Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

SPALLATION NEUTRON SOURCE (SNS) PROJECT

November 2001

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science (SC) review of the Spallation Neutron Source (SNS) project was conducted at Oak Ridge, Tennessee, during November 6-8, 2001, at the request of Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences, Office of Science. The purpose of this review was to evaluate progress in all aspects of the project: technical; cost; schedule; management; and environment, safety and health (ES&H). Special emphasis was given to evaluating the SNS updated Estimate-to-Complete (ETC), as well as its installation and commissioning plans. In addition, the Review Committee was asked to verify that the project's technical, cost, and schedule baselines are consistent with the current DOE-approved Project Execution Plan.

Overall, the Committee judged that the SNS project is continuing to make satisfactory progress and remains on track to meet its Level 0 Baseline objectives: Total Project Cost (TPC) of $1,411.7 million; project completion date of June 2006; and ≥ 1 megawatt (MW) proton beam power on target. Technical progress has been excellent since the May 2001 DOE review. The design baseline still exceeds requirements, all key design decisions have been made, and the Linac design is complete. Five Best-in-Class instruments have been formally baselined with a construction budget of $62.3 million. A radiofrequency (RF) testing capability is being established at Thomas Jefferson National Accelerator Facility on schedule per an Action Item from the May review. Significant component fabrication and site construction activities are underway. The Linac tunnel structure is over three quarters complete and work has begun on the Target, Front End, and Klystron Building foundations.

The SNS project is a multi-laboratory partnership led by the SNS Project Office in Oak Ridge, Tennessee. The partners are Argonne National Laboratory, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Thomas Jefferson National Accelerator Facility. Relations among the SNS partner laboratories are excellent and communications are good. There has been a smooth transition to a new SNS management team which began with the appointment of a new Project Director in February 2001, and all key management positions (including all three Division Directors) have now been filled.

At the end of September 2001, the project was 33.3 percent complete compared to 35.3 percent planned, and the cumulative cost variance was nearly zero. Sixty-nine percent of all design work and 90 percent of the R&D are finished. Most of the remaining R&D is for the instruments and to resolve a target window material pitting issue. Over $220 million in procurements have been awarded and the amounts tracked well against the baseline budget—there was a net savings of about $8 million in FY 2001. At present, the project is running about one month behind the internal working schedule, which contains six months of schedule contingency. Adequate funding is being provided to support the schedule. At $291.4 million, FY 2002 is the peak year of the funding profile and marks the second straight year that the full amount has been appropriated by Congress. The greatest sources of schedule risk appear to be in vendors meeting hardware delivery dates (e.g., klystrons) and the complexity of orchestrating equipment installation in parallel with civil construction.

The Committee expressed confidence that the project could be completed on schedule and within the baseline TPC. The project prepared a comprehensive ETC, and the Committee recommended its implementation as an updated project cost baseline. This would require the use of $31.1 million in contingency (a Level 2 Baseline Change for the DOE Project Manager to approve), leaving $124.6 million of contingency remaining. Taking into account other pending actions, the contingency would stand at about 20 percent of the ETC. The Committee felt this contingency level was adequate but tight, and cautioned SNS management to conserve and tightly control use of the remaining amount.

The project's ES&H performance has continued to be outstanding, far better than either DOE or industry norms, accumulating about 355,000 work-hours without a lost workday case. The State of Tennessee has praised the project's environmental practices and showcased them to others.

Installation and commissioning plans were completed as required by an Action Item from the May 2001 DOE review. These plans were found to be appropriately detailed and complete for the current stage of the project, and the Committee observed that they have improved the understanding of the roles and responsibilities for all SNS project participants. There will need to be further integration of these plans across the project, and additional details will need to be incorporated with special attention to equipment staging requirements and vendor/partner laboratory delivery schedules. The schedule for Target Systems component installation is especially tight. Lastly, an integrated instrument installation plan still needs to be developed that covers the initial instrument suite as well as those instruments to follow.

In summary, the Committee found the project to be on track and well positioned to meet its Level 0 technical, cost, and schedule baseline objectives. The Committee felt that the project is appropriately managing the issues, has adequate but tight contingency, and must remain very aggressive in managing all phases of the project.

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1. INTRODUCTION

1.1 Background

When completed in 2006, the Spallation Neutron Source (SNS) will be the world's foremost neutron scattering facility. It will be an important scientific tool for basic research in materials science, life sciences, chemistry, solid state and nuclear physics, earth and environmental sciences, and engineering sciences. The design calls for a beam of negatively-charged hydrogen ions (H^-) to be generated and accelerated to an energy of one billion electron volts (1 GeV) using a linear accelerator (Linac). The H^- beam will then be transported to an accumulator ring, where it will be injected by stripping away the electrons to leave the desired protons and bunching them into a short (under one microsecond) pulse 60 times per second. Finally, the proton beam will be directed onto a liquid mercury target, where pulses of neutrons will be created through spallation reactions of the protons with the mercury nuclei. Inside the target building, the emerging neutrons will be slowed or moderated and channeled through beamlines to instrumented experimental areas where users will carry out their research. Figure 1-1 shows a schematic view of the facility.

The SNS project is being carried out as a multi-laboratory partnership, led by the SNS Project Office at Oak Ridge, Tennessee. Besides Oak Ridge National Laboratory (ORNL), the other laboratory partners include: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and the Thomas Jefferson National Accelerator Facility (TJNAF). This collaborative approach is being used to take advantage of the best expertise available in different technical areas and to make the most efficient use of Department of Energy (DOE) laboratory resources. As indicated in Figure 1-1, and defined in the SNS Project Execution Plan (PEP), each laboratory is responsible for a specific scope of work. Design and construction management of the conventional facilities is being handled by a commercial architect engineer/construction management (AE/CM) team (Knight-Jacobs) under a task order contract to ORNL.

A Final Environmental Impact Statement (FEIS) for the SNS was issued in April 1999. On June 18, 1999, the Secretary of Energy signed the Record of Decision to proceed with construction of the SNS at ORNL. A Mitigation Action Plan (MAP) was prepared, identifying

Figure 1-1. The Spallation Neutron Source

actions taken by DOE and the project to avoid or minimize environmental harming building and operating the facility. The Department is monitoring progress against the MAP to ensure the plan is properly implemented.

The SNS conceptual design was carried out during FY 1996 and FY 1997, at a cost of about $16 million, and evaluated by a DOE review committee in June 1997 (report DOE/ER-0705). At the same time, a DOE Independent Cost Estimate was performed. In response to recommendations from these reviews, the project schedule was extended from six to seven years, and other adjustments were made that increased the Total Project Cost (TPC) from $1,226 million to $1,333 million (as spent[1]).

Critical Decision (CD) 1, Approval of Mission Need, and CD-2, Approval of Level 0 Project Baseline, for the SNS were approved by the Secretary of Energy in August 1996 and December 1997, respectively. The SNS PEP, which governs how the project is managed, was initially approved by the Secretary at the time of CD-2; it was most recently updated in July 2001. The Level 0 cost and schedule baselines set at CD-2 comprised a TPC of $1,333 million and a seven-year design/construction schedule, with facility commissioning to occur at the end of FY 2005. The approved Level 0 technical baseline stipulated that the accelerator complex would produce a proton beam on target of $\geq$ 1 megawatt (MW). Receiving $23 million in FY 1998, the project carried out advanced conceptual design and further R&D activities in anticipation of starting Title I design in FY 1999.

A DOE Technical, Cost, Schedule, and Management Review of the project was conducted in June 1998. Its principal finding was that the project's management organization and systems were sufficiently mature to initiate the construction project at the beginning of FY 1999. Further work was deemed necessary, however, to complete a detailed cost and schedule baseline, and to restore project contingency to at least 20 percent. A strong recommendation was made to hire a permanent Project Director as soon as possible and to continue building the Accelerator Systems Division (ASD) at ORNL.

The FY 1999 SNS project construction line item was approved and funded by Congress to start Title I design and initiate long-lead procurements, but only at a level of $130 million, as compared to $157 million requested in the President's FY 1999 Budget Request. As a result of the $27 million funding shortfall in FY 1999, the project schedule was extended by three months

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[1] All cost figures throughout this report are in "as-spent" (i.e., escalated) dollars.

(completion due in December 2005), and the TPC was increased to $1,360 million. The President's FY 2000 Budget Request for the SNS project was $214 million ($196.1 million of line item construction funds and $17.9 million of operating expense funds).

In November 1998, ORNL competitively awarded an AE/CM contract to a joint venture led by Lester B. Knight and Sverdrup Facilities, Inc. (Sverdrup has since been acquired by Jacobs Engineering Group, Inc.). The AE/CM team is responsible for design and construction of all conventional facilities.

At a DOE review of the SNS project in January 1999, the review committee determined that the SNS collaboration was continuing to work well together, and technical progress was generally good, however the baselines were still not judged to be ready for DOE approval. The main reason was lack of technical leadership and project-wide ownership by the relatively inexperienced SNS Project Office management team then at Oak Ridge. The committee strongly recommended that a new Project Director be recruited with extensive experience in construction of large technical/scientific facilities and with the technical background, including accelerators, needed to make major design decisions. Overall, the $1,360 million TPC was deemed to be adequate to complete the facility as designed. The committee, however, urged a further increase in contingency.

As an immediate result of the January 1999 DOE review, a new Project Director was brought on board from ANL in early March to lead the project for a two-year term. He brought with him a strong track record in managing large scientific construction projects and a user perspective as a neutron scientist. Between April and June 1999, the SNS Project Office at Oak Ridge was reorganized and additional technical and management staff members were recruited to fill key positions. The partner laboratories were directed to optimize and fully integrate the technical design, and to strengthen the business and project management systems to support construction activities. The SNS technical parameters were revised to include an average proton beam power on target of up to 2 MW, enhanced ("Best-in-Class") instruments, and expanded laboratory and office space for users and staff.

In July 1999, another DOE review was conducted for the purpose of evaluating the project's proposed technical, cost, and schedule baselines. The review committee judged the baselines to be credible and consistent with the FY 2000 Budget Request funding profile, and recommended their approval by DOE. Confidence was expressed that the new SNS Project

Office team could lead the project to success. The Committee felt that the management team had moved aggressively to take full ownership of all technical, cost, and schedule aspects of the project, and defined a clear vision and a disciplined management approach.

In order to strengthen the commitment among the partner laboratories, the 1998 inter-laboratory Memorandum of Agreement (MOA) was revised, and signed by the laboratory directors in October 1999. It replaced the original MOA in the SNS PEP, and is also included by reference in the laboratories' management and operations (M&O) contracts. The latter step had the effect of making the MOA a legally binding agreement.

At $117.9 million, the FY 2000 appropriation for SNS was $96.1 million less than the $214 million request. This, coupled with the project's restructuring under new management, led to an estimated delay in project completion of six months (to June 2006), and a corresponding increase in the TPC of $80 million (to $1,440 million including Tennessee taxes, see below). In addition, the House report (Report 106-253, pages 113-114) accompanying the FY 2000 Energy and Water Development Appropriations Act prohibited DOE from obligating FY 2000 funds to SNS until seven conditions had been satisfied. The project was able to make continued progress, however, by using uncosted obligations remaining from FY 1999 while efforts were made to satisfy these conditions. In particular, DOE approved CD-3, Start Construction, on November 5, 1999, and site preparation work on Chestnut Ridge began soon thereafter. A formal groundbreaking ceremony for SNS was held on December 15, 1999. By February 2000, DOE and the project had satisfied the seven congressional conditions and all FY 2000 construction funds were released to the project. Later in FY 2000, the project managed to complete most Title I design activities, as well as nearly all site clearing, excavation, and road work.

One of the conditions in the FY 2000 House report was for the cost baseline and project milestones for each major SNS construction and technical system activity to be reviewed and certified by an independent entity as the most cost effective way to complete the project. In order to satisfy this condition, DOE tasked an External Independent Review (EIR) contractor (Burns & Roe) who then conducted such a review during September through November 1999. The final Burns & Roe EIR report (December 1999) stated: "Burns and Roe's view is that the planned approach to executing the SNS project, as reflected by the baseline documents that support the FY 2000 Budget Request, is the most cost effective approach to project completion."

Another condition imposed by Congress was that the General Accounting Office (GAO) had to certify that the total taxes and fees on SNS paid to the State of Tennessee or its counties/ municipalities would be no greater than if SNS were located in any other state that contains a DOE laboratory. In response, the Tennessee state government enacted a law to completely exempt SNS from state and local sales and use taxes (estimated at $28.3 million). This tax exemption addressed the last remaining condition in the House report, and GAO provided the necessary certification.

In April 2000, the M&O contract for ORNL was turned over from Lockheed Martin Energy Research Corporation to a team led by the University of Tennessee and Battelle Memorial Institute. From the perspective of the SNS project, the transition went smoothly and there were no adverse impacts.

The President's FY 2001 Budget Request for SNS was amended to reduce the TPC from $1,440 million to $1,411.7 million to account for the Tennessee tax exemption. Congress appropriated the entire requested amount for FY 2001 (minus a $512,000 rescission) and DOE provided the project with $258.9 million in construction funds and $19.1 million in operating expense funds.

In October and December 2000, a two-phase DOE review was conducted that included an initial evaluation of the SNS pre-operations plan and cost estimate. Three major issues were identified in the first review phase, two of which had to do with the potential for significant cost growth in different areas, one in conventional facilities and the other in pre-operations. It was also noted that the project was using contingency at an alarming rate. The cost growth concerns stemmed from the AE/CM's preliminary Title I design estimate for Conventional Facilities (CF), which was about $80 million over the cost baseline, and an overly aggressive pre-operations staffing plan. The third issue was that the Integrated Project Schedule (IPS) required more Budget Authority (BA) than that contained in the FY 2001 Project Data Sheet's annual funding profile.

SNS management took immediate steps to resolve these issues, and by December, the committee found that the project had developed workable plans to address them. The overall approach to dealing with the cost concerns involved value engineering and selective scope reductions that still allowed the project to meet its Level 0 Baseline objectives. There were significant scope reductions in conventional facilities that included deleting the Central Laboratory and Office (CLO) Building (while retaining a minimum level of functionality) and reducing the size of the Target Building, and the instrument budget was reduced from $93 million to $53 million (still more than the conceptual design level of $45 million). In addition, the last three cryomodules of the Superconducting Linac (SCL) were deleted to save money, resulting in a lower Linac output energy of 840 MeV, while still providing a proton beam power on target of over 1 MW. The pre-operations staffing level was reduced to the minimum level necessary to commission the machine. Lastly, the IPS was re-planned to be consistent with the BA in DOE's annual funding profile and still provide 6 months of schedule contingency.

SNS management met with DOE in February 2001 to finalize the actions needed to resolve the cost and schedule issues described above. As a result, a reduced-scope CLO was retained in the baseline; the instrument budget was adjusted to $60 million to provide for at least five instruments plus design of common components for future instruments; certain DOE milestones were relaxed to conform with the revised IPS; and the energy specification for Linac output energy was broadened (while retaining the proton beam power on target requirement of $\geq$ 1 MW). Although there was a net shift in baseline installation scope from the partner laboratories to SNS to allow the necessary buildup of ASD staff, there was no change in TEC or TPC.

In February 2001, the Project Director had reached the end of his two-year term as leader of the SNS project, and rather than extend, he elected to return to ANL. After an extensive search by the Director of ORNL, the SNS Experimental Facilities Division (XFD) Director (Dr. Thomas Mason) was selected to take charge as SNS Project Director. Having been with the project since its inception, he is thoroughly familiar with SNS and is also well known in the neutron scattering research community. Other changes in the senior management team were completed later in the year with the appointment of new personnel to the three SNS Division Director positions (ASD, XFD, and Conventional Facilities Division (CFD)).

During the latter half of FY 2001, construction activities at the Chestnut Ridge site have included extensive structural work on the Front End Building, Linac Tunnel, Target Building foundation, and site utilities. As of September 30, 2001, the project had awarded over $220 million in procurements, completed 69 percent of all design work and 90 percent of all R&D. A large number of additional procurements are planned for award in FY 2002. Technical components have begun to arrive in Oak Ridge at the Receiving, Assembly, Test and Storage (RATS) Building. The overall size of the project work force, including construction workers, has exceeded 700 full-time equivalents (FTEs) and will reach its peak level of about 1,000 FTEs in FY 2002 - 2003.

For FY 2002, Congress appropriated the full requested amount for SNS of $291.4 million, which is the peak of the project's annual funding profile.

1.2 Charge to the DOE Review Committee

In a September 6, 2001 memorandum (see Appendix A), Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences (BES), Office of Science, requested that Daniel R. Lehman, Director, Construction Management Support Division lead a review to evaluate all aspects of progress, including technical, cost, schedule, management, and ES&H. Special emphasis was given to evaluating the SNS updated Estimate-to-Complete (ETC), as well as its installation and commissioning plans. In addition, the Review Committee was asked to verify that the project's technical, cost, and schedule baselines are consistent with the current DOE-approved PEP.

1.3 Membership of the Committee

The Review Committee (see Appendix B) was chaired by Daniel R. Lehman. Members were chosen on the basis of their independence from the project, as well as for their technical and/or project management expertise, and experience with building large scientific research facilities. Continuity and perspective were provided by the fact that many of the members served on one or more of the previous seven DOE review committees. The Committee was organized into eleven subcommittees, each assigned to evaluate a particular aspect of the line item project corresponding to members' areas of expertise.

1.4 The Review Process

The Review was accomplished during November 6-8, 2001, at Oak Ridge, Tennessee. The agenda (Appendix C) was developed with the cooperation of the SNS Project Office, DOE Headquarters, and DOE Oak Ridge Operations Office (ORO) staff.

Comparison with past experience on similar projects was the primary method for assessing technical requirements, cost estimates, schedules, and adequacy of the management structure. Although the project requires some technical extrapolations, similar accelerator projects in the United States and abroad provide a relevant basis for comparison.

The morning of the first day was devoted to a plenary session with project overview presentations by members of the SNS Project Office staff, followed by a tour of the construction site. In the afternoon and throughout the second day, there were presentations by the participating laboratories (ANL, BNL, LANL, LBNL, ORNL, and TJNAF) with subcommittee breakout sessions to discuss detailed questions from the Committee. The third day was spent on Committee deliberations, report writing, and drafting a closeout report. The preliminary results were discussed with SNS management and staff at a closeout session on the last day.

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2. TECHNICAL SYSTEMS EVALUATIONS

2.1 Accelerator Physics

2.1.1 Findings

There is ample evidence of good accelerator physics work being performed at the SNS partner laboratories, in an efficient environment, with the Accelerator Physics group at Oak Ridge continuing to enhance its lead role.

For example, the project is creating an applications code environment in which rapid prototyping can occur. This will be a great help in responding flexibly to unanticipated needs during commissioning, and to individual needs during machine development and experimentation.

Also, real progress is being made at the SNS partner laboratories in developing simulation codes, such as electron cloud and space charge codes that are useful not only to the SNS project, but also to the community at large. These contributions are world-class.

The CD-4 performance goals, 10^{13} protons per pulse through the accelerator and 5×10^{-3} neutrons per steradian per proton at the target, correspond to 100 kW operation. This is significantly short of the project's goal of 1.4 MW (≥ 1.0MW is the baseline) that drives many of the equipment specifications.

Since the May 2001 DOE review, improved emittance measurements have been made at the output of the Low Energy Beam Transport (LEBT), in which DC offsets have been removed from the raw data. This leads to normalized rms (root mean square) emittance values of 0.2 π mm-mrad and 0.15 π mm-mrad (horizontal and vertical), although with significant non-Gaussian tails. The Ion Source "outlet electrode contour" will be remodeled, with the goal of reducing these tails. Some collimation in the LEBT is possible (and likely), but it now appears unlikely that the Radio Frequency Quadruple (RFQ) would collimate the phase-space volume.

Simulations using the nominal emittance and a water bag distribution indicate that beam halo is generated in the RFQ. This could lead to intolerable beam loss in the Drift Tube Linac (DTL) and Coupled Cavity Linac (CCL). Collimation in the Medium Energy Beam Transport (MEBT) is also possible, but the limited amount of phase advance (2π) limits its effectiveness.

Very recently the possibility of adding collimators in each of the 30 drift tube elements in DTL Tank #1 has been raised. In principle, this would efficiently truncate the halo, removing about 0.3 percent of the beam, which would otherwise lead to Linac activation.

The newest simulations of the Proton Storage Ring (PSR) instability are closing the gap between prediction and observation. The impedance of the extraction kicker in the Ring could be a concern as full baseline performance is approached. There is space in the lattice where a transverse damper could be added, if necessary.

2.1.2 Comments

Although the emittances reported coming out of the LEBT are much improved, it is entirely possible that the beam leaving the RFQ will have a significant halo.

The presence of an enhanced collimator system just downstream of the RFQ could have a major impact in reducing the activation of Linac components due to beam losses. At least, such collimators could significantly reduce the sensitivity of beam losses due to minor Ion Source and other tuning fluctuations. One possible place to put collimators is in DTL Tank #1. It may or may not be possible to retrofit these collimators once Tank #1 has been constructed.

Performance significantly beyond CD-4 parameters appears to be straightforward up to—or beyond—half MW operation. Ultimate performance up to the 1.4 MW level may depend on invoking contingency items, such as a transverse damper in the Ring, which will not initially be installed. Such planning is entirely reasonable, so long as such contingency upgrades are not precluded in the meantime.

One recommendation of the May 2001 DOE review has not been addressed. It asked: “Prepare, by April 2002, a diagnostic system in the MEBT for beam parameter measurements in a dynamic range of greater than three orders of magnitude, for measuring transverse halo and demonstrating beam gap cleanliness.”

The project stated they could not respond to the item: “This is a goal well beyond CD-4 and therefore beyond the end of the project. None of this is required to achieve CD-4 either. Suggestion: close out the item because it is not project relevant."

The diagnostics adequate to meet CD-4 performance goals are not necessarily sufficient to meet 1.4 MW performance. Retrofitting of diagnostics to meet design goals should be avoided, wherever possible. This is true, in particular, of diagnostics in the MEBT, a location where many of the beam distribution characteristics have been permanently set, but where the activation due to destructive beam observations (such as laser wire profile measurements) is minimized. MEBT instrumentation should be state-of-the-art; it is insufficient to merely measure the rms emittance. A dynamic range of five orders of magnitude has been consistently obtained in the Low Energy Demonstration Accelerator (LEDA) experiments at LANL.

Implementation of a collimator system in the DTL may relax the requirement of detailed on-line monitoring of the beam halo. However, the need to measure the beam gap cleanliness at the level of one part in 1,000 remains.

The gap between prediction and measurement of the PSR instability can be further closed with continued studies at the PSR.

It is not clear that an integrated method is in place for assembling, maintaining, and making available for general technical use the overall design of the SNS. Ideally this would include aspects such as a “live” Design Manual of the “as built” facility as it evolves, configuration data such as accelerator physics and controls databases, and engineering drawings.

2.1.3 Recommendations

1. Resolve, by January 2002, how to control the halo of the beam distribution as it emerges from the RFQ, for example by deciding to put collimators in DTL Tank #1.

2. Prepare, for Front End re-commissioning at ORNL in fall 2002, a diagnostic system in the MEBT to demonstrate beam gap cleanliness, as well as to measure transverse halo.

2.2 Front End Systems (WBS 1.3)

2.2.1 Findings

The project has made significant progress since the May 2001 DOE review in the following areas: 1) Ion Source antennae reliability, 2) RFQ fabrication and tuning, 3) MEBT hardware completion, and 4) equipment hand-off planning.

The project has also made good progress against all three recommendations from the May 2001 DOE review. The three recommendations are discussed separately.

1. The Front End Systems (FES) team has managed to make up about a month of schedule since the last review and now appears to be in good shape for RFQ testing with beam in the December 2001 to January 2002 time frame. Plans for testing the MEBT with beam beginning in February or March 2002 also are progressing well.

2. LBNL has received written verification of component delivery from their partner laboratories and verified schedule dates for all remaining hardware.

3. Installation Plan, and Cost Estimate Draft Installation and Commissioning Plans are in hand.

The schedule remains tight, but LBNL is confident of making their acceptance completion date of May 31, 2002. By July 15, 2002, shipping of the FES to ORNL is to be complete.

LBNL expects to complete their scope within the current budget and expects no significant new Project Change Requests (PCR). Some minor put-and-take PCRs with no net cost increase may be processed. The project has assumed that slightly over 1,100 man-hours of LBNL technician support will be needed for FES installation at SNS in Oak Ridge, but the Committee could not confirm that this had been included in the baseline cost estimate.

The Ion Source and LEBT have recently completed a 24-hour-per-day reliability test extending beyond 107 hours at reduced power levels, and plans are underway to repeat the tests at full power with a ten-layer porcelain antennae coating.

All four modules of the RFQ have been delivered, assembled, and tuned. The final two buncher cavities of the MEBT have been plated, and are expected to be delivered by the end of November 2001. The plus and minus chopper power supplies have been accepted and are being shipped directly to LBNL. The anti-chopper power supplies may be delivered in January 2002, but of all FES components, they are the most uncertain with respect to delivery date.

2.2.2 Comments

Interaction between FES and ASD personnel at Oak Ridge continues to be beneficial. The involvement of ORNL ASD personnel is expanding beyond just the Ion Source effort and is having a continued positive impact on the overall FES effort. There are ongoing discussions concerning the ORNL/LBNL interaction after delivery to SNS. Some of the assumptions of personnel availability during installation and commissioning may need further clarification.

Since the May 2001 DOE review, LBNL has made good progress on improving their schedule situation, but the schedule remains tight. The installation of FES components between July and October 2002 will precede the availability of certain site utilities, and temporary work-arounds will be required. The time left for beam commissioning of the RFQ and MEBT at LBNL is limited.

The FES will be the first SNS system to be commissioned. Beam operation is dependent on the successful completion of the Accelerator Readiness Review (ARR). The time required to achieve completion of the review, requires continued attention by both ORNL and DOE representatives.

The complexity of the MEBT, the limited testing time available at LBNL, and the funded set of diagnostics will result in partial verification of MEBT performance before shipping to ORNL. The remaining verification of the MEBT performance will have to be done at ORNL. Any modifications or efforts related to beam halo and collimating strategies will be the responsibility of ORNL.

The current budget and contingency appears to be adequate for this state of the project. The project’s assumption that LBNL personnel will be available for supporting FES installation could not be confirmed in the Committee’s examination of the baseline cost estimate, and these costs may have been overlooked. For example, the FES installation presentation included 1,153 hours of partner laboratory technician effort that is not in the FES cost estimate provided by

LBNL. All parties (i.e., partner laboratories, ORNL installation groups, and ORNL commissioning groups) need to reach a uniform consensus concerning partner laboratory support during installation and commissioning.

2.2.3 Recommendation

1. Clarify the availability of and budgeting for partner laboratory participation in FES installation/commissioning.

2.3 Linac Systems (WBS 1.4)

2.3.1 Linac Overview

2.3.1.1 Findings

The Linac structure is unchanged since the May 2001 DOE review. As shown in Figure 2-1, the Linac structure is a conventional DTL to 87 million electron volts (MeV), a CCL from 87 MeV to 186 MeV, a "medium- β" (β=0.61) SCL from 186 MeV to 379 MeV, and a "high- β" (β=0.81) SCL from 379 MeV to approximately 1 GeV. The medium-β SCL has 33 cavities in 11 modules and the high- β SCL has 48 cavities in 12 modules.

Considerable progress has been made since the May 2001 DOE review. The Linac physics design was reviewed at the September 2001 meeting of the SNS Accelerator Systems Advisory Committee and was judged to be complete. The conventional Linac RF and mechanical systems underwent final design reviews. Fabrication of the DTL and CCL accelerating structures is underway. FY 2002 will be the peak year of obligations for the Linac. The Linac Estimate-at-Completion (EAC) has been revised on the basis of a bottoms-up estimate. The CCL hot model tests successfully validated the engineering designs, and manufacturing and tuning techniques consistent with an action item from the May 2001 DOE review, an RF system is being assembled at TJNAF to support the prototype medium- β cryomodule tests. The cost and schedule performance are reported as satisfactory.

Substantial progress has been made to prepare for the handoff of the Linac from LANL and TJNAF to SNS-ORNL. Detailed acceptance criteria have been prepared and mutually

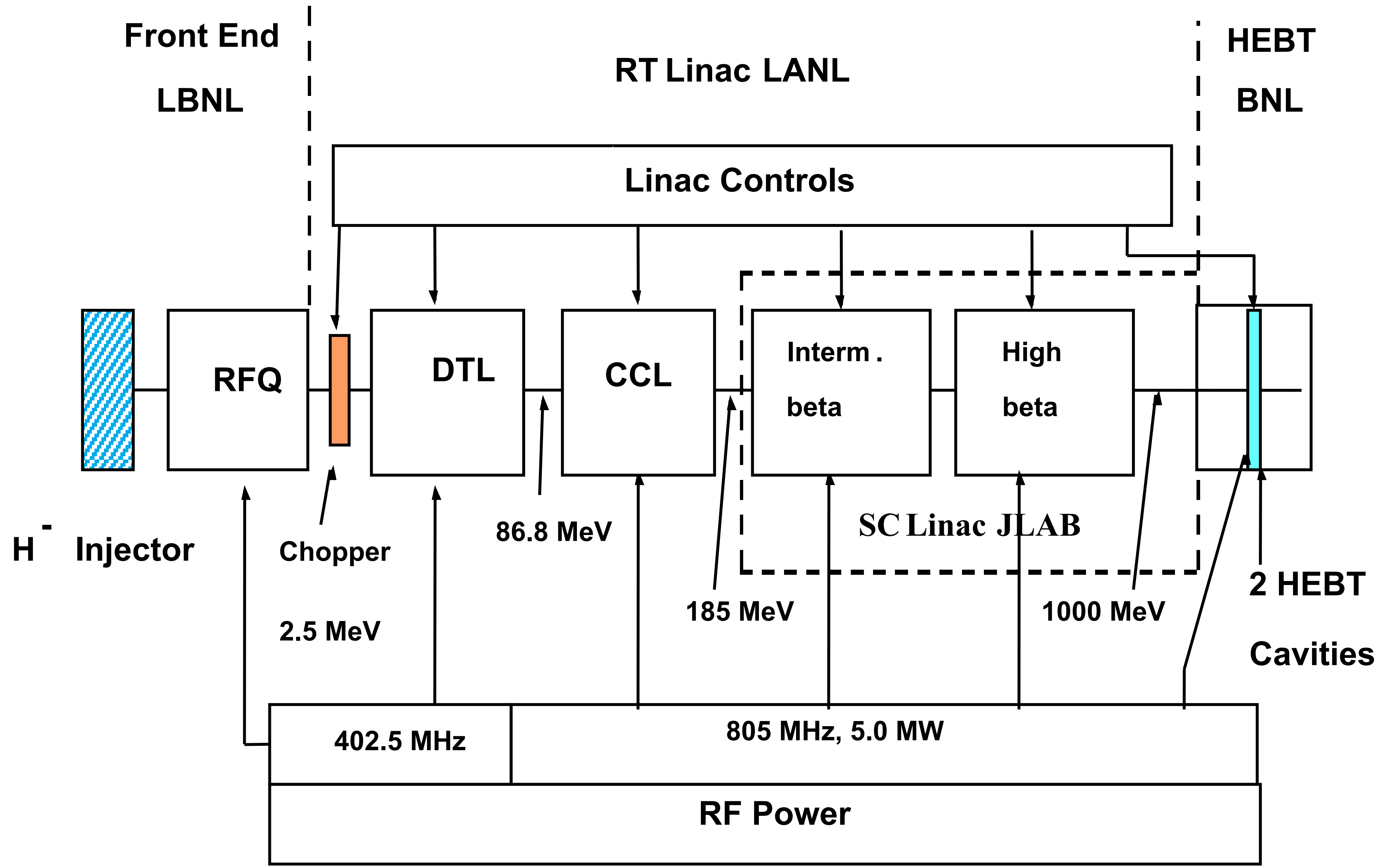

Figure 2-1. SC Linac Configuration

approved. For all of this, the staff at the partner laboratories and the SNS management at ORNL deserve congratulations. Management at the SNS and the partner laboratories is demonstrating the close cooperation that is necessary for a successful execution of a complex collaborative project.

The project reported a few issues. The orders for the various types of Linac klystrons have been distributed (by type) to several vendors. One of the vendors has announced the intention of leaving the business on a schedule that would terminate all production shortly after the scheduled delivery of the last SNS DTL klystron ordered from this vendor. This DTL klystron is a new design. First items of this new design have been assembled and are ready for powered testing at the vendor. Some uncertainty was reported about the status of the first item prototypes and the ability of the vendor to deliver the full order on time prior to the closing of the business. Warranty repairs and the eventual provision for rebuilding failed klystrons are also a concern. SNS management is reviewing options to provide a second source for these DTL klystrons.

A second issue centers on a suggestion to "clean-up" the beam received in the Linac from the Front End by placing collimators in the first DTL tank. This issue is very recent, and was not considered in the Linac beam physics and mechanical systems reviews conducted prior to the start of DTL structure fabrication.

2.3.1.2 Comments

The progress on the Linac is very encouraging. The estimated cost at completion is close to the same as one year ago. Although some schedule contingency has been consumed, the schedule to completion remains consistent with the IPS. The first Linac structures and RF equipment will be ready to install when the appropriate civil facilities are "ready for equipment" (RFE).

Production and fabrication will peak in FY 2002. SNS management must develop systems to ensure a rapid response to any vendor issues that may emerge. This is necessary to protect the IPS, because the schedule contingency in many systems is not large. The identification of local representatives to visit and act for the SNS project at foreign vendor sites may be advisable.

Issues that have recently emerged must be resolved before problems either develop or intensify. It would be advisable to develop and execute a plan to identify and engage a second vendor to back up the identified weakness of the DTL klystron vendor. An investigation of the available options to provide collimation in the DTL will be urgently needed if it is determined that a future retrofit is inadvisable and that a modification is required.

Although all the recommendations from the May 2001 DOE review received attention, some of the recommendations are judged worthy of continued consideration.

ASD technical staffing is generally proceeding well, but still needs strengthening in areas such as Linac RF power. It is important to get needed staff on board soon so that information transfer from partner laboratories can be optimized.

2.3.1.3 Recommendations

1. Solicit a proposal for a second source design and prototype of the DTL klystron and place such an order prior to May 2002. This action should be followed regardless of the prototype test results from the first vendor.

2. Develop a plan that would permit the insertion of collimators in DTL Tank #1. This plan should include a recommendation for either the immediate redesign of DTL Tank #1 for this purpose, or assure that a remedial insertion at a later date would be possible if necessary. A decision should be made by January 15, 2002.

3. Maintain a close watch on, and a good working relationship with, all vendors.

4. Build upon the excellent work that has been done to define Linac acceptance criteria, as well installation and commissioning activities. Review and update these plans, activities, and criteria every six months.

5. Continue reliability studies. Update an overall assessment of integrated reliability performance, based upon latest designs and test results, every three months.

2.3.2 Superconducting Linac

2.3.2.1 Findings

The SNS Project Office and partner laboratories have moved very effectively to provide a high-power RF source for tests of the prototype medium-β cryomodule (an Action Item from the May 2001 DOE review).

Good progress has been made in the construction and testing of prototype superconducting (SC) cavities and in procurement of elements of the prototype cryomodule. Good progress has also been made on procurements for the SCL.

Major elements of the SCL refrigeration system have been delivered. Vendor fabrication of cryogenic subsystems is in progress. The contract for SC cavity construction has been placed.

2.3.2.2 Comments

The timely completion of tests of the prototype cryomodule is needed to establish the adequacy of the system designs to cope with the electromagnetically induced mechanical vibrations resulting from pulsed operation of the SC cavities. The use of a piezoelectric device to reduce vibration-induced detuning seems promising, and inclusion of such a device in the prototype cryomodule development is appropriate.

Delays in the scheduled tests increase the risk of schedule slip and cost increase for the SCL, so that the high priority given this activity is entirely justified.

2.3.2.3 Recommendation

1. Hold monthly meetings between SNS ASD management and TJNAF management to review and document the status of cavity and cryomodule development activities.

2.4 Ring Systems (WBS 1.5)

2.4.1 Findings

Sextupoles are now included in the Ring technical baseline. The inclusion of sextupoles has been essentially cost neutral (within BNL-managed work) due to savings in power supply procurements. This addresses a recommendation from the May 2001 DOE review.

SNS management believes that the Linac will produce 1 GeV beam for machine commissioning, achieved by higher gradients in the SCL cavities (see recommendation below). Consistent with the previous DOE review findings on staffing, BNL has reduced the number of physicists working on the SNS project to five. This compliments the accelerator physicists in the SNS ASD working on the Ring.

Following recommendations from the May 2001 DOE review, a comprehensive plan has been put together to define the hand-off between BNL and SNS-ORNL. The plan is detailed, addressing hand-off issues at the component level. Funds have been transferred to ORNL to handle installation issues that were originally in the BNL scope of work. Both laboratories are satisfied with the format and the content of the plan. One hand-off point is still being debated (RF installation) and both parties are aware of the issues and implications.

The low-level RF engineer, hired by the SNS ASD, has arrived and has begun to spend time at BNL. This is an encouraging example of the policy to place ASD staff at partner laboratories to gain expertise in areas that presently lack experience.

Good progress has been made in all technical areas. With respect to magnets, all Ring dipoles are now fabricated and are in storage at BNL. The first magnet has been measured and meets specifications. The end shaping of the Ring dipoles is now complete. Of the thirty different magnet designs, one-half are out for bid. The remainder (with the exception of the sextupoles) are in final design.

In Vacuum Systems, HEBT and Ring chambers have been ordered and most have been received. Gate valves have also been ordered and received. Orders have been placed for ion pumps, and first articles have been received. Orders have also been placed for ion pump controllers. The procedure for Ti-N coating of the vacuum chambers has been developed and production coating has begun.

In the area of collimators, a design review in October 2000 resulted in a redesign of the collimator tube. It is now a double-walled tube manufactured of Inconel-718 cooled by water. The conceptual mechanical design has been completed for all components. There has been a cost increase in collimators of around $1 million, primarily due to the change in tube design. An order has been placed for a first article (Ring to Target Beam Transport collimator).

An order for the 160 corrector power supplies has been placed and the first article has arrived at BNL. The bids for the medium range power supplies have come back very favorably. In fact, the order has been re-specified to support 1.3 GeV operation while still realizing a savings of about $1 million. The first article injection kicker has been tested and the delivery of the remainder of the units is on schedule. The procurement package for the Ring main bending magnet supply is nearly complete, and the Request for Proposals (RFP) is scheduled to be released by the end of November 2001.

Considerable progress has been made on the design of the extraction kicker power supplies. Prototypes have been built that look promising. A first article pulse-forming network is being fabricated with testing to begin in November 2001.

All production units (265) of the power supply interface/controller units have been delivered to BNL. These units are now being used by vendors developing power supplies for the Ring. An Experimental Physics and Industrial Control System (EPICS) interface is being developed.

At this review, there was a dedicated session on the Ring RF design. It is well developed and based on BNL experience with the Alternating Gradient Synchotron (AGS), where applicable.

Thorough installation and commissioning plans have been put together for the transfer lines and the Ring. Commissioning and installation activities are further addressed in Section 4.

2.4.2 Comments

Working relations between the BNL Ring team and the SNS Project Office are good. The hand-off documents and the commissioning and installation documents are excellent, and the Committee encouraged both groups to continue to refine and execute them.

The project should continue to evaluate reliability issues, particularly with respect to kickers, and present results at each DOE review. A plan for obtaining spares was presented. The Committee had concerns regarding spares in high radiation areas. These concerns are addressed in the recommendations below.

A bottoms-up estimate of the cost to complete the Ring Systems has been performed as part of the project's ETC update. For WBS 1.5, this has resulted in an increase to the EAC of $153.1 million. There are two main components to this number, the BNL portion, and the SNS ASD portion. The BNL portion is $112.7 million. This number is $10.6 million smaller than the existing cost baseline, primarily due to the transfer of scope to SNS ASD ($9.8 million). The SNS ASD portion of WBS 1.5 is now $40.5 million. This number has increased, due in part to the transfer, noted above, but has also drawn on $7 million of contingency to cover miscellaneous labor rate adjustments, travel costs, and electrical distribution, and cables and trays that were previously included elsewhere. Thus, the SNS ASD portion of WBS 1.5 has increased by $16.7 million. The contingency analysis for WBS 1.5 by the project yields a value of 20 percent. BNL has suggested contingencies at Level 3 of the WBS that roll up to 15 percent at Level 2 for their portion of the work. A sufficiently large fraction of the cost estimate update was based on quotes and first article procurements, so that the Committee was comfortable with the numbers.

2.4.3 Recommendations

1. Present a plan, at the next DOE review, of how to proceed with commissioning if the surface field goal of 37 megavolts per meter (MV/m) in the SCL cavities cannot be met. This plan should include a firm deadline for installation of additional RF, or for lower energy commissioning, leading to full-energy operation.

2. Present a plan, at the next DOE review, for spares of all devices that will be in high radiation areas. The project is encouraged to obtain spares for these devices before beam is introduced in order that these devices can be replaced in-situ, in a "dry run" scenario. This would provide the one chance to work out unforeseen problems before these devices become activated, and should be made part of the installation schedule.

2.5 Target Systems (WBS 1.6)

2.5.1 Findings

As in the past, the Target Systems (TS) team proved to be in full control of their tasks and critically responsive to outside advice. They acted positively to almost all of the recommendations and comments made in the previous DOE reviews and made excellent progress in all aspects of their part of the project.

The Committee noted with satisfaction that the project was able to recruit a Division Director for Experimental Facilities in accordance with one of the recommendations given in the last review. The new Division Director, who will report for duty in March 2002, has a background in neutron scattering and brings expertise in neutron optics to the project, which is highly welcome.

There was also positive action on another recommendation to interact closely with ASD to work out a scheme that would ensure that the beam be shut off instantaneously if the required profile could not be guaranteed on the Target. A document was generated describing the surveillance system that will be implemented.

In response to a comment made at the previous DOE review, the project examined its remote handling issues more closely. It was discovered that there was no cask in the planning to handle the spent target shells. Currently, this cask is in the list of spare parts to be put back into the scope of the project. The Committee noted that this is not a spare part, and its procurement is not urgent at the present time since the cask will only be needed about one year after the start of target irradiation.

Finally, the project followed up on a long-standing recommendation to carry out an experiment irradiating, under realistic conditions, a mercury-steel interface with a proton current density representative of that in SNS. These experiments, which were carried out at the Weapons Neutron Research (WNR) facility in Los Alamos, yielded valuable data for code benchmarking with respect to the stress amplitude generated by the thermal shock. They also hinted that the velocity of sound in mercury might be strongly reduced after the pulse, which may indicate gaseous cavitation in the mercury. Another finding, which needs to be further examined, was the discovery of pitting near the centers of the front and rear flanges of the cylindrical model target.

Commendably, the project took immediate action after the first discovery of the pitting in the WNR irradiation experiments. As a first measure, surface hardened steel was used instead of the annealed steel in which the pitting was first observed. This reduced the effect, but did not completely eliminate it. It is not clear, however, whether the hardening was uniform over the whole surface. In fact, hardness measurements taken on a sample that had been subjected to the same treatment seem to indicate it was not.

The project is now calling an international workshop that will focus on this pitting issue and that aims at establishing a coordinated international research effort to investigate this problem. This will include out-of-beam testing as well as further in-beam experiments in December 2001 and July 2002. The project is still in a position to redirect some of its planned R&D funds so that there is no immediate effect on the TS budget.

2.5.2 Comments

While the project is determined to solve the pitting problem and make the liquid mercury target concept a success, SNS management has wisely decided to step up a parallel effort on a solid target design that might be used to commission the SNS facility in case the pitting problem takes longer to solve than the project schedule would allow. A similar approach was followed at the 1 MW SINQ facility in Switzerland, where a water-cooled rod target is being successfully used, while a liquid lead-bismuth target is still under development. [SINQ is not a pulsed source, and therefore pitting is not an issue there.]

So far, the TS team has managed to stay within their tight schedule. Procurements may, however, become a critical path concern. Minimal or no schedule contingency is left in at least one major item due for delivery in the near future. This may be an indication of possible difficulties when the project has to rely increasingly on vendors and outside contractors. Extensive auditing and a close monitoring of manufacturer progress will be necessary to keep the large amount of procurements on track. Also, caution should be used in handing responsibility over to the AE/CM, since insight into the underlying needs and requirements may be missing in many cases. The Committee was not able to identify a comprehensive auditing and QA concept.

The project has been proactive in taking early steps to get the plan for an ARR with a transition period to the Operation Readiness Review (ORR) approved by DOE, and to identify the approving authority on a working level. The present detailed facility commissioning plan provides for low-power operation as a Radiological Facility in order to prepare for the transition to a Hazard Category-2 Nuclear Facility. This is a cost effective and time saving approach, which the Committee strongly endorsed. It was also good to see that the project is analyzing alternative approaches and the resulting cost impact.

All spare parts were removed from the scope of Target Systems during the cost cutting exercise about a year ago. The Committee shared the project's concerns that this bears the risk of a costly wait if anything breaks down during the early operating phase. The Committee observed that spare parts are included in other parts of the project, and considered it a matter of prudence and consistency to do the same for Target Systems.

The project decided to change the material for the outer reflector from clad lead to directly cooled stainless steel, arguing that this would eliminate potential cooling problems that might arise when the lead detaches from its cladding as a consequence of thermal cycling. This is a simplification of the whole reflector design, which comes at a penalty of an estimated reduction of 3 percent in neutron flux from the moderators. While the Committee cautioned against "small" flux compromises in general, it concurred with this decision in view of the increased operational safety and reduced design complexity.

Up to June 2001 Target Systems has spent 28 percent of their revised EAC. The Committee concurred with the revised cost estimate, but cautioned against any reduction of the contingency level since there is substantial uncertainty in the final unit price of the machined steel that still needs to be procured for the target shielding. In addition, some extra cost may arise from pursuing a solid back-up target in parallel with the liquid metal target. The Committee also saw a cost risk associated with the project's plan to procure only part of the installation effort on a fixed-price basis and have the rest offered on an hourly rate basis due to lack of comprehensive detailed planning.

The Committee noted the project's decision not to follow a previous DOE review recommendation to test the target module and mercury piping in the Target Test Facility prior to their installation in the SNS. Instead, the project elected to reduce this testing to a trial run of the final pump in the present loop. Although the experience gained with the modified piping system and the successful code validation have reduced the risk of a faulty design, there is a risk of losing valuable time in a very tight schedule if some unexpected difficulty is encountered during the first trial runs of the loop in the hot cell.

Plans call for the CM to install most parts of the target shield. Although the project has done an outstanding job in establishing a detailed installation sequence that will ensure an optimized procedure, the Committee still had concerns about the installation plan, which requires the work to be carried out in parallel with the construction of the Target Building. Staging of an estimated 500 to 1,000 parts to be mounted in exactly the right positions in a prescribed sequence is, in itself, a major task. Furthermore, some of the parts such as the core vessel inserts and shutter systems are quite delicate and need careful handling. Leaving this responsibility in the hands of the CM means that a well structured labelling of all parts and comprehensive guidance will be required. In this context, there is also a concern that the installation will be done with a heavy-duty mobile crane through an open roof of the Target Building. This makes the whole operation sensitive to weather conditions since it is not acceptable for moisture to be trapped inside the shielding.

2.5.3 Recommendations

1. Include spare parts essential to achieving high facility availability, and add the spent target shell transport cask to the scope of the project.

2. Make every effort to obtain highest priority for conducting material pitting experiments at WNR in June or July 2002 as they may have to be scheduled within the LANL facility's user program.

3. Work with the CM to find a scheme that will allow installation of at least the shutters and inner parts of the shielding / reflector plug (including the core vessel inserts) in a covered room under reasonably clean conditions.

2.6 Instrument Systems (WBS 1.7)

2.6.1 Findings

The five instruments included in the SNS baseline are all Best-in-Class instruments that significantly advance neutron scattering capabilities in the world. For example, the backscattering spectrometer will give neutron researchers access to regions of phase space with unprecedented energy resolution, while the powder diffractometer (the conceptual design of which has now been finalized) will produce high-quality data for profile refinement at unprecedented rates. When combined with the two externally-funded instruments[2] being built by Instrument Development Teams (IDTs), these instruments cover a good range of momentum-energy phase space.

The budget for Instrument Systems has remained stable, consistent with a recommendation of the May 2001 DOE review. In order to fit the five baselined instruments into the available budget, it has been necessary to reduce the scope from the original designs. In each case, there is a straightforward method to recover the original scope, should additional funds become available in the future. For example, only about 25 percent of the planned detector coverage is included in the baseline for the powder diffractometer. It is estimated that it would cost a total of about $10 million to recover the original scope of the five planned instruments (excluding spare parts).

The cost estimates and schedules for the five baselined instruments are, in and of themselves, reasonable, with no identifiable issues for completing three instruments by CD-4. However, the bulk of procurements for the instruments have not yet been made, and are scheduled for FY 2002 and FY 2003. Thus, while the cost estimates seem reasonable, it is still a bit early to judge their accuracy on the basis of contract awards. Moreover, to ensure that the project meets the CD-4 milestone of having three of these instruments installed, an intricate coordination of installation efforts will be necessary.

The shared resources effort is working to develop a “plug-and-play” approach to the design of common components for neutron spectrometers. These shared resources will represent an invaluable contribution to the development of future instruments. The current activities have concentrated on detectors and data acquisition systems, neutron choppers, optical components, and shielding. These efforts are proceeding well and are already resulting in significant cost savings for instruments in progress. Efforts are just beginning in the areas of sample environment and common analysis software.

The costs associated with the shared design effort, which account for approximately 30 percent of the total instrument R&D and construction budget, are reasonable in view of the positive impact on the instrument program.

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2 These two instruments are funded through grants from DOE/BES to two university teams led by Pennsylvania State University (Cold Neutron Chopper Spectrometer or CNCS) and the California Institute of Technology (Atomic scale Resolution Chopper Spectrometer or ARCS).

The user program, while just in its infancy, is making good progress in informing the community of the capabilities of SNS through workshops and co-sponsorship of meetings. These efforts should be applauded and continued.

2.6.2 Comments

The interfaces that the Instrument Systems team must manage continue to proliferate with the recent emergence of IDTs. The Committee urged continued diligence in fostering communications, both within the Instrument Systems team and between the Instrument Systems team, IDTs, and the user community, as well as with other parts of the SNS project.

The development of shared resources represent an important contribution to the instrument development program at the SNS. In the same light, the combined experience of the current team of instrument scientists represent an important resource for the design of new instruments. Every effort should be made to communicate this knowledge base to the instrument scientists and IDTs developing future instruments. Procedures should be instituted to ensure that full advantage of the potential savings are realized.

The Committee had concerns about the period of time from late 2004 to CD-4 when three SNS instruments are due to be installed in the Target Building. In addition to those, there are two IDT and two more SNS instruments that should be nearing readiness for installation during this period. It is highly desirable to get the instruments installed in as efficient a manner as possible. The installation process will be complicated by competing needs for space, especially for work close to the Target, and limited resources such as cranes. Initial plans have already been formulated for the installation of individual spectrometers. This involves installation of large amounts of massive shielding in coordination with mounting and precision alignment of neutron guides. It is prudent to now take the next step, and develop an integrated plan for instrument installation. Such planning is needed to ensure that the goal of having three instruments installed by CD-4 is achievable.

As noted above, there are two more SNS instruments plus two IDT instruments that will likely be ready for installation near the end of the project. The installation of these instruments needs to be carefully considered in the installation plan. An important case is that of the CNCS IDT spectrometer, which will be on a beam line between and immediately adjacent to beamlines used by two SNS instruments. In addition, there are also three more IDT Letters of Intent that have been approved by the Environmental Facilities Advisory Committee (EFAC). It is time to start planning for how these instruments can be installed in a relatively continuous fashion. The installation process will require close coordination between the Instrument Systems team and external IDTs.

To manage the installation effort, it is important to have one person who can act as the coordinator, determining schedules and resolving conflicts in real time. It appears that Instrument Systems has identified someone in Target Systems to play this role; however, there seems to be some confusion as to whether the person identified will accept these responsibilities. This issue needs to be resolved.

The success of the initial suite of instruments at the SNS will strongly depend on the sample environment equipment that is available for experiments and the analysis software used to interpret the data. Flexible control of temperature, pressure, and magnetic field at the sample would broaden the science addressed by the instruments and broaden the user base. Instruments such as the powder diffractometer should be not only Best-in-Class for intensity resolution, but should also have outstanding capabilities for sample environment. Important variables such as pressure will likely be covered by new IDTs. The SNS should work to ensure that these items will be ready at the time of commissioning of the instruments.

Instrument Systems should periodically carry out a global examination of the costs associated with each activity. These reviews should take into account developments in shared activities and refinements in the costs resulting from experience. They should carry out global optimization of the funds available to maximize the performance of the instruments. At the same time, the instrument scientists should aggressively seek opportunities to leverage construction and development funds, such as collaborations with university participants (e.g., use of university machine shops, post-doctoral personnel, summer programmers).

2.6.3 Recommendations

1. Develop an integrated instrumentation installation plan by the next DOE review. Identify a person who will be responsible for coordination of operations during instrument installation, together with any budget requirements.

2. Develop a plan for continuous installation of new instruments, especially those developed by IDTs, following project completion. An aggressive rate is two per year.

2.7 Control Systems (WBS 1.9)

2.7.1 Findings

The cost, schedule, and technical baselines for the control systems are consistent and there is adequate progress to meet the objectives. One upcoming PCR is that of the diagnostics interface to Control Systems. The interface has changed architecturally to achieve the goal of a standard approach and architecture for diagnostics across the different accelerator systems.

The Committee has continued to be impressed by the quality of the SNS team. The managers of the Controls and Diagnostics efforts are excellent, as is the team leader of Accelerator Physics Application Programming. This leadership is supported by an enthusiastic and professional staff. The SNS project and ASD management are to be commended for their support in these areas. Installation, commissioning, and handover plans have raised the standard for future accelerator projects. These represent truly excellent work.

The ETC is credible and reasonable. There is some risk in the Control Systems ETC because of the upcoming PCR for the diagnostics interface mentioned above. But this only affects 10 percent ($6 million) of the EAC for Control Systems ($59.6 million).

The major environment, safety and heath (ES&H) aspect of Control Systems is the Personnel Protection System (PPS). The PPS functional requirements definition is in excellent shape, due to the close involvement of the Pre-operations team. The PPS design is also proceeding very well, with an experienced team leader. The procedures for how to review/approve repairs and modifications need to be negotiated between the Pre-operations and Control Systems teams before the Front End PPS is operational.

The following paragraphs summarize the project's responses to previous DOE review recommendations in the area of Control Systems:

- Cabling: Excellent progress. Cabling Handbook, database (design and loading), roles and responsibilities, criteria, etc. are all in place or being put in place (even cable labeling standards).

- Rack Factory: Also excellent progress. A local supplier has been found. How much this supplier will be used is ultimately up to the individual groups to determine. The Rack Factory proposal coordinator has suggested a Basic Ordering Agreement relationship, but this service could also be purchased using Purchase Requisitions (more costly), or not at all (groups could do in-house – will cost still more).

- Application Programming: Excellent – as good as it gets. Congratulations go to ASD for the Commissioning Plan, which allows the definition of applications needed and schedule. This, in turn, has allowed the team to develop a realistic schedule and staffing plan. The support of ASD management for increased staff in this area and support from the partner laboratories (BNL and LANL) has allowed the team to reach a size sufficient to accomplish the task as now planned.

Conventional Facility Controls is quite tightly coupled and well integrated with the Control Systems team, since the coordinator working on this is part of the Control Systems organization. This same person is also responsible for coordination of the Cable-plant Installation and the Rack Factory proposals – very productive! The project pointed out that using the CM to develop an EPICS-based Conventional Facilities Control System will provide a source of EPICS expertise that will be available for possible future use by the SNS project.

2.7.2 Comments

In the Commissioning Plan, the Machine Protection System (MPS) appears to be given the same level of certification as the PPS. However, the two systems are very different. PPS is life safety and MPS is not. MPS checkout and verification does not require the same level of oversight as the PPS certification, and the Commissioning Plan should clearly make that point.

3. CONVENTIONAL FACILITIES (WBS 1.8)

3.1 Findings

Since the May 2001 DOE review, CF progress has been maintained in design and construction at the site. The project has made significant accomplishments on planned activities and resolved design uncertainty to a commendable state. CF Title II design is substantially complete and the ETC is based on defensible technical information including certified for construction drawings and the actual results of procurement awards. Procurement actions supporting construction are approximately 57 percent complete and site construction progress is approximately 14 percent complete.

The Committee found that the CF EAC is $308.9 million with cumulative costs through October 2001 of $134.1 million and anticipated additional commitments through November of $61.7 million. Overall, the project remains four to six weeks behind the early project finish schedule (December 2005). The proposed update to the cost and schedule baselines and the associated planned use of contingency are consistent with the project BA profile.

The Committee endorsed the project's proposed update to the cost and schedule baselines. Consideration should be given to including build-out options proposed in the current procurement strategy to enable a fully built-out CLO Building at the end of the SNS project.

The Committee found that the CF procurement strategy has resulted in significant benefit to the SNS project with an average savings of more than ten percent on procurement awards. Additionally, the decision to allow heavy equipment to finish excavation, and the tunnel contractor's use of slip-form technology resulted in both cost and schedule improvements.

There are sufficient manpower resources to support the current planned work, and the construction sequence identifies the peak manpower requirements in FY 2002 and FY 2003. The construction site is well maintained and site management has achieved a commendable safety record with the result of lower insurance costs and actual project savings.

The Committee reviewed the Target Building as an integrated design and construction example. CFD and XFD staff conducted a joint presentation, which clearly demonstrated a high level of integration. The level of planning and design integration is not complete; however, the approach and detailed plan are highly commendable for this stage of the project. The Committee also reviewed the ASD installation plan and found that a good first step has been made on integration; however, improvement is necessary as fundamental definitions regarding RFE access are resolved.

Highlighted below are changes that were noted from the project's status at the time of the May 2001 DOE review:

- The proposed cost baseline for WBS 1.8 is currently $308.9 million, which is an increase of $1.2 million since May 2001. The increase is due to normal adjustment of construction cost estimates based on actual award. The estimate is documented in the CF ETC, which incorporates actual cost and commitment data from the project's Microframe Project Manager (MPM) system.

- The project presented a Budget Obligation (BO) profile, construction sequencing plan, CF schedule and budget that were self-consistent and continue to reflect the project's BA profile.

- Title III costs have been included in the ETC, and they have been negotiated with the AE/CM and specified in their contract.

The November 2001 CF Cost Performance Index (CPI) of 0.97 and Schedule Performance Index (SPI) of 0.96 indicate reasonable progress using a defensible baseline.

All recommendations from previous DOE reviews have been adequately addressed.

3.2 Comments

The Committee recognized the tremendous effort of the CF team in aggressively moving forward with design and site construction activities. The level of completeness was reflected in crisp presentations and readily available information.

The draft installation and commissioning plans are a good start. These plans need to be finalized and approved by the project in time for the next DOE review.

Full agreement has not yet been reached between ASD and CFD on the definition and acceptance criteria for RFE, turnover of construction, and installation design / Title III incorporation. Full agreement needs to be reached as part of the finalized plans.

The sudden increase in construction manpower from 77 FTE (average) in FY 2001 to 300 FTE (average) in FY 2002 may be a burden on the local labor market. The CM has conducted job fairs and worked with local labor representatives to bring more craft support to the local area. This effort should be encouraged and continued.

As noted in previous DOE reviews, the Committee would like to reinforce that equipment installation poses a near-term issue as beneficial occupancy and equipment installation occur in parallel with continuing construction. The project must ensure adequate field engineering and installation coordination between CF forces and technical installation staff.

The interface between CF and installation activities has become more indicative of actual project performance issues, and as a result, DOE and the SNS project should consider the benefit of additional combined reviews of these activities in the future.

3.3 Recommendations

1. Complete the CF equipment integration, installation, commissioning and start-up plan with an integrated schedule by the next DOE review and include:

    a. The constraints of site construction activities including environmental conditions that affect installation.

    b. "Ready for Equipment" acceptance criteria and definitions that meet both CF and ASD/XFD objectives.

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4. INSTALLATION AND PRE-OPERATIONS

4.1 Findings

In response to recommendations at the last DOE review, the ASD has provided a turnover plan, an installation plan and schedule, and an accelerator commissioning plan. All three documents are at a very detailed level of development and represent a major step towards a successful integration effort.

The ASD turnover plan describes the transfer for all subsystems and components from the partner laboratories to ORNL and defines the acceptance criteria. The plan is very detailed and also very timely as the first hardware is already starting to arrive at the RATS Building in Oak Ridge.

The ASD installation plan is amazingly comprehensive and detailed. This plan has served as a basis for a new installation cost estimate included in the ETC. The new cost estimate resulted in an increase of about $6 million, which includes items that were missed during the original cost estimates. The installation plan will also be used to measure progress of the installation process.

The installation schedule is very tight and relies heavily on installing equipment before the "Beneficial Occupancy Dates" (BODs) of the conventional facilities. Intermediate RFE dates are being negotiated with the CM contractor, and the conditions for RFE have been defined in a draft document.

The installation schedule makes extensive use of the RATS Building for staging the sub-assemblies. However, the schedule requires an amount of additional intermediate storage area, which is presently not available. Funding for this extra storage area was not included in the ETC.

The component and subsystem hand-off agreements are now in place for LBNL, BNL and JLAB, and an agreement with LANL is expected to be completed soon.

The commissioning plan is very comprehensive and the Committee judged the allocated time for completing the various commissioning tasks to be quite adequate. The plan includes conducting a commissioning ARR for all the accelerator systems at the same time, and then conducting a "readiness assessment" before commissioning actually starts. Fault studies are scheduled when stable beam conditions are established. This could be difficult during early commissioning with many interruptions due to the ongoing installation effort.

The beam commissioning organization consists of WBS managers for the four main accelerator systems (FES, DTL/CCL, SCL, Ring). They are responsible for the overall commissioning process and they must ensure that all components meet the required physics parameters.

4.2 Comments

The present installation plan is based on the assumption that the components are available when needed ("Accelerator-in-a-Box" concept). The actual availability of components may be different and needs to be included in the installation plan. This will require a schedule for assembly activities to take place in the RATS Building.

The installation process will also require very careful coordination to avoid interference between facility construction, multiple equipment installations, and commissioning efforts. This has not yet been included in the installation plan and will have to be done at the next iteration.

The installation will require a considerable amount of Davis-Bacon labor. It will be challenging to both obtain and effectively supervise such a large labor force. SNS management should ensure that adequate in-house expertise for supervising the Davis-Bacon installation work is available.

The project is planning to use a second installation shift or reduce the time for commissioning if the installation process is delayed. If the project is forced to use a second shift, a substantial amount of additional trained labor will be required.

SNS management has put together an excellent team for application program development. This is a considerable improvement since the last DOE review. This team should make a priority-order list of the programs needed for commissioning. These programs should be internally reviewed with the programmers, physicists and the operations staff.

The project has also put together a team of instrumentation personnel and augmented each commissioning team with them. This group should work closely with the commissioning staff to ensure that all the hardware and some level of software are available for commissioning data collection and analysis.

The Committee received information on off-site assistance from the partner laboratories in commissioning the SNS. SNS management should ensure that this capability is there in case special expertise is needed.

4.3 Recommendations

1. Complete the hand-off agreement with LANL by the end of 2001.

2. Develop a fully resource-loaded schedule for assembly, acceptance, and testing of subsystems and components at the RATS Building before the next DOE review.

3. Integrate the turnover plan, the RATS activity schedule, the installation plan, and the commissioning plan into the IPS before the next DOE review.

4. Develop a fully resource-loaded plan for the installation of the Target Systems and the Instrument Systems, and integrate it into the IPS before the next DOE review.

5. Plan for system integration tests ("dry runs") to take place before the beam commissioning phases that include all parts of the operating accelerator system—from the hardware components to the controls to the application software to the operations team.

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5. ENVIRONMENT, SAFETY, AND HEALTH

5.1 Construction Safety

5.1.1 Findings

ES&H considerations are being given due attention given the project's current stage of evolution. The AE/CM is doing an excellent job implementing its construction safety program. The CM (Jacobs Constructors) has also done an excellent job protecting the environment within the project through their erosion control program. Their program has been recently cited by the Tennessee Department of Environment and Conservation (TDEC) as a model for others to emulate.

The construction site is neat, organized, and free of debris. The SNS project has completed 355,000 contractor hours worked without a lost-time case on site or at the partner laboratories. The AE/CM's construction safety performance to date as measured by their Total Recordable Incident Rate (TRIR)[3] is 2.1 (4 recordable injuries) compared to the industry average of 7.8 for similar work and is indeed noteworthy.

This well executed construction safety program has resulted in fewer injuries and loss claims than was anticipated by the insurance company that provides worker compensation coverage. In FY 2001, their wrap-up insurance program returned $239,000 of premiums from a total payment of $3,440,670 (a cost reduction of 6.9 percent).

The establishment of a job site medical clinic staffed with a full-time case manager at this stage of the project is also noteworthy. This clinic has already prevented several relatively minor personal injuries from otherwise becoming lost-time cases. The CM's subcontractors feel that the SNS project's safety program is the most effective one out of all construction projects in the local area.

The CM's documented ES&H Plan is complete and addresses topical issues, including Integrated Safety Management. The CM's process for selecting its subcontractors embodies current safety philosophies. The CM's Safety Manager participates in the pre-bid meeting and by all accounts is involved in the resolution of marginal cases. Although the ES&H selection

3 TRIR = (No. Incidents * 200,000)/ Manhours Worked

criteria do not yet apply to lower tier subcontracts, Jacobs Constructors has implemented this requirement on other projects, and they are in the process of defining this requirement in their subcontracts for SNS.

There are several routine field inspection processes in place on the construction site such as the weekly Site Manager's inspection. This inspection is conducted by the CM's Site Manager and includes a Jacobs Resident Engineer, a subcontractor foreman and two contractor journeymen. This is a good mechanism for building contractor trust across the CF workforce.

The CM has also implemented a "Safety Contractor-of-the-Month Award" and a "Construction Crew Safety Recognition-of-the-Month Award" to recognize proactive safety performance. This type of recognition program has proven to be a successful mechanism for promoting safe work practices on other major multi-contractor projects.

Even though their safety program results to date have been commendable, the CM is not resting on its laurels. The installation of fall protection stations on the steel, even before it is raised into place, indicates that Jacobs is including safety in their project phase analysis and work planning.

All recommendations from the May 2001 DOE review have been satisfactorily addressed.

5.1.2 Comments

The CM has been conducting a self-assessment of their safety program that includes such initiatives as evaluating their medical clinic records and near-miss incident reports. They have determined, as a result of this analysis, the need to place increased emphasis on training their subcontractors to more effectively complete their daily Job Safety Analysis (Jacobs – Safe Plan of Action).

Jacobs management has been working with the local unions to assure that adequate manpower resources will be available when the project manpower requirements begin to escalate in the near future. They have also been addressing the concern that individuals sent to the job-site from the Union Halls are not experienced in the work to which they will be assigned. The CM recognizes the need to verify that tradesmen are trained and qualified to perform the work to which they have been assigned.

The project is entering a period where the success of its safety program is at increased risk. During the next few months, project manpower will triple. The increased site manpower during the year-end holiday season will challenge the ability of the CM to capture the attention of new workers and integrate them into the safety program.

5.2 Safety Documentation and Quality Assurance

5.2.1 Findings

The Committee reviewed the status of a number of ES&H topics, the progress of resolving open issues, and the current list of ES&H items in the SNS action-tracking system. Among these, most had to do with safety documentation in the form of the Preliminary Safety Analysis Report (PSAR) for the Nuclear Facility (i.e., Target) portion of SNS and the Preliminary Safety Assessment Report (PSAD) for the balance of plant.

Past reviews of the PSAR have advised the project to prepare a centralized listing of design standards to help ensure SNS mission performance in the regulatory/safety area and assure consistency. The project has developed such a list, which has now been issued as document SNS 102030102-ES0012-RO, September 2001. Specifically included is the identification of safety Structures, Systems, and Components (SSCs) to which the standards must be applied. This issue is considered closed.

Past reviews of the PSAR have also noted that not all SSCs performing a safety function had been identified and should be identified in the PSAR. A list of those safety SSCs is now contained as Attachments A and B to SNS 102030102-ES0012-RO. During review of the Safety Class SSC list, it was noted that the mercury collection tank/liner needed to be added to the listing since it is Safety Class.

The PSAR update review in March 2001 identified a need to establish an update and revision schedule. The project has done so and presented the following schedule:

PSAR update	March 2002
PSAR full revision	March 2003
PSAR update	2004
Final Safety Analysis Report (FSAR)	2005

Past PSAR reviews identified the need to capture the seismic design criteria and basis for the Target Building foundation and construction. The PSAR update in March 2001 did not have that information. A redraft of the affected sections was provided, but did not contain sufficient description of how the seismic design meets current standards. The affected sections need to contain this information.

New seismic design requirements applicable to SNS will soon be issued in an revision of DOE Standard 1020-94 *Natural Phenomenon Hazards Design Criteria*. The SNS Target Building structure is seismically designed to PC-3 using the current requirements of DOE-STD-1020-94 (Chapter 1). The design basis hazard levels and response spectra are from ES/CNPE-95/2, "Seismic Hazard Criteria for the Oak Ridge, Tennessee; Paducah, Kentucky; and the Portsmouth, Ohio US Department of Energy Reservations," which was prepared in accordance with DOE-STD 1022, 1023 and 1024. The next revision to STD-1020 will increase the return period for a PC-3 earthquake from the current 2,000-year return period to a 2,500-year return period. Also, the design basis response spectra for Oak Ridge will then be based on regional U.S. Geological Survey seismic hazard studies embodied in IBC 2000, rather than the current site-specific study. Both of these changes are expected to result in increases in the design basis seismic acceleration response spectrum for which the Target Building is currently designed. However, the Target Building is structurally very robust due to the extremely large dead loads and live loads that it must support. For this reason, and because of conservative design methods employed by the AE in designing the building, the project strongly believes that the Target Building will still satisfy the design codes even with the higher seismic accelerations. The Committee considered it worthwhile to substantiate this belief to be able to satisfactorily address concerns that could be raised during FSAR review and approval. The SNS project will accordingly conduct a structural design margin study to confirm that the Target Building can withstand the new seismic acceleration response spectrum. In the study, those structural members with the lowest design margin and whose design is most affected by increased seismic loading will be evaluated to see if they will meet the design codes after applying the increased accelerations. The study is expected to be complete by January 2002. The results of this study should be specifically described in the PSAR update in March 2002.

The Committee reviewed the status of the Target Building fire protection design and, in particular, the design considerations for using hydrocarbon instrument shielding, which is preferred for its constructability and operational flexibility. The conventional fire hazard is mitigated primarily by fire barriers and suppression features of the design. Accident analyses are currently under way to bound the potential source terms occurring under highly unlikely PC-3 earthquake/fire scenarios that impact the current fire protection design features. These accident analyses will validate hydrocarbon encapsulation and other design requirements. Although the analyses have yet to be completed, it does appear that these preferred shielding materials can be accommodated. The analytical results should be included in the March 2002 PSAR update.

Related to the fire protection analysis of the Target Building, the project has initially taken an ultra-conservative approach to modeling the accidental release and dispersion of mercury from the Target Building during an earthquake. This conservatism lies in the assumptions for the release fractions and dispersion of the mercury. For mercury doses, recent published data in Health Physics (October 4, 2001) identifies data that will likely be accepted by the International Council on Radiation Protection. Such data will result in dose conversion factors 4 to 10 times lower than values assumed early in the SNS accident analysis. This is significant since it reduces categorization of safety SSCs performing a Safety Class (public protection) function to the function of Safety Significant (work protection) and reduces the emergency planning zone.

The Committee received information on the design status of the PPS and a demonstration of PPS prototype development. The PPS design for SNS is based on that for TJNAF, and lessons learned from the latter system are being incorporated into the SNS design.

The project plans to issue the PSAD in June 2002 to support the start of accelerator system commissioning activities soon thereafter on the Front End and Linac.

Refinements to the design for radiation shielding were presented. In the examples shown, it was apparent that the analytical process was thorough. The project has recently identified a need for shielding in the Front End, and further analytical refinements would require improvements in cross section data to design for "As Low As Reasonably Achievable" (ALARA).

The Committee was shown around the RATS Building, which is now operational, from the perspective of quality assurance related activities. There are storage areas for equipment, fabrication areas for cryogenic lines, RF support structures (still undergoing installation), accelerator tunnel mockups for developing approaches to equipment installation and maintenance, and areas for development of inspection processes such as alignment.

5.2.2 Recommendations

1. Address the following points for the Target Facility in the next PSAR update in March 2002:

    a. Revise the seismic design analysis to reflect the results of the seismic design margin study, current seismic design basis data, and any further analysis of the Target Building base-mat and foundation.

    b. Add the mercury collection tank structure to Attachment A of SNS 102030102-ES0012-RO, since it is Safety Class and should be listed there.

    c. Add the results of the fire hazard and mercury dispersion analyses that address both the impact of reducing the conservatism in modeling mercury dispersion, and the use of hydrocarbon shielding material for the instruments.

6. COST ESTIMATE

6.1 Findings

The SNS TPC has remained unchanged at $1,411.7 million. A breakdown of the cost estimate can be found in Appendix D. Briefly, it contains a Total Estimated Cost (TEC) of $1,192.7 million (construction line item) and $219.0 million of operating expense funded activities (including R&D and pre-operations).

The actual FY 2001 costs and commitments through September 2001 amount to $313.1 million ($292.7 million for construction line item activities, and $20.4 million for R&D and pre-operations activities). Cumulative costs and commitments through September 2001 amounted to $538.5 million ($436.7 million for line item activities, and $101.8 million for R&D and pre-operations activities).

Project staff performed a full, bottoms-up ETC over a five-month period beginning in June 2001. The effort was led by the Project Controls team in the SNS Project Office, but it involved project staff at all of the partner laboratories. A set of boundary conditions were set (start date, definitions, exception handling, etc.), a tool set was beta-tested and then distributed, and the results of the process evaluated and then iterated upon. The ETC was reviewed by the Committee and found to be satisfactory.

A revised EAC of $1,068.1 million was presented along with a new contingency total of $124.6 million. SNS management is proposing to baseline the new EAC in December 2001.

The project calculated a contingency fraction of 23.9 percent (of the remaining effort) by taking into account the following assumptions:

October 2001 costs: $15.0 million;
October 2001 commitments: $6.7 million;
November 2001 costs: $14.0 million;
November 2001 commitments: $44.6 million;
No additional application of contingency through November 2001;
Credit for contracts awarded but not funded: $29.7 million.

SNS management is making substantial use of phased-funded procurements in the technical as well as the CF portions of the project. Overall, forty-nine contracts with a total value of $131.3 million have been phase-funded. Twenty-four of those, with a total value of $62.8 million, have been completed.

The integrated cost performance module (MPM), appears to be fully functional, including both the cost estimate and detailed schedule baselines. The project staff confirmed that the old Cost Estimate Database has been retired and the data is now maintained in MPM.

6.2 Comments

Following a recommendation from the May 2001 DOE review, the project performed a new bottoms-up ETC. The process used appears to have been carefully planned, implemented, and managed with the result that SNS management has ETC numbers in which it can have increased confidence.

This confidence, however, comes with a cost. The present contingency level ($124.6 million) is $45.9 million less than $170.5 million presented at the May 2001 DOE review. While this represents a 27 percent reduction in the available contingency, roughly two-thirds of these funds ($31 million) were used to cover costs discovered during the ETC process. In general, this ETC-generated contingency usage should reduce the risk of future cost growth. However, the project reported that the total value of new (pending) PCRs has already reached $5.9 million. As project activities are planned to peak over the next twenty-four months, it is especially important for SNS management to remain vigilant on the subject of contingency usage.

The project's approach to calculating contingency is optimistic. Their assumptions substantially decrease the ETC, the denominator in the percentage formula (calculated as contingency funds remaining divided by the ETC). The Committee made different assumptions to calculate the contingency remaining as of the end of October 2001: the denominator included costs, commitments, and awards through October; and presumed that the pending change orders, valued at $5.9 million, would be approved. This produced a contingency figure of 20.4 percent. A more conservative approach would recognize that commitments and awards are likely to end up costing more than the original contracted prices. Assuming an increase in costs of 5 percent on these commitments and awards would yield 19.1 percent contingency.

While the ETC process was a lengthy one, its product is extremely valuable. To reinforce that point, it is worthwhile to repeat a paragraph from the May 2001 DOE review report:

> "Most best management practices published by DOE recommend that projects should conduct a formal periodic reassessment of the ETC. Since a detailed baseline cost estimate already exists, there is no need to start the bottoms-up cost estimate using a "clean sheet of paper" perspective. Rather, a disciplined approach that revisits and reassesses each existing cost estimate line entry, adding new entries where appropriate for areas such as installation and commissioning, should suffice. This process should be completed annually. The job will become easier as the work remaining diminishes."

The phased-procurement strategy appears to provide SNS management with a powerful tool to manage the use of precious BA. It allows the efficient use of funds to speed up procurements where necessary to maintain critical path schedules, as well as the application of any available BA at year's end. The project's procurement staff should be commended for its role in the intelligent and effective application of this strategy.

6.3 Recommendations

1. Implement the new ETC as a baseline by the end of December 2001.

2. Plan to prepare a new ETC every 12 to 15 months.

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7. SCHEDULE and FUNDING

7.1 Findings

The project's current cost baseline remains at a TEC of $1,192.7 million and a TPC of $1,411.7 million, which are both specified in the FY 2002 President's Budget Request and in the SNS PEP. As indicated in Appendix E, the FY 2002 Budget Request contains a BA profile of: $291.4 million in FY 2002, $225.0 million in FY 2003, $143.0 million in FY 2004, $112.9 million in FY 2005, and $74.9 million in FY 2006. The project's planned profile for estimated costs and commitments is: $325.7 million in FY 2002, $268.4 million in FY 2003, $167.2 million in FY 2004, $71.9 million in FY 2005, and $37.6 million in FY 2006.

The IPS is consistent with the BA funding profile cited above. This IPS calls for an internal goal for project completion of December 2005, providing six months of project schedule contingency relative to the CD-4 commitment date of June 2006. Project performance continues to track well against existing DOE milestones.

The IPS assumes that contingency is distributed throughout the duration of the project, with most of the available contingency allocated to the out-years. The project is running approximately one month behind the early finish date in the IPS, but the project aims to recover this one month by re-sequencing activities such that the early finish date of December 2005 is preserved. No DOE Level 0, 1, or 2 milestones would be changed as a result of implementing the new ETC, although there will be some minor adjustments to the project early finish milestones.

The Project Summary Schedule (see Appendix F) is derived from the detailed schedules provided by each WBS manager. This Project Summary Schedule will not change as a result of implementing the new ETC. The integrated detailed schedules will be comprised of a slightly higher number of activities (approximately 13,500 versus 11,000) and relationships (approximately 17,850 versus 16,000), but the number of inter-project links that tie activities among the individual partner laboratory schedules will remain the same. In addition, the project has now identified approximately 400 inter-project links among the individual partner laboratory schedules and the IPS. Project elements that are on or near the critical path include: FES, DTL, CCL, SCL, Ring components, Target installation, RFE and beneficial occupancy in some buildings, and commissioning.

The project has developed an ASD subproject schedule that reflects the hand-off of component designs from the partner laboratories to the SNS Project Office at ORNL. In addition, ASD has developed a separate and very detailed (20,000 + activity) resource-loaded installation schedule. ADS is approximately 15 percent along in developing a similarly separate and detailed schedule for the receipt, acceptance, testing, and storage of ASD components. They plan to integrate these into a more detailed ASD schedule at some point. It is assumed that the components delivered for installation will be complete racks or units and that subcomponent assembly will occur in the RATS Building. Currently, links between the ASD schedule, the IPS, and project detailed schedules are being done manually, but plans are in process to automate this in the near-term.

The technical baseline control system appears to be extensive. SNS Project Office staff have made an effort to streamline the document control process and this is continuing. Further simplification in this area is encouraged.

7.2 Comments

The proposed schedule is consistent with the overall funding profile. The project's financial obligations are being effectively tracked and managed against available BA, with phased-funding of contracts used as an effective tool for maximizing flexibility.

In order to create a schedule consistent with the available funding profile, scope has been re-evaluated, and sequencing of activities has been modified as part of the ETC process. In particular, the project intends to make several buildings available for initial installation of equipment (RFE) prior to beneficial occupancy. Although this method of accomplishment is certainly viable and appears to be working well, very detailed planning must continue in order to mitigate potential physical interferences, cost impacts, and increased risk.

Critical path (or near critical path) activities are distributed among many areas of the project, indicating that resources have been distributed appropriately across all WBS elements. FY 2002 and FY 2003 activities that are schedule drivers include the FES and CF work.

The level of detail in the ASD installation schedule is indeed impressive. It is not clear that sufficient attention is being placed on relationships between activities within each "fragnet" (schedule inputs from each partner laboratory) as well as between fragnets. Since the detailed schedule for ASD activities within the RATS Building is in its formative stages, no conclusions could be derived as to its adequacy. The project asserted that it is taking a disciplined approach to identifying and scheduling activities. Integration of these extremely detailed schedules into the higher level ASD schedule should be given a high priority as should automatic integration of the ASD schedule with the detailed project schedule and IPS.

XFD has used the ETC process to achieve improved accountability and schedule ownership by the individual cost account managers. A major step forward in this process was providing the cost account managers with greater visibility of the various participating institution plans and costs. This has enabled the cost account manager to better understand and approve work being done by all participants in his WBS element.

XFD has developed installation schedules. These were not presented in enough detail for the Committee to ensure that the Target Building beneficial occupancy/RFE dates, Target Systems installation, and Instrument Systems installation had been sufficiently detailed and integrated to preclude conflicts. In addition, there was no indication of how and where the instruments would be assembled.

The SNS Change Control Process was modified to allow for higher thresholds. However, the Deputy SNS Project Director maintains complete control over the application of contingency. The data indicate a decrease (approximately 35 percent) in the number of PCRs in the period following implementation, although it is not yet clear whether this is a true indicator or whether the ETC exercise contributed to this decrease. The project believes that these new thresholds (up from $10,000 to approximately $500,000 of unrecoverable variance) will result in more flexibility and a significantly reduced number of PCRs.

7.3 Recommendations

1. Finalize the ASD schedule, including the detailed installation and RATS Building sections, and integrate it with the overall project detailed schedule by the next DOE review.

2. Prepare a detailed schedule for all Target and Instrument Systems assembly and installation activities by the next DOE review.

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8. MANAGEMENT

8.1 Findings

The transition to the new management team has been smooth and effective. Relations with the DOE and the partner laboratories are excellent. The SNS project appears to be on track for completing the project scope within the baseline cost and schedule. Contingency appears adequate but tight (about 20 percent after taking into account the ETC and other pending actions, with a five-month schedule contingency on the baseline schedule).

Notable progress has been made on the SNS project since the last review. The R&D is reported at 90 percent complete (the remaining R&D is focused on instrumentation and the Target window material pitting issue), while the design work is 69 percent complete and construction is at 14 percent complete. The construction progress can easily be confirmed by the number of completed concrete foundations and walls for the Front End, Linac and Target Building, as well as, the number of completed technical components that have been accepted from vendors. The overall project is about 33 percent complete through the end of September 2001. At the last DOE review in May 2001, the SNS project was only 22 percent complete. The rate of overall progress on the project is about 2 percent per month.

SNS management has been very responsive to the recommendations from the May 2001 DOE review. Several plans were presented on the installation and commissioning of the technical components. Considerable effort has been dedicated to the defined interfaces between the technical components and the construction of the conventional facilities. An updated estimate of the annual operating cost for the completed facility, reviewed by an independent committee in August 2001, has been prepared as recommended at the May 2001 DOE review. In addition, a revised ETC has been completed and served as the basis for the November 2001 presentations.

Two positions in the project's senior management structure (see Appendix G) have been permanently filled with the hiring of the CFD and XFD Directors (one was already in an "acting" capacity). Permanent staff now occupies all key management positions. The transition to the new management team has been smooth.

FY 2002 is the peak funding year for the SNS project at $291.4 million. This amount is in the final Appropriations Bill, awaiting signature by the President. The SNS project obligated $313.1 million in FY 2001. The project plans to spend or commit all of the $291.4 million in FY 2002 funds.

Costs are favorably tracking the baseline estimate, and the cumulative cost variance is very small. More than $200 million in procurements have been awarded under the baseline estimate. The cumulative schedule variance is about 6 percent and the project has remained at about 1 month behind an internally driven schedule completion date (resulting in a 5-month schedule contingency compared to the baseline schedule). Cost contingency was reported at 24 percent of the remaining work; however, it is about 20 percent after taking the updated ETC and other pending actions into account. Recently, market conditions have been favorable with bid prices generally at or below the project estimates.

The SNS project performed a bottoms-up ETC this summer that is being proposed as an update to the SNS project cost and baseline. The results of this ETC are consistent with the Level 1 milestones and budgets.

ORNL management, through the ORNL Director, has continued to demonstrate significant support for the SNS project. Integration of the SNS project into the parent ORNL organization is progressing well. This integration facilitates the development of the SNS Research Program and provides cost efficiencies for shared resources. The SNS management is working closely with ORNL management to secure storage space for technical components until the required project buildings are completed for the installation of the technical components.

The SNS Project Office staff includes about 59 FTEs. Integrated cost/schedule reports are produced routinely. These reports include staffing profiles and provide a mechanism for leveling of staff resources.

FY 2001 was the peak-staffing year for the partner laboratories outside of Oak Ridge, and some roll-off of their staff is already underway. The SNS project presented a staff roll-off plan. Additional responsibility for installation and commissioning is being assigned to the SNS Project Office at ORNL. The associated funding has also been re-assigned to the SNS Project Office from the respective partner laboratories.

The SNS project relationship with both the DOE/BES Program Office and the DOE/ORO Project Office has been positive and cooperative. The DOE/ORO Project Office has begun discussions with the SNS Project on "readiness reviews" for the facilities and technical components. This interface between DOE and the SNS project is an important one.

The SNS project has conducted a variety of internal management reviews to ensure that the approach and details of the project plans are adequate. These have included reviews by the project's Accelerator Systems Advisory Committee and the Experimental Facilities Advisory Committee.

8.2 Comments

The SNS Project Director has had a steep learning curve. He has demonstrated a solid understanding of a broad range of issues facing the Project. Both the SNS Project Director and Deputy Project Director are providing the necessary kind of leadership. The working relationship among the partner laboratories has been improving and is considered to be very good. In fact, the SNS Project Director made a special mention of the positive support provided by the Director of LANL. Based on actions taken by the present SNS management team, they continue to have the confidence of ORNL and DOE management, as well as that of the other partner laboratories.

Project cost and schedule status is satisfactory, and the remaining contingency is tight but adequate. Timeliness for resolving change control actions has improved. The changes that occurred due to the recent ETC update will be handled as a single change control action to update the project cost baseline. It will also accommodate lower-level scope changes (inclusion of sextupole corrector magnets, RF Test Stand at TJNAF) to the project.

Project management systems are in place to provide adequate information to manage the project. Multiple laboratory partnering arrangements provide timely information for integrated cost/schedule tracking and management. Installation and commissioning plans have been developed to minimize project transition issues. An updated estimate for the annual cost of operating a completed SNS facility, starting in FY 2007, was prepared and reviewed by a DOE committee in August 2001.

The cost baseline for CF (WBS 1.8) has been maintained at less than $310 million. The Instrument Systems (WBS 1.7) cost baseline is consistent with original project commitments and allocated budget. Pre-operations cost estimates are accommodated within the baseline TPC of $1,411.7 million. Project planning has also successfully integrated the future placement of the Center for Nanophase Materials Sciences on the SNS site.

The SNS project is maintaining a very constructive relationship with key external organizations. Planning is continuing between SNS and ORNL management to derive some early benefits to ORNL while maintaining the project's independence to successfully complete the SNS within the baseline scope, schedule, and cost. There continues to be a positive relationship with the State of Tennessee, which has committed to make available $8 million to build a Joint Institute for Neutron Science at the SNS. In addition, the SNS project is viewed positively in Congress as demonstrated by the Appropriations Committees' support of the SNS FY 2002 budget request. The SNS project is working well with the Neutron User Community to plan and prioritize instrument availability and experimental operations, and it is maintaining good relations with existing neutron research facilities. Negotiations with the Tennessee Valley Authority to construct an electric substation and provide power to the SNS facility are proceeding well. Lastly, there is good communication with labor unions, and no problems are expected in providing the necessary workforce to the project as it continues to ramp up.

The project cost estimate requires that the partner laboratory staff roll-off the project in a timely manner as assigned work is completed. Installation and commissioning plans are in place to ensure that this occurs. These plans were developed using the partner laboratories' input and they contributed to a revised cost estimate and a resource-loaded installation schedule that are tied to equipment hand-off from the partner laboratories.

ES&H performance on the project has been excellent. More than 350,000 work-hours have been expended without a lost workday case at the SNS site. The AE/CM has a strong focus on safety management. No environmental fines or violations have been imposed. The CM's insurance program has been rated by the industry as outstanding and has resulted in a return of premium payments to the project. A well-developed strategy is in place for preparing safety documents and conducting reviews as part of the commissioning process. The project team has collaborated effectively with DOE staff in determining the safety requirements, timing for the reviews, and the approval levels. The entire facility will be commissioned under the DOE Accelerator Safety Order.

The pace of procurement activity on the project is increasing rapidly. This will present some management challenges in working with multiple subcontractors and vendors. A major effort will be necessary to work closely with these providers to ensure expedited delivery of quality products and services to the project.

The SNS project should continue to develop the details of the installation and commissioning plans with special attention to equipment staging requirements and actual delivery schedules from vendors and partner laboratories.

8.3 Recommendation

1. Identify the critical spare parts across the project and ensure that their estimated costs are included in the updated cost baseline that incorporates the ETC.

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