The SSC Takes On a Life of Its Own

Despite rising cost estimates and continuing fights over technical issues among its supporters, political backing for the Superconducting Super Collider remains strong—for now

TRYING TO FIGURE OUT exactly what the Superconducting Super Collider will cost has a near-perfect analogue in high energy physics itself, where researchers seeking the elusive top quark have had to increase their estimate of the subatomic particle's mass each time their quarry eluded them. SSC budgeters have followed a similar pattern, increasing their cost projections every time they take a fresh look at the project (see box). And, much like the top quark's mass estimates, the SSC's cost projections probably haven't hit the ceiling yet.

This week, Department of Energy officials deliver to Congress their long-promised "hard numbers" estimate of the SSC's cost—a figure that takes into account a recent major redesign that even now some physicists say left some issues unresolved. Although the exact number DOE will present to Congress wasn't available at press time, Deputy Energy Secretary W. Henson Moore told reporters last week (*Science*, 3 August, p. 473) that the department was almost certain to favor the lowest of the three cost estimates then available—$7.835 billion, as calculated by Universities Research Associates, the contractor responsible for constructing and managing the project. Two substantially higher price tags have been submitted by DOE's Office of Energy Research ($8.3 billion) and its High Energy Physics Advisory Panel ($8.9 billion). These include additional funds to account for plausible—some say inevitable—technical and political delays.

A fourth estimate drawn up by the DOE's Independent Cost Estimating Group hadn't been officially released at press time and may never be released in its original form. The newsletter *Inside Energy* reported on 6 August that the ICE estimate would come in somewhere between $9.7 billion and $11.7 billion—by far the largest such price tag for a high-energy physics project ever imagined. Members of other cost estimating panels have tried to explain these huge numbers by suggesting that the ICE estimate not only includes higher contingency costs, but uses a different accounting methodology that lumps as "construction costs" spending that the other groups treated as "operating expenses."

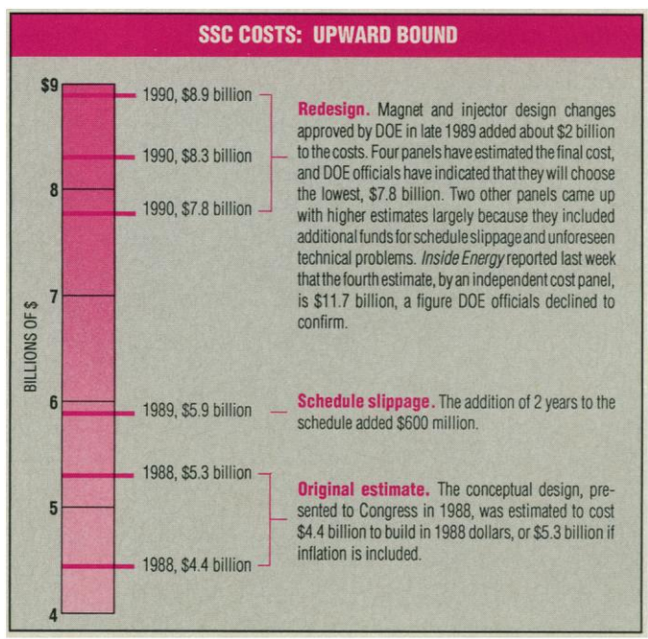
Even if the ICE estimates truly are out of the ballpark, the low estimate favored by DOE isn't much better, according to a majority of the department's advisers. So why is DOE willing to run the risk of coming back to Congress a few years down the road, hat in hand, to explain its cost overruns? Moore says rather testily: "If your contractor says, 'I can build it for this and I can do it in this time frame,' then that's the base line. And that's the hard figure we're willing to live by." But good old-fashioned budget politics is also playing a role: in a tight fiscal climate, where high-cost projects such as the SSC are already under tight scrutiny, going with the lower estimate is politically prudent. "DOE is clearly embarrassed by these cost estimates," says an aide to the Senate energy committee. "It's gotten to the point where someone has got to be saying, 'Can't you round those numbers down instead of up?' "

So far, at least, Congress has not been unduly fazed by the SSC's ballooning costs. Earlier this year, the House passed a 1991 energy appropriations bill that would provide the full $318 million DOE requested for the project, and the Senate followed suit just 2 weeks ago. And, by inaction, the Senate has effectively killed a bill passed by a 3 to 1 margin in the House that would have limited total federal SSC funding to $5 billion, including inflation.

Although that requirement could have given the project's managers heartburn, an aide to the House energy subcommittee said that Representative Robert Roe (D–NJ), who drafted the bill as chairman of the House Space, Science and Technology Committee, was mainly concerned with getting Congress to make a long-term commitment to the project, not just with holding down costs. The bill would have authorized funds for the entire construction of the project. "Without an authorization, you have to get a year-to-year commitment, and that support can get soft," the aide says.

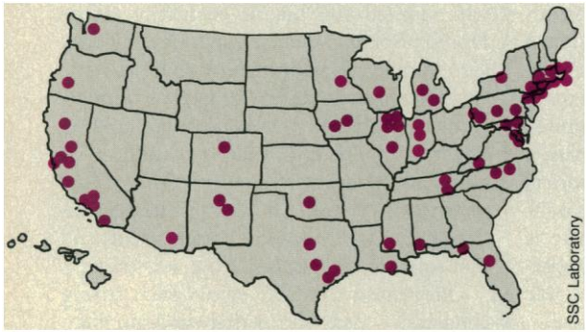
One reason the SSC enjoys such strong congressional support is that program managers have been working overtime to "Congress-proof" the project in a manner reminiscent of the way the Strategic Defense Initiative was sold. "The program has been busy spreading money around congressional districts like it was a public works program," says a Senate aide. For instance, the SSC Laboratory (SSCL) is funding "generic" research on particle detectors in 30 states, and program directors expect to see at least three different contractors—with an unknown number of subcontractors—participating in prototype magnet construction.

Even so, the SSC's congressional honeymoon may not last. This year's $318-million appropriation will probably shrink if Congress and the Administration strike a deal on cutting the deficit or if automatic Gramm-Rudman spending cuts are imposed. If that happens, planned increases in SSC annual budget requests—scheduled to rise to $1.2 billion by 1992—look increasingly un-



likely. And given the history of government construction projects, which are regularly completed late and over budget, DOE's efforts to lowball the cost of the SSC could backfire politically. "If these estimates keep rising, people are going to wonder why we're funding this project with tax dollars," says the Senate aide.

All this suggests that non-federal contributions to the project are badly needed. But the only sizable contribution that DOE has nailed down so far is a pledge from the state of Texas to provide just over $1 billion, a figure that includes the cost of land on which the accelerator will be built. Among potential foreign partners, only India has moved beyond "expressions of interest" to make a firm commitment. Indian officials told visitors from DOE on 31 July that India would send a team of eight scientists to cooperate in SSC design and development. Indian companies might also manufacture SSC components such as vacuum systems, correction magnets, and control systems at a cost of up to $50 million. When differences in labor costs are accounted for, such a contribution might save the United States $200 million.



Spreading the wealth. *This year, the SSC Laboratory distributed 15% of its $200-million budget for detector-oriented and generic R&D to researchers in 30 states.*

The chances of getting more than token assistance from other nations look similarly bleak. Despite Moore's much-touted trip to Japan and South Korea last June, neither country has yet formally agreed to participate—although Moore is optimistic that South Korea could sign a partnership agreement by the end of the year. Both nations are apparently still weighing the pros and cons of contributing to the project. DOE officials are tight-lipped about the arrangements under consideration, but no one seems to expect those foreign contributions that do materialize to include much cash. Instead, "in-kind" donations of technical assistance, scientific expertise, or manufacturing help seem more likely. For instance, a South Korean embassy spokesperson says that his government is "tentatively" considering sending a group of scientists to participate in the project. And a DOE official says that Japan may build a "fraction" of the SSC's 8000 dipole magnets—just how large a fraction, he refused to say, but added that the Japanese government was still trying to reach consensus on the matter.

DOE officials are still upbeat about obtaining significant foreign participation, pointing to the ongoing Asian negotiations and planned visits to several European countries this fall. But the enthusiasm of European governments toward contributing money to the SSC may be limited by their heavy investment in CERN accelerators. And there is another sign of European indifference to the SSC: among international high-energy physicists who have expressed interest in conducting experiments on the SSC, Europeans are disproportionately absent.

Fiscal problems aren't the only worries dogging SSC managers these days—even as they were putting together the final cost estimate, some physicists were complaining that a redesign completed earlier this year did not go far enough. The redesign was intended to alleviate worries that narrow, 4-centimeter magnet apertures and a one trillion electron-volt (TeV) injection energy could lead to distortions in the proton beam. The SSCL increased the aperture in the 17-meter dipole magnets to 5 centimeters and doubled the injection energy to 2 TeV, a move that not only satisfied most physicists, but boosted the magnets' operating margin to about 10%. Recent tests on dipole magnets have gone well, and the SSCL has asked industry to submit proposals for constructing prototype dipoles.

Now, however, there's new concern over the quadrupole magnet design, which retains the old 4-centimeter aperture. Whereas dipole magnets guide the proton beam, the 2000 quadrupoles distributed throughout the accelerator ring keep the beam focused. To physicists like Tom Kirk, an associate director of Argonne National Laboratory who co-chaired the panel that recommended the design changes, it might have made more sense to leave the dipole aperture alone while increasing those of the quadrupoles. When he first saw that the redesign had retained the 4-centimeter aperture in the quadrupoles, "I wondered if that was a misprint," he says. "The beam envelope gets largest in the quadrupoles. Those magnets are only 10% of the total cost—you could get a lot of advantage for a relatively small amount of money." Ron Scanlan, a physicist at Lawrence Berkeley Laboratory, adds that it is "very difficult" to maintain the same magnetic field gradient between magnets with different apertures.

Furthermore, increasing the quadrupole aperture is necessary if SSCL managers ever want to upgrade the SSC's "luminosity"—a measure of the frequency with which the collider smashes protons into one another. According to Robert Palmer, an accelerator physicist at Brookhaven National Laboratory, the SSC's magnets could theoretically conduct 40 times the current they're now scheduled to carry. Boosting the current could increase the collider's luminosity by two orders of magnitude, but would also cause the beam to emit more synchrotron radiation, in turn heating up the superconducting magnets. If these get too warm—above, say, 7 K—they cease to superconduct, and the beam crashes. To prevent such heating, physicists would like to place cryostat shielding cooled to 20 K between the magnets and the beam. There's plenty of room for such shielding in the new 5-centimeter aperture dipoles, but not in the cramped 4-centimeter quadrupoles.

SSCL magnet director Thomas Bush argues that the 4-centimeter quadrupole aperture is perfectly adequate. "There's no technical reason to change the quadrupole aperture," he says. "The only issue raised is one of increasing accelerator performance." But this issue is particularly important to accelerator physicists, who point out that accelerators have always been built with the capacity for future upgrades. "It seems to me an incredibly stupid thing," says Palmer, who heads an advisory panel that just last week recommended increasing the quadrupole aperture. "When they did the redesign, some committee members thought they were changing both apertures, not just the dipoles."

The fight over the quadrupole aperture illustrates a larger issue that has haunted the project since its beginning—the tradeoff between costs and accelerator reliability. Several physicists said the dipole design changes—without which the accelerator "never would have worked," according to one—were approved only after a "close fight" within DOE. Quadrupole design changes, they say, probably just aren't in the cards. "It's a tricky issue in Washington," says Palmer. "The bureaucrats say, 'We've approved this machine. We're not going to pay extra for a future upgrade.' "

Isn't this a responsible stance in tight fiscal times? Maybe so, but given the high expectations for the SSC's experimental program, DOE may have picked the wrong place to wage a rearguard budget action—particularly if its own cost estimates fail the test of time. ■ DAVID P. HAMILTON