

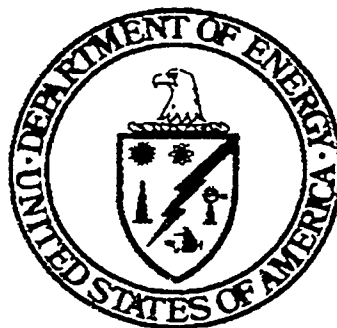
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Review of Project Definition Studies of Possible On-site Uses of Superconducting Super Collider Assets and Facilities

December 1994



U.S. Department of Energy
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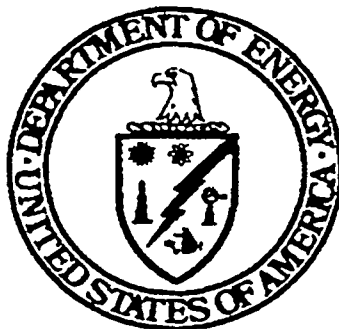
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EXECUTIVE SUMMARY

This document reports on the results of a peer review and evaluation of studies made of potential uses of assets from the terminated Superconducting Super Collider (SSC) project. These project definition studies focused on nine areas of use of major assets and facilities at the SSC site near Waxahachie, Texas. The studies were undertaken as part of the effort to maximize the value of the investment made in the SSC and were supported by two sets of grants, one to the Texas National Research Laboratory Commission (TNRLC) and the second to various universities and other institutions for studies of ideas raised by a public call for expressions of interest.

The Settlement Agreement, recently signed by the Department of Energy (DOE) and TNRLC, provides for a division of SSC property. As part of the goal of maximizing the value of the SSC investment, the findings contained in this report are thus addressed to officials in both the Department and TNRLC. In addition, this review had several other goals: to provide constructive feedback to those doing the studies; to judge the benefits and feasibility (including funding prospects) of the projects studied; and to help worthy projects become reality by matching projects with possible funding sources.

General Comments and Recommendations

There is an Opportunity for Synergy. With few exceptions, the activities studied do not conflict in space and equipment requirements. Given approval and funding, they could be pursued in parallel. In general, each activity would benefit from the presence of the others. These benefits range from the cross-pollination of intellectual vision and technical expertise, through cooperation in education and training, to the sharing of infrastructure costs.

The Proposed Activities Must Compete for Funding. There are no Federal funds available specifically to implement the activities suggested by the project definition studies reviewed here. (The recently signed Settlement Agreement between DOE and TNRLC does provide for a \$65 million contribution from SSC termination funds for a Regional Medical Technology Center, but that project was reviewed earlier and is outside the scope of this report.) None of these studies are, at this point, formal proposals, and they will have to compete for funding with other ongoing and proposed work elsewhere. In general, it will be very challenging to start new activities in the present fiscal climate.

Infrastructure Must be Provided. The proposed activities at the site all need considerable infrastructure, and to get started they will need it at highly subsidized rates. In many cases it will take some time for the activities to become self-sustaining, and, more importantly, it would be both unfair and improbable to expect the first project to shoulder the entire infrastructure burden until other projects are funded and can share the burden. In some cases

programmatic support will also be needed for startup. For example, it is difficult to imagine attracting superconducting magnet customers without a strong core of relevant expertise.

Stability Must be Assured. Funding agencies are unlikely to invest in on-site activities without a strong expectation of a long-term future for the facilities. Nor will researchers want to commit to long-term projects without assurance of being allowed to bring them to fruition. Key elements in this stability will be the method of governance for the facility and financial underwriting by the State of Texas.

Timely Decisions are Needed. Decisions should be made in the near future regarding the use of the equipment and assets. Saving them for proposed, but highly uncertain, projects for an indefinite period of time would entail storage and maintenance costs, the risk of deterioration and obsolescence, and the loss of opportunity for other DOE or State programs that could otherwise put them to good use. Obsolescence is especially critical with regard to computers.

Many Good Ideas and Much Hard Work Have Gone into These Studies. The studies were completed in a very short time, so the peer reviewers were all the more impressed with the quality and detail in most of the study reports and oral presentations. Many of the ideas in these studies will continue to evolve as their proponents move into the proposal stage.

Uses of the Superconductivity and Cryogenic Facilities

The **Applied Superconductivity and Cryogenics Technology Center** (Chapter 8) would use the assets at the N15 site for a broad range of applications related to superconducting magnets and cryogenics. While the facilities and associated equipment are first rate, similar capabilities exist elsewhere; further, the remaining on-site technical expertise is thin and even completely lacking in certain critical areas. Given the existence of strong capabilities elsewhere and the general low levels of funding in many of the areas of potential use, the reviewers felt that it will be very difficult to attract sufficient customers to allow cost-effective operations of the massive N15 facilities.

Two studies on the **Velocity of Light in a Magnetic Field** (Chapter 2) looked at the possibilities for measuring small variations in this quantity in the intense magnetic field of a "string" of SSC magnets in the N15 area. Such experiments would enable a new test of quantum electrodynamics and also search for the effects of axions, as yet-unobserved particles that could make up the dark matter in our universe. The experiments are based on the sophisticated use of laser interferometry and are very challenging. There would be very stiff competition for funding from proposals for studies of various areas of high energy physics that have received excellent ratings but have gone unfunded thus far.

Cryogenic Helium Convection Research (Chapter 3) would have major significance for both technology and fundamental science. Technological applications include aircraft and ship design, improvement of global climate models, and weather prediction. As proposed, one of the N15 cryogenic plants would cool a large cryogenic vessel (to be built by the experimenters) for use as a Very High Reynolds Number Test Facility. A crucial factor is TNRLC's commitment to provide the necessary long-term infrastructure at N15. The reviewers felt that such a facility would be highly productive and that the DOE should work closely with other agencies such as the National Science Foundation to establish a multiagency collaboration to fund it.

West Campus Opportunities in Other Sciences

Also based at the N15 site, but benefiting a very different aspect of science and technology, would be an **Underground Facility for Geoenvironmental and Geotechnical Research** (Chapter 4). It would use a portion of the 14-mile tunnel to perform *in situ* measurements and testing to provide a new class of geotechnical data that is important in a number of environmental, energy-resource, and construction applications. While the reviewers found the concept to be scientifically and technically well founded, they felt that a proposal would need a clearer definition of the specific experiments to be done. A partnership of Federal agencies interested in using the results for practical applications was felt to be the most likely funding source. Decisions should be made soon on whether to proceed with such a facility, and on what scale, so that the necessary shafts and tunnel segments can be preserved.

The **Blackland Prairie Restoration Project** (Chapter 10) involves restoration of most of the SSC west campus. Hand-in-hand with this would go basic prairie restoration research, education, and recreational facilities. The project as written is basically feasible, but its present scope is expected to make funding difficult. The reviewers felt that if the focus of the project were reoriented toward applied research in prairie restoration, technology transfer, and education, a much wider array of funding sources would be available and greater benefits would result.

Computing and Education

Several proposals included the use of the SSC computing facilities in support of education at various levels.

The **Research Facility Access and Science Education Project** (Chapter 5) would have two thrusts. It would provide academic and small-business access to scientific and technical resources remaining at the facility; it would also use educational technology, in particular the use of computers, to accelerate systemic reform throughout the various, independent Texas school districts. The reviewers felt that funding for research facility access is unlikely at the level suggested. The proposed development and distribution of educational technology would be in line with State and national education goals, and the reviewers suggested that the best ideas of this "bottoms-up" proposal be combined with those of the "top-down" educational efforts proposed by the next study discussed.

The **Southwest Center for Computing Information Technology** study (Chapter 9) addressed three very loosely related projects: a High-Performance Computing Center; a Computer-Aided Design, Manufacturing, and Engineering Training Center; and a High-Performance Learning Center. The High-Performance Computing Center would use many of the SSC computing assets and was viewed as the most promising of the three projects; State interest is high and funding seems likely.

The Training Center would be established at the SSC Central Facility; as presented, it appears neither self-sustaining nor likely to have more than a local impact on this part of the educational community.

The third element, the High-Performance Learning Center, fits well with long-term education goals of the State of Texas. The reviewers found that many of the ideas presented in this study are complementary with those discussed in Chapter 5, and it was suggested that the two groups work together with Texas educational agencies. The project should be more tightly focused and the budget refined. Closer and clearer involvement with the High-Performance Computing Center would also strengthen the proposal. State interest in the proposed educational activities appears high and it seems likely that the State will take the lead in establishing an education program at the SSC site.

Another possible application of SSC computer resources in support of research and education is described in the study on **Minority Institution Network Access** (Chapter 6). This is an idea for using SSC computer and networking equipment to increase the Internet access of minority colleges and universities, and to link each campus to a central computing facility. The reviewers of this study were uniformly supportive of the overall goals, but felt that the project, as it now stands, lacks sufficient detail and planning to warrant the transfer of existing SSC assets and may have great difficulty in attracting outside funding.

Industrial Outreach and Assistance

An ancillary theme of several studies, this was the major focus of the two studies for a **Regional Industrial Technology Institute** (Chapter 7). The first study, for a Manufacturing Technology Deployment Center, emphasizes technology incubation and is based on ideas that have worked well elsewhere. The other study, which would develop an Inland Regional Industrial Technology Institute, aims to be more of a teaching factory for manufacturing (primarily electronics, with an emphasis on small business) and is more innovative, more complex, and riskier. The reviewers felt that these centers would not be cost-effective if implemented on the scale proposed, but perhaps the best concepts of the two could be combined at a lower level that would meet the reasonably expected demand. It is clear that the State of Texas wants such activities in Texas and in the region. The State would be the major beneficiary of improved regional competitiveness, and it must decide in a timely manner how it wants to proceed and at what level.

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1. INTRODUCTION

When it terminated the Superconducting Super Collider (SSC) project, Congress instructed the Secretary of Energy to develop a plan to maximize the value of the investment in the SSC while minimizing the loss to the United States and to affected states and persons. Because many of the SSC assets and facilities would be difficult or impossible to move, because they may have greater value as operational systems than as individual components, and because of the special interest the State of Texas has in the SSC assets, it was decided to investigate their on-site uses as major systems as a first step.

Two sets of project definition studies of potential on-site uses of major SSC assets were commissioned by the Department of Energy (DOE) in the spring and summer of 1994. This report describes the results of a peer review and evaluation of the ideas put forward in eleven of these studies, covering nine areas of potential use. The review was organized by the DOE Office of Energy Research in cooperation with the Texas National Research Laboratory Commission (TNRLC). The results are described in this report, which was written by DOE staff members, based on the individual reports of the peer reviewers and on their own knowledge and expertise.

1.1. The SSC Project

The SSC was to have been a proton-proton colliding-beam accelerator complex and laboratory for basic research, providing particle collision energies 20 times greater than available at existing facilities. The project was terminated by Congress in October 1993. Significant cost sharing was provided by the State of Texas prior to termination, and a number of facilities were constructed at the site in Ellis County, Texas, about 30 miles south of Dallas. Numerous systems, components, tooling, and related pieces of equipment are located at these facilities. As of termination, approximately \$2 billion had been spent and about 2,600 people were employed at the laboratory.

1.2. On-site Facilities and Assets

The SSC site has significant facilities and assets that have potential beneficial uses. One of the first on-site activities of the SSC project involved the construction and use of the N15 area at the northwest corner of the West Complex (see Figure 1.1) for superconducting magnet development and testing. The site includes several large buildings: the Magnet Development Laboratory (MDL), the Magnet Test Laboratory (MTL), and the Accelerator Systems String Test (ASST) facility, totaling about 200,000 square feet in floor area. These buildings contain considerable magnet tooling and test equipment, as well as three large helium refrigerators (devices capable of making liquid helium), each having 4 kilowatts of refrigeration power at a temperature of 4.5 Kelvin (K).

1. INTRODUCTION

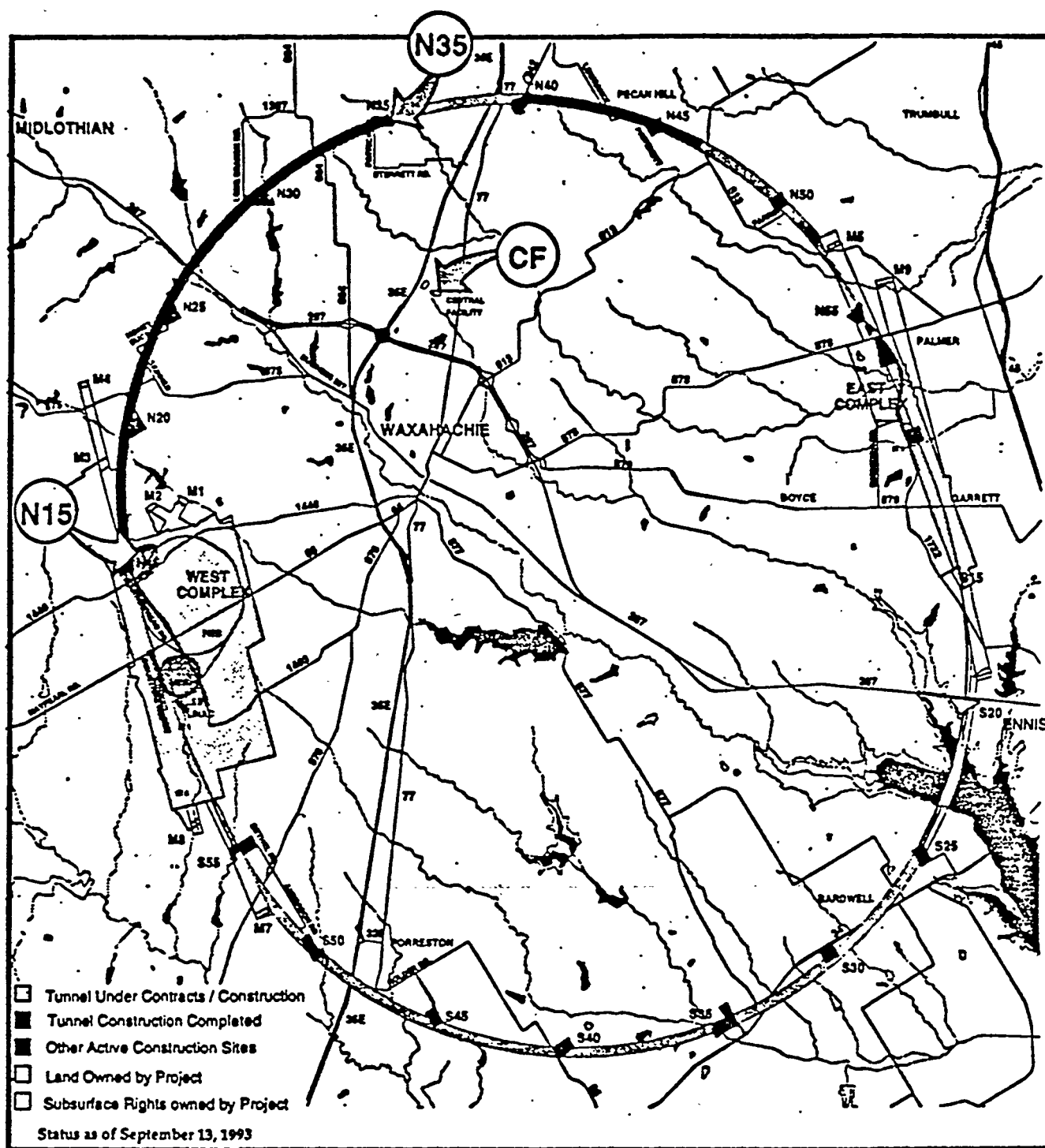


Figure 1.1. The SSC Site.

The Central Facility (CF) is located on a 46-acre site three miles north of the town of Waxahachie. This large building (550,000 square feet), originally built as a warehouse distribution center, was purchased and refurbished by TNRLC for use as office, laboratory/shop, and warehouse space. The office environment (about 220,000 square feet) allows for flexible use of office systems furnishings; it has a combination of walled offices and cubicles with extensive connections for computer networking. The laboratory/shop space (about 240,000 square feet) contains machine shops, electronics shops, and a considerable variety of technical systems and equipment.

The linear accelerator, or linac, was the closest to completion of the accelerators in the SSC injector cascade. The completed portion includes buildings (in the West Complex), a negative hydrogen ion source, and a 2.5 million electron volt (MeV) radiofrequency quadrupole accelerator. The higher energy sections of the linac were partially completed.

Nearly 15 miles of tunnel, 14 feet in diameter, were dug at a depth of typically 150 feet, and are connected to the surface by several vertical shafts.

The computer resources are extensive. The Physics Detector Simulation Facility (PDSF) features a series of integrated workstations to carry out parallel processing in an architecture that is powerful, economical, and scalable to larger sizes. The system has been capable of up to 12 billion instructions per second. The SSC Hypercube consists of 64 i860-based RISC processors interconnected with a high-speed network. Other resources include some 4,000 personal computers and workstations of various capabilities, and associated peripheral equipment.

1.3. Project Definition Studies

On March 1, 1994, after termination of the SSC project, an Agreement in Principle regarding the closeout of the project and studies of future uses of the assets was signed by the Secretary of Energy and the Chairman of the TNRLC. The agreement set out two parallel approaches to develop project definition studies of possible on-site uses. First, the TNRLC, in conjunction with the Governor's Advisory Committee on the SSC, submitted a grant application to the DOE for the study of certain potential future on-site uses of the assets of the SSC: 1) research and development in superconductivity and cryogenics; 2) high-performance computing; 3) medical technology based on use of the SSC linac; and 4) restoration of Blackland Prairie at the SSC site. On March 30, 1994, the DOE announced the award of a grant to TNRLC for up to \$6 million to study these uses. These studies included the work of SSC Laboratory experts seconded to TNRLC for this purpose. Final reports from the studies were received October 17, 1994.

In the second parallel process, the DOE and TNRLC initiated a search for additional ideas for the on-site use of major SSC assets through a call for Expressions of Interest (EOIs) that was published in the *Commerce Business Daily* and in the *Federal Register* in March 1994. Twenty-five EOIs were received with suggested on-site uses of assets and facilities. They were peer-reviewed at the SSC site April 25–28, 1994, and a DOE report was written recommending further study in six areas: 1) velocity of light in a magnetic field; 2) cryogenic helium gas convection research; 3) a geotechnical research facility; 4) a research and science education center; 5) minority institution network access to the SSC computer facility; and 6) a regional industrial technology institute.

Through a competitive program solicitation, which closed June 6, 1994, the Department received a total of 17 grant applications to carry out project definition studies in these six areas. In July 1994, the Department made awards to researchers at eleven institutions for eight separate project definition studies at a total cost of \$1.3 million. The reports from these studies were received on or about October 31, 1994.

1.4. DOE-Texas Settlement

In the time since commissioning the project definition studies, other events have provided additional ground rules and context for the future of the SSC site assets. On July 22, 1994, DOE and the State of Texas signed a Terms of Settlement outlining the resolution of the claim by the State of Texas for reimbursement of its contributions to the SSC. This was made definite by the Settlement Agreement, signed November 3, 1994. In broad terms, it calls for payment of \$145 million to TNRLC; deposit into escrow of \$65 million as a contribution toward completion of the proposed Regional Medical Technology Center (RMTC), once the requirements of the National Environmental Policy Act are met; a division of property; release of all claims by Texas against the United States; and completion of the project definition studies and the DOE evaluation of these studies.

The agreement was implemented at the Closing, held on December 1, 1994, and included the formal transfer to TNRLC of all real estate including buildings; equipment and other “personal property” at the N15 area; and equipment and other assets pertaining to the linac. The TNRLC was also given the option to purchase (at 25 percent of the original cost) the PDSF, Hypercube, and somewhat over half of the remaining computer equipment. Other equipment and assets remain DOE-owned (located primarily at subcontractor facilities and in the CF).

Alternative Settlement Terms are provided in the event that DOE does not approve, in a timely way, the TNRLC application for the medical center (RMTC) or that TNRLC were to withdraw its application: the \$145 million payment would be increased to \$210 million and DOE, rather than TNRLC, would be entitled to the land, buildings, and equipment associated with the N15 area.

1.5. The Evaluation Process

To evaluate the project definition studies, DOE, in coordination with TNRLC, established a peer review process. The review panel of experts consisted of DOE staff, staff from other Federal and State agencies, and technical experts from national laboratories, universities, and the private sector (Appendix A). The panel was organized into nine subpanels, one for each of the study areas being evaluated (the medical and scientific feasibility of the RMTC had already been peer reviewed as described in a previous DOE report).

Each of the nine subpanels had a DOE leader. Following discussions with the TNRLC and with the principal investigator(s) of the study or studies to be evaluated by the subpanel, the DOE leader established the membership of his subpanel. A vigorous effort was made to include representatives from possible funding agencies and other funding sources. The charge to the review panel is given in a memo from Dr. David B. Nelson (Appendix B). As stated in the memo, this evaluation process had several interrelated purposes:

- a. Provide input to the Secretary's plan for maximizing the value of the investment in SSC assets.
- b. Provide constructive feedback to those doing the studies.
- c. Judge the feasibility and benefits of the projects studied and provide an estimate of their funding possibilities.
- d. Help worthy projects become reality by matching projects with possible funding sources.
- e. Determine equipment and assets needed for meritorious projects with a reasonable likelihood of going forward so that the remaining DOE-owned equipment can be released for use by other DOE efforts in a timely manner.

In evaluating the activities suggested by the studies, reviewers were asked to consider the motivation and benefits, feasibility, match of SSC assets to needs, comparisons to activities elsewhere, reasonableness of cost estimates, and the realism of business plans and/or funding expectations.

The review panel was convened at the SSC CF November 29–December 1. (Because of schedule conflicts, the subpanel on Minority Institution Network Access met on November 18 in Washington, D.C.) Appendix C is the agenda for the review. On the morning of the first day, in plenary session, the charge was discussed and brief overviews of each of the studies were presented. The

reviewers then split into the individual subpanels for more-detailed technical presentations. During the morning of the second day, the subpanels interacted with the proponents of the studies as necessary to clarify information and receive answers to their questions. In the late afternoon, the individual reviewers finalized their assessments and provided their independent, non-consensus reports to their DOE leaders. A final plenary session was held on the morning of the third day to discuss summary reports from each of the subpanels.

1.6. Report of Evaluation Results

Following plenary closeout discussions, the independent assessments of the peer reviewers were synthesized by the DOE staff for inclusion in this report. A first draft DOE report was prepared by DOE staff on-site. The draft was refined the following week and presented to DOE officials in Washington, D.C. on December 8, 1994. This report was then finalized and submitted for printing.

The following nine chapters of this DOE report contain the reports from the nine subpanel leaders. The Executive Summary contains an overview of the conclusions. These conclusions will be used by the Department as it considers disposition of the DOE-owned SSC equipment and assets and as input to the Secretary's plan to maximize the value of the investment in the SSC. The evaluations will also be used by TNRLC as it decides the optimal use of its assets and facilities. While there is no specific set of Federal funds identified to support the activities suggested by these studies (other than the RMTC), it is hoped that the proponents and prospective funding sources will also find the report to be helpful.

2. VELOCITY OF LIGHT IN A MAGNETIC FIELD

2.1. Summary

Two studies examined this topic. Both would investigate the possibilities for ultra-high precision interferometry to measure the effects of a strong magnetic field on a linearly polarized light beam. There would be two major physics goals: to make a new test of quantum electrodynamics (QED) and, especially in the case of one of the studies, to search for effects that indicate the production of "axions," a type of particle that could explain the dark matter in our universe.

Each project would directly use a major asset of the SSC Laboratory (the ASST facility), which would need to be reconfigured, possibly upgraded, and then staffed and maintained with sufficient infrastructure during the life of the experiment. The experiments require very demanding optics and interferometry systems. The goals of the two studies overlap, but the Jet Propulsion Laboratory (JPL) study is substantially more ambitious in scope and sensitivity than the Colorado State University (CSU) study.

The physics topics are of fundamental importance; the project is very attractive from that standpoint. The first goal is a new test of QED, albeit a test at low energy where surprises are not expected. The projected test of the theory would be comparable with, but not better than, that achieved by other methods. As for the axion search, an improvement in sensitivity by several orders of magnitude is expected, but the projected precision, even for the more ambitious project, is well short of the level needed to detect the signs of axions as described by current theory.

The experiments are very challenging, with requirements well exceeding those of other difficult projects based on laser interferometry, especially in the power and finesse of the interferometer. The two groups have different strengths—CSU in optics and the JPL in project management and engineering. Both strengths are needed and a viable proposal might be developed by a combination of the groups. The magnet facility represents half of the projected incremental costs, uses a substantial asset of the SSC, and would need considerable support and infrastructure.

Funding would be required for running the magnet facility, for developing the optics, and for precision engineering, integration, and project management. The funding sources have not been identified, but it appears that a crucial element is TNRLC's commitment to provide the infrastructure needed for the magnet facility itself. The CSU study estimates a \$10 million budget over five years; the JPL study estimates \$30 million over seven years. Assuming that any

viable proposal would have a total cost in this range, there would be very stiff competition from known proposals in various areas of high energy physics that have received excellent ratings but have gone unfunded thus far.

2.2. Introduction

This study topic was selected on the basis of an Expression of Interest submitted by a collaboration between the JPL, Southern Methodist University (SMU), and universities in the Republic of China on Taiwan (ROC). Two grants for studies on this topic were provided, one to the JPL/SMU/ROC collaboration led by Talso Chui of JPL and the second to a group led by Siu Au Lee of CSU. This chapter presents the evaluations of these studies separately.

2.3. Overview of the Proposed Project

The two studies investigated the possibilities for ultra-precise interferometry to measure the effects of a strong magnetic field on a linearly polarized laser beam.

QED theory predicts that because of vacuum polarization (due to virtual electron-positron pairs) the velocity of light in a strong magnetic field will be slightly reduced, and that light which is polarized parallel to the magnetic field will be slowed more than light polarized perpendicular to the magnetic field. This effect can also be thought of as the laser light scattering off the virtual photons in the magnetic field (light-light scattering). The difference in velocity for the two polarizations is proportional to the square of the magnetic field; at 6 tesla (T), which is slightly below the 6.6 T operating specification for the SSC dipoles, the difference is predicted to be about 0.7 parts per 10^{22} . This difference introduces a small ellipticity into the outgoing beam polarization which is proportional to the path length in the magnetic field. This path length is greatly enhanced by bouncing the light back and forth a large number of times (100,000 or more) in a very-high-finesse Fabry-Perot cavity. This measurement would be one of the most sensitive probes of QED ever made. An anomalous result would be an indication of new physics beyond the so-called Standard Model. This measurement would be complementary to other high-precision QED experiments—in particular, measurements of the electron and muon magnetic moments.

The proposed experiments would also look for the effects of axions. These particles were postulated in order to explain the apparent absence of parity (P) and charge-conjugation-parity (C) violation in the strong interactions. The discovery of an axion would have an enormous impact, not only on high energy physics, but also on cosmology and astrophysics, where it could play an important role in stellar evolution and the dark-matter problem (the “missing mass” thought to represent the bulk of the universe). In these experiments, a small fraction of the laser light polarized along the external dipole magnetic

field would be absorbed to produce axions. Since light perpendicular to the magnetic field would not be absorbed, this would result in a small rotation of the light, initially polarized at 45 degrees with respect to the magnetic field.

The experiments would use strings of five to ten SSC magnets in the ASST facility in the N15 area. Measurements would be made at high and low field in order to pick out the QED and axion signals from other effects. This requires ramping the magnets through repetitive cycles of a few minutes each.

The optics schemes are similar to those developed recently by the Laser Interferometry Gravitational Wave Observatory (LIGO). The use of a Fabry-Perot cavity increases the sensitivity by many orders of magnitude over previous methods, but imposes very strict requirements on the relative position of the mirrors at each end of the magnet string in order to keep the cavity in the resonating mode. Active and passive mechanical isolation/stabilization, together with active optical controls, would be used to reduce and control the effects of seismic and other vibrations. Further, in the JPL study, the optical components at each end of the string would be housed in magnetically shielded and thermally isolated rooms.

The CSU collaboration hopes for an enhancement in sensitivity of about ten million (10⁷) over the previous experiment of this type, which was carried out at Brookhaven National Laboratory (BNL). Of this improvement, a factor of 100 for QED ellipticity (1000 for rotation due to axions) comes from the increased magnetic field and length of this experiment; the rest comes from increases in the number of passes through the magnetic field and from increased optics sensitivity to ellipticity and rotation. Their goal is to measure the QED effects at the half-percent level. The JPL collaboration is more ambitious, hoping to ultimately push their sensitivity by another two orders of magnitude.

The CSU study lays out a five-year program, which they estimate would cost a total of about \$10 million; \$5 million for the optics equipment and operating costs and \$5 million for the magnet and operating costs at the ASST. The JPL study shows a seven-year program with a preliminary cost estimate of \$31 million, \$14 million for the optics and \$17 million for the magnets and other ASST activities. The ROC collaborators have submitted to their National Science Council a five-year plan asking for support of their collaboration. It projects contributions equivalent to \$3.6 to \$5 million; they would provide in-kind contributions of optical and laser equipment.

2.4. Findings

The overall benefits of the proposed experiments are threefold. The results would represent significant new knowledge of nature. Technological developments that may be accomplished by attaining the goals would be broadly useful—for example, in the area of high-power interferometry. Finally, there would be a very good educational research opportunity for students working toward a future career in science.

2.4.1. Motivation and Benefits

2.4.1.1. CSU

This experiment proposes to measure the birefringence of light in vacuum, in the presence of a strong magnetic field. This elementary effect predicted by quantum electrodynamics has never before been observed. (Birefringence transforms linearly polarized light into elliptically polarized light. If the birefringence is absorptive, it also results in a rotation of the direction of polarization.)

The experiment would measure ellipticity to a precision of about 3×10^{-11} . This would result in the first detection of the birefringence induced by a magnetic field normal to the direction of propagation. The phenomenon comes purely from QED by a process corresponding to the Feynman diagram for light-by-light scattering. This process would be measured to a precision of about 0.5 percent. This experiment would complement the measurement of the gyromagnetic ratio of the muon, which has been measured to a precision of 4.5 percent in the light-by-light term of QED, soon to be improved to 0.5 percent by an experiment at BNL. Direct measurement of the light-by-light scattering would be a much-quoted result, but it seems highly unlikely to be in disagreement with other low energy tests of QED. However, one cannot be certain of this, especially if the experiment is done at the 0.5 percent level of accuracy.

The experiment envisioned in the CSU study would detect the effects of axion-like particles if they proved to have a coupling to light several orders of magnitude stronger than predicted. The investigators do not expect to be able to see the effects of axions with “standard” coupling.

2.4.1.2. JPL

The JPL experiment would perform, as its Phase I goal, approximately the same test of QED described above.

The goal of Phase II is to measure the rotation of polarization and the ellipticity to a precision of about 7×10^{-13} . This would allow a more sensitive search for effects of axion-like particles. The planned precision of the experiment, however, is still insufficient by about three orders of magnitude to detect "standard" axions that have the properties described by current theory.

2.4.2. Feasibility

2.4.2.1. CSU

This experiment appears to be relatively straightforward. It would use the magnets of the ASST in a manner very similar to the way that they were run in previous SSC tests. However, a reasonably large effort would be required to bring the ASST facility into a state of readiness to provide the necessary precision, including installation of the optics. The optical techniques would be plausible extensions of what has currently been achieved; however, R&D is required in order to reach the goal of an 0.5 percent measurement of light-by-light scattering. Examples of developmental problems are:

- Maintaining ultrahigh vacuum in the presence of photodesorption of hydrogen and helium from the cold walls of the beam tube.
- Handling of scattered light from the beam tube walls and design of baffles.
- Reduction of seismic motion of the beam tube.
- Eliminating the correlation of motion of the apparatus with the ramping of the magnet.
- Maintaining stable birefringence of the mirrors.

The proponents are aware of these problems and are experienced in dealing with such development work. This proposed experiment should be feasible.

2.4.2.2. JPL

Phase I, similar in sensitivity and difficulty to the CSU experiment, is highly feasible, but Phase II is very challenging with regard to both the magnet string and the optics.

During Phase II, the string would be expected to operate at 2 K and 7.5 T, whereas it was designed for 4.5 K and 6.6 T. This may be very difficult to achieve, given the large amount of loss to heating due to eddy currents at the high ramp rate needed. Even with coolers at every magnet, the peak temperature at the outlet of the second magnet of each pair is 2.6 K. The one SSC dipole that has been tested at temperatures below 3.5 K showed increasingly erratic quench behavior and little improvement in the field that could be reliably reached with decreasing temperature (until the temperature dropped below the

lambda point of helium). Unless the peak temperature in the string can be kept below 2.2 K, there is a good chance that the string will not reach the high fields proposed. To reach the goals stated in the study, it is likely that considerable magnet development would be required.

As for the optics, achieving the goals of Phase II would require a substantial technology development program in high-power optical coatings and substrates. It is not a foregone conclusion that such a program would succeed, but the technical problems resemble those associated with making advances in other high-precision optical phase measurements, so spinoffs might result, benefiting interferometric gravitation wave detectors and possibly leading to better laser gyros. For this experiment, problems are likely to arise from the birefringence of the mirror changing with power and time.

In summary, this Phase II experiment is probably feasible, but the time and effort required to reach the stated goals may greatly exceed the current plan.

2.4.3. Match to SSC Assets

2.4.3.1. CSU

The magnets would be run in nearly the same way as in the SSC string test. A significant amount of work would be needed to reach the required configuration, i.e., with the optics installed, but this experiment would be a good match to the facility.

2.4.3.2. JPL

Phase I is very similar to the CSU study. Its match to the available facility would be good.

For Phase II, substantial changes in the configuration and the operation of the SSC magnets would be required. The proponents suggest that considerable R&D would be needed to achieve the planned goals. The existing facility would require a major upgrade.

2.4.4. Similar Activities Elsewhere

A competing experiment is under construction in Italy under the direction of E. Zavattini. They intend to measure the QED birefringence but will use a single 10-T superconducting magnet that is only one meter long. Rather than modulating the field electrically, they will rotate the magnet with a period of two seconds. The experiment should be taking data in the next two years and has a goal of reaching one percent accuracy.

2.4.5. Costs

2.4.5.1. CSU

For a five-year period this experiment is costed at approximately \$10 million—roughly half for implementing and operating the magnet system and half for implementing the laser interferometer system. The magnet system is costed for a minimal staff, with little overhead or contingency, and it is assumed that the optics can be built by a very small group of three professors, three postdocs, and three students, plus some technical help. Compared to other challenging high-tech experiments of comparable scope, this estimated cost appears to be very low. The group also appears to lack the necessary engineering and management strength.

2.4.5.2. JPL

For a seven-year period this experiment is costed at approximately \$30 million, roughly half for the magnet and half for the laser interferometer system. The magnet work includes upgrading to run at lower temperature and a higher ramp rate, and employs a rather long magnet string. The gains for this development program do not appear to be cost-effective.

As previously noted, the JPL plan is very ambitious, involving not only R&D and substantial modifications to the magnet facility but also very challenging R&D in the optics area in order to reach the goals of Phase II.

2.4.5.3. Infrastructure Requirements for Both Experiments

Substantial though the estimated costs may be, it is clear that for the actual costs to be as low as stated, one must assume that the N15 site at the SSC would be an operating laboratory. The proponents have estimated the incremental costs that would be incurred in order to carry out the work essential to the experiments. Before such experiments could become real, some way to bring the N15 site to an operating level similar to that of a working laboratory would be essential.

2.4.6. Funding

Though selected primarily for their ability to judge the technical feasibility and scientific merit of the proposals, the reviewers were also asked to draw upon their experience as active researchers and consider the likelihood that the proposed experiment would be funded at the required level. Of course one cannot predict the future, but there is general agreement that, in the present climate, obtaining sufficient funding would be very difficult.

Assuming that a detailed proposal had been transmitted to appropriate agencies and had received favorable reviews, it would be sufficiently expensive that some ongoing project or projects would have to be drastically cut, or even

turned off, in order to fund this work. In the context of high energy physics, these proposals would surely have to compete with a number of experiments or projects which are not yet fully funded, but which are considered to be crucial to the U.S. program. For example, these include completion of the upgrade of the CESR collider and CLEO detector at Cornell University; completion of the B-factory detector (BaBar) at the Stanford Linear Accelerator Center; new fixed-target experiments utilizing the full-time availability of the Main Injector at Fermilab; and, of course, the muon storage and decay (g-2) experiment at BNL.

History shows that the way to proceed is to make the detailed proposal and initiate the decision-making process. However, in the present climate, obtaining the necessary funding for this experiment is expected to be difficult.

2.5. Conclusions

1. The physics topics are of fundamental importance; the experiments are very attractive from that standpoint.
2. Achieving the technical goals of the experiments would not only provide new knowledge of nature, but also provide significantly improved techniques for high-power interferometry. It should also be a very good educational research project for students.
3. The QED test is feasible, but it is hard. The axion search in the JPL proposal is highly challenging. The goals could prove unattainable.
4. Generally, the match to the assets at the SSC is good. Phase II of the JPL study involves major upgrades to the assets and the match to present assets is thus not as good.
5. Carrying out the proposed experiments with the estimated cost stated in the proposals implies that the N15 site is somehow maintained and operated as a working laboratory.

The CSU group and the JPL group have complementary talent and experience. The reviewers recommended that they explore the possibility of collaborating on further efforts to bring this experiment to realization.

3. CRYOGENIC HELIUM CONVECTION RESEARCH

3.1. Summary

The creation of a Very High Reynolds Number Test Facility using the SSC N15 cryogenic facilities would have major significance in both technology and fundamental science. This novel project could lead to a productive research facility that would be unique in the world. The proposed five-year program would involve the design, construction, and commissioning of the facility's most important apparatus (a cryotank ten meters high by five meters in diameter, containing helium near the critical temperature), followed by an initial set of experiments. Technical applications include aircraft and ship design, with both civilian and military implications, as well as improved understanding of atmospheric phenomena. *The time has come for this research; the reviewers recommended that DOE work closely with other agencies, such as the National Science Foundation (NSF), in establishing a multi-agency collaboration to fund this vital research.*

3.2. Introduction

This study was carried out under grants to the University of Oregon, Duke University, and Yale University under the leadership of Russell J. Donnelly (Oregon). Other participants include former SSC Laboratory scientists and X. Z. Wu from Northern Illinois University. Cost estimates for this new facility were prepared by Glen McIntosh of Cryogenic Technical Services.

3.3. Overview of the Proposed Project

Turbulent flow is a widespread, diverse, and important phenomenon in the natural world. Examples include atmospheric motion, ship-generated sea-surface flows, aircraft-created disturbances, etc. The scale of the observed phenomena is usually beyond the sizes normally accessible in the laboratory. Fortunately, some of the observed phenomena may be simulated on a reduced scale, using a fluid with different physical properties, notably lower kinematic viscosity, an approach called Reynolds-number scaling. The smaller the viscosity, the smaller the velocity and length scale needed in order to observe a given level of turbulence. In nature, the fluid with the smallest viscosity turns out to be helium at about 5 Kelvin. By varying the temperature slightly in that regime, it is possible to vary the viscosity by many orders of magnitude.

With the extraordinarily high Reynolds numbers (signifying flow dominated almost exclusively by nonlinear effects) and similarly high Rayleigh numbers (signifying heat transfer dominated primarily by turbulent convection) available through a large volume of low-temperature helium, it is expected that fundamental new insights would be obtained in the phenomena of turbulence,

which is often the limiting factor in the design and operation of various energy systems in aeronautical, chemical, and mechanical engineering, as well as an important ingredient in geophysics, astrophysics, and meteorology.

The very-large-scale refrigeration and helium storage facilities at the N15 area would be used to study thermal convection and turbulence phenomena over a wide range of Reynolds and Rayleigh numbers. A very large cryostat would be built, ten meters high and five meters in diameter, allowing a range in Rayleigh number from 10^{11} to 10^{19} . There are no competing facilities of this type anywhere in the world; it would open up a number of opportunities for a broad scientific community to become users of the facility. Input from the community would be obtained via workshops and an advisory committee.

The study lays out a five-year program. The ten-meter cryostat in the N15 area would be designed and built in the first two years and commissioned in the third year. Meanwhile, university groups would develop instrumentation and gain experience in using models. The fourth and fifth years would see experiments in convective flow, single-point velocity measurement, and multi-point temperature and velocity measurement. The experimental program thereafter would be ongoing, evolving, and continually benefiting from improvement in techniques and instrumentation.

A detailed scenario is given for the on-site manpower, totaling typically about ten full-time equivalents, the mix of skills varying with time. The scenario assumes that a number of management activities and other resources could be obtained from the host facility. The cost of the equipment is estimated to be about \$3.1 million, including a 17 percent contingency; the ten-meter cryostat accounts for about one-half of this cost. The total direct costs for the five-year program, including the associated activities at the universities and 78 weeks of cryogenic operations, is estimated to be \$8.3 million; including an estimate of indirect costs brings the total to nearly \$11 million.

Many important experiments beyond this initial program have already been identified and could lead to decades of research at a Very High Reynolds Number Test Facility. The experience gained could lead to other devices being added to this facility, including low temperature helium wind tunnels and tow tanks. Such devices could be of considerable importance, for example, in the testing of designs for submarines and surface ships, as well as aircraft and high-speed trains, adding to the competitiveness of U.S. commerce, energy efficiency in the transportation sector, and the effectiveness of our defense.

3.4. Findings

3.4.1. Motivation and Benefits

The understanding of phenomena ranging from weather prediction to drag on a submarine depends on a thorough grasp of turbulence and convective flow at large Reynolds and Rayleigh numbers. At present there is no facility to experimentally obtain this critically-needed knowledge. The central issue in this field is that the length scale needed for experiments has been too large for controlled laboratory work using ordinary fluids. In meteorology, for example, the scale is kilometers. To solve this problem, the facility discussed here would use the flow of helium at low temperature to enable experiments in the laboratory that are equivalent to the large-scale problem.

With laboratory scaling, a whole range of variables can be changed at will to test theories and look for new phenomena. Because the viscosity of helium is so low and the range of gas density is so large in the region near the critical point of helium, the facility would enable model systems to be constructed and tested at a laboratory scale, which would otherwise be impossible. The facility will open a whole new field of science and create the knowledge base to aid in improvement in global climate models and the design of the fuselages of commercial jumbo jet aircraft, just to name two examples.

3.4.2. Feasibility

There is absolutely no doubt that many new experiments could be done with this facility. The refrigeration equipment has been developed and is available. The cell design and construction is a substantial task but is based on well-proven methods used for large magnets that have already been built. Basic experiments like the towing of grids and other shapes through the fluids can certainly be done. The experiments on convective flow, in which temperature at the far ends of the tank are different, can certainly be done and will provide valuable tests of theory. The development of single-point velocity measurement is difficult but seems feasible. The development of multi-point temperature and velocity measurements will require substantial development, but the projected designs appear likely to succeed. Instrumentation development is a key component in the proposal, and the U.S. could be a world leader in the development of such instrumentation.

3.4.3. Match to SSC Assets

The dominant cost of establishing this facility, the refrigeration system, is estimated at approximately \$50 million; this asset is in place and working. The secondary detailed instrumentation for basic flow measurements is easily added to the SSC assets and the match is excellent. Laboratory and office space need to be provided.

3.4.4. Similar Activities Elsewhere

Large cryogenic facilities exist elsewhere, but not experimental facilities of this sort. The proposed facility is historically based on the work of Dr. Wu at Chicago (now at Northern Illinois University). That research, done on a scale several orders of magnitude smaller, supplied important background information. It is simply physically impossible to reach the desired parameter regime without equipment of the type available at the N15 site. The uniqueness of this experimental facility would naturally lead to international collaboration.

3.4.5. Costs

The cost of entering this vital and intellectually exciting field appears to be in the range of \$2 million per year. Cost estimates for direct operating cryogenic expenses come from people working on the project definition study for the Applied Superconductivity and Cryogenics Technology Center (see Chapter 8), and are about \$2500/day "including operators." Judging from the operating costs, there are no operations planned for the cryogenic system on behalf of this facility in years one and two; 65 days of cryogenics operations in each of years three and four; and 300 days in year five.

The cost estimates seem reasonable as far as they go. But the big uncertainty is the relationship of this effort and the Applied Superconductivity and Cryogenics Technology Center. Several issues will have to be resolved with TNRLC, including how overhead is paid, who pays for the cryogenics system when it is not in use, etc.

3.4.6. Funding

The list of potentially interested parties is impressive; the reviewers feel that it could include the DOE, NSF, Office of Naval Research, AFOSR, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration (NASA), and possibly other agencies. A multi-agency collaboration is considered as the best scenario at this time. Collaborations and interactions between government agencies are increasing so as to best utilize talents and be responsive to customer needs. A multi-agency funding mode would reduce outlays by specific agencies and enhance their likelihood of participation. International participation, possibly through in-kind instrumentation contributions, would also help defray the costs.

3.5. Conclusions

The creation of a Very High Reynolds Number Test Facility would have major significance. High-Reynolds-number turbulence is pervasive in nature, occurring in astrophysics, oceanography, atmospheric surface layers, thunderstorms, hurricanes, etc. Technological applications include aircraft and ship design, improvement of global climate models, and weather prediction.

This facility would be unique in the world. Many letters recommending it have been received from eminent researchers at universities and industrial concerns; the support is international.

The reviewers recommended that the DOE work closely with other agencies, such as the NSF, in establishing a multi-agency collaboration to fund the Very High Reynolds Number Test Facility. In addition, the TNRLC should develop and implement an appropriate long-term organizational structure (possibly including a consortium of universities) and commit to supporting the necessary infrastructure (including machine maintenance, Environment, Safety and Health (ES&H), etc.) to ensure the long-term health and productivity of this facility. If this cannot be ensured at N15, the reviewers felt that this research in understanding turbulence is of such importance that an appropriate alternate site should be found.

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4. UNDERGROUND FACILITY FOR GEOENVIRONMENTAL AND GEOTECHNICAL RESEARCH

4.1. Summary

The concept of using a portion of the 14-mile tunnel to perform subsurface *in situ* measurements and testing is scientifically and technically well founded. The experiments would provide a new class of geotechnical data on properties of the shallow subsurface that are scale-dependent and thus cannot be studied in scale models. The resulting new data and concepts would aid the analysis of dynamic material response to natural and manmade perturbations, which is important in a number of environmental, energy-resource, and engineering problems. The project is technically feasible and takes full advantage of unique SSC assets. Adding to its importance, the geologic setting of weak sedimentary rocks is unique among facilities of this scale—the others are in strong, brittle rocks such as granite. Besides its importance in hydrology, environmental engineering, and energy production, fractured, sedimentary rock of the type found at the SSC site underlies a large fraction of the urban infrastructure of the United States.

The cost estimates are reasonable, though preliminary, and provide a basis for assessment of funding potential. Infrastructure and operational costs would need to be discussed with TNRLC. An annual base cost of about \$2 million would cover the maintenance and operation of the facility, but not the cost of recommissioning the shafts and tunnels, of actually performing experiments, nor of eventual decommissioning. A partnership of Federal agencies that are interested in using the results for practical applications could turn out to be the best funding source. In any case, to be successful in the current funding climate, the project needs clearer definition of potential basic science and technological advances.

Decisions should be made soon on whether to proceed with such a facility and, if so, which portions of the tunnels and shafts to use. Parts of the tunnel are already deteriorating for lack of maintenance, and, more important, plans are underway to fill and seal most of the shafts beginning this spring as part of the SSC shut-down and site remediation.

4.2. Introduction

This study was written by Professor Herbert F. Wang of the University of Wisconsin and Dr. Larry S. Myer of Lawrence Berkeley Laboratory (LBL) on behalf of a Steering Committee composed of individuals from LBL, University of Texas at Austin, Texas A&M University, the Texas Bureau of Economic Geology, and Lawrence Livermore National Laboratory. Since 1982 the Steering Committee and its predecessors have been studying the advisability and

feasibility of an underground facility in the United States for rock mechanics and hydrogeology research. This group held a workshop at LBL on September 1-2, 1994, to consult with the geosciences community and further develop the ideas presented in the study report.

4.3. Overview of the Proposed Project

The study proposes to establish an underground geotechnical facility in most of the 14 miles of SSC tunnel. This facility would be used to study fundamental geomechanical and hydrogeologic processes in fractured sedimentary rock masses, with applications to environmental remediation and protection of ground water resources, and to large civil works. It would provide an opportunity to advance scientific investigations of fluid flow, chemical transport, and mechanical behavior *in situ* in weak and fractured rock on a scale relevant to civil and environmental engineering applications. Experimental data could be used to test conceptual models and numerical predictions, which have application for environmental remediation and large-scale underground construction. Appendices in the study report list hydrogeologic and geomechanics research questions, together with sequences of experiments at the facility to answer these questions.

The 14 miles of existing SSC tunnel lie mainly in the north arc, between points N15 and N45, passing through both Austin Chalk and Eagle Ford Shale. The Austin Chalk, a rather brittle and fractured rock, is a light to medium gray limestone interspersed with thin interbeds of shaly limestone and bentonite shale. In the chalk, the tunnel was mined by a tunnel boring machine to a diameter of 14 feet and left unlined, generally unsupported except for some tie bars in the crown. The presence of shale interbeds led to breakouts of the tunnel wall in certain sections and structural rehabilitation would be needed in these areas if they were to be used as part of an underground research laboratory.

The Eagle Ford Shale, a weak and anisotropic rock, is softer than the chalk and has a high shrink-swell potential. In this section, the tunnel was mined to a diameter of about 15.5 feet and then concrete liner segments were installed, giving a finished diameter of 14 feet.

An extensive geotechnical and hydrogeologic data base was collected over the years in identifying the SSC site and preparing for construction of the tunnel. Numerous test borings were made, a 17-foot diameter exploratory shaft was driven near the linear accelerator site, and a horizontal adit was excavated along the shale-chalk interface and highly instrumented. The rock is fractured in places, with the test borings, shafts, and tunnels showing fault and joint strikes. Such fractures play an important role in ground water flow. The precise surveys used in tunnel construction provide an additional information

asset for the design and planning of experiments. These existing data sets enhance the value of the SSC site because they would be necessary to provide initial data for any underground research facility.

At a minimum level, the staff would consist of a mining crew responsible for keeping portions of the tunnel operational and safe for personnel conducting experiments. The study authors estimate that this maintenance and operating crew would cost \$2 million per year. The experimental costs might be an additional \$2 to \$4 million per year, over a lifetime for experiments of at least ten years.

Before operations can begin, the selected shafts and tunnel would have to be recommissioned. Recommissioning costs depend on many variables, including how much of the tunnel and how many of the shafts would be recommissioned, as well as the condition of the tunnel sections to be used. Many sections of the tunnel would not require much restabilization and could be used for initial experiments. The study authors estimate the costs of recommissioning to be between \$2 and \$14 million. There is some urgency to the decision-making and funding process, as tunnel closure, including the sealing and filling of most shafts, is scheduled to begin in spring 1995.

Finally, at the end of the facility's useful life, it would have to be decommissioned in a safe and environmentally responsible manner. This cost is not included in the present study.

4.4. Findings

4.4.1. Motivation and Benefits

In many respects, the operational needs in geotechnical and geoenvironmental practice have outstripped their scientific foundation. The underlying drive for this project is a need to extend and develop the scientific basis for current practice, thereby providing a higher level of confidence and contributing economic benefits through reduction of costs incurred by over-conservative engineering design. The proposed project represents an opportunity to provide new elements of a strong scientific foundation to address important national problems relating to flow of fluids and behavior of materials near the earth's surface.

The facility would make it possible to conduct a broad spectrum of *in situ* geomechanical, geochemical, and geophysical experiments of unprecedented scale and duration. These experiments would provide a new kind and class of observational data essential in the testing and development of models for the behavior of subsurface materials. The ability to make direct observations at a wide range of sizes in three dimensions provides a means to assess and treat the issue of sample size related to distribution of fractures and heterogeneities in three dimensions. Similarly, the ability to make these observations over an

extended period provides a unique opportunity to assess dynamic response of geologic media to natural and manmade perturbations. An underground research facility provides a new opportunity for analysis of variance of properties through repeated experiments on comparable samples as well as on contrasted samples as a function of sample size.

In addition to the scientific value of an underground research facility, there are clear technological benefits. It would provide a unique test-bed for development of new technology for subsurface characterization and measurement. The known and realistic conditions would provide an unusually good venue for calibration and validation of new approaches. A technological test-bed for new measurement and analysis techniques at this site would provide new opportunities for developing partnerships between industry, academia, and government which take advantage of the linkage between basic and applied research leading to technology development.

4.4.2 Feasibility

The proposed project is, in general terms, scientifically and technically feasible. However, the broad and non-specific nature of the study does not allow detailed assessment of the feasibility of specific experiments. One can visualize research and development activities which could be conducted using only a few meters of the tunnel length and others using ten kilometers of the tunnel—all consistent with the project definition study. The overall infrastructure support needed, and the cost, would be quite different, as would be other factors entering into specific feasibility assessment. To evaluate feasibility of specific experiments and observations, additional information is needed on site-closure and restoration plans, the projected condition of the lined and unlined tunnel segments, and the nature of scientific infrastructure support at the surface facilities.

Finally, if the project's funding could not be obtained within a year or so, there would be questions about how to fund preservation of the tunnels to keep them in accessible and usable condition. Access to the tunnels and selected vertical shafts and adits, particularly in Sections N15–N35, is a key aspect of the proposed facility and must be preserved. There are indications that the water level in N35 is rapidly making part of the tunnel unavailable. Further, the prevalence of actively-spalling fractures in N30–N35 makes it a candidate for detailed study; these sections could all be damaged by flooding if too much time elapsed before recommissioning, especially if the water flow exceeds the capacity of the pumps.

In general, the issues raised on scientific and technical feasibility were not believed to be limiting in light of currently available information.

4.4.3. Match to SSC Assets

The proposed project would take advantage of existing tunnels and shafts, an attribute of the SSC that is practically unique in terms of scale and of rock type. It would also benefit directly if existing infrastructure at the SSC site, including shops and the high-speed computer communication node, remained available. The particular rocks exposed or accessible to experiments in the SSC tunnels and shafts are common in the urban subsurface, and information derived from experiments here would be broadly applicable in the U.S. and overseas.

Experiments and measurements in the unlined tunnel where Austin Chalk is exposed would provide valuable information on fluid flow in fractured media where scale-dependent phenomena could be treated explicitly. The chalk contains thin units of shale, which provide contrasts in physical properties and an opportunity for assessment of hydrologic transport across and through such units. During tunnel construction, these units acted as planes of weakness, which resulted in some collapse from the roof as the tunneling encountered them. The tunnel segment in the Austin Chalk, being unlined, is particularly amenable to experiments that would require mine-back operations to assess hydrologic, mechanical, geophysical, and geochemical parameters. The nature and distribution of fractures in this near-surface occurrence of the Austin Chalk are somewhat different than fractures encountered at depth in the same formation. The opportunity for detailed study, time-dependent measurements, and evaluation in the tunnels would provide new information that would be useful in developing an understanding of the differences in fracture regime.

Experiments in the tunnel segments where Eagle Ford Shale is exposed represent an opportunity to obtain new information on the mechanical, hydrologic, geochemical and geophysical properties of *in situ* material. Shale exposed at the earth's surface rapidly alters through interaction with the atmosphere and atmospheric fluids which changes many important properties. The Eagle Ford Shale is a weak material, as are shales in general, and an underground research facility provides an opportunity for experiments that would greatly increase our level of understanding of these important rocks.

Exposure of shales in underground construction and in drilling for resources often results in technical problems and increased cost. The combined issues of weak and easily altered material and extremely fine-grain size have resulted in rather less study of shales than of other common rock types; further, it is very difficult to correlate properties measured in the laboratory with expected properties *in situ*. The proposed underground research facility provides an opportunity to make a giant step toward a better understanding of shales.

4.4.4. Similar Facilities

There are similar facilities in brittle granitic rocks (often called crystalline rock) in Sweden, Switzerland, and Canada. They have provided extremely useful information on scale-dependent transport properties in granitic rocks, and their success has, in part, provided motivation for the proposed study. The chemistry and physical properties of the SSC rocks and fluids contrast greatly with those noted above.

There are a large number of smaller (one-ten meters) geotechnical facilities used in civil and geological engineering. None are comparable in scale to the proposed facility at the SSC site, nor do they have the SSC's infrastructure. There are mines in sedimentary rocks such as limestone, shale, and salt. These could be used for similar experiments, but active mining projects clearly limit the nature and kind of experiments that could be performed. An additional advantage of the SSC site is the large amount of existing data characterizing the geology of the site.

4.4.5. Costs

The cost estimates have a high level of uncertainty, reflecting lack of information on infrastructure content and cost, and of the time that it would take to obtain funds and initiate experiments. The annual costs of \$2–4 million cited in the study are estimates of the funding necessary to keep the facility available for experiments and measurements. Research support costs for specific projects are not included.

4.4.6. Funding and Business Plan

The costs exceed the available funding from Federal program offices traditionally supporting this area of basic research; additional, incremental funding would be required. It is expected that the specific research projects to be conducted at the underground research facility would be technically competitive with other research efforts in geoscience and geotechnology—the principal barrier is the “overhead” cost of keeping the facility in a safe and usable condition. This was recognized by the proponents in the project definition study.

The business plan does not contain enough detail to warrant extensive comment. In essence, it states that if funding is available, it will be managed. Governance and management issues would have to be resolved before the project could proceed.

There is widespread and growing interest in the geoscience and geoengineering communities regarding research and development opportunities in an underground research facility, and availability of interested personnel in academic and governmental laboratories is not perceived to be a problem.

4.5. Conclusions

The project definition study lacks specificity in the nature of the proposed experiments and needs expansion in this direction. This lack of specificity led the reviewers to express concern relative to the nature of the overall project. It was recognized that the study was not a proposal; nonetheless, a more thorough discussion of specific experiments, measurements, and models to be tested would have strengthened it. There was considerable agreement among the reviewers that an underground research facility offered promise for significantly advancing both science and technology. There was a major concern that the case had not been made, through adequate discussion of specific activities, for an underground research facility at this specific site.

Although a number of specific funding sources at the Federal level were considered and discussed, it was clear that obtaining adequate funding in the near-term from traditional sources for basic research would be a very problematic undertaking. The proponents intend to present the opportunity in the next few months to Federal agencies whose missions involve subsurface knowledge for environmental remediation, urban subsurface infrastructure, and national defense. They hope that these funding agents, individually or together, will provide the funds necessary for keeping the facility open. Industry may also be interested in supporting certain activities. Partnerships involving applications which provide opportunities for basic and applied research activities in close physical and technical proximity to each other would be particularly beneficial.

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5. RESEARCH FACILITY ACCESS AND SCIENCE EDUCATION

5.1. Summary

This project definition study proposes to 1) use resources for educational technology, in particular the use of computers to accelerate systemic reform throughout the independent Texas school districts, and 2) provide academic and small-business access to the SSC research facilities. These two activities are, for the most part, discussed separately in this chapter.

A market survey was conducted to determine the interest of university researchers and technology firms in obtaining access to SSC research facilities. Considerable interest was expressed in the computing facilities, with somewhat lesser interest in machine shop and electronics capabilities. The study assumed that other projects would operate these facilities and suggested that an Access Fund be established to aid physics-related R&D in universities and industries in the use of these facilities. Funding sources were not identified and the reviewers felt that they would be difficult to find. The possibilities for on-site computing facilities were also investigated by the study discussed in Chapter 9, and the use of SSC facilities to help small businesses is discussed in Chapter 7. The need for an additional mechanism to facilitate access to these facilities was felt not to justify the cost.

Applying SSC resources to develop and distribute educational technology and to accelerate systemic reform would be in line with State and national education goals. These activities, if implemented, could serve as models both nationally and internationally by demonstrating technological, societal, and partnering interactions. The match of SSC assets with the goals of, and needs for, systemic reform in science education at all levels is ideal. The activity is reasonable and feasible.

Probable funding sources were identified for the educational activities, and interest is evident on the part of potential funding sources. It is expected to be a State-led effort, augmented by Federal grants. The operational components identified in this study represent a grass-roots, bottom-up effort. This contrasts with the educational components of the Southwest Center of Computing, Information Technology, and Learning (SCCIL) study (Chapter 9), a top-down approach. It is recommended that the best educational components from both studies be combined. A core set of critical SSC equipment should be provided for the implementation of that combined effort, provided that the operational plan, organizational structure, and funding to implement it are in place within the next few months.

5.2. Introduction

This study was done as a collaboration between the University of Texas at Arlington and SMU. The principal investigators were Professors S. Peter Rosen (University of Texas at Arlington) and Vigdor L. Teplitz (SMU). Dr. Jane Armstrong served as the study's full-time Project Director. As part of the effort, Professor Daniel Howard (SMU) developed, managed, and analyzed a market survey on R&D infrastructure and training issues and needs. The study also benefited from an Advisory Board composed of working advisors from industry, education, and government, as well as two workshops held early in the study, one on educational aspects and one on research infrastructure.

5.3. Overview of the Proposed Project

The stated goal of this study is, "To provide realistic advice and recommendations for using SSC assets to enhance science research, education, and economic competitiveness in Texas." The study describes and recommends implementation of two major components addressing regional needs for 1) science education, and 2) academic/small business R&D facility access fund.

As written, the science education program (Cyberscience Coalition) would address computer literacy for science teachers and would involve maximal exploitation of the personal computers, workstations, mass storage capabilities, and connectivity access assembled by the SSC. These would be used both on-site and in Texas schools. The program would include intern activities for teachers and students and an on-site Science Education Enhancement Center for teacher training, on-line classrooms, a software-on-science clearinghouse, and an equipment lending pool. A second component would be the Connectivity Support Center providing technology deployment and maintenance services, digital libraries, and networking facilities for science education users. The education program would eventually include research efforts on educational technology and work force development. These science education activities are closely related to aspects of the studies discussed in Chapters 6, 7, and 9.

The second element of this study would use an academic/small business R&D facility access fund to aid physics-related R&D in Texas universities and industries. It would help to provide access to infrastructure and expertise at the SSC site in a variety of areas, including computing, information technology, machine shops, electronics shops, etc. It would include an R&D Laboratory Equipment Lending Pool. Twenty percent of the access fund would be prioritized for minority and/or female users, or project teams involving minorities and/or females in principal roles.

The study assumes that other projects using SSC assets will be selected for primary funding and that there will be a sharing of facilities and expertise. The concept is to benefit not just the local region, but the entire State, and possibly the broader region beyond the State borders.

The exact management structure for these activities is left open and would depend on the overall Texas management organization for the SSC facilities. Suggested manpower and costs are laid out for an initial five-year period. The science education program is budgeted at 20 full-time equivalents (FTEs) and about \$1.7 million per year, while the facility access programs would have three FTEs and cost about \$3 million per year. The two programs would require about 10,200 and 1,500 square feet of space, respectively, and could be either at the CF or the N15 area, depending on the location of the appropriate computing facilities.

5.4. Findings: Science Education Center

5.4.1. Motivation and Benefits

The reviewers generally agreed that it would be beneficial to have networking equipment and expertise within the public schools as proposed in this study. Anticipated benefits from such networking include not only immediate enhancement of student motivation and programmatic options, but also development of student data-handling skills for the high-tech workplace of the next decade. The networking of schools using SSC resources was viewed as a possible catalyst for needed curriculum reform. In order to optimize the potential benefits, the reviewers had the following suggestions:

- 1) A way of equitably distributing resources to schools must be devised.
- 2) Training needs for users of equipment must be met to assure effective utilization of networked equipment (with particular assistance offered to poorer schools where experience levels may be lower).
- 3) Links with related State efforts need to be agreed upon and better defined; TENET should be supported; collaboration would be needed with the regional education service centers and with the 17 Texas Centers for Professional Development and Technology; maintenance issues are likely to be much more significant than imagined and must be dealt with effectively on a broad scale.
- 4) Expected educational outcomes of enhancing science classrooms with networking need to be specified; the present focus appears to be "new technology with old teaching strategies"; more inclusion of internships and other strategies to bring actual research into the classroom would be highly beneficial.

- 5) The proposed linkage with Mexico is already established through the University of Texas system; such linkage should not be a high priority for initial implementation of networking.

5.4.2. Feasibility

The activity was seen as technically feasible with possible implementation problems. Some of the problems foreseen are 1) identifying funding to support the training and network installation/maintenance staff; 2) identifying funds to sponsor phone lines into classrooms; 3) funding software costs; and 4) engineering collaborations with other, ongoing and planned developments within the State (turf battles). Appropriate sizing of the project is the key to dealing effectively with many of these challenges.

Some reviewers did not see a large-scale project as necessary to demonstrate the functionality of networking science classes. One reviewer suggested putting together a small representative sample of schools along a continuum of least to best qualified (as measured by previous exposure, awareness of resources available on the net, etc.) to benefit from networking and investigating these sites to determine the actual spectrum of real needs. Funding is currently available within the State for similar projects, suggesting that funding may be likely here as well.

5.4.3. Match of SSC Assets to Needs

Computer equipment required for the Cyberscience project is well matched to SSC assets. For the purposes intended, a large digital data storage facility is essential, and the SSC supercomputing equipment would be hard to duplicate. To provide the desired connectivity to it and the Internet, a large number of late-model personal computers would be needed. The types of professional development discussed (teacher skills) are indeed useful for implementing technologies in the classroom but were considered peripheral to the project by most reviewers. The use of SSC-related manpower was seen as an excellent match by at least two reviewers. Regarding one of the components of the study, work force development, most reviewers did not find a reasonable match to SSC assets.

5.4.4. Comparison to Similar Activities

Successful efforts to establish programs using the concepts presented in this study are sparse throughout the United States. Curriculum development and software clearinghouse activities exist. Several instances occur where school districts have special buildings that are interconnected and use some of the technology advocated in this study. Few, if any, locations would match the potential represented by blending the best components of this study with those of the High-Performance Learning Center (HPLC) addressed in Chapter 9. The State of Texas is a leader in providing Internet implementation in the

classroom, and numerous programs exist throughout the State to support the use of Internet access. These activities are limited and a collaboration between this study and the HPLC could coalesce into a more comprehensive effort, concentrating resources and ensuring the beginning of a true paradigm shift.

5.4.5. Reasonableness of Cost Estimates

One knowledgeable Texas reviewer reported that personnel costs appear high for the area, and another felt that administrative budgets appeared overdone. A cost/benefit analysis was not possible at this point, but at least one reviewer felt that the potential benefits of the project to education could support much higher costs than are currently projected. All cost estimates would, in any case, need to be revised as the activities are better defined and combined with the HPLC. Other cost issues include equipment and its maintenance and software acquisition.

5.4.6. Funding Expectations

According to Texas reviewers, Texas funds are potentially available to support the implementation of this type of project. Whether or not State monies will be made available will not be known until action is taken by the legislature in the session that begins in January 1995. To enhance funding probabilities, partnerships should be pursued with other Texas educational entities. Some work also needs to be done on narrowing the project's scope and objectives and providing operational details. Given the current thrust for technical development within the State, and assuming partnerships are developed for integrating regional efforts, funding possibilities for an appropriately scaled effort seem strong.

5.5. Findings: R&D Research Facilities Access

5.5.1. Motivation and Benefits

This study targets the use of state-of-the-art technical facilities of the SSC by university researchers and small businesses. A fund is proposed to provide support for accepted research proposals and assist small businesses in conducting experiments and using the mechanical and electrical shops. The benefits of this activity would be in allowing users to design, fabricate, and test equipment using shop facilities not readily available at many universities and small businesses. In addition, it would further spread the kind of understanding of science and technology that can only be gained from first-hand experience with equipment and apparatus of this type.

5.5.2. Feasibility

The study concept is feasible but only if the commercial and university communities choose to become involved and a source of funds can be found to support the idea. As is the situation with efforts of this nature, a strong administrative structure would be required. The study assumed that computer and shop facilities would be operated by others. The effort would also be enhanced by a broad scientific effort continuing at the SSC site.

5.5.3. Match of SSC Assets

There is a good match with the SSC equipment insofar as facilities that will remain at the SSC site will determine the potential use by investigators. Given the continuation of the HPLC and the proposed RMTC, the access proposed here would answer needs of other research and development for the machine and electrical shops.

5.5.4. Comparison to Similar Activities Elsewhere

User facility programs exist elsewhere in the U.S., mainly at DOE national laboratories, although they generally involve highly sophisticated scientific or engineering systems. Such facilities are normally managed by an active program and time is provided for the user. In the case of facilities such as machine shops, the user normally pays an hourly rate.

5.5.5. Reasonableness of Cost Estimates

The budget level would control the amount of use. This could be increased should paying business users be found, or if university users come with their own funding.

5.5.6. Reasonableness of Business Plans and Funding Expectations

The study did not present a business plan; however, it was assumed that other activities in the SSC facilities would operate the shops. This plan assumes that the operator(s) of the facilities would be sympathetic to a plan of this nature. It is not expected that Federal funds would be available at the level suggested by the study. The current budget climate indicates that establishing a fund of the kind put forth in the study is most unlikely without other sources of income. Funding from income paid by business users is a potential source, as is pointed out in the market survey.

5.6. Conclusions

The science education portion of this project definition study provides a framework for utilizing SSC resources to disseminate educational technology and accelerate systemic reform throughout the independent Texas school

districts. Such activities are in line with national educational goals. The NSF and the Department of Commerce (DOC) have initiated programs for national information infrastructure improvement and educational connectivity. Systemic reform is a major concern of the National Science and Technology Council and this has led to the planning of national efforts in several Federal agencies. In addition, the State of Texas also supports these goals. The implementation of this activity could serve as a model nationally and internationally. It is uniquely significant in that it addresses societal, organizational, and partnering interactions, as well as technological and educational considerations.

The operational components of the educational activities identified in this study represent a grass-roots, bottom-up effort. The SCCIL study (Chapter 9) also has an educational component, the HPLC, representing a top-down approach. It is recommended that components from both studies be incorporated in the final effort. Funding possibilities from the State for an appropriately scaled effort seem strong. A core set of critical SSC equipment should be provided for implementation of that effort, provided that the operational plan, organizational structure, and the funding to implement it are in place within the next few months.

The funding possibilities for a Research Facility Access Fund do not seem high. However, access to many of the facilities would be a part of some of the activities proposed in other studies.

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6. MINORITY INSTITUTION NETWORK ACCESS

6.1. Summary

This study addresses the use of SSC computer and networking equipment to increase the Internet access of Historically Black Colleges and Universities (HBCUs) and other minority campuses and to link each campus to a central computing facility. It is proposed by a team of high-energy physicists and a computer scientist from Prairie View A&M University, working in partnership with a consortium of researchers at minority and majority institutions known as the Tuples Collaboration.

The reviewers were uniformly supportive of the overall goals of the Prairie View team and the Tuples partners. However, the project definition study has neither a clear justification for the distribution of SSC assets to the various sites nor a coherent plan for the utilization of the computing and networking assets once they are in place.

The reviewers also noted the absence of discussion of several key areas. These areas include proposed mechanisms for providing ongoing maintenance of the systems and training for faculty and students in the use of computing and networking tools; a reasonable estimate for the outyear costs of maintaining and upgrading networks and communications links; and a contingency plan for making good use of the SSC assets if outside funding at the requested level is not forthcoming. The project, as it now stands, lacks sufficient detail and planning to warrant the transfer of existing SSC assets and may have great difficulty in attracting outside funding.

6.2. Introduction

The study was funded by a DOE grant to Prairie View A&M University. Working with the Tuples Collaboration, the Prairie View team conducted a planning effort that used results of a survey of the current state of network access at HBCUs and minority institutions across the country, along with recommendations of a fall 1994 workshop held at Prairie View A&M. They solicited the advice of experts on implementing a minority institution networking plan and input from an external advisory committee. The result was a proposed series of network installations and upgrades at eleven minority institution sites, along with an estimate of the cost of purchasing new equipment at each site.

6.3. Overview of the Proposed Project

Much progress has been made in improving research and education at HBCUs and minority institutions through the installation of computing and networking equipment at a number of sites, and through the formation of

partnerships for graduate education and research between majority research institutions and minority institutions like the Tuples Collaboration. Nonetheless many of these colleges lack basic network connections and access to the Internet. This lack of connectivity means that they do not have access to the NSF or DOE supercomputer centers, so they are unable to use the computing resources and information technology that majority researchers, faculty, and students take for granted.

Based upon an assessment of the current state of networking facilities (local area networks, wide area networks, and Internet access) at HBCUs and minority institutions conducted as a part of this project definition study, the Prairie View A&M team proposes computing and networking installations and upgrades there and at ten other HBCUs and minority institutions. The ten institutions are: Lincoln University, Cheyney University, Langston University, Howard University, Texas A&M University-Kingsville, Southern University, Paul Quinn College, Morgan State University, Southwest Indian Polytechnic Institute, and Morehouse School of Medicine. The networking access, equipment, and communications needs of the institutions were identified through a survey conducted by the Prairie View A&M team and a workshop held at Prairie View in the fall of 1994.

The project definition study proposes to make a start on alleviating these deficiencies by placing SSC assets and new equipment initially at the eleven sites. This effort will link individual units on each campus to one another, then link the campus to the Internet. Once the various networking systems are operational and stabilized, the Prairie View A&M team will attempt to link the eleven campus sites to a national supercomputer user facility.

The study contains a one-year budget of roughly \$3.6 million for the new resources (equipment) and operating costs. This money is needed to accomplish the network installations and upgrades. It requests some existing SSC computer equipment and networking hardware, which would be placed at the 11 sites. Of the \$3.6 million, roughly \$2.7 million is budgeted (in the form of subcontracts) for new equipment, personnel, and infrastructure costs at the ten institutions working with Prairie View in the project. The cost of new equipment and communications links is estimated to be roughly \$1.2 million in the first year, but the project definition study does not contain a budget for outyear equipment and operating costs. Presumably, in the outyears of the project, the cost of new equipment would decline substantially.

6.4. Findings

6.4.1. Motivation and Benefits

The reviewers recognize the importance of the goals and are supportive of the efforts of the Prairie View team and the Tuples Collaboration in this regard. However, they came away from the Prairie View presentation and a reading of

the project definition study with a number of unanswered questions. First and foremost, beyond the indisputable but very general statement that increasing minority access to computing and networking resources is a worthy activity, they found no clear explanation of the benefits to be derived if the study recommendations were implemented. It is also not clear that there resides on the individual campuses sufficient technical expertise to make effective and sustained use of the equipment, nor that the study team has a workable plan for the equitable distribution of the SSC resources, given the adversarial relationship between administration and faculty with regard to assets on many minority campuses. Unless administration and faculty come to an agreement on distribution and use before the equipment is actually provided, there is the danger that the equipment will not be accessible to all members of the university community, and the major goal of the project will not be achieved.

6.4.2. Feasibility

The reviewers were in overall agreement that the project, as described in the study and the presentation, is *technically* feasible. However, a number of unanswered questions arose in this regard as well. The study itself documents problems that already exist at most minority sites in having suitable personnel available on site for network installation, administration, and maintenance; and so clearly there must be plans for hiring such technical staff at most of the 11 sites. Unfortunately, the study only addresses this hiring in a "lump-sum" fashion at ten of the sites—that is, in the form of subcontracts totaling \$2.7 million to be spread over the ten sites for new equipment and personnel. In addition, the lack of outyear budgets in the study leaves the impression that the Prairie View team has not considered the ongoing costs of maintaining the networking infrastructure once it is finally in place.

The requested level of funding for the first year is roughly \$3.6 million, but there is no indication, either from the study itself or the presentations, that the project study team has looked into obtaining funding from any source other than DOE, or that the team has contacted university administrators or vendors about possible cost-sharing arrangements. During the presentation, the team was asked specifically what would happen to the project if the funding did not materialize, and members did not give a clear answer, except to say that "the equipment would still be utilized."

6.4.3. Match to SSC Assets

The project study has addressed the equipment requirements in generic terms and made a good case for the overall suitability of the SSC computer and networking assets for the proposed networking of minority campuses. However, it was not made clear, even during the oral presentations, why the existing SSC assets would be distributed to the 11 campuses in a more or less uniform manner even though the institutions differ considerably in size. The proposed distribution may be a less than optimal use of SSC assets. In addition,

there was considerable confusion as to the number of SSC desktop computers and workstations needed. The summary tables showed a much larger number than did totaling of the needs listed by each of the 11 participating institutions.

6.4.4. Similar Activities Elsewhere

The proposed networking implementation plan involves very little risk, since setting up local- and wide-area networks and Internet access has become a commonplace activity. What distinguishes this implementation from others is that it is directed at minority institutions that historically have lacked the equipment and personnel resources to install and maintain adequate networking and communications facilities on their campuses. The study does describe successful efforts of this type at several HBCUs, so the project team does have models for help and guidance.

Successful networking implementations of this type require, in addition to the right equipment, the right technical personnel on site and a commitment from the administration to support the activity now and in the future. If the latter two requirements can be met on a campus-by-campus basis, then the project outlined in the study will be indeed a worthwhile use of SSC computing and networking assets, provided that a clear and consistent plan for distributing and utilizing the assets is forthcoming.

6.4.5. Costs

There were many unanswered questions in regard to the overall costs of the project, both in its initial start-up phase and in the outyears. The bulk of the first-year budget, specifically \$2.7 million, is in the form of subcontracts from Prairie View A&M to the ten participating institutions. Roughly \$1.2 million of this amount was identified in the study as the funds needed for new equipment and communication lines at the ten sites, but this leaves \$1.5 million for "personnel" that is almost completely unspecified. Over and above this, the numbers in the budget listed at the back of the study are inconsistent, and the sums do not always add up to the stated totals. Again, as was mentioned earlier, the study contains no budget information for the outyears of what is obviously a multi-year project. In sum, the reviewers were frustrated by the evident lack of care in the preparation of the budget, and was concerned that if the study were funded at close to the requested level, then large amounts of money would be changing hands with little or no oversight. Clearly, the budget presentation has to be improved dramatically before the study can hope to attract SSC assets as well as outside support.

6.4.6. Funding

Given the inconsistencies and lack of detail in the budget as presented and the overall lack of a specific campus-by-campus network installation and maintenance plan, the ability of the project to attract outside funding appears to be severely limited. The two deficiencies of course go hand-in-hand. Putting together an explicit, detailed business and implementation plan would enable the project study team to estimate initial and outyear costs accurately and to adjust the level of effort to the amount of funding received, since it is unlikely that full funding can be obtained in this difficult budgetary climate. Instead, the project study came across as a largely undocumented request for new equipment and substantial operating funds, in addition to the request for existing SSC assets, that does not lay out a clear plan for maintaining control over the different networking activities at the 11 sites and assessing their effectiveness over time.

Given these concerns, the reviewers were reluctant to recommend the transfer of any SSC assets, even in the presence of external start-up funds, to this project, unless and until the Prairie View team addresses the deficiencies noted throughout this study. As it stands now, the project has virtually no chance of attracting any level of external funding, since any potential funding source would require a level of detail in the implementation plan and budget that is almost totally absent from the project definition study.

6.5. Conclusions

The reviewers remain very supportive of the overarching goals of the project definition study and the broader Tuples Collaboration and were impressed by the dedication and commitment of Professor Dennis Judd and the rest of the Prairie View A&M team in advancing research and education at minority institutions. Many members of the review panel have firsthand experience dealing with the opportunities and problems at HBCUs and minority institutions, and they recognize the scope of the undertaking that is contained in the study. Professor Judd and his Tuples colleagues continue to use their own time and resources, without hesitation, to address needs that are important to their university communities and ultimately to the research and education infrastructure of the country.

Nevertheless, the members of the review panel were disappointed that the written study and oral presentation did not contain certain elements: clearly defined goals, milestones, and metrics for assessment of the proposed networking activities; detailed short- and long-term plans for achieving these goals; detailed multi-year budgets for the various activities that explicitly state how money and resources will be distributed and how the infrastructure will be maintained; or an indication that the many administrators whose institutions are involved in the on-site activities are genuinely supportive of the goals of the

project. The last point is especially important, because without the explicit support of administrators, the project is doomed to fail despite its worthy overall goals. The project team needs to pay much more attention to these kinds of details before their project can hope to compete with similar minority institution infrastructure projects—and before the requested SSC assets can be transferred.

7. REGIONAL INDUSTRIAL TECHNOLOGY INSTITUTE

7.1. Summary

Two studies examined concepts that would be beneficial to the manufacturing sector in the region. The first study emphasizes technology incubation and is based on ideas that are working well elsewhere. The other aims to be more of a teaching factory for manufacturing and is more innovative, more complex, and riskier. The concepts developed in these two studies cover the full range of manufacturing services from product conception to initial manufacturing, as well as technical education and customized training at levels ranging from student to senior executive.

It is clear that the State has a strong, recognized desire for these types of activities in Texas and in the region. Each element could make a valuable contribution. However, the reviewers felt that these concepts would not be cost-effective if implemented on the scale proposed, which would use most of the SSC Central Facility (CF). The proposed supply of services greatly exceeds the expected demand. If the best concepts of the two studies were combined and implemented at a level that met the expected demand as judged by the reviewers, in total they would require:

- Less than 20 percent of the SSC Central Facility.
- Approximately \$2 million per year for expenses.
- A small fraction of the SSC equipment.

This is important, because the concepts would be cost-effective in the SSC CF only if there were other substantial uses as well. Constraining the use of equipment to on-site applications may not necessarily maximize the return on this investment to the State. Some of the concepts may also have applicability at DOE laboratories and facilities, since many of the desired core competencies already exist to meet other DOE mission needs. In any case, since the State would be the major beneficiary of improved regional competitiveness, it must decide in a timely manner how it wants to proceed and at what level.

7.2. Introduction

The concept of a Regional Industrial Technology Institute (RITI) at the SSC site was developed via the EOI process. Two RITI studies were funded by the Department. One, "A Feasibility Study for a Manufacturing Technology Deployment Center" (MTDC), was submitted by the Texas Engineering Extension Service of the Texas A&M University System and the Automation & Robotics Research Institute of the University of Texas at Arlington, referred to as TEEEX/ARRI. The second was the "Inland Regional Industrial Technology

Institute" (I-RITI) developed by the Texas Manufacturing Technology Center (TMTC). The remainder of this chapter compares, contrasts, and sometimes combines the ideas presented in the two studies.

7.3. Overview of the Proposed Projects

The Manufacturing Technology Deployment Center (MTDC) concept, as proposed by TEEEX/ARRI, has four main activities: 1) Product and Process Development, 2) Manufacturing Incubator/Accelerator, 3) Teaching Factory and Shared-Use Manufacturing Center, and 4) Regional Trade Distribution Teaching Factory; with three supporting elements: a) Outreach Center, b) CAD/CAM Center, and c) Technology Resource Center.

The MTDC concept also assumes a functioning and accessible High-Performance Computing Center (HPCC) in place at the CF. The manufacturing incubator would help start-up manufacturing companies become viable by assisting in the development of their products and processes, and to initiate low-rate production. The product and process development center would further expand on these activities by providing prototype design and fabrication, concurrent design of product and manufacturing processes, and market research, as well as access to technology opportunities and expertise available from the region.

The Inland Regional Industrial Technology Institute, or I-RITI, concept, as explored by TMTC, consists of four main activities as well: 1) Teaching/Learning Factory & Technology Training Center, 2) Manufacturing Technology Center, 3) Manufacturing Test and Evaluation Center, and 4) Manufacturing Commercialization Center. However, the I-RITI focuses on the electronics-related segments of the manufacturing sector, further concentrating on the needs of small manufacturing enterprises (less than 100 employees).

7.4. Findings

7.4.1. Motivation and Benefits

The motivation for instituting a RITI at the SSC site has a strong basis in both the needs of the Texas manufacturing industry (especially its small business component) and the State's desire to stimulate economic activity. The industry needs were identified and detailed at some length by both studies and were verified by several of the study evaluators familiar with Texas manufacturing. Industry representatives also expressed interest in using a facility such as the RITI at "focus group" meetings recently conducted by one of the study proponents. Although the number varies depending on location, it is estimated that each new job in the manufacturing sector creates another three jobs in the regional economy. The State of Texas would like to turn SSC-related assets toward activities that could help replace the economic wealth and multiplier effect originally anticipated from the SSC project.

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It is clear that the State has a strong, recognized desire for these types of activities in Texas and in the region. Each element could make a valuable contribution. However, the reviewers felt that these concepts would not be cost-effective if implemented on the scale proposed, which would use most of the SSC Central Facility (CF). The proposed supply of services greatly exceeds the expected demand. If the best concepts of the two studies were combined and implemented at a level that met the expected demand as judged by the reviewers, in total they would require:

- Less than 20 percent of the SSC Central Facility.
- Approximately \$2 million per year for expenses.
- A small fraction of the SSC equipment.

This is important, because the concepts would be cost-effective in the SSC CF only if there were other substantial uses as well. Constraining the use of equipment to on-site applications may not necessarily maximize the return on this investment to the State. Some of the concepts may also have applicability at DOE laboratories and facilities, since many of the desired core competencies already exist to meet other DOE mission needs. In any case, since the State would be the major beneficiary of improved regional competitiveness, it must decide in a timely manner how it wants to proceed and at what level.

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Institute" (I-RITI) developed by the Texas Manufacturing Technology Center (TMTTC). The remainder of this chapter compares, contrasts, and sometimes combines the ideas presented in the two studies.

7.3. Overview of the Proposed Projects

The Manufacturing Technology Deployment Center (MTDC) concept, as proposed by TEEEX/ARRI, has four main activities: 1) Product and Process Development, 2) Manufacturing Incubator/Accelerator, 3) Teaching Factory and Shared-Use Manufacturing Center, and 4) Regional Trade Distribution Teaching Factory; with three supporting elements: a) Outreach Center, b) CAD/CAM Center, and c) Technology Resource Center.

The MTDC concept also assumes a functioning and accessible High-Performance Computing Center (HPCC) in place at the CF. The manufacturing incubator would help start-up manufacturing companies become viable by assisting in the development of their products and processes, and to initiate low-rate production. The product and process development center would further expand on these activities by providing prototype design and fabrication, concurrent design of product and manufacturing processes, and market research, as well as access to technology opportunities and expertise available from the region.

The Inland Regional Industrial Technology Institute, or I-RITI, concept, as explored by TMTTC, consists of four main activities as well: 1) Teaching/Learning Factory & Technology Training Center, 2) Manufacturing Technology Center, 3) Manufacturing Test and Evaluation Center, and 4) Manufacturing Commercialization Center. However, the I-RITI focuses on the electronics-related segments of the manufacturing sector, further concentrating on the needs of small manufacturing enterprises (less than 100 employees).

7.4. Findings

7.4.1. Motivation and Benefits

The motivation for instituting a RITI at the SSC site has a strong basis in both the needs of the Texas manufacturing industry (especially its small business component) and the State's desire to stimulate economic activity. The industry needs were identified and detailed at some length by both studies and were verified by several of the study evaluators familiar with Texas manufacturing. Industry representatives also expressed interest in using a facility such as the RITI at "focus group" meetings recently conducted by one of the study proponents. Although the number varies depending on location, it is estimated that each new job in the manufacturing sector creates another three jobs in the regional economy. The State of Texas would like to turn SSC-related assets toward activities that could help replace the economic wealth and multiplier effect originally anticipated from the SSC project.

The benefits to be gained from these activities, as presented in the studies, were hotly contested, especially in relation to the costs and funding required for startup and operations of the SSC facility. The two studies evaluated by this group offered differing combinations of similar activities, with different levels of complexity and risk. Both concepts proposed preferential benefits to small companies; the creation of productive alliances amongst the academic community, private businesses, and Federal laboratories; benefits to the educational system; and self-sufficiency of the RITI over time due to an income stream from certain activities. They also claimed economic impacts on hundreds of thousands of jobs, billions of dollars of income, sales, and production. While there is some benefit to be had from all the activities considered under the RITI concept, both studies vastly overstated the possible benefits, especially those in quantifiable economic terms. Experience to date is that significant and substantial benefits do result from activities such as these, but can seldom be measured in other than anecdotal terms.

While both proponents stressed the great value of the concentration of facilities and equipment at the current physical locale (the SSC CF), neither made a convincing case that the benefits were tied exclusively to installation of RITI activities at the CF versus other sites. The details of the projects' match to specific SSC assets is discussed in Section 7.4.3.

In summary, it has been the reviewers' experience that activities such as the ones proposed do result in substantial industrial benefits, but the benefits given in the studies are overstated. Based on experience at comparable facilities, the needs of regional firms could support up to about \$2 million per year and could be accomplished in about 70,000 square feet of the 550,000-square foot CF:

7.4.2. Feasibility

While, in general, both concepts were considered to have only conditional feasibility, when contrasted against each other, they exhibited differences in feasibility. For both concepts, feasibility is directly dependent on funding levels, with greatly differing mixes of component activities in high-end versus low-end funding projections. In addition, both studies sought to ensure technical feasibility by requesting extensive—even excessive—amounts of equipment and facility space. Further, they both assumed limitless availability of computer capacity and connectivity, as well as significant levels of no-cost Federal personnel of various skills. Finally there is an extremely pragmatic consideration: the SSC site may be at an inconvenient location for most firms, which could reduce the desirability of RITI.

The reviewers all felt that the diversity of activities under the general RITI concept greatly improved its probability of success, even though it added complexity. The RITI concept offers an important advantage that other

proposed concepts lack, a portfolio approach to risk. This advantage is especially useful in the unique situation of the SSC where there is the strong desire to maximize the value of the investment when and where possible.

Cost-effectiveness discussions place an upper limit on the level of feasible activity. This limit seems to be in the range of \$2 million based on experience with similar facilities elsewhere. Although the services are all worthwhile, practical limitations of small business, including travel time, prevent the demand from being higher, nearly independent of the variety of activities offered. The demand could increase significantly if the State were to provide the services at essentially no cost. Even so, it would be difficult to fully utilize the CF for these purposes; its scale is more appropriate to the thousand-person, hundred-million-dollar scope of the SSC construction activities that were conducted there.

In general, the I-RITI concept was considered unfocused and might not ensure good management. In particular, the I-RITI staff would be too small for RITI purposes; their flat management organization, with semi-independent component centers each offering all services, responsible for its own management, and drawing on "virtual management teams" to serve customer needs, did not promise enough integration or synergy between activities; and the multiplicity of customer bases, staff members performing multiple functions, and multiple uses of equipment was seen to reduce the feasibility of their concept. The reviewers judged that it was unrealistic to be able to establish and maintain, at the costs proposed, the large number of specialized manufacturing facilities involved, such as the semiconductor manufacturing cleanroom, vacuum deposition facility, etc.

The MTDC management organization, on the other hand, seemed to closely fit the desire for management of the type described in the original call for expressions of interest. Aside from the inappropriate scale of activities proposed, the MTDC management plan was considered feasible, as there is a proven model in California. The MTDC concept of one-stop shopping by small businesses for needed services has proven worthy and workable in other experiences. Their emphasis on facilitation was deemed preferable to the I-RITI focus on education and training. Further, the two partners in this one study, TEEEX and ARRI, are acknowledged to be well-connected to existing similar activities in this region, and have proven effective in efforts similar to those presented here.

7.4.3. Match to SSC Assets

There are two aspects to this evaluation. The first is the CF itself, which is the single major asset being considered. Both concepts have proposed using the entire facility. However, it is unlikely that the demand would materialize to achieve a high level of utilization. A cost-effective use of the facility would only be about 70,000 square feet of the total 550,000 square feet, less than 20 percent of

the total. In addition, the location of the site reduces the value of the facility for the proposed concepts, relative to a location within the Dallas/Fort Worth Metroplex.

The second aspect is the equipment itself. Qualitatively there is an excellent match between the equipment needs of the concepts and the SSC assets. Since the majority of the small companies in the region are in the metalworking industry, the machining, metal-forming, and metal-fabrication equipment at the site would be suitable for the proposed application. The MTDC concept addressed to some extent what and how much equipment was needed. Since the concepts were judged to be too ambitious, the equipment needs would also have to be scaled back accordingly. The I-RITI concept has indicated it would need much of the equipment on site, since its aim is to have all major core competencies for the electronics industry resident in the facility, and proposes specific electronic laboratories based on core competencies. In this case, reducing the scope would mean identifying which laboratories to establish with a satisfactory complement of equipment, and which ones to eliminate altogether.

Under no circumstances should the potential contributions be judged only by what equipment is left on-site. On the contrary, the whole field of technology transfer is expanding rapidly by leveraging assets among participants. Many of the technical services that these studies are proposing to provide at a price are being offered for free at Federal government centers and national laboratories in the southwest. Therefore, the proponents should concentrate on how to make these free government services available to small manufacturers in the region, and then only provide services that cannot be obtained elsewhere.

7.4.4. Similar Facilities

Other states, as well as several important Federal programs, have successfully utilized a variety of technology transfer and business assistance activities similar to those in these studies. Teaching factories exist elsewhere in the State and the nation; none of them have approached the success rates assumed in these studies. In general, larger firms increasingly out source training. The Texas community college system already fills many of these needs.

There are a number of incubators elsewhere in the State and nationwide. In the local region, there are no activities of this sort that focus on manufacturing companies, and a definite need exists for a manufacturer's incubator of the sort in the MTDC study. Experience with such centers indicates that two years or more would be required to achieve an acceptable level of participation by small companies. In general, such activities have proven to be successful, but at a lower level of usage than was assumed in these studies.

7.4.5. Cost Estimates

Two types of costs pertain: operating and additional capital equipment. Both studies predict a far higher level of operation than is likely to materialize. As indicated earlier, \$2 million or less is the normal level for these types of activities. This point aside, for the MTDC, the estimated operating expense of \$4–6 million appears to be reasonable for the level of effort proposed and is based on actual experiences and input from competent organizations. It is pointed out that staff, other than start-up staff, would only be added as needed; this is important for keeping operating expenses in line with revenues.

For the I-RITI operating expenses, it is difficult to assess the reasonableness of the cost estimates of \$11–15 million, partly because of its innovative approach of having over a dozen major electronics laboratories operating at a high level of performance. Other than for the incubator, there is very little detail provided to allow an evaluation of the accuracy of the cost estimates shown in the operating expense forecasts, including maintenance. In addition, the infrastructure requirements needed to support a level of 500 students would have to be addressed more fully.

As for additional capital equipment, neither study indicated that additional capital equipment will be acquired over the five-year extent of the business plan. For either project to be successful, it would have to maintain an inventory of state-of-the-art equipment, hardware, and software. In today's manufacturing environment, equipment becomes obsolete very quickly, and a facility such as this must replace certain equipment, hardware, and software every two-three years. The original cost of the equipment at the CF is \$185 million, so replacing even a small fraction of this would be substantial. It is stated that after the initial five years, there will be a need to upgrade the equipment in the center, and that the capital required for this upgrading could come from corporate "sponsors." Based on experience, it is unlikely that the facilities will generate support in the amounts alluded to in the studies. Corporations are not willing to provide funds to the extent shown without a more definitive statement of the benefits.

7.4.6. Realism of Business Plans and Funding Expectations

The I-RITI funding plan, including projected income from over 20 different sources covering several different specialties, appears to be too widespread to be effectively implemented. The reviewers felt that if the range of offerings were narrower and more specialized, the center would be more effective in serving its client base. Based on the experiences of similar centers across the country, it appears to be unrealistic that this center could generate over \$5 million in revenues during the first year of operation and over \$16 million in revenues in the fifth year. It is rare even for a for-profit manufacturing company to generate this magnitude of revenues in the first five

years of operation. The study calls for some 500 students to be educated in the facility, and this level of student activity is questionable. In addition, there is some doubt as to whether a mix of academic users and companies will be effective, given the conflicts for resources that are sure to arise.

The MTDC business plan is comprehensive and well thought out. The only questionable area is revenue. The amounts indicated for corporate sponsors, engineering services, and market assessments are very high and probably overpriced. In addition, the study states that the center will have 1,000 companies participating in the first year of operation and this number appears to be high. Experience has shown a large percentage of smaller companies will not allow their employees time off to go to a training center.

The studies state that funding from Federal and State sources during the first five years of operation will need to be \$13-15 million. The facility is not included in the funding proposal and is, apparently, assumed to be available rent-free. It appears unlikely that this amount of funding would be made available for primarily operating expense purposes. There was little interest expressed by any of the Federal agencies in being a major source of funds for either proposal. However, the agencies expressed interest in participating, especially with in-kind contributions, if the State took the lead in the program.

7.5. Conclusions

Both proposed concepts could have significant benefits to the State's small manufacturers. However, the level of effort proposed is much greater than would be effectively used and would not be an efficient use of the SSC CF. The I-RITI carries a significant amount of risk since it is a relatively new, more complex concept, but it could have a high payoff. The reviewers thought it reasonable to try parts of it at a low level of effort.

If the State were to take the lead in carrying out these types of activities (some combination of I-RITI and MTDC) at a reduced level, roughly 20-25 FTEs, it is likely that a number of Federal agencies would want to participate in ways that would leverage their regional facilities and assets, such as developing Cooperative R&D Agreements (CRADAs). For example, DOE has a mission in competitiveness and has major laboratories and facilities in the region (Los Alamos National Laboratory, Sandia Laboratories, the Kansas City Plant, and Pantex); the Department could make its expertise and assets available for assistance to small manufacturers, and the State could provide operating funds. However, no Federal agency with members on the panel (DOE, NASA, NSF, DOC/NIST, and the Air Force) appeared to be interested in taking the lead in funding the proposed activities.

The concepts studied could have a role in a dynamic State program of small business/manufacturing assistance and customized training, and it might be a better use of resources to have modest facilities at a number of

locations than to concentrate the resources in one facility. Within an integrated State-wide program, the most important issues to be addressed for these concepts are: scaling down and narrowing the concepts; achieving and maintaining a balance between manufacturing assistance and training; and institutional and management issues. In any case, since the State would be the major beneficiary of improved regional competitiveness, it must decide in a timely manner how it wants to proceed and at what level.

8. APPLIED SUPERCONDUCTIVITY AND CRYOGENICS TECHNOLOGY CENTER

8.1. Summary

This Center would turn the assets at the N15 site into a user facility for a broad range of applications related to superconducting magnets and cryogenics. While the facilities and associated equipment are first-rate, it appeared to the reviewers that the costs to maintain and operate the facilities were underestimated and the expected revenues overestimated. The remaining on-site technical expertise is thin, and even completely lacking in certain critical areas. Together with the general low levels of funding in many of the areas of potential use, as well as the existence of similar strong capabilities at several of the national laboratories and in private industry, this led the reviewers to conclude that it would be very difficult to attract enough customers to allow cost-effective operation.

8.2. Introduction

This was one of the four studies done under the direction of TNRLC, following the recommendations of the Governor's Advisory Committee on the SSC. It benefited from the guidance of a strong advisory committee composed of members having wide and varied experience. The study considers a variety of uses for the superconducting magnet and cryogenic facilities located at the SSC N15 site, five miles west of Waxahachie. These facilities have been transferred to the State of Texas by the U.S. DOE under the recently signed Settlement Agreement.

8.3. Overview of the Proposed Project

8.3.1. SSC Superconducting Magnet and Cryogenics Facilities

The Center is predicated on using the superconducting magnet and cryogenics facilities and associated infrastructure at the SSC N15 site. The complex includes the following major facilities: the MDL, equipped for fabricating superconducting accelerator magnets; the MTL and associated cryogenic facilities, designed for the testing of accelerator magnets as well as producing and characterizing superconducting cable; and the ASST, a facility for testing a string of superconducting dipoles, quadrupoles, and "spool pieces." At the time of SSC termination, the ASST was engaged in the testing of a full "cell" of magnets comprised of ten dipoles, two quadrupoles, and three spool pieces. Other important assets include the Short Magnet and Cable Test (SMCT) facility, a stand-alone component of the MTL, and the massive helium refrigeration system at N15, comprising three large refrigerators of 4kW-capacity each.

In addition, there are some superconducting magnet facilities in the SSC CF. The most germane to the proposed activities of the Center is the direct wire coil fabrication equipment, originally designed for producing corrector magnets for the SSC. The CF also has considerable cryogenic and test capacity for evaluating superconducting correction windings and devices.

8.3.2. Proposed Activities

The Center would be a user facility with opportunities for collaborative work with governmental, industrial, and educational organizations. Two of the activities described in other chapters could be performed at the facility—the experiments on the velocity of light in a magnetic field (Chapter 2) and the facility for investigating phenomena at very high Reynolds number (Chapter 3). Other ideas discussed include magnet work for the Large Hadron Collider (LHC) at CERN; work on magnets and components for superconducting magnetic energy storage (SMES); testing of high-current superconductors suitable for the U.S. fusion energy program and stabilized cable for energy storage; and production of compact, lightweight, superconducting or normal-conducting coils of complex geometry for special applications on demand. “Incubator” program possibilities for small companies might include superconducting wire cabling and cable insulation. Finally, various applications are under discussion involving cooperative work with external partners in high-temperature superconductivity on topics such as thin films, leads, and bulk applications. Operations and maintenance costs for the facility are estimated at about \$3 million per year; an additional \$10–15 million per year would be required to implement the full range of activities considered.

8.3.3. Management

The Center would be organized as a not-for-profit research corporation, as a subsidiary of an existing State-operated organization. Its charter would include the creation of a for-profit subsidiary, free to pursue commercial opportunities in the private sector, much like the Houston Area Research Center (HARC). Activities at the Center would start with the development of proposals by potential users. A successful proposal would be implemented by a suitable project team headed by a project manager.

The Center’s management would involve a small core staff. The director, technical manager, and operations manager would be responsible for all aspects of the Center’s activities, while the marketing manager and the business/personnel manager would work closely with them in handling marketing efforts and normal business/personnel matters, respectively. Approximately 35 full-time equivalents would be needed to operate the Center.

Certain projects might require a variety of services. In addition, technical assets at the Center would have specific requirements to keep them in working operation, including technical equipment maintenance, materials, and

supplies. Implementation of Environment, Safety and Health and Quality Assurance programs would also be necessary, as would user support, site maintenance, etc.

8.4. Findings

8.4.1. Motivation and Benefits

The goal of the Center would be to provide U.S. industrial, academic, and government organizations with cost-effective access to modern, specialized facilities, enabling extended research, development, manufacturing, and commercialization of superconductivity and cryogenics technology. The benefits would include progress in accelerator-based high energy and nuclear physics and increased industrial access to technologies still viewed as somewhat exotic.

8.4.2. Feasibility

Most or all of the proposed work is technically feasible. The remaining questions are primarily human and financial: whether the Center could attract enough customers (starting from an equipment-rich but talent-depleted position and going up against strong, established competitors) to reestablish intellectual vigor and efficiently operate the very large facility.

Much depends upon the ability of TNRLC to fund the Center over approximately a five-year period. This period, which is based on the project stream in the business plan, would be required for marketing its unique capabilities.

The reviewers expressed concern that, although for the time being, staff members highly experienced in the operation of the test facility are still employed at the SSC, there is no longer a staff of experienced magnet designers. Work for the LHC might also need to attract accelerator physicists, another specialty whose representation at the SSC has diminished greatly; CERN has recently indicated that U.S. assistance should focus on providing certain full accelerator systems, not simply magnets (though beam transfer lines, using the Relativistic Heavy Ion Collider (RHIC) dipole magnets, remain high on LHC project management priorities). Given these facts, competing for LHC work against three fully staffed national laboratories and their diversely supported infrastructure would be a tremendous challenge. Existing national laboratories and private industry also have superconductivity and cryogenics expertise in areas other than accelerators. Any opportunities that arose in power transmission, energy storage, magnetically levitated trains, etc. would be in competition with many other players.

8.4.3. Match to SSC Assets

With regard to the LHC, the proponents of the Center claim that the facilities are "one-of-a-kind" and the best for the job. Indeed, the magnet tooling at the MDL is first-rate, as is the space allocated for such work. It is not known exactly how good the magnets would be, because the tooling was never used to build full-length magnets that were subsequently tested. Further, tooling similar to that in the MDL exists elsewhere, and by now the MDL tooling is not even the most up-to-date. However, it would be expected to produce quality magnets, because it is robust and incorporates many of the features that were recognized as important over the years of R&D in the SSC magnet program.

Cabling would be a good match to assets in a technical sense, but cancellation of the SSC leaves the U.S. with excess cabling capacity, even considering the prospect of LHC work, and, furthermore, much of the technology has already been transferred to industry.

The ASST facility is clearly a promising testbed for the velocity of light experiments, though extensive modifications to the magnet string would be necessary for the more sensitive second phase of one of the two proposals.

The Very High Reynolds Number facility would provide a good use of the refrigerators at N15, though only one of them is required. In fact, any one of the three refrigerators could probably handle all of the activities studied. (The other two units may be of value to programs elsewhere.)

It came to the attention of the reviewers that DOE has assigned authority to Universities Research Association (URA), which was the management and operating contractor for the SSC Laboratory, to enter into an exclusive licensing agreement for the "Direct Wind Coil Winding Head Assembly" and that URA is proceeding to place this technology in the private sector for exploitation. Thus, the future role of the Center in regard to this technology is far from clear.

Testing of the Babcock and Wilcox (B&W) SMES coil modules at the Center would require installation of lower-temperature facilities and modification of the power supplies. The conductor might be testable at Brookhaven without modifications. Some remaining SSC conductors could be used in the B&W effort. Other SMES-related work is strictly speculative at this time.

In general, the Center's resources would not be a good match for high-temperature superconductivity R&D, which is performed on a much smaller scale and is rooted in different disciplines of science and engineering.

Finally, even if a technically competitive Center were established, there would be a question about whether it could attract enough customers to make cost-effective use of facilities scaled to support a megaproject like the SSC. The

overhead costs of operating the facilities appear disproportionate to even an optimistic estimate of the potential demand for the Center's services.

8.4.4. Similar Activities Elsewhere

There are currently three national laboratories engaged in superconducting magnet work for accelerators: BNL, Fermilab, and LBL. Fermilab has a superconducting collider on site and BNL soon will, so out of necessity, both will maintain the ability to design, build, and test superconducting magnets. The LBL also has a long history and a still-active program in superconducting magnet and materials R&D. In addition, technology for building such magnets has been transferred to U.S. industry in the RHIC project at BNL. Currently, B&W has the only SMES project funded on a relatively large scale. If the proposed Center were to divert already meager resources from the existing U.S. programs, the result could be an overall weakening, rather than strengthening of U.S. capabilities and competitiveness.

8.4.5. Costs and Funding

Two scenarios are presented in the study for costs and funding. The "best case" cost plan indicates a positive cash flow for the Center beginning in 1997, assuming a 1995 startup. This plan assumes a number of funded projects at the facility, including special LHC magnets; a fusion reactor component test facility; work on superconducting magnetic energy storage; high-temperature superconductor projects; an experiment on velocity of light in a magnetic field; a facility for the study of cryogenic helium convection; and a manufacturing technology and business incubator program. Based on these assumptions, operations, maintenance, and capital costs through the first five years (1995-1999) are estimated to total \$68 million (then-year dollars).

The business plans indicate a heavy reliance on funding from the LHC project and the SMES development program. Considering that the actual LHC work would most likely be consigned to the existing national laboratories, and given the present funding situation for SMES, this reliance should be reduced. In any case, even assuming that the proposed Center were successful in attracting LHC work, very little U.S. funding for LHC is expected in FY 1995-96, contrary to the funding plan that shows substantial LHC funding in these years.

The reviewers felt that the stated rates for labor, especially for professional and technical personnel but also support personnel, are generally underestimated throughout the study.

8.5. Conclusions

The assets of the Center could be used for two of the activities described in other chapters; namely, the velocity of light experiment and the helium convection facility. However, the expected revenues from these projects would

only partially support the Center as proposed. In general, estimates of both operating costs (especially for labor) appear underestimated, while revenues seem to be overestimated.

If funding is authorized for a U.S. contribution to the LHC, the reviewers felt that the design and fabrication of the LHC magnets would be more effectively carried out using the existing expertise and facilities at the national laboratories. It would appear that there is no singular unique capability at the Center and there is a paucity of scientific and technical staff. The High Energy Physics Advisory Panel, in a recent report (the "Drell Report"), anticipated difficulties with the building of LHC magnets at the SSC. The present reviewers concurred in their concern that, "Prospects for rebuilding and maintaining a scientific and technical staff of the highest caliber, far from a high energy accelerator laboratory, are, in our judgment, not good."

Given the general funding situation and the many considerations discussed above, the reviewers concluded that it would be very difficult to attract enough customers to allow cost-effective operation.

9. SOUTHWEST CENTER FOR COMPUTING, INFORMATION TECHNOLOGY, AND LEARNING

9.1. Summary

Three very loosely related projects were described in detail in this project definition study: a High-Performance Computing Center (HPCC), a CAD/CAM/CAE Training Center (CCCTC), and a High-Performance Learning Center (HPLC).

The HPCC study was viewed by the reviewers as the most promising of these three projects in terms of benefits, feasibility, match to SSC assets, and costs. The HPCC should be established as proposed with the Parallel Distributed Systems Facility (PDSF) maintained as its high-end computing focal point. The Information Technology and National Information Infrastructure (NII) components, supported by high-bandwidth networking, as well as the data farm effort are integral parts of the HPCC and all should be included. State interest in the HPCC is high and funding seems likely.

The CCCTC is not expected to be a successful on-site activity, in spite of the fact that the workstations and software are in place. The hardware could be sold or donated, possibly to local community colleges and others throughout the State. Facilities of this type could then be established at both Navarro and Mountain View Colleges and technical experts hired on at those institutions to operate them.

The HPLC fits well with long-term educational goals of the State of Texas. The authors should work together with the State education agencies and with those involved in the education study discussed in Chapter 5 in order to gain the highest leverage from the SSC assets and reinforce the educational advantages for Texas students. State interest in the proposed educational activities appears high and it seems likely that the State will take the lead in establishing such a program at the SSC site.

9.2. Introduction

This study was done under the direction of the TNRLC. The study contains a number of appendices, including details on the proposed HPLC that would be a user of the SCCIL. The goals, as well as some of the facility and equipment needs, partially overlap those of several of the other studies, in particular those on Research Facility Access and Science Education (Chapter 5), Minority Institution Network Access (Chapter 6), and the RITI (Chapter 7). In addition, having on-site computing capability would be quite useful to most (or all) of the other activities proposed.

9.3. Overview of the Proposed Project

The study defines three separate projects that would use computing equipment and certain other assets of the former SSC:

- HPCC A High-Performance Computing and Information Technology Center that would use the PDSF and an upgraded version of the Intel Hypercube, as well as a small number of Unix workstations and the extensive networking infrastructure of the CF.
- CCCTC A computer-aided design, manufacturing and engineering (CAD/CAM/CAE) Training Center to supplement community college training.
- HPLC A High-Performance Learning Center that would use many of the low-end personal computers and other equipment for educational purposes. The proposed activities overlap those of several of the other studies. In particular, having on-site computing capability would be quite useful to most (or all) of the other activities proposed.

The HPCC would be a major node of the NII, making use of existing high-bandwidth ties to State and national networks. With large mass-storage capabilities, it would also be a major data repository. It would use and expand the PDSF, which was originally designed and used for simulation and analysis of SSC particle detector events. This configuration of networked assemblies ("ranches") of Unix workstations was capable of 12,000 MIPs (million instructions per second). Together with the Hypercube, these facilities could be used by a variety of user communities, including high energy physics, electronic commerce, the petroleum industry, and the planned RMTC (based on the SSC linac assets). The emphasis would be on research and development activities rather than standard data processing, with no attempt to compete with commercial, 100 percent-uptime service providers.

Navarro College and the Waxahachie Independent School District would use the CAD/CAM facilities for vocational training in a broad range of skills including both mechanical and electronic design.

A support group would provide graphics, editorial, library, and publication services for the various on-site users.

The HPLC would be a "tenant" or user of the SCCIL, and like other users, would have its own governance; business plan, revenue sources, etc. The HPLC design includes four major components: 1) a Professional Development Collaborative for educators, providing training and fellowships on site for about 60 professors and students, focusing on the use of computer-based technologies as instructional tools; 2) an on-site K-12 Academy, established as a Texas Governor's School with about 500 students, diverse in ethnic, racial, socioeconomic, and ability levels (at the time of the presentations, the proponents were reconsidering the academy concept); 3) a Distance Learning Education

Outreach Program, with the Texas Center for Educational Technology (TCET) coordinating creation of a distance learning and telecommunication linkage; and 4) Virtual Science Laboratories with both on-site and mobile state-of-the-art science laboratories.

In addition to the computing assets, as proposed, SCCIL would use about 60 percent of the available floor space of the SSC CF and much of its contents, including video equipment, libraries, publication resources, laboratory equipment, and machine tools. The on-site K-12 Academy would occupy nearly a third of the space.

The study recommends that a not-for-profit organization manage the SCCIL center, initially with a staff of five. Operations for the HPCC would start with a staff of 10, growing to 32, and an annual budget of about \$5 million, including equipment upgrades (following initial major hardware acquisitions of \$5 million). The proponents hope to break even after about three years. The CAD/CAM training center would have a staff of 27 and an annual budget of about \$2 million.

The HPLC is expected to be a stand-alone enterprise with its own business plan. An estimated \$2.5 million would be needed to upgrade the CF to meet safety requirements for the on-site K-12 Academy. Assuming the purchase of computer hardware from DOE at 25 percent of the original purchase cost, the total costs during the construction and planning phase (April 1995 to July 1996) is estimated to be \$9.6 million (\$11.6 million with 800 Unix servers for school districts), including salaries. Estimated operating costs total \$4.4 million for the first year of operation, about half of it for the 500-student on-site academy.

9.4. Findings

Because the three projects described in this project definition study are essentially independent, with the exception that the CCCTC and HPLC would have access to the computing, networking, and data-farm facilities of the HPCC, comments on each of them are given separately in the following subsections. It is further noted that the HPCC is composed of four parts: (1) high-performance computing, (2) information technology, (3) NII activities, and (4) mass storage and retrieval.

9.4.1. Motivation and Benefits

9.4.1.1. HPCC

The HPCC would make the best use of the PDSF, which is operational and should be maintained and appropriately upgraded. This is especially true since the Regional Medical Technology Center, which can make extensive use of the HPCC, is expected to be established on the former SSC site.

9.4.1.2. CCCTC

The plan to provide vo-tech training in CAD/CAM/CAE, using on-site hardware, software, and expertise, to students in the region and the interconnection to local community colleges would have benefit, especially since the local institutions are currently unable to provide facilities at this level of sophistication.

9.4.1.3. HPLC

Students in the vicinity would have enhanced learning opportunities at the K-12 level through the on-site academy. The distance learning activities of the HPLC would address students throughout the southwest. This study would also create a testbed for the new paradigm for education as advocated by the authors of the project definition study and certain State educational organizations.

9.4.2. Feasibility

9.4.2.1. HPCC

The successes in high energy physics applications bode well for expansion to a general purpose center.

9.4.2.2. CCCTC

The CCCTC does not appear to be feasible because the projected usage versus operation costs were unfavorable. New staffing and the logistics of bringing trainees on-site are additional problems.

9.4.2.3. HPLC

The original study proposed the establishment of a 500-student K-12 academy in the CF. This option was viewed by the proponents as probably unfeasible due to the large cost of upgrading the required space to conform to regulations. A more likely scenario is to set up a 100-student academy in the area presently housing DOE staff. The distance learning capability is only limited by the availability of appropriate hardware and network connections at remote locations. This could be addressed by a combination of State and local funding sources. Another option is to scale back even further to in-service teacher training and a testbed of a few classes in the K-12 range with participation by college and university education departments.

9.4.3. Match to SSC Assets.

9.4.3.1. HPCC

The HPCC as proposed is a near-perfect match to the hardware, software, and personnel assets currently in place.

9.4.3.2. CCCTC

The equipment and software are ideal for the proposed activity. The personnel are not currently available, however.

9.4.3.3. HPLC

The match to SSC assets is good. The hardware and networking on-site lend themselves well to the activities proposed. The suggestion to move the on-site academy to the current DOE office area in the CF is a good one.

9.4.4. Similar Activities Elsewhere

9.4.4.1. HPCC

There are a number of State and regional supercomputer centers as well as NSF, DOE, NASA, and Department of Defense centers currently in existence. None of these are self-sustaining, even though many have links to private industry. The center at Florida State University supports a cluster platform similar to the PDSF. The Microelectronics Center of North Carolina and the Northeast Parallel Architectures Center support many of the activities proposed here. There are currently no similar facilities in the southwest region of the U.S., however.

9.4.4.2. CCCTC

Such a program is clearly not available in the immediate vicinity. Large universities and technical institutions do provide similar programs elsewhere.

9.4.4.3. HPLC

Similar educational network and off-site learning activities are ongoing in other states. Few of these are built on such a new paradigm for education, especially if an on-site academy is included in the overall plan. Since these activities are to be conducted under a State mandate, they will be coordinated with related State programs elsewhere.

9.4.5. Costs

Rough estimates of first-year costs are shown in parentheses.

9.4.5.1. HPCC

If the HPCC restricts its compute-engine capability to the PDSF at the outset, then the costs as described are reasonable and the center should be sustainable with modest State and industry funding. (\$4-8 million)

9.4.5.2. CCCTC

The costs of operating this facility outweigh the benefits, and the facility would run in the red if student enrollment is not kept high. (\$1-1.5 million)

9.4.5.3. HPLC

The entire program, including remote professional development, on-site academy (100 students), distance learning, and mobile science laboratories, will require a funding level that is feasible and achievable within a scenario that includes sources from the State and local governments. The plan is flexible enough to adjust for less funding if the requested levels are not realized. (\$2-4 million)

9.4.6. Funding

9.4.6.1. HPCC

The existing facilities can be maintained and upgraded with backing from the State of Texas, plus some industrial buy-in. The chances for securing Federal funding appear less likely.

9.4.6.2. CCCTC

It is claimed by the proponents that most of the costs of operation will be met through tuition payments, sponsoring organizations, and industry support. This is viewed as overly optimistic.

9.4.6.3. HPLC

The funding plan for this study is one of its strengths. It has contacts at State agencies (TCET, in particular), and it seems likely that there will be State funding at an appreciable level. The availability of the hardware and networking capabilities of the HPCC reinforce the prospects for success.

9.5. Conclusions

The HPCC was viewed by the reviewers as the most promising of the three projects considered here in terms of benefits, feasibility, match to SSC assets, and costs. The PDSF should be retained and upgraded, but the Hypercube computer should be disposed of unless a particularly favorable arrangement can be made regarding an upgrade to a Paragon. If a new, massively parallel computer is acquired, it may be preferable to locate it at another site (such as Houston), but still have it be part of the HPCC. Interconnection of all the networks in the southwest and extending the user base throughout the region and into Mexico was a strong component of the study. The specifics regarding who will be connected to the HPCC and the bandwidth requirements must be clarified. The involvement with North American Free Trade Agreement should be better defined; an effort to motivate high-performance computing activities in Mexico is included in the plan. The mass-storage capabilities described in the study would be important for many regional needs, especially the on-site Regional Medical Technology Center and digital library activities in the context of the HPLC. The study should be revised to provide a somewhat clearer focus;

in particular, the plan to sell computer time is not expected to be workable. There appears to be considerable interest in the State for the HPCC, and it is hoped that State funds can be made available to initiate the project.

The CCCTC was to be established at the CF, incorporating approximately 70 workstations with servers, plotters, and printers, overseen by technical experts in computer-aided design, manufacturing, and engineering. Initially, Navarro and Mountain View Colleges would use the facilities and personnel of the CCCTC as part of associate degree programs. The staffing of the CCCTC was a concern. Although the workstations would be connected to the HPCC via the local-area network, there was no real interaction proposed between the CCCTC and HPCC and, consequently, no plan to include any kind of remote activity. The CCCTC, as presented, does not appear to be self-sustaining; nor does it appear to have more than a local impact on the educational community.

The HPLC component of this study is consistent with the State of Texas goal to support educational technology and to experiment with a new learning paradigm. The HPLC study should be combined with educational aspects of the study discussed in Chapter 5 to best utilize the SSC assets for educational activities. The proponents should also continue to work closely with Texas educational agencies. It is essential that expert educators and sociologists be involved. This will be primarily a State-led activity, and it appears that there is a good likelihood for State funding. However, the project will have to be more tightly focused, and the budget needs to be refined. It will be important to have a mechanism for regular evaluation, preferably by an external advisory committee. There was concern that the SSC site was not shown to have unique features that make it the overwhelming choice for locating a HPLC. Further, the study made many unsubstantiated statements about the general state of education, the need for computer-mediated learning, etc. All such claims should be corroborated with hard data and references. A unified team should be set up and a concise proposal generated. Closer and clearer involvement with the HPCC would strengthen the proposal.

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10. BLACKLAND PRAIRIE RESTORATION

10.1. Summary

The project definition study for Blackland Prairie Restoration involves restoration of most of the SSC West Campus to a grassland prairie, a noble and worthwhile goal. Hand-in-hand with this would go prairie restoration research, education, and recreational facilities. The project as written is basically feasible, but limitations placed on its scope would likely make its funding difficult. The reviewers concluded that if the focus of the project were reoriented toward applied research in prairie restoration, technology transfer, and education, a much wider array of funding sources would be available and greater benefits would result.

Further, the reviewers concluded that this project would be compatible with many of the other activities discussed in this report. Combining these activities into a science, technology, and education center would not only provide economies of scale, but help to synergistically integrate common purposes, such as research, education, and networking.

10.2. Introduction

This study was conducted under the grant to TNRLC and was a cooperative effort by TNRLC, the Texas Parks and Wildlife Department, Texas A&M University, and the Texas Nature Conservancy.

10.3 Overview of the Proposed Project

The study proposes an integrated land management plan that would restore much of the SSC site to native prairie, mitigate the effects of SSC construction, create an educational resource and various recreational opportunities for the public, and utilize the agricultural potential of selected lands. This includes:

- Restoring 7,000 acres of the West Campus to a natural, biologically diverse Blackland Prairie landscape, primarily grasslands with some woodlands and wetlands.
- Creating a center for restoration research and education.
- Revegetating lands disturbed by SSC construction.
- Establishing a park to provide public access and educational programs.
- Establishing agricultural lease programs for prime farmlands.

In Texas, fewer than 5,000 of the original 12 million acres of Blackland Prairie remain, all in small isolated fragments. The proposed project would be one of the largest prairie restoration efforts ever undertaken. The West Campus

provides a large enough area to satisfy numerous criteria, such as providing horizon-to-horizon views relatively free of evidence of modern man, including a landscape mosaic of grassland, upland savannah, riparian woodland, and wetland habitats, and accommodating diverse wildlife. The East Campus is not large enough to satisfy these criteria and would be used to support the restoration processes through leases of land for farming and production of seed.

As proposed by this study, prairie restoration would be conducted in five phases over the years 1996 through 2000, each year concentrating on a specific area of the West Campus. Research facilities would be constructed in 1995–1996, followed by construction of park facilities in 1997–1998.

Where possible, existing SSC facilities and equipment would be used. Costs for new construction are estimated at \$7.7 million (1994 dollars), not including any fringe benefits, overhead, or contingency. After subtraction of anticipated revenues, the annual operating costs in the year 2001 are estimated to be about \$800 thousand, split roughly equally between research, public use, and land management.

Five options for organizational management are discussed in the study report, with listings of their advantages and disadvantages.

The restoration of available acreage from the SSC project to a native Blackland Prairie landscape provides a great opportunity to the educational and research community. Long-term benefits would include technology development in areas of land restoration, revegetation, and environmental mitigation technologies. In addition, this restoration project will create and preserve a vanishing native ecosystem for use by future generations while mitigating SSC construction impacts. However, the greatest potential for the restoration project exists in the areas of research and the development of new technologies with value to industry.

The emphasis on research and development also provides the greatest potential for outside sources of funding. The potential exists for the development of various partnerships to reduce the overall cost of the restoration project. This project, through proper management and marketing, can provide an invaluable natural resource to the State while minimizing cost impacts.

10.4. Findings

10.4.1. Motivation and Benefits

The motivation for the project is both noble and practical, with several complementary benefits. Among these benefits:

- Scientific knowledge about ecological processes in an evolving prairie ecosystem would be advanced.

- The technical knowledge acquired would be transferable to subsequent phases of the project and, even more importantly, would be transferable to applications off-site. The utility and mining industries, as well as government entities (such as state and Federal departments of Transportation, EPA/Superfund, DOE, and DOD) vested with the regulatory and ethical obligations of reclamation, would be able to use information derived from the restoration activities carried out at the SSC site to improve results and cut long-term costs.
- Educational benefits would derive from the opportunities afforded to thousands of school-age children who would have easy access to the open-air laboratory created by the restored Blackland Prairie. The educational value of the site would be enhanced if other activities at the site were integrated in such a way as to demonstrate that human activities (i.e., land/site utilization) can be carried out in an environmentally sensitive manner, and that ecological principles can be applied in a way that complements other disciplines.

The primary benefits are ecologically rather than economically measurable and should not be expressed solely in economic terms. The benefits are oriented toward environmental quality and heritage—a safe haven for flora and fauna in an area being inevitably changed by man. Additionally, the restored area would serve as an uncontaminated freshwater recharge zone for local aquifers.

10.4.2. Feasibility

The project is feasible, provided that prairie simulation is the goal, rather than true restoration. Modifications in project design and scope could improve the cost/benefit ratio by spreading out both costs and benefits among the partners in a public/private-sector partnership. It was not evident to the reviewers, however, that any public comments and involvement had been sought in the development of this study. There exists a spectrum of public and governmental opinion in the area regarding the philosophical foundations and practical aspects of land use; these cultural and other factors must be taken into account in further developing this project.

Is it feasible to think that the goals of this study can be reached using the implied and described activities and methods? The answer is not clear, nor did the brief study truly evaluate such a question. The final biological state of the Blackland Prairie is not defined; the strengths of evolutionary dynamics are not considered, and the time for an ecosystem to self-organize after the restoration has been started is only implied.

The study suggests a completion date for implementing the project of 2001. It will take some time for the site to reach an equilibrium condition. A stable geochemical condition is essential for the various measures of ecosystem

sustainability (e.g., habitat, species, and genetic diversity, variation in organismic resilience, reproductive success among genetic variants, diversity included in biomass production, stable complexities in the ecosystem foodwebs, responsive adjustments for survival at the community, species, and genetic levels during environmental changes, etc.).

As written, the study presupposed constraints that may have limited its perspective and content. Specifically, it was apparently assumed that 1) five-year funding for all integrated activities must be secured at the start of the restoration program; 2) all activities must be integrated with the restoration activities; 3) activities are entirely independent of other proposed programs, such as the Regional Medical Technology Center and the Applied Superconductivity and Cryogenics Technology Center; 4) the initial restoration effort must be completed in five years; and 5) offsetting financial income from the program must be generated. Although some of these constraints may presently be necessary for programmatic reasons, others are not, and all may change as the restoration program is implemented and as it progresses.

10.4.3. Match to SSC Assets

The extensive SSC real property (land)—rather than “personal” property such as computers—is critical to the success of this project. The West Campus is of primary importance for restoration, while the East Campus plays a less critical support role. Within reasonable expectations, there will probably never again be such extensive real estate that can be restored, at such a low cost, to a grassland prairie.

Availability of other SSC assets, such as modular buildings and roads/grounds equipment, would decrease up-front capital costs of the project, but is not otherwise critical to the restoration activity.

10.4.4. Similar Activities Elsewhere

Although there are numerous prairie sites in North America where reconstruction of prairie facsimiles has occurred, they vary greatly in size and in degree of naturalness. The SSC site would be the largest reconstruction effort in North America. Efforts should be made to contrast this site with the 6,000-acre Konza Prairie in Kansas, which has not been reconstructed but rather, left to its own resources, and the reconstruction of northern tallgrass prairie at Fermilab, which includes less than 1,000 acres. If successful, the SSC restoration would be exceptional among other efforts.

10.4.5. Costs

Generally, the cost estimates appear to fairly represent the proposed project-associated actions. A question that does arise when considering costs, however, is whether the actions are necessary—such as the cost for

restoration of the Dunaway house. While favorable to have, there does not appear to be a critical need for this structure and the associated restoration expense.

Cost estimates, while detailed, appear to be optimistic in the belief that each projected action will be successful. There do not appear to be adequate provisions for adjustments for results less than expected—such as funding for reseeding an area in the event of adverse weather—or for unforeseen conditions requiring attention.

Along with the public use alternatives listed in the study document, other possibilities could be explored that could offer cost savings or other economies. For example, the idea of a park could be abandoned completely in favor of limiting public access to open land uses such as hunting, bird-watching, day hiking, etc.

10.4.6. Funding

Programs as comprehensive as these have so many different goals and activities that multiple funding sources will likely be necessary. Integrating the goals into interdependent activities will complicate the funding process. Unless projected finances for the different activities are clearly identified in the finance statement, it will be difficult to determine what possible funding sources can support and what their costs will be. The finance statement needs to be reorganized and simplified by activity.

The reviewers believe that funding might well be found if the project were marketed in a more specific manner over a longer time. Funding to complete all the activities projected is not likely to become available in a five-year period and the time to complete restoration should be lengthened by several years. Likewise, funding may become more accessible if the goals and purposes are more flexible from the onset. If this were the case, other agencies may fund portions, State interests may grow, environmental industries may become interested, technology industries may be approached, foundations may want to become involved, and local educational and financial interests may find novel ways to assist the activities. As presently written, the cast of possible financial players is limited.

Depending on how the project is rescoped, there could be numerous funding sources. Among these may be:

- State/Federal grants (to include Superfund, transportation, and mining interests, among others).
- Partnership agreements with universities and industry to include funding in exchange for new technology.
- Research grants.
- Exchange of labor and equipment for agricultural use of the land.

- Utilization of volunteer labor.
- Sale of prairie-restoration and related technology.
- Partnership agreement with private industry and/or educational institutions to include the development and management of the land in exchange for research opportunities.
- Partnerships with private landowners to include long term management of the land in exchange for agricultural use.
- Donations.

10.5. Conclusions and Recommendations

1. The recreation concept of the "Park" needs to be reconsidered—perhaps redirected, but certainly relaxed to encourage alternative private and industrial interests.
2. The restoration process needs to extend beyond the initial planting activities to include the pervasive evolutionary processes of ecosystem self-organization.
3. Research needs to become the integrating theme for long-term enhancements of ecosystem adjustments.
4. The final state of the ecosystem needs to be reinterpreted to focus on the organizing processes, rather than on some State variable that may be unstable in the long-term.
5. Research should be emphasized, with a focus on the development of technologies that can be generally adapted for restoration projects.
6. The restoration program should be reorganized by activity to encourage a broader affiliation with other technology interests at the site and to expand the potential financial base.
7. This prairie restoration program must have passionate leadership.
8. An attitude of patience with the natural biological processes should be evident in future and interim management decisions.
9. The initial restoration activities must be critically linked with mitigation and regulatory requirements of the DOE for the SSC site.
10. Development of the East Campus as a plant materials center may not be economically feasible due to operational and maintenance costs needed to support such a facility. In addition, development of a suitable seed source may require three to four years.
11. Partnership with a seed company for establishment, operation, and maintenance of a plant materials center on site in exchange for seed materials for use in the revegetation process may be an option.

Appendices

**Review of Project Definition Studies
of Possible On-site Uses of SSC Assets and Facilities**

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Shirley A. Rawson, Associate Center Manager, Earth and Environmental Sciences Center, PNL. Ph.D. in Geological Sciences, 1984. Four years experience in research in the effects of sediment pore geometry and mineralogy on the distribution of bacteria in groundwater aquifers; three years radionuclide geochemistry and transport in the unsaturated zone and in groundwater aquifers; four years low-temperature diagnoses in basaltic aquifers, and four years phase equilibria and metasomatism in mafic and ultramafic rocks. Other positions held: technical group manager, transport geochemistry, PNL; technical group leader, Solid Earth Geophysics, PNL; technical group leader, Geochemistry and Hydrology, and Senior Research Scientist, INEL, 1988-91; Senior Research Scientist/Senior Research Chemist DOE Basalt Waste Isolation Project, 1984-88; and visiting Assistant Professor, 1976-84 (summer teaching).

Joseph T. Senftle, Director, Science Office, Arco Power Technologies, Inc., Washington, D.C. Ph.D. in Geology, 1981, Penn State University. Experience in Onshore Gulf of Mexico Exploration, Arco Oil and Gas/VASTAR, 1993-94. Served as Director of Geochemistry and Basin Analysis Research and Technical Service program, supporting Arco's domestic and international exploration efforts, 1987-92; and Research Geochemist UNOCAL Science and Technology Division, 1981-87. Other positions include: Associate Editor Geochemical Cosmochemical Act, 1991 to present; President Commission on Dispersed Organic Matter, International Committee on Coal Petrology, 1986-94; and President, Society for Organized Petrology, 1989-90.

Don W. Steeples, McGee Distinguished Professor of Geophysics, University of Kansas. Ph.D. in Geophysics, Stanford University, 1975. Eighteen years experience at Kansas Geological Survey, including several years each as Chief Geophysicist, Associate Director for Research, and Deputy Director. Also served as Geophysicist, U.S. Geological Survey.

Group 4—"Research and Science Education Center"

Larry Barker, DOE Leader. Office of University and Science Education, Office of Science Education and Technical Information, DOE.

Rita Abdeladim, Statewide Planning Analyst, Telecommunications, State of Texas (since 1983). B.A. in Business, University of Texas at Austin, 1980, and B.S. in Communications, 1979. Experience includes technical evaluation and analysis of statewide applications including TENET, TSTAR, ELECTRONIC BENEFITS Transfer, and TEXAS-ONE. Was a key developer of the Biennial Report to the Governor and Legislature on Information Resources Management, November 1994; a Steering Committee member of the Telecommunications Planning Group which developed the Texas Telecommunications Strategic Plan, September 1994; and a key contributor to the development of the State Strategic Plan for Information Resources Management, 1993. Also a distance learning expert for the Department of Information Resources.

David Austin, Retired. M.S. in Electrical Engineering, 1966. Experience includes program management and communications management. Also held position as a Design Engineer for General Electric.

Nan Broussard, Director, Eisenhower Mathematics and Science Grants Program, Texas Higher Education Coordination Board (since 1985). Master of Education, University of Pittsburgh, 1971. More than 16 years in higher education research and policy analysis; design and development of pre-college programs in mathematics and science education; and contract and grant administration. Other positions include: Assistant Research Administrator at Rice University; Principal Investigator, DOE Funded Research Projects; Foreign Student Advisor for Texas Southern University; Research Assistant, Institute for the Study of Educational Policy, Washington, D.C.; Lecturer, University of Nigeria, North Sukka, Nigeria; School Counselor, Wilkinsburg Schools, Pennsylvania; Social Worker, Pittsburgh.

Delia R. Duffey, Division Director for Educational Technology, Texas Education Agency. Doctorate of Educational Technology, 1985. Experiences includes: Education Specialist responsible for elementary technology program at the state level; Program Director responsible for instructional technology demonstration sites; and Division Director with responsibility to supervise elementary, middle, high school technology programs at the state level and statewide public school library services program. Other positions held include: College faculty member; School District Technology Coordinator; Elementary School Assistant Principal; and Classroom Teacher.

Mary Lee, State Match Pool Administrator, Texas Office of State/Federal Relations. Ph.D. in Sociology, Texas A&M University, 1993. Ten years experience working in the arena of technology development/transfer policy and implementation in Texas and scholarly research and publication in the field of social studies of science, technology, and social organization. Other positions

include: Lecturer, Department of Sociology, Texas A&M University; Associate Research Sociologist, Texas Engineering Experiment Station; Advanced Technology Program Specialist, Texas Economic Development Commission; Advisory Board Member, Texas Innovation Information Network, TINS Outstanding Commitment to Excellence and Innovation Award, 1990; Staff, Texas SBIR Advisory Board; Technical Steering Group Member, Texas Occupational Information Coordinating Committee, Labor Market Information System; Staff, Texas Technology Training Board; Participant, Texas Technology Industry Legislative Task Force, 70th and 71st Sessions.

Keith L. Mitchell, Market Development Executive for Apple Computer, Inc (Southeast region). Also one of three national science education specialists for Apple. Ph.D. in Science Education (with an emphasis in education technology), University of Texas at Austin, 1983. Experience includes ten years as a high school science teacher, five years as an education technology specialist for the Texas Education Agency, and seven years as a curriculum specialist for Apple Computer, Inc. While at TEA, coordinated with others the definition of the Computer Literacy curriculum required in every district in Texas, and also defined the essential elements for Computer Science I and II curriculum in Texas. Was an integral planner in establishing the state-wide education network which later evolved into TENET.

Nora Sabelli, Program Director, Applications of Advanced Technologies, Education and Human Resources, NSF. Received Ph.D. in 1964. Experience in Computational Chemistry, networking, and educational technologies. Held positions in Networking Infrastructure for Education, Directorates for Education and Human Resources; and Computer and Information Science Engineering.

Bryan B. Valett, Retired. Ph.D. from Oregon State University, 1969. Experience includes teaching and research at the university level. Also the Director for Northwest College and the University Association for Science.

William N. Watson, Physicist, SSC Project Office, DOE. Ph.D., University of Texas at Dallas, 1988. Experience includes work as a Technical Topic Manager and Technical Project Manager for research/development of technology related to the SSC in DOE's SBIR program; theoretical physics research in general relativity and quantum field theory; and eight years of teaching physics and mathematics courses at levels ranging from high school to graduate school. Was an instructor in Physics, Eastfield Community College, Mesquite, Texas; a lecturer in Mathematics and Teaching Assistance in Mathematics and Physics, University of Texas at Dallas; and a private tutor in Physics.

Carol Woodall, an independent consultant. Received Ph.D., 1985. Experience includes University teaching and research; National laboratory research; National laboratory project management; and science education program management at a DOE laboratory, including state, regional, and local collaboration.

Group 5—"Minority Institution Network Access"

Fred Howes, DOE Leader. Program Manager, Office of Scientific Computing, DOE (since 1991). Ph.D., Mathematics, 1974. Positions as: Program Manager, Division of Mathematical Sciences, NSF, 1989-91; Consultant, Computational Physics Division, LLNL, 1985-89; and Professor of Mathematics, University of California at Davis, 1979-89.

Richard Allen, Manager of the Applied and Numerical Mathematics Department at SNL. Ph.D. in Mathematics, University of New Mexico, 1968. Also serves as the New Mexico State Coordinator for the DOE Adventures in Supercomputing Program and participates in several state and national educational initiatives. Over 40 technical papers authored in applied mathematics and numerical analysis and three published textbooks. Other positions include: Professor of Mathematics, University of New Mexico, 1981-86; Research Professor of Medicine, University of New Mexico, 1980-86; Visiting Staff Member, LANL, 1973-86; Consultant, Air Force Weapons Laboratory, 1978-84; Associate Professor of Mathematics, University of New Mexico, 1973-81; Director of the Los Alamos Graduate Center, University of New Mexico, 1973-76; Assistant Professor of Mathematics, University of New Mexico, 1968-73; and Mathematician/Engineer, Martin Marietta Corporation, 1960-64.

Kristine Forsberg, See Deputy Review Committee Chair.

Barb Helland, Assistant Program Director, Applied Mathematical Science, Ames Laboratory. B.S. in Computer Science, 1971. Experience in UNIX, VAX/VMS, DOS, and MAC operating systems; FORTRAN C, ALGOL, PL/I computers; Local Area Networking via TPC/IP, Wide Area Networking hardware and software; and Strategic Planning and Instructional Leadership, Ames School District. Other positions include System Administrator, Ames Laboratory Computer Systems; Associate Scientist, Applied Math; and Assistant Scientist, Materials Chemistry.

Deborah Lockhart, Program Director, Applied Mathematics Program, Division of Mathematical Sciences, NSF. Ph.D. from Rensselaer Polytechnic Institute, 1974. Experience includes: Program Director, Applied Mathematics, NSF, 1993-present; Program Director, Office of Special Projects, Division of Mathematical Sciences, NSF, 1988-93; Staff Associate for Education and Human Resources, Directorate for Mathematical and Physical Sciences, NSF, 1990-91; Associate Professor of Mathematics, Michigan Technological University, 1979-90; Head, Department of Computer Sciences, MTU, 1987-1985; Head, Department of Mathematical and Computer Sciences, MTU, 1984-85; Assistant Professor of Mathematics, MTU, 1976-79; Assistant Professor of Mathematics, State University College of New York at Geneseo, 1974-76; and Instructor of Mathematics, State University College of New York at Geneseo, 1973-74.

Talitha Powell, Research Associate, Office of Science Education Programs, Office of Science Education and Technical Information, DOE. Received M.A., Science Technology and Public Policy, 1993. Experience includes managing and evaluating education programs, and writing the education plan for the SSC Laboratory.

George Seweryniak, Computer Scientist, Program Manager, DOE. Received M.B.A., Management, 1980; M.S.C.S., Computer Science, 1972; and B.S.E.E., Electronics, 1970. Experience includes extensive technical and program management experience of large R&D projects; and management of satellite communications and navigation, underwater sonar systems, ground and shipboard phased array radar systems, experimental high speed computer networks and communications systems, and design of computer circuits. Extensive experience in private industry as Director of R&D Engineering, as well as program manager for the DOD (Army, Navy, and Air Force) and the DOE. Other positions held include: Program Manager for Networks, DOD; Director of R&D, Engineering Computer Scientist, DOD and DOE; and Computer Systems Department Head.

James C. Turner Jr., Assistant Professor of Mathematics at Ohio State University and Director, Department of Mathematics, Central State University, Ohio. Ph.D. in Applied Mathematics, Carnegie Mellon University, 1986. Other positions include: Director of Academic Programs, University Consortium for R&D, 1991-94; Co-Funding Director, Carnegie Mellon University and Hampton University, Center for Nonlinear Analysis, 1991-93; and Chairman and Associate Professor of Mathematics, Department of Mathematics, Hampton University, 1989-91.

Group 6—"Regional Industrial Technology Institute"

Thomas Finn, DOE Leader. Office of the Deputy Under Secretary for Technology Partnerships and Economic Competitiveness. Ph.D. in Physics, 1972, Johns Hopkins. Experience in Technology Transfer, Space Technology, Fusion Energy, High Energy Lasers, and Atmospheric Physics. Other positions include: Executive Assistant, Office of Space, DOE; Executive Director, Energy Research Advisory Board; Special Assistant, Office of Fusion Energy; positions at Naval Research Laboratory, SAIC, W. J. Schafer Associates, E-Systems, and Jaycor.

Curt Carpenter, Principal Strategy Analyst, Corporate Staff, Texas Instruments Incorporated. Received M.S., 1970. Experience includes various engineering, management, and staff position in the electronics industry. Also held positions as design engineer, systems analyst, project manager, business manager, staff analyst, soldier, and teacher.

Hank Davis, Johnson Space Center.

Roger W. Elliott, Assistant Commissioner, Texas Higher Education Coordinating Board. Ph.D. from University of Texas at Austin, 1965. Experience includes higher education administration, university teaching, and research. Other positions include Professor and Department Chair, University of Florida 1977-87; Associate Director, Engineering Experiment Station; Associate Dean, College of Engineering; Assistant Professor, Associate Professor, and Professor, Department of Industrial Engineering, Texas A&M University; Assistant Professor, Indiana State University 1965-67; Computing Engineer, North American Aviation, 1959-61.

G. Ray Guthrie, Manager, Technology Deployment Network, at MID TEC. Received B.S. in 1958. More than 30 years experience in manufacturing, engineering, and management in the electromechanical fabrication and assembly industry. Also VP of Operations; VP of Manufacturing; General Manager; Plant Manager; Quality Manager; Manufacturing Engineer; and Junior Engineer.

Greg Hartman, Director of Communications, Comptroller of Public Accounts and Executive Assistant to the Comptroller, Texas Comptroller's office. B.A. from University of Texas at Austin, 1985. Experience includes: Director of Special Programs, Texas Railroad Commission; Chief of Staff, Office of State Senator Carlos Truan; Legislative Assistant, Office of State Representative Tommy Adkisson; and Senior Associate, Emory, Young & Associates, a media/public affairs consulting firm. Other positions include: Chair, City of Austin Ethics Commission; Member, Travis County Elections Study Task Force.

George A. Hazelrigg, Senior Advisor for Technology Integration, Engineering/DMIL, NSF. Received Ph.D. in 1968. Experience includes: mechanical and aerospace engineering; techno-economics; policy research and analysis; research grant management; and engineering education. Other positions held: Professor, Ajou University; Teaching positions; NJIT, University of California at San Diego, and Princeton Polytechnic; Consulting at Princeton University; Mathematical, Econ, Inc.; Research at JPL, Curtiss-Wright, and General Dynamics.

Hank Lees, Burlington Northern.

April Markgraf, Office of the Deputy Under Secretary for Technology Partnerships and Economic Competitiveness, DOE.

Purabi Mazumdar, Technology Analyst, Office of Technology Policy, DOC. Received Ph.D. in 1976. Experience includes industrial experience in semiconductor research, development and manufacturing, and analyzing Federal technology partnership programs. Other positions include: IBM; Perkin-Elmer; Technology/Policy Analyst Office of Technology Policy; and Technology Administration, DOC.

Kevin McIntyre, Regional Manager, Manufacturing Extension Partnership, NIST. Received B.S.M.E. in 1984. Experience includes: manufacturing engineering, project management, engineering management, and marketing for

defense conversion. Other positions include: Manufacturing Engineer; Manager of Technical Services; and Manager of Production Engineering (all positions were at Babcock & Wilcox Naval Nuclear Fuels Division).

Geoffrey Phillips, Chief Scientist and Engineer Executive, McClellan Air Force Base. Received M.P.A./M.B.A., CSUF, 1980. Experience includes: Government procurement, private sector business, strategic planner, and logistics management. Also held positions as FCC Regional Coordinator.

Paul Sanders, Texas Business Association.

Group 7—"Applied Superconductivity and Cryogenics Technology Center"

Per Dahl, DOE Leader. Staff scientist at LBL, detailed to Advanced Technology R&D Branch, Division of High Energy Physics, DOE. Received Ph.D. in 1960. Experience includes: Director, Project Management, Conventional Construction Division, SSCL; Superconducting Accelerator Magnet Design and Development, BNL; and History of Physics, with two books published. Other positions held: SSC Laboratory, Dallas; CDG, LBL; BNL, New York; Air Force Weapons Laboratory, New Mexico; and Niels Bohr Institute, Copenhagen.

Eugene Colton, SSC Project Office, DOE. Ph.D. from UCLA, 1968. Twenty-five years experience in high energy physics, beam lines, and accelerators. Positions include: Chief, Technology Branch, SSC Project Office, DOE, 1991-present; and staff member at LANL, LBL, and ANL, 1969-90.

William V. Hassenzahl, Retired. Ph.D. in Physics, University of Illinois, 1967. Experience includes: Superconducting magnet design, accelerator design and production, and analysis of magnet quality for accelerator performance. Other positions held: Group Leader, Applied Superconductivity, LLNL, 1991-93; Group Leader, Advanced Light Source, Experimental Systems, LBL, 1988-93; Physicist, Accelerator Magnet Design for SSC, LBL, 1984-88; Author, Energy Storage, Volumes I and II, Hatchinson Ross, 1982; Consultant/advisor, SMES program EPRI, 1981-present; and Director, SMES program, LLNL, 1972-78.

Juris Kaugerts, detailed to DOE as Senior Staff Physicist, two 1/2 years in High Energy Physics division of Energy Research, and nearly two years in Energy Efficiency's Advanced Utility Concepts Division, 1990-94. Received Ph.D. in 1972. Experience includes: program management at DOE on Superconducting Magnetic Energy Storage, high temperature superconductors, advanced technology R&D for high energy physics, including superconducting accelerator magnets and materials, and cryogenic technology; magnet development, testing, and analysis at SSCL, 1987-90; MRI magnet R&D at Oxford Superconducting Technology, 1984-87; accelerator magnet design, construction testing, and analysis at BNL, 1975-82; Superconducting fusion magnet development at Princeton Plasma Physics Laboratory, 1973-74. Head of Cryogenics Laboratory Accelerator Magnet conductor testing and analysis, LBL, 1972-73.

Claus H. Rode, Deputy Associate Director, Accelerator Division, CEBAF. Professional Degree in 1971. Experience includes: Cryogenic accelerator design, construction and operation of cryogenic systems, and component design, construction, commissioning and operation of beam extractor, splitting and transport. Other positions held: Tevatron cryogenic systems group leader; CEBAF engineering manager; and HERA machine committee.

Ronald M. Scanlan, Head, Superconducting Magnet Program, LBL. Ph.D. from Cornell University, 1970. Five years experience at General Electric Corporation in R&D and Superconducting Materials; ten years at LLNL in fusion magnets and superconductors; and nine years in accelerator magnets and superconductors, LBL.

Bruce P. Strauss, Vice President, Cosine, Inc. Ph.D. from M.I.T., 1967 and M.B.A., University of Chicago, 1972. Experience includes: Manager/ Senior Contributor in the independent cost estimating process for the DOE for major national programs; Director of Advanced Conductor Development at the Magnetic Corporation of America in Waltham, Massachusetts, where responsible for superconducting wire, cable, and conventional and superconducting magnet development for medical imaging systems and other high technology projects; Assistant Division Head of the Energy Doubler Magnet Division at the FNAL; author of approximately fifty technical papers; holder of several patents; serves on numerous technical conference committees; founder of the Applied Superconductivity Conference, Inc., (presently serves as treasurer); and serves on the Journal of Superconductivity Editorial Board.

Erich Willen, Senior Physicist, BNL. Received Ph.D. in 1963. Experience includes: high energy physics experiments at BNL; magnet construction for CBA, SSC, and RHIC projects (superconducting); head, and BNL magnet division, 1984-93. This period included the development of the SSC dipole magnet and all the RHIC magnets, currently being produced for the machine. Also have held numerous technical positions (various committees, review panels, and lecturing) in the course of the superconducting magnet work at BNL.

Group 8—"Southwest Center for Computing, Information Technology, and Learning"

Walter Ermler, DOE Leader. Senior Program Manager, Office of Scientific and Technical Computing, Office of Energy Research, DOE (Intergovernmental Personnel Assignment). Ph.D. in Physical Chemistry, Ohio State University, 1972. Experience as Research Associate, Department of Physics and Chemistry, University of Chicago; and Research Associate, Department of Chemistry, LBL. Experience includes theory of molecular structure and spectra. Other positions: Professor of Chemistry and Physics, Stevens Institute of Technology.

Ernest Chung, Area Manager, Chevron USA Production Company. Ph.D. in Chemical Engineering, California Institute of Technology, 1980. Experience in management of Chevron's domestic non-conventional gas business, Thermal Recovery Technology Section, Reservoir Modeling and Simulation Technology

Section. Other positions held: Senior Engineering Associate, Chevron Petroleum Technology Company; senior Petroleum Engineer, Chevron; Senior Reservoir Engineer, Chevron Geosciences Company.

Harrison Coleman, Jr., GTE Area Manager, Market Response. Education in Electrical Engineering Technology, Louisiana Technology University, 1977; Industrial Technology Grambling State University, 1977. Experience includes: high band width wide area network design; PABX engineering; production manager-frame relay; account manager; market response to emerging technology and applications; and national small business manager.

John Curtiss, South Central Manager, Silicon Graphics Computer Systems. B.S. in Mechanical Engineering, U.S. Naval Academy, 1974. Experience includes various sales, marketing, and management positions with high technology firms including eight years with McDonnell Douglas Corporation and six years with Silicon Graphics Computer Systems. Also held positions as Houston Branch Manager, Silicon Graphics; Manager, Valisys Product Marketing, McDonnell Douglas, Information Systems Group; and Houston Sales Manager, McDonnell Douglas, Information Systems Group.

Delia R. Duffey, See Group 4.

Ann Hayes, Executive Director, Advanced Computing Laboratory, LANL. M.S. in Electrical Engineering and Computer Science, University of New Mexico, 1976. Experience includes: Supercomputing benchmarker; manager of parallel processing group; and program chair, SC '92 Conference. Also held position as Group Leader for the Computer Research Group, LANL.

Richard Hirsh, Deputy Division Director, Division of Advanced Scientific Computing, NSF. Ph.D. from Case Western Reserve University, 1971. Seventeen years of research in Computational Fluid Dynamics and Numerical Methods for Partial Differential Equations; and in program management of research programs and large Centers. Other positions include: Acting Division Director, DASC; Assistant to the Director of the Office of Science and Technology Research Centers Development; Program Director for New Technologies, DASC; Program Director for Centers, DASC; and Scientist at Johns Hopkins Applied Physics Laboratory, JAYCOR, McDonnell Douglas, NASA.

Don Sheffield, Retired, Mobil Research and Development Corporation, 1992. B.S. in Geology/Geophysics, Texas A&M, 1954. Experience includes: Senior Management Science Advisor, Support Explorationist Development Program, Management of Computer Operations and Services, Technical and Architectural Planner, Environmental Engineering, Geophysicist, Technical Team Leader for interactive graphics, CAI systems design and development, and Large Computer Advisor for Control Data, Inc., etc. Several patents for technical systems and equipment. Involved in public education as a school board member for 31 years (president for 22 years). Served on Texas Education Agency's committees for establishing the Texas Long Range Technology Plan, Teacher Induction, and Texas Public Education Information Management System. Served on Texas

Learning Technology's board for nine years (chairman for seven years), in developing and implementing Level III interactive video-disk courseware and CD-ROM courseware systems for public education. Also served as a board member of the Texas Alliance for Science, Technology, and Math Education, etc.

Randy Teakell, Area Manager for External Affairs for South Western Bell Telephone Company. B.A. from Lubbock Christian College, 1979. Experience includes: local, state, and Federal regulatory issues regarding SWBT, and promoting education/economic development projects to mutually benefit SWBT and project entity. Also comptroller for an organization within SWBT with responsibility for oversight of engineering jobs in north central Texas.

Group 9—"Blackland Prairie Restoration"

William Hasselkus, DOE Leader. Environmental Engineer/NEPA Compliance Officer, SSC Project Office, DOE. Masters in business administration, Fairleigh Dickinson University, 1973. Experience as an ES&H manager for the SSC project leading the SEIS effort for the project. Provides general environmental support for the Office of Energy Research. Team leader for the DOE Office of Environmental Audit. Other positions held: Consultant to EPA Superfund program and EPA facility environmental compliance program; Director, Environmental Quality Division, U.S. Army Material Command; Team Leader, Water Quality Engineering Division, U.S. Army Environmental Hygiene Agency; Environmental Coordinator, U.S. Army Electronics Command/Ft. Monmouth, New Jersey; and Past president, Conference of Federal Environmental Engineers.

David Dunlap, Natural Resources Coordinator with the Environmental Affairs Division of the Texas Department of Transportation. Received Master of Arts Degree in Biological Science, University of Texas at Austin, 1983. Experience in applied ecology, including: development and implementation of integrated vegetation management program for highway rights-of-way; development of erosion-control grass seeding specifications for the Texas Department of Transportation; application of vegetative solutions to meeting National Pollution Discharge Elimination System requirements of the Clean Water Act; and preparation and review of Environmental Assessments and Environmental Impact Statements. Other positions include: Environmental consultant to EXIST! GmbH, Paderborn, Germany, Vegetation Management Coordinator for Lane County, Oregon; and Administrator of Technical Programs with the Texas State Department of Highways and Public Transportation (now called TxDOT).

Jay D. Gensler, Colonel, Retired, U.S. Army. Currently an Environmental Management Consultant. M.S. in Civil Engineering, University of California at Berkeley, 1970. Over 33 years of military and commercial experience specializing in the areas of: program management; environmental programs and compliance; occupational safety and health programs; air pollution and water quality engineering programs; environmental impact analysis and assessment; and occupational health and environmental quality research and development.

Other positions held: Senior Associate, Booz-Allen and Hamilton, Inc.; Assistant for Environment, Office of the Assistant Secretary of the Army for Installations and Logistics; Deputy Commander for Mission Services, U.S. Army Environmental Hygiene Agency; Chief, Air Pollution and Water Quality Engineering Divisions, USAEHA; and Chief, Health Effects Research Division, U.S. Army Medical Bioengineering Research and Development Laboratory.

Robert Gentry, Texas Utilities Company. M.S. in Agriculture, 1980. Currently a Revegetation Specialist. Work includes development and implementation of a program for reclamation and restoration of lands disturbed by surface mining activities for compliance with State Surface Mining Regulations. Responsibilities include development of revegetation specifications; management program; and establishment of evaluation criteria for determination of revegetation success. Previous position as a Vocational Agriculture Instructor, High School Level, three years.

Clive Jorgenson, detailed from ANL to the Office of Health and Environmental Research, Office of Energy Research, DOE.

United States Government

Department of Energy

memorandum

DATE: OCT 21 1994

REPLY TO
ATTN OF: ER-20

SUBJECT: Evaluation of Project Definition Studies

TO: Robert E. Diebold, Deputy Director for the Superconducting Super Collider

Thank you for agreeing to organize and lead the evaluation of the results of the Project Definition Studies that have been examining possible on-site uses of Superconducting Super Collider (SSC) assets and facilities. This includes studies of three areas that have been examined under the aegis of the Texas National Research Laboratory Commission (TNRLC), but not the Regional Medical Technology Center which has already been reviewed, and the six areas identified through the Expressions-of-Interest (EOI) process.

Several interrelated purposes or goals should be kept in mind as this evaluation proceeds. The evaluation process should:

- a. Provide input to the Secretary's plan for maximizing the value of the investment in SSC assets.
- b. Provide constructive feedback to those doing the studies.
- c. Judge the feasibility and benefits of the projects studied and provide an estimate of their funding possibilities.
- d. Help worthy projects become reality by matching projects with possible funding sources.
- e. Determine equipment and assets needed for meritorious projects with a reasonable likelihood of going forward so that the remaining DOE-owned equipment can be released for use by other DOE efforts in a timely manner.

During the week of November 28, you should assemble teams of technical experts and representatives of appropriate funding agencies at the SSC Central Facility to review and evaluate the concepts developed by the studies. The Principle Investigators of the studies and TNRLC officials should be asked for suggestions regarding possible funding sources

with interest in the proposed activities. Selected officials from these funding sources should be invited to participate in the review. The evaluation teams should take into account the study reports, presentations and answers to questions by the proponents, and team members' knowledge of the topics being addressed.

While the exact criteria and their relative importance will vary somewhat with the activity proposed, the reviewers should evaluate and discuss questions such as:

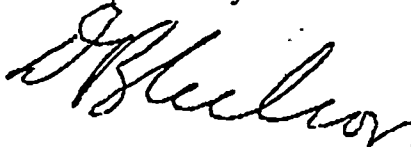
1. The scientific, technical, educational, and/or economic motivation and benefits of the proposed activities.
2. The feasibility of the project, including technical feasibility, access to necessary personnel and expertise, and the anticipated availability of funding and other required resources.
3. The match of SSC assets to needs, including the suitability of SSC assets for the proposed use(s), a discussion of which assets are required (as opposed to "would be nice"), and whether this is the best use of these assets.
4. Comparisons to similar activities elsewhere, including a brief discussion of whether these activities have been successful and whether the proposed activity is competitive.
5. Reasonableness of cost estimates, both for additional capital equipment required and for eventual operations, and completeness of the listing of infrastructure needs.
6. Realism of business plans and funding expectations.

In organizing this evaluation and review of the activities proposed by these studies, you should work closely with the TNRLC, recognizing the partnership of the State of Texas and the United States Government over the years as both invested in the SSC project. In many cases, the expected settlement with the State is expected to result in ownership by the State of much or some of the equipment or facilities required to carry out the proposed activities. Further, TNRLC is well positioned to identify and seek the involvement of local and state agencies, as well as regional sources of funding from the private sector. TNRLC staff should however, recuse themselves from the actual review of the studies carried out under their aegis.

The study proponents should be invited to make presentations of the salient features of their proposed projects and to answer questions. Following their discussions of the proposed activity and related questions, the technical experts, including those from the

funding agencies, should give you individual evaluation reports, and you, with assistance from other Department staff as required, should prepare a summary report of the review together with any recommendations. A draft of this summary report should be made available to me by December 9, and the final report should be ready for printing by December 21.

Thank you again for accepting this important responsibility.



David B. Nelson
Associate Director
Office of Energy Research

cc:

P. Didisheim, S-1
D. Pearman, FM-1
R. Nordhaus, GC-1
E. Bingler, TNRLC
EOI Principal Investigators

REVIEW AGENDA

<u>November 29</u>	<u>Convene Review at SSC Central Facility (Waxahachie, Texas)</u>
8:30 a.m.	Plenary Overview Session
12:00 noon	Lunch
1:00 p.m.	Parallel Presentations by Proponents
5:00 p.m.	Plenary Executive Session (DOE, TNRLC, and Reviewers)
6:15 p.m.	Adjourn
<u>November 30</u>	
8:30 a.m.	Subpanel Discussions –Interact with proponents as necessary to answer questions
12:00 noon	Lunch
1:00 p.m.	Subpanel Discussions and Writing of Individual Reports by Technical Experts
5:00 p.m.	Plenary Executive Session –Reports from each subpanel –Final Drafts of Individual Review Reports Due
<u>December 1</u>	
8:00 a.m.	Subpanel Discussions (as required)
9:30 a.m.	Final Plenary Session –Conference Call with David Nelson, Associate Director, Office of Energy Research –Summary reports from each subpanel and brief comments from reviewers –Summary paragraph due from each subpanel leader
12:00 noon	Reviewers Released with Thanks –Subpanel Leaders, Editors, ORISE, and DOE Staff continue editing draft report

GLOSSARY

AFOSR	Air Force Office of Scientific Research
ANL	Argonne National Laboratory
APS	American Physical Society
ASST	Accelerator Systems String Test
B&W	Babcock and Wilcox
BNL	Brookhaven National Laboratory
C	charge-conjugation-parity
CCCTC	CAD/CAM/CAE Training Center
CF	Central Facility
CRADA	Cooperative Research and Development Agreement
CSU	Colorado State University
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
EOI	Expression of Interest
EPA	Environmental Protection Agency
ES&H	Environment, Safety and Health
FNAL	Fermi National Accelerator Laboratory
FTE	Full-Time Equivalent
HARC	Houston Area Research Center
HBCU	Historically Black Colleges and Universities
HEPAP	High Energy Physics Advisory Panel
HPCC	High-Performance Computing Center
HPLC	High Performance Learning Center
INEL	Idaho National Engineering Laboratory
IRITI	Inland Regional Industrial Technology Center
JPL	Jet Propulsion Laboratory
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LLNL	Lawrence Livermore National Laboratory
LHC	Large Hadron Collider
LIGO	Laser Interferometry Gravitational Wave Observatory

Appendix D

MDL	Magnet Development Laboratory
MeV	million electron volts
MIT	Massachusetts Institute of Technology
MTDC	Manufacturing Technology Deployment Center
MTL	Magnet Test Laboratory
NASA	National Aeronautics and Space Administration
NII	National Information Infrastructure
NIST	National Institute of Science and Technology
NSF	National Science Foundation
P	parity
PDSF	Physics Detector Simulation Facility, also know as Parallel Distributed Systems Facility
PNL	Pacific Northwest Laboratory
QED	quantum electrodynamics
R&D	research and development
RHIC	Relativistic Heavy Ion Collider
RITI	Regional Industrial Technology Institute
RMTC	Regional Medical Technology Center
ROC	Republic of China
SBIR	Small Business Innovative Research
SCCIL	Southwest Center for Computing, Information Technology, and Learning
SLAC	Stanford Linear Accelerator Center
SMCT	Short Magnet and Cable Test
SMES	superconducting magnet energy storage
SMU	Southern Methodist University
SNL	Sandia National Laboratory
SSC	Superconducting Super Collider
T	tesla
TCET	Texas Center for Education Technology
TEEX/ARRI	Texas Engineering Extension Service/Automation & Robotics Research Institute
TMTC	Texas Manufacturing Technology Center
TNRLC	Texas National Research Laboratory Commission
URA	Universities Research Association