SDC-92-401

SDC
SOLENOIDAL DETECTOR NOTES

DOE REVIEW
1992

EXECUTIVE SUMMARY AND CONCLUSIONS/RECOMMENDATIONS

EXECUTIVE SUMMARY

At the request of Dr. James F. Decker, Deputy Director of DOE's Office of Energy Research, a technical review committee was assembled to perform a peer review of the Solenoidal Detector Collaboration (SDC) from October 26 to October 30, 1992, at the Superconducting Super Collider Laboratory (SSCL). The Energy Research Review Committee (ERC) evaluated the technical feasibility, the estimated cost, the proposed construction schedule, and the management arrangements for the SDC detector as documented in the SDC Technical Design Report, SDC Project Cost/Schedule Summary Book, SDC draft Project Management Plan, and other materials prepared for and presented to the Committee by the SDC management.

The SDC detector is one of two major detector facilities anticipated at the SSC. The SDC project will be carried out by a worldwide collaboration of almost 1000 scientists, engineers, and managers from over 100 universities, national laboratories, and industries. The SDC will construct a state-of-the-art, general-purpose detector weighing over 26,000 tons and the size of an eight-story building, to perform a broad class of high energy physics experiments at the SSC beginning in the fall of 1999. The design of the SSC detector emphasizes tracking in a strong solenoidal magnetic field to measure charged-particle momenta and to assist in providing good electron and muon identification; identification of neutrinos and other penetrating particles using a hermetic calorimeter; studies of jets of hadrons using both calorimeter and tracking systems; and studies of short-lived particles, such as B mesons, and pattern recognition within complex events using a silicon-based vertex tracking system. These capabilities are the result of the intensive research, development, and design activities undertaken since 1989 by this very large and capable collaboration.

Construction of the SDC detector will be carried out within the framework of the SSC Project Management Plan for Detectors, which provides the link between the SDC management plan and the overall SSC project. The SSC plan establishes organizational, approval, and other guidelines for the SDC to proceed and to be coordinated within the overall SSC project. In this context, the SDC is to be managed in accordance with SSCL guidelines with respect to safety, quality assurance, configuration management, management-control systems, and reporting.

Based upon this review, the ERC concludes that the technical design of the SDC detector is sound and that the detector is properly scoped to enable a strong, broadly based approach to TeV-scale physics research at the SSC. The design of the SDC detector is based to a large extent on previous experience with large, general-purpose detector systems at Fermilab (CDF, D-Zero), SLAC (SLD), CERN, KEK, DESY, and other high energy physics laboratories worldwide, and on the judgment and experience of an outstanding team of scientists and engineers. While, in some aspects, the SDC detector requires a significant extension of experience with past detectors, the ERC believes that it can be successfully constructed and operated.

The scope of the SDC cost estimate includes project management, tracking systems, hadronic and electromagnetic calorimetry, muon detection, a superconducting solenoid, electronics and data acquisition systems, integration/installation activities, online computing systems, some detector-related conventional facilities, and test-beam activities, as well as associated R&D to support construction activities. The total estimated cost of the SDC detector in FY 1992 dollars is $609M, including $20M already expended in FY 1991 and FY 1992 and $117M contingency, which represents 25 percent of the base estimated cost. The SDC detector is targeted for completion and readiness to begin taking data when the SSC experimental program begins in October 1999.

The ERC judges the estimated cost of the SDC to be adequate for the scope of the project; however, the costs of a number of items may be estimated in an overly conservative manner. An intensive system integration and value-engineering study of the project should result in significant savings.

The total funding tentatively identified as available to construct the SDC detector (in FY 1992 dollars) is $589M, with funding expected to be provided by the SSC project ($298M), foreign contributions (mostly in-kind) to offset costs ($231M), redirected resources from the base High Energy Physics program ($40M), and the Texas National Research Laboratory Commission (TNRLC) ($20M). This level of funding would leave a shortfall of $20M below the presently estimated total cost of $609M. The SDC management states that the shortfall could be accommodated by staging certain detector components. This staging would reduce small-angle coverage until the deferred components are installed. The ERC believes that any further major descoping of the detector would have negative impact on the physics goals of the SDC. Moreover, staged installation would shut down the SSC experimental program for a significant amount of

time. The ERC believes that it should be possible to recover the present shortfall of $20M (FY 1992 dollars) and avoid staging by system integration and value engineering and a careful optimization of the project. The foreign contributions are of critical importance and are still being negotiated. Commitments for this support must be in hand within the next 6 to 9 months for the detector construction to proceed as planned. The status of resources to support the SDC will be the subject of a second phase of this review to be held in the spring of 1993.

The SDC schedule is judged by the ERC to be very aggressive and success-oriented. There is little or no float for a number of major detector subsystems. In addition, only if the following conditions are met could the schedule be achievable: (1) the required SSC project funds are provided at a rate consistent with the SDC funding profile, (2) foreign contributions are adequate and provided in a timely manner, (3) support from the base HEP program is available as planned and can be utilized effectively to offset costs, (4) TNRLC provides support in a timely manner, (5) the SDC is given phase II approval in the spring of 1993, and (6) the SDC management successfully meets the challenge of guiding and controlling this widely distributed and complex activity. The project's critical path, which includes several large, complex detector subsystems and the underground hall, depends on hardware from the People's Republic of China, the Confederation of Independent States, and Japan being available early in the installation period. It will be a challenge to put in place the complex international arrangements needed to assure that this hardware is constructed and delivered on schedule. The total funding required from all sources in FY 1993 to remain on schedule is $50M (FY 1992 dollars), which includes $33M from SSCL.

Management of the SDC will be a tremendous challenge with its large scale-up over previous detector projects and with its design and fabrication responsibilities dispersed worldwide. For example, assuring the quality of components fabricated at remote sites both within the U.S. and overseas will require careful attention by the SDC management, as will planning for successful integration of these components into a precise and unified detector system. The recent addition of an experienced and highly regarded project manager and a project engineer represent very significant additions to the management team. However, there are still many positions in the core management team that must be filled with full-time, highly talented people in the next 6 months.

Successful management of this detector project will require that the SDC leadership have support from and access to the highest levels within the SSCL and the funding agencies. Strong central management by the SDC will be required to assure a high level of coordination and to guarantee that decisions are made in an effective and timely manner. Clear decision-making authority must rest with the SDC Project Manager and be well recognized throughout the collaboration, even in the context of the collaboration's very strong democratic tradition.

Finally, the ERC was very impressed with the substantial amount of high-quality work accomplished by the collaboration and with the excellent quality of the presentations and the information provided at the review.

9. CONCLUSIONS AND RECOMMENDATIONS

The SDC detector is one of two major detector facilities anticipated at the SSC. The SDC project will be carried out by a worldwide collaboration of almost 1000 scientists, engineers, and managers from over 100 universities, national laboratories, and industries. The SDC will construct a state-of-the-art, general-purpose detector weighing over 26,000 tons and the size of an eight-story building, to perform a broad class of high energy physics experiments at the SSC beginning in the fall of 1999. The design of the SDC detector emphasizes tracking in a strong solenoidal magnetic field to measure charged-particle momenta and to assist in providing good electron and muon identification; identification of neutrinos and other penetrating particles using a hermetic calorimeter; studies of jets of hadrons using both calorimeter and tracking systems; and studies of short-lived particles, such as *B* mesons, and pattern recognition within complex events using a silicon-based vertex tracking system. These capabilities are the result of the intensive research, development, and design activities undertaken since 1989 by this very large and capable collaboration.

Construction of the SDC detector will be carried out within the framework of the SSC Project Management Plan for Detectors, which provides the link between the SDC management plan and the overall SSC project. The SSC plan establishes organizational, approval, and other guidelines for the SDC to proceed and to be coordinated within the overall SSC project. In this context, the SDC is to be managed in accordance with SSCL guidelines with respect to safety, quality assurance, configuration management, management-control systems, and reporting.

Based upon this review, the ERC concludes that the technical design of the SDC detector is sound and that the detector is properly scoped to enable a strong, broadly based approach to TeV-scale physics research at the SSC. The design of the SDC detector is based to a large extent on previous experience with large, general-purpose detector systems at Fermilab (CDF, D-Zero), SLAC (SLD), CERN, KEK, DESY, and other high energy physics laboratories worldwide, and on the judgment and experience of an outstanding team of scientists and engineers. While, in some aspects, the SDC detector requires a significant extension of experience with past detectors, the ERC believes that it can be successfully constructed and operated.

The scope of the SDC cost estimate includes project management, tracking systems, hadronic and electromagnetic calorimetry, muon detection, a superconducting solenoid, electronics and data acquisition systems, integration/installation activities, online computing systems, some detector-related conventional facilities, and test-beam activities, as well as associated R&D to support construction activities. The total estimated cost of the SDC detector in FY 1992 dollars is $609M, including $20M already expended in FY 1991 and FY 1992 and $117M contingency, which represents 25% of the base estimated cost. The SDC detector is targeted for completion and readiness to begin taking data when the SSC experimental program begins in October 1999.

The ERC judges the estimated cost of the SDC to be adequate for the scope of the project; however, the costs of a number of items may be estimated in an overly conservative manner. An intensive system integration and value-engineering study of the project should result in significant savings.

The total funding tentatively identified as available to construct the SDC detector (in FY 1992 dollars) is $589M, with funding expected to be provided by the SSC project ($298M), foreign contributions (mostly in-kind) to offset costs ($231M), redirected resources from the base High Energy Physics program ($40M), and the Texas National Research Laboratory Commission (TNRLC) ($20M). This level of funding would leave a shortfall of $20M below the presently estimated total cost of $609M. The SDC management states that the shortfall could be accommodated by staging certain detector components. This staging would reduce small-angle coverage until the deferred components are installed. The ERC believes that any further major descoping of the detector would have negative impact on the physics goals of the SDC. Moreover, staged installation would shut down the SSC experimental program for a significant amount of time. The ERC believes that it should be possible to recover the present shortfall of $20M (FY 1992 dollars) and avoid staging by system integration and value engineering and a careful optimization of the project. The foreign contributions are of critical importance and are still being negotiated. Commitments for this support must be in hand within the next 6 to 9 months for the detector construction to proceed as planned. The status of resources to support the SDC will be the subject of a second phase of this review to be held in the spring of 1993.

The SDC schedule is judged by the ERC to be very aggressive and success-oriented. There is little or no float for a number of major detector subsystems. In addition, only if the following conditions are met could the schedule be achievable: (1) the required SSC project funds are provided at a rate consistent with the SDC funding profile, (2) foreign contributions are adequate and provided in a timely manner, (3) support from the base HEP program is available as planned and can be utilized effectively to offset costs, (4) TNRLC provides support in a timely manner, (5) the SDC is given phase II approval in the spring of 1993, and (6) the SDC management successfully meets the challenge of guiding and controlling this widely distributed and complex activity. The project's critical path, which includes several large, complex detector subsystems and the underground hall, depends on hardware from the People's Republic of China, the Confederation of Independent States, and Japan being available early in the installation period. It will be a challenge to put in place the complex international arrangements needed to assure that this hardware is constructed and delivered on schedule. The total funding required from all sources in FY 1993 to remain on schedule is $50M (FY 1992 dollars), which includes $33M from SSCL.

Management of the SDC will be a tremendous challenge with its large scale-up over previous detector projects and with its design and fabrication responsibilities dispersed worldwide. For example, assuring the quality of components fabricated at remote sites both within the U.S. and overseas will require careful attention by the SDC management, as will planning for successful integration of these components into a precise and unified detector system. The recent addition of an experienced and highly regarded project manager and a project engineer represent very significant additions to the management team. However, there are still many positions in the core management team that must be filled with full-time, highly talented people in the next 6 months.

Successful management of this detector project will require that the SDC leadership have support from and access to the highest levels within the SSCL and the funding agencies. Strong central management by the SDC will be required to assure a high level of coordination and to guarantee that decisions are made in an effective and timely manner. Clear decision-making authority must rest with the SDC Project Manager and be well recognized throughout the collaboration, even in the context of the collaboration's very strong democratic tradition.

Finally, the ERC was very impressed with the substantial amount of high-quality work accomplished by the Collaboration and with the excellent quality of the presentations and the information provided at the review.

The ERC made the following major recommendations:

1. An overall, in-depth value engineering analysis and optimization of the project should be undertaken during the design phase. The Committee believes that this exercise will have many positive impacts, including eliminating the need to consider staging detector components.
2. An overall in-depth reexamination of the SDC schedule should be undertaken. Opportunities for accelerating various activities should be investigated so that the number of parallel critical paths can be reduced and an appropriate float be built into the schedule. The outcome of the exercise should be an overall project schedule that is still aggressive, but has a reasonable probability of success.
3. The variances in the cost estimate suggested by the ERC should be carefully evaluated by SDC management, the SSCL, and DOE, and an appropriate cost baseline established.
4. The SDC, SSCL, and DOE should make a focused, concentrated effort to solidify the necessary foreign commitments in order that construction of the SDC detector can proceed in a timely manner.
5. The SDC Project Manager should move aggressively to complete his core management team within the next 6 months.
6. A credible and realistic integrated project schedule appropriate for use as a management tool should be developed as soon as possible.
7. Care should be taken to avoid circumstances in which the very aggressive, success-oriented schedule could unnecessarily drive the making of technical decisions before adequate R&D has been completed.

The ERC also made the following recommendations; discussion of the circumstances underlying these recommendations appear in the sections noted:

a. Project Management, Cost, Schedule, Funding and Collaboration Resources (sections 7 and 8).

1. Strong central leadership is required to assure that decisions are made in the timely and effective manner that will be necessary to stay on schedule and within budget. The Project Manager must be given clear decision-making authority by the SSCL and the SDC.
2. SDC project leadership must be given appropriate support from and access to the highest levels within the SSCL and the funding agencies.
3. SDC management should provide and utilize more specific procedures for monitoring and evaluating costs, schedule, and performance than it now does.
4. At present there are three different types of cost books. While compatible, these books are not easy to use. The SDC project management team and the SSCL Physics Research Division should develop a consistent process for cost-information display and then develop easy-to-use, integrated cost books to match.
5. Particular care should be taken in establishing the elements of the cost estimate, particularly labor costs, which serve as the basis for negotiating compensatory payments.
6. The Project Manager should be given control of some portion of the SDC contingency on an annual basis. Control of some of the funds derived from cost savings realized at the subsystem level should also reside with the Project Manager.
7. The current status of the detailed design of the various components of the detector should be carefully controlled, updated, and documented in a document similar to the "SDC Detector Parameters" book. This document will eventually become the as-built documentation.
8. A large and complex set of procurements will be needed to build the SDC detector. SDC management should carefully assess the resources it will require to manage these procurements effectively.

b. SDC Physics (section 4)

1. In order to avoid negative impacts on the SDC physics capabilities, there should be no additional major reductions in the scope of the detector.
2. If staging should be required, the Collaboration should thoroughly review the various staging scenarios in order to identify those which

minimize the impact on physics capabilities and the impact on the physics program due to shutdowns for retrofitting. The calorimeter should not be staged in any way that destroys its hermeticity.

c. Tracking Systems (section 10.1)

1. The scintillating-fiber technology for the outer tracker should be given consideration as an equal alternative to the combined straw/gas-microstrip outer tracker. The moderate technical risk of the fiber technology may make it attractive when the high-straw occupancy and the high-technical risk of the gas microstrip approach are considered.
2. The management of the intermediate tracking detector (ITD) activity should make a concerted effort to add additional collaborators. A more aggressive stance should also be taken towards acquiring R&D funds for this effort.
3. The Collaboration should develop a plan to meet the substantial R&D requirements for the tracking system. It is of particular importance that a proof of principle be established for the large ITD tiles. The design of the system should undergo reevaluation if a full-size prototype tile has not been proved to be feasible by the time required by the SDC schedule.
4. Realistic beam tests of the barrel, straw, and fiber trackers should be made a high priority. Tests should be planned to demonstrate the feasibility of the Level 1 trigger scheme and offline tracking in a suitably high-rate environment and to address the rates from low-energy neutrons and photons.
5. The Collaboration should appoint an overall system-level coordinator for the tracking system who would also coordinate the tracking system with the rest of the detector.

d. Calorimetry (section 10.2)

1. R&D should continue with the goal of achieving an initial yield of at least four photoelectrons per minimum ionizing particle per tile, taking into account the effect of cumulative radiation damage and losses due to response equalization that may degrade fiber response.
2. Consideration should be given to the production of additional barrel and endcap modules that could be used for further performance studies in test beams after the SDC detector is operational.

e. Muon System (section 10.3)

1. An overall reevaluation of the staging plan for the forward muon system should be undertaken.
2. Support should be provided to IHEP for muon system design and integration efforts related to the forward region.
3. The barrel toroid installation schedule appears to be overly aggressive. In response to this concern, resource (manpower, time, funds) allocation plans for this phase of the muon program should be carefully reevaluated.
4. The operation of the support-structure jack system for the muon magnet should be reanalyzed to make sure that undue stresses cannot be induced in the structure under any conditions that will be encountered during assembly and operation.
5. A full, detailed simulation of the muon Level 1 trigger should be performed to better evaluate its likely performance.
6. A detailed plan should be developed for acquiring the barrel toroid steel in the Confederation of Independent States. This plan should address contractual arrangements, engineering liaison, quality assurance, and other relevant issues.

f. Superconducting Magnet (section 10.4)

1. If possible, the schedule for completion and testing of the prototype coil should be accelerated.
2. The cryostat design should be developed to a level comparable with that of the cold mass as soon as possible. More attention should be given to understanding and balancing the distribution and sharing of loads in the cold mass support systems when there are displacements of the coil with respect to the calorimeter.
3. As a cost saving measure, the magnet should be supported by a dedicated liquefaction system sized (~750 W) to provide recovery from 1.5 quenches per day.
4. The design and procurement of the cryogenics system should be "subcontracted" to SSCL to take advantage of expertise in place and to realize economies of scale.

g. Electronics Systems and Online Computing (section 10.5)

1. A redundancy and failure rate analysis of all electronics subsystems, in more detail than exists at the present time, should be performed.
2. If the electronics system leadership does not reside at SSCL, significant technical design staff should then be based at the home institutions of these managers.
3. Additional attention should be paid to evaluating the needs and solutions for in-detector cooling of electronics.
4. Many costs are likely to shrink with time faster than was assumed for the electronics and computing hardware. A consistent approach, using the best estimates for cost trends, should be applied to the projection of costs to be incurred in coming years in areas of rapid technological progress.
5. For reasons of efficiency and improved coordination, the Collaboration should consider combining the online computing and the data acquisition groups.

h. Hall Conventional Facilities, Subsystem Installation and Test, and Detector Integration (section 10.6)

1. A single individual should be identified who is fully responsible for, and who can effectively coordinate, the installation effort. Each subsystem should identify an installation coordinator who provides liaison with the overall installation coordinator
2. Contingency installation plans should be developed to minimize the impact should some major components not be delivered at the top on the hole on time.
3. A careful review of the cable volume, routing, and effect on the installation sequence should be done to assure that the routing is adequate and that the installation sequence is optimized.
4. SDC management should identify a single individual to provide the necessary interfaces between the SDC and the SSCL Conventional Construction Division (CCD) and the AE/CM.
5. The interrelationship between alignment and adjustment mechanisms of the various detector subsystems should be reviewed by project-level management to assure that these are appropriate and effective in meeting all alignment and adjustment requirements for the overall detector, as well as for individual subsystems.

i. Environment, Health, and Safety (section 6)

1. Safety analysis documentation for the SDC should include the requirements of the newly issued Radiation Control Manual, as required by DOE Order 5480.11.
2. DOE Order 5480.ACC, "Safety of Accelerator Facilities," will be issued for implementation within the next few months and should be incorporated into the overall SDC Safety Analysis Program.
3. SDC management should formally respond to the comments and suggestions made by the SDC Review Panel in the May 1992 review of the SDC CSAR.
4. SDC management should continue development of the personnel-egress plan for the SDC hall that complies with the intent of NFPA 101, "Life Safety Code."
5. Efforts should continue to find a substitute for Halon in the fire-protection systems in the SDC detector and hall.
6. The interface for safety-compliance responsibility between the SDC and the SSCL Conventional Construction Division should be carefully defined, taking into account activities during the turnover of the hall to the SDC and the rigging of detector components.