congress soon will be deciding the fate of the Superconducting Super Collider--the \$11 billion Department of Energy atom smasher. After five years of skyrocketing cost estimates and increasing skepticism about the scientific merit of the SSC, there is now growing support on Capital Hill for pulling the plug on what would be one of the most expensive science projects ever undertaken by the federal government. The administration, however, has been lobbying furiously to spare the SSC from the budget knife and even proposes a 30 percent increase in the project's budget.

The SSC appears to be an ill-conceived project with weak economic justification but a tremendous amount of special interest support. With federal deficit spending rising to new heights, satisfying the curiosity of a small segment of the scientific community should not be considered a high national priority.

Introduction

The U.S. Congress soon will be deciding the fate of the Superconducting Super Collider--the \$11 billion Department of Energy atom smasher. After five years of skyrocketing cost estimates and increasing skepticism about the scientific merit of the SSC, there is now growing support on Capitol Hill for pulling the plug on what would be one of the most expensive science projects ever undertaken by the federal government. Unfortunately, the Bush administration does not share that view. The administration has been lobbying furiously to spare the SSC from the budget knife and even proposes a 30 percent increase in the project's budget.

If built, the SSC will be the world's largest and most powerful high-energy particle accelerator and could help to unlock the puzzle of the fundamental nature of matter. Government funding is said to be essential because the SSC would be used for "pure" research--trying to advance man's general scientific knowledge.

Whether or not it is in the financial interest of the U.S. taxpayer to fund the SSC has never been satisfactorily examined, even though \$600 million has been, or soon will be, spent on its preliminary stages. The official cost estimate to build the SSC to completion is about \$8.3 billion;^[1] it would consume another estimated \$350 million in annual operating expenses.^[2] But many experts believe that those estimates are far too conservative and that the true price tag will be nearly \$12 billion for construction and \$500 million yearly for operations.^[3] The private sector has shown virtually no interest in helping to fund the project.

There are a number of reasons for giving up on the SSC project.

1. Supporters of the project have never demonstrated that its scientific value outweighs that of other, competing scientific projects or the immense cost to taxpayers.

2. Cost estimates for the project continue to escalate far above the original price tag--thus casting considerable doubt on the accuracy of current revised projections. The history of wildly optimistic cost estimates for the SSC is beginning to resemble that of the Pentagon's B-1 bomber. Furthermore, promised international contributions to the project have never materialized, so even greater costs will be imposed on U.S. taxpayers.[4]

3. The commercial applications of the SSC technologies may well be minimal. In any event, the SSC itself will not contribute to the future international competitiveness of American industry.

4. Recent experience with federally sponsored projects has yielded disappointing payoffs for the taxpayer. From the eventually discarded Department of Energy Synthetic Fuels Corporation of the late 1970s to the bedeviled U.S. space program--with the Challenger explosion and the Hubble telescope debacle--the government's "big" projects have been multibillion-dollar disasters.

5. The SSC promises to do little more than provide permanent employment for hundreds of high-energy particle physicists and transfer wealth to Texas.

What Is the Superconducting Super Collider?

Essentially, the SSC is an "atom smasher." It would accelerate subatomic particles to incredibly high velocities and ram them together, rather like hitting one bullet with another. Its purpose is to enhance scientists' understanding of the building blocks of matter.

The SSC would be a huge, highly complex machine. It would consist of an oval, underground tunnel some 54 miles in circumference--or roughly the size of the Beltway surrounding Washington, D.C.--and approximately 12 feet in diameter. Two streams of protons would be accelerated around the loop in opposite directions. The particles within those two beams would reach almost the speed of light before being smashed together within huge detector chambers. There would be about 100 million separate collisions per second.[5] The energies generated by the intended subatomic particle collisions are to approach 40 trillion electron volts--more than 10 times the energy generated by any existing accelerator.[6] The particle collisions are expected to mimic the conditions that prevailed at the creation of the universe. Scientists hope to record the resulting smaller particles and bursts of energy and study them for clues to the fundamental structure of all matter.

Magnets play a vital role in the operation of the SSC. There are two basic types of magnets. Permanent magnets generate a constant magnetic field, and electromagnets generate a field only when an electric current is passed through them. If the electricity is shut off, the magnetic field dies. The strength of an electromagnetic field is proportional to the strength of the electric current. Although electromagnets can achieve more powerful magnetic fields, the resistance of the coils generates heat, so those magnets require cooling systems. A superconducting magnet can do the same job without producing any heat.[7]

A superconducting magnet, therefore, can be far more powerful than an ordinary electromagnet of the same size. The particle beams of the SSC would be guided through the 54-mile tunnel by over 8,600 superconducting dipole magnets and about 2,000 superconducting quadrupole magnets.[8] Each magnet would weigh about 12 tons and be approximately 50 feet in length. The magnets must be kept at a temperature no higher than 452 degrees below zero Fahrenheit (more than 268 degrees below zero Celsius) to remain superconducting.

More than 2,500 scientists and technicians are expected to run the SSC and participate in the experiments. The SSC would become the world's leading subatomic particle research center. Although several less powerful particle accelerators are in use around the world, the SSC is to be significantly more powerful than any existing facility and capable of producing more energetic collisions.[9] It is possible, however, that the SSC will have a useful lifespan only a few years longer than that of the tiny particles it will create.[10] Although proponents insist that the SSC will enable scientists to conduct unique research for decades, most of the research results will have no application to human needs, only to human knowledge.

One specific goal of the SSC is to confirm or refute the "standard model" of modern physics, the scientific theory that

successfully predicted the existence of several subatomic particles that were later produced in research laboratories. Those particles are considered the fundamental "building blocks" of which all matter is composed. If the SSC succeeds in its mission, supporters say the project could yield substantial benefits from a technological point of view--for example, in the design of the next generation of computers. However, the SSC is intended only to confirm or refute abstract theories of physics; it will not be used to produce computers or consumer goods. Any research and development of useful products will occur independent of the SSC. In fact, uncertainty about any tangible technological benefits to be derived from the SSC is used as a justification for federal funding, since private firms would not make such huge investments in projects with such dubious future payoffs.

Practically the only commercially useful aspect of the SSC project is the possibility of improved superconducting-magnet technology. However, that marginal benefit could be produced at a fraction of the SSC budget and is well within the financial reach of private industry--should it perceive the need.

The Legislative History of the SSC

One of the original champions of the SSC was President Ronald Reagan. In 1987 Reagan announced that the United States was committed to the design and construction of the world's largest and most powerful scientific instrument--soon to be called the Superconducting Super Collider. Proponents asserted that the SSC was necessary to maintain the United States as the world's preeminent scientific nation and suggested that it would result in domestic economic benefits in addition to international prestige. Opponents doubted the advertised benefits, the urgency of the scientific inquiry, and the justification for such an expensive project, especially in a time of budgetary crisis.

Before Reagan's announcement, from 1984 through 1986, the Department of Energy had spent \$60 million on research on the SSC. Spending on the SSC project ballooned to \$130 million in fiscal years 1988 and 1989 and then to \$190 million in 1990.

President Bush continued Reagan's support for the SSC with steadily rising budget requests of \$260 million in 1991, \$530 million in 1992, and \$650 million in 1993. The House of Representatives voted in May 1991 to cut \$100 million from the administration's budget request.[11] But in July 1991 the Senate approved a \$500 million appropriation for the SSC. Fiscal 1992 funding finally settled at \$483 million. The administration's request for fiscal 1993 is \$650 million. A House vote is expected in June 1992, and final passage is anticipated by September. If Congress gives the Department of Energy the green light on the SSC, budget projections indicate that spending will rise to \$1.3 billion by fiscal year 1996.[12]

The Politics of the SSC

As with any major federal spending program, the competition among the states to play host to the SSC--and the billions of federal dollars the program would eventually generate--was fierce. Twenty-six states entered the sweepstakes in the late 1980s, and Texas was eventually declared the winner in 1988.

Initially, Congress strongly endorsed the SSC, as many members were eager to lure the huge federal project into their states. Influential scientific groups and government contractors rallied behind it. According to the Congressional Quarterly: "Support for the super collider was nearly unanimous in 1987 and 1988 before the Energy Department selected its location in Waxahachie, Texas. But now that construction is about to begin, it is increasingly seen as a costly project that largely benefits Texas." [13]

Not surprisingly, the large congressional delegation from Texas--including some of Congress's leading fiscal conservatives--is now championing the SSC and vigilantly guarding it from the budget-cutting knife.[14] Sen. Phil Gramm, a Republican, explains his support for projects such as the SSC by saying: "If we should vote next week on whether to produce cheese on the moon, I would oppose it. However, if the government institutes the policy, I would see that a Texas contractor builds this celestial cheese plant, that the milk comes from Texas cows, and that the earth distribution center is in Texas." [15]

Many corporations also stand to gain financially from the SSC program, and they are understandably optimistic about the project. General Dynamics' 1990 Shareholder Report praises the SSC as "a prime example of leveraging

capabilities from a high-technology military project for use in another market sector."[16]

Similarly, in a letter to U.S. House Appropriations Committee chairman Jamie L. Whitten (D-Miss.), representatives of several interested corporations declared the SSC "another example of the partnership our companies have with the federal government on programs vital to our country's economic well-being, infrastructure, safety and quality of life." [17] The companies also warned that previous subcommittee action to reduce the Bush administration's SSC funding request by \$100 million in 1992 would "cause the project completion date to slip by three months, increase the total project cost by an additional \$100 million, and adversely impact magnet fabrication." Those implicit threats of cost overruns, and their casual acceptance by government agencies, are reminiscent of the expensive scandals that have plagued military procurement. The urgency of the corporations' plea that Congress approve SSC construction funding is understandable. They fear that mounting opposition to the SSC program may kill it in the next few years. Unless they can create a large number of financially dependent special interests in numerous congressional districts, the SSC may lose out to other competing demands for federal funding or be excised at the budget-cutting table.

The cozy relationship that has evolved among the Department of Energy bureaucrats, the states, and corporate clients is not unique to the SSC. Indeed, it is rampant throughout the process of setting federal budgets for science and technology. An example of that unholy alliance is the defense of the space program now being waged by NASA and its corporate clients. The story is almost always the same: Congress is told that it must fund a particular science project immediately or condemn America to second-rate status in a crucial area of technology. By the time the facts can be marshalled in opposition, the proponents of those programs have developed well-funded special interest lobbies that maintain pressure on Congress and the administration.

That process is now being repeated with the SSC. Rosy scenarios of both the technology and the eventual benefits are presented as indisputable facts. Good-faith challenges to the optimistic forecasts are characterized as short-sighted or the result of insufficient information. As Rep. Howard Wolpe (D-Mich.) recently complained, "The way [the SSC] is being presented to Congress, there appear to be only two stages: too soon to tell and too late to stop." [18]

The Growing Case against the SSC

The more details the scientific community, Congress, and the American public learn about the super collider, the less justified its \$11 billion price tag appears to be. The many objections to the SSC, first raised when Congress launched the project in the 1980s, remain to be addressed satisfactorily. Together, these deficiencies make a powerful case against continuing funding.

Escalating Cost Estimates

Supporters of the SSC have consistently understated its cost. The earliest cost estimate for the SSC, which incorporated all design and construction costs, was presented in the Conceptual Design Report of 1986. The total project cost was estimated to range from \$3.9 billion to \$4.2 billion (in constant 1986 dollars). The "as-spent" estimate was approximately \$5 billion. [19] In the first SSC budget request in 1988, the total project cost estimate was put at \$5.3 billion as-spent. The Congressional Budget Office then released a report that indicated that, judging from historical costs for other high-energy particle laboratories, the SSC costs might be understated by as much as 46 percent. [20]

The 1990 budget request for the SSC was based on a total project cost estimate of \$5.9 billion (as spent). [21] The 10 percent increase was attributed to congressional failure to fully fund construction of the tunnel and support facilities. Before the 1991 budget request was presented, several design changes were accepted. Department of Energy secretary James D. Watkins testified that those changes would increase the total costs by between \$1 billion and \$2 billion.

By 1990 the SSC Laboratory was admitting that significant design changes were necessary to conform to the original, 1986, performance characteristics. In other words, the project, as originally sold to Congress and the administration, could not have performed as promised without expensive improvements. That was precisely what the critics of the SSC had claimed would happen. In January 1990 the SSC Laboratory estimated total project costs at \$7.2 billion (as spent), which did not include many of the actual costs associated with providing the huge amount of electricity required to run the SSC. [22] When those costs were added, and expenditures from prior fiscal years were included, the

as spent cost estimate exceeded \$7.8 billion.

Several detailed investigations of the cost estimates had been conducted by June 1990. After reviewing them, the Department of Energy concluded that the most realistic estimate of total project baseline cost was \$8.25 billion (as spent). In approximately one year the official cost estimate for the SSC had grown from \$5.9 billion to over \$8.2 billion, an increase of almost 40 percent.

But the runaway costs did not stop there. The Independent Cost Estimating staff of the Department of Energy developed a revised as-spent total project cost of over \$9.3 billion.[23] In addition, the ICE staff felt that the peripheral expenditures--those that would never occur without the SSC--should be included in the total project cost estimates. Those costs would add approximately \$2.5 billion, for a true "total" cost of about \$11.8 billion.[24] The latter figure is the most important, since it reflects the total estimated increase in overall spending that would result from the SSC project.

The Charade of International Funding

A related problem is that promised international cooperation does not appear to be forthcoming, which means that the entire cost of the project will be borne by U.S. taxpayers. The proponents of the SSC have repeatedly assured Congress that the discoveries arising from the program will enlighten all mankind. They argue that many countries are eager to participate and contribute financially if only Congress will demonstrate "good faith" by funding the SSC more fully. Thus far, however, India is the only nation to pledge any sort of support for the SSC project--a total of \$50 million--or about half of 1 percent of the project's total cost.[25]

SSC supporters originally anticipated \$1.7 billion in foreign contributions. The European Community, which is planning its own super collider, was never a realistic source of funding for a U.S. project. Japan was expected to be a major contributor, but the Japanese government has resisted pressures by the U.S. government to become a major partner.[26]

There is domestic political opposition to foreign bids on construction of the SSC and participation in future experiments. As stated in a report on the SSC by the Congressional Research Service, "Some Members of Congress contend that the technologies involved in the SSC project, and those which may flow from it, should not be given away to other nations, but should benefit the United States." [27] There is little reason to suspect that as Congress pumps billions of additional U.S. taxpayer dollars into the SSC it will want to make the project a multinational effort.

Overstated Technological Benefits

Proponents typically claim that federally funded research of this type pays for itself by advancing general scientific knowledge, which makes possible the introduction of new technologies and, eventually, new innovative products. The argument continues that society in general profits from the new technology, which makes such projects appropriate recipients of government funding.

Since World War II that logic has been used to justify federal intervention in nearly every area of scientific research in America. The trend of federal funding of science accelerated in the 1960s in response to the Soviet Union's launch of Sputnik. From 1950 through 1990 the federal budget for science and technology jumped from \$600 million to \$16 billion. Increasingly, the technological spin-off argument has been used to buttress the national security rationale for the dominant federal role in scientific research. But the spin-off argument--that military-related research and development produce significant incidental advances in civilian technology[28]--has been refuted. For example, a 1974 study by the National Academy of Engineering concludes, "With a few exceptions the vast technology developed by federally funded programs since World War II has not resulted in widespread 'spinoffs' or secondary or additional applications of practical products, processes and services that have made an impact on the nation's economic growth, industrial productivity, employment gains, and foreign trade." [29]

In the case of the SSC, political support for the project is, to a large degree, premised on potential spin-offs, especially those related to superconducting magnets.[30] Without federal funding, supporters argue, those spin-offs would never be developed, because the benefits of a greater understanding of the fundamental forces of nature are diffuse and

difficult to capture. Thus, profit-oriented private industries are reluctant to finance such projects. Generally, pure knowledge is not protected as intellectual property and therefore may be used by anyone without paying the discoverer. Spending private billions to build the SSC would not be beneficial to the shareholders of the funding corporation even if it could produce spin-off products since any other firm would be free to produce similar products without first paying for a share of the research. Consequently, advocates of the SSC maintain that the government needs to fund that type of pure research so that U.S. businesses can exploit spin-off technologies. That would supposedly boost U.S. international competitiveness.

There are several flaws in that analysis of the SSC. A major one is that many experts contend that the value of any commercial derivatives from the SSC will be negligible. Furthermore, it is not enough for SSC supporters to show that there would be some commercially valuable new technologies developed from the SSC. For the SSC to be a good value for taxpayers, the total spin-off benefits (if they exist) from the \$11 billion federal investment must outweigh the benefits from an equivalent private-sector investment in product improvement and research. Applied science is precompanies excel and that has made America an economic success. Applied science and engineering, while less glamorous than huge pure-science projects, actually put food on the table, medicine in the pharmacy, and computers in the workplace.

The high-energy particle physics community has overreached before. The most infamous example was the ill-fated Isabel project slated for the Brookhaven National Laboratory on Long Island. Intended to detect certain predicted particles, in particular the Z-zero subatomic particle, Isabel ran over budget and well behind schedule because of serious technical obstacles. A team at the European Center for Nuclear Research detected the particles before Isabel was more than a hole in the ground. The Isabel project was eventually canceled.

Nevertheless, SSC proponents still claim that super- collider research, especially magnetic resonance imaging, an important diagnostic tool, has already benefited medical science. However, Harvard's Nicholaas Bloembergen, president of the American Physical Society, Nobel Prize winner, and pioneer in magnetic resonance technology, refuted those claims by stating that "these are spin-offs of small-scale science and not of the SSC." [31]

Dubious Benefits to Science Education

A Science Education Advisory Committee was recently formed to develop justifications for the SSC "as a catalyst for improved science and mathematics instruction in American schools." [32] The purpose of that group, which was formed after the SSC project was begun, appears to be to justify the spending after the fact and seize control of a portion of the funding. It should be clear that if improving the quality of science education were an important goal, the money should go directly to that purpose. The indirect catalyst approach will benefit only a handful of universities and elite students. According to Rep. Jim Slattery (D- Kans.), "SSC funding will concentrate research dollars in an area that accounts for less than one percent of all science education." [33] It makes little sense to try to improve basic science education in America by heavily subsidizing such a specialized group of scientists.

The Texas National Research Laboratory Commission has established a Disadvantaged Business Enterprise Program "designed to maximize participation of minority and woman- owned firms" in the SSC project. [34] In addition, a program for Historically Black Colleges and Universities was created "so that African-American SSC staff members can travel to historically Black colleges and universities across the U.S." [35] There is even a program for integrating SSC technology into the Texas community college curriculum. The unmistakable objective of those "educational" programs is to distribute federal dollars widely and thereby create political constituencies. Those programs show the SSC to more closely resemble a public works project receiving federal dollars than a high-priority science project essential to America's technological capability.

The proliferation of SSC-based educational claims even extends to elementary schools. A new "Adopt a Magnet" module, developed for students from kindergarten through fifth grade, is promoted as a benefit, not merely to science education, "but other curriculum areas as well including language arts, music, art, theater arts, math, social studies, and physical education." [36]

Technological Defects

Despite its supporters' claims to the contrary, the SSC will rely on several untested technologies that are proving to be extremely expensive and riddled with problems. Some of the obstacles that the SSC has run into were predicted by its opponents. The gigantic atom-smashing machine will not be built with off-the-shelf technologies because neither the individual pieces nor any comparable systems have been built before.

The SSC has been designed to the scientifically optimum limits of a circular collider configuration. The size of the loop around which the atoms will circle was changed when researchers determined that there was a slightly different optimum size than originally assumed. There is even new evidence suggesting that a circular configuration may not be necessary for exploring high-energy particle collisions. Improved linear designs, which are potentially much less expensive than the SSC, may be technologically feasible in only a few years. Far less expensive linear design electron-positron accelerators soon may be able to compete with the SSC design as a scientific tool.[37]

In addition, only 11 prototypes of the more than 8,600 dipole magnets and only 1 prototype of the 2,000 quadrupole magnets have been built and tested. In fact, even if the prototypes are successful, most of the magnets will not be tested until after they are installed in the underground tunnel. The recent experience with the out-of-focus Hubble space telescope should provide a lesson on the desirability of pretesting complex equipment.

In addition, the subatomic particle collisions must be detected by complex devices and interpreted by powerful computers if the experiments are to yield any information whatsoever--yet the budget for that vital feature of the project has not been approved. The Department of Energy's estimated budget for the SSC includes no more than \$640 million for design and construction of the massive detectors.[38] The people working on the designs "have been instructed to plan on a budget of no more than \$500 million each, only half of which will come from the U.S. government." [39] So far, only one design has been accepted (but not built) by the SSC project managers, although the SSC plan requires two separate detector designs. The accepted design was to have been peer reviewed in April 1992. The estimated cost of the first detector alone is \$712 million.

Even bigger roadblocks have impeded the development of the SSC's second detector. Selection of a designer of the detectors necessary to measure and record the experimental results has been slow and painful. The L-Star detector project proposal, developed by an international consortium of European, Soviet, and American institutions (90 institutions in 13 countries) has been rejected by the SSC management team. In January 1991 the SSC management team rejected a second design known as EMPACT/TEXAS. A June 1991 workshop was organized to investigate design options and create a new consortium. Currently, the gamma-electron-moon detector proposal is scheduled for review in November 1992.

The detector design problems demonstrate that the SSC is much further from reality than its proponents claim. In addition, the decision to develop only two detectors was based on cost, not scientific, considerations. Regardless of funding levels, the lack of appropriate detection devices and workable computer software could limit the SSC's scientific usefulness and greatly delay the scheduling of experiments.

Conclusion

The stated purpose of the proposed Superconducting Super Collider is to expand man's knowledge of the fundamental forces of nature: to peer back in time to the origin of matter immediately after the theorized "Big Bang" that created the universe. But even before the SSC has been built, it has provided an object lesson in the fundamental forces of politics that shape governmental scientific endeavors.

Monument building has been a political trait since ancient times. However, in a democratic republic, funding an edifice the size of the SSC requires a solid political consensus. Not unlike the biblical Tower of Babel, which was designed to reach into heaven itself, the SSC is intended to reach into the heart of matter. Unfortunately, the SSC is rapidly becoming the Tunnel of Babel, a monument that will benefit only a near-priesthood of scientists.

Despite persistent claims by the Bush administration that "the SSC will provide valuable scientific data into the 21st century,"[40] the SSC appears to be another ill-conceived science project with weak economic justifications but a tremendous amount of special interest support. Until this year expenditures were small, at least by Washington standards. But with the SSC's costs mounting, congressional support is showing signs of waning. The SSC is smashing

the federal budget long before it can smash any atoms.

With federal deficit spending rising to new heights, satisfying the curiosity of a small segment of the scientific community should not be considered a high national priority. As Sen. Dale Bumpers (D-Ark.) has said of the SSC: "It would be nice to know the origin of matter. It would even be nicer to have a balanced budget." [41]

Notes

[1] U.S. Department of Energy, Report on the Superconducting Super Collider Cost and Schedule Baseline (Washington: DOE, January 1991), Table 9, p. 62.

[2] Faye Flam, "The SSC: Radical Therapy for Physics," *Science* 254 (October 11, 1991): 194.

[3] U.S. Department of Energy, p. 27.

[4] Frederick Shaw Myers, "SSC: The Japan That Can Say No," *Science* 253 (December 13, 1991): p. 1579.

[5] Luminosity, or the rate of scientifically useful collisions, is anticipated to be 1033 per square centimeter per second.

[6] However, planned accelerators in Europe and Russia would close the gap substantially.

[7] Report of the National Commission on Superconductivity (Washington: NCS, August 7, 1990): p. v.

[8] The dipole magnets would be used to direct and bend the particles; the quadrupole magnets would be used to focus the beams.

[9] Fermilab at Batavia, Illinois; the European Center for Nuclear Research in Switzerland; and the Stanford linear accelerator, for example.

[10] The SSC may outlive its subatomic creations by less than 20 years.

[11] The Energy Subcommittee of the House Appropriations Committee also cut \$43 million from the request for a new particle injector at Fermilab, but the full House voted to shift \$10 million from the Department of Energy's high-energy physics budget to the Fermilab Tevatron main injector project. Fermilab, a smaller scale rival of the SSC, is currently one of the top three U.S. particle physics laboratories.

[12] U.S. Department of Energy, Table 9, p. 62.

[13] Alissa J. Rubin and Holly Idelson, "Super Collider Gets Green Light As Energy, Water Bill Passes," *Congressional Quarterly*, June 1, 1991, p. 1440.

[14] To secure the winning bid for the SSC, the taxpayers of the State of Texas have been committed by their elected officials to put up at least \$1 billion to support the project. According to the Texas National Research Laboratory Commission, Texas committed \$700 million to pay for site improvements, \$100 million to subsidize research efforts, and \$175 million to subsidize the cost of electricity for the SSC. Texas politicians simply recognized that \$1 billion is the minimum political ante in Washington these days.

[15] Adam Meyerson, "The Genius of Ordinary People," *Inter view with Sen. Phil Gramm, Heritage Foundation Policy Review* 50 (Fall 1989): 11-12.

[16] General Dynamics 1990 Shareholder Report, p. 27.

[17] Signing the letter dated May 21, 1991, were R. H. Oeler, vice president of Air Products and Chemicals, Inc.; R. E. Tetrault, vice president of Babcock & Wilcox; Michael W. Wynne, corporate vice president and general manager of General Dynamics Space Systems Division; Carl H. Rosner, president of Intermagnetics General Corp.; Richard F.

Harig, Sr., vice president of Parsons Brinckerhoff Quade & Douglas, Inc.; and Vincent J. Buonanno, president of Tempel Steel Co.

[18] David P. Hamilton, "SSC Savaged by Soundbites," *Science* 252 (May 17, 1991): 909.

[19] U.S. Department of Energy, p. 7.

[20] Congressional Budget Office, "Risks and Benefits of Building the Superconducting Super Collider: A Special Study by the Congressional Budget Office," October 1988.

[21] *Ibid.*, p. 11.

[22] U.S. Department of Energy, p. 14.

[23] The Independent Cost Estimating staff often draws on outside expertise. Its study was submitted directly to Deputy Energy Secretary Henson Moore. The results are reported in U.S. Department of Energy, p. 17.

[24] *Ibid.*, p. 27.

[25] See Mark Crawford, "SSC's Forlorn Quest for Foreign Partners," *Science* 252 (April 5, 1991): 25.

[26] Myers, p. 1579. See also Jacob M. Schlesinger, "Bush Seeks Supercollider Donation from a Japan Short of Funds for Its Own Basic-Science Projects," *Wall Street Journal*, January 3, 1992, p. A-8.

[27] William C. Boesman, "Superconducting Super Collider: Current Issues and Legislation," Congressional Research Service Issue Brief, April 1, 1991, p. CRS-10.

[28] See Lloyd J. Dumas, "Taxes and Militarism," *Cato Journal* 1, no. 1 (Spring 1981): 277-92.

[29] National Academy of Engineering, Committee on Technology Transfer and Utilization, "Technology Transfer and Utilization: Recommendations for Reducing the Emphasis and Correcting the Imbalance," Washington, 1974, p. i.

[30] Another claimed benefit of the SSC is the potential improvement in tunnel-building techniques, since the oval ring will be 54 miles long and at least 50 feet deep. Private-sector tunnel building is not what it used to be, but it is still unclear why the federal government should spend billions of dollars to improve technologies in that field. Most major tunnel projects are for government infrastructure, such as mass transit and water supply systems. Almost all of those government projects are big money losers for reasons that have nothing to do with tunnel-building technology.

[31] Quoted in C. David Chaffee, "Can Big Science Claim Credit for MRI?" *Science* 253 (September 13, 1991): 1204.

[32] Texas National Research Laboratory Commission, Office of Public Affairs, De Soto, Texas, News Release, May 1, 1991.

[33] Jim Slattery, "The Superconducting Supercollider," *Roll Call*, Space Policy Briefing, May 20, 1991, p. 20.

[34] Quoted from the Texas National Research Laboratory Commission Chamber of Commerce Information Package.

[35] *Ibid.*

[36] From "Adopt a Magnet Program," SSC Laboratory, Dallas, Tex.

[37] Boesman, p. CRS-8.

[38] U.S. Department of Energy, p. 59.

[39] David P. Hamilton, "Ad Hoc Team Revives SSC Competition," *Science* 252 (June 21, 1991): 1610.

[40] Henson Moore, "Why It's Worth Paying \$8.25 Billion for Super Collider," Roll Call, May 27, 1991, p. 5. Considering that the SSC is not scheduled to begin operating until 1999, this is a task even the SSC may be able to accomplish.

[41] Alissa J. Rubin and Holly Idelson, "Senators Come Out in Favor of Funding Super Collider," Congressional Quarterly, July 13, 1991, p. 1893.