Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

SPALLATION NEUTRON SOURCE (SNS) PROJECT

May 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 May 15-17, 2001, at the request of Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences, SC. 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 to be given to evaluating the SNS installation and commissioning plans. Also, the review Committee was asked to verify that the project's cost and schedule baselines are consistent with the President's FY 2002 Budget Request to Congress.

Overall, the Committee judged that the SNS project is making satisfactory progress and should be able 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. The three major issues noted at the October 2000 (Phase I) DOE review, namely potential cost growth in pre-operations and in conventional facilities and a schedule that was incompatible with the Project Data Sheet Budget Authority profile, have all been resolved. A few significant changes have occurred since the December 2000 (Phase II) DOE review which include restoring the Linac output energy from 840 mega electron Volts (MeV) to 1 giga electron Volt (GeV), increasing the number of instruments from four to five with a total instrument budget of $60 million, and adding a reduced-cost Central Laboratory and Office Building back into the project scope.

The SNS project is being carried out as 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. The SNS partner laboratories are generally working quite well together and communications are good. The partnership appears to be well prepared to begin large-scale construction of conventional facilities.

The Committee observed that there had been a smooth transition to a new Project Director and Deputy Project Director since the last DOE review, and that steady progress was being made in R&D and design work. A search is underway to permanently fill two Division

Director positions at the Project Office: Experimental Facilities and Conventional Facilities. The Committee encouraged the project to expedite these efforts, particularly for the latter position, considering the increasing pace of site construction activities.

At the end of March 2001, the project was 22 percent complete (as compared to 23 percent planned) and reported about 25 percent contingency ($170.5 million) on the Estimate-to-Complete of $692.2 million. Over half of all design work and over three-fourths of all R&D have been completed. The fundamental design concept for the liquid mercury target has essentially been validated. Site excavation is nearly finished, including installation of the Target Building foundation pilings. The initial site concrete work is to begin shortly for the Front End, the Target, and the Linac tunnel. At present, the project is running four to six weeks behind the internal working schedule, which contains six months of schedule contingency.

The Committee felt generally confident that the project could be completed within the baseline TPC. Although much of the cost estimate has been revisited over the past two years, the Committee recommended that a bottoms-up Estimate-to-Complete be prepared for the entire project by the next DOE review. The project was advised to do these re-estimates annually in the future. Looking beyond project completion, SNS management was also urged to update the estimate for annual SNS facility funding requirements (operations, maintenance, upgrades, etc.).

As noted above, SNS management has adopted a plan for restoring the Linac output energy to 1 GeV by increasing the accelerating field gradient in the superconducting cavities. Although preliminary R&D results are encouraging, the fallback solution is to add cryomodules, klystrons, modulators, and power supplies at a cost of $10 to $15 million (from contingency). While supporting this plan, the Committee assigned the project an action item to establish a radio frequency test stand at Thomas Jefferson National Accelerator Facility by February 2002 so that adequate technical performance of the superconducting cryomodules can be demonstrated before full-scale production begins.

Although not yet complete, significant progress has been made by the project in developing detailed installation and commissioning plans. The Committee tasked the project with an action item to complete the installation and commissioning plans that define these activities, their costs, and organizational roles by October 2001. Because successful commissioning will require a great deal of integrated planning and oversight across the entire project, it was also recommended that a single person in the SNS Project Office be designated to lead and coordinate all SNS commissioning activities.

ES&H is well integrated into project activities, and the construction safety record to date has been exemplary (256,000 worker-hours without a lost workday injury—far better than normal DOE or industry records). Similarly, the project's environmental record and relationship with the State of Tennessee are good.

In summary, the project was found to be on track and well positioned to meet its technical, cost, and schedule objectives. The Committee was pleased to see that the issues identified at the fall 2000 DOE review have been successfully resolved, for which the project is to be commended. Nonetheless, given the magnitude of the work ahead, SNS management must continue to exercise diligent oversight and tight control over cost and schedule.

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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 nearly 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 for the SNS was issued in April 1999, and on June 18, 1999, the Secretary of Energy signed the Record of Decision to proceed with construction of the SNS at ORNL (Chestnut Ridge). A Mitigation Action Plan (MAP) was

Figure 1-1. The Spallation Neutron Source

prepared that identifies actions being taken by DOE and the project to avoid or minimize environmental harm in building and operating this facility. The Department is monitoring progress against the MAP to ensure that 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 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 April 2001. The Level 0 cost and schedule baselines set at CD-2 comprised a TPC of $1,333 million and a seven-year design and 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 Physics Group 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, as well as installation of major technical components (Front End, Linac, Ring, Target, and Instruments) supplied by the partner laboratories.

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 and 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, Dr. David Moncton from ANL agreed 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 (e.g., Project Director, Technical Director, Accelerator Systems Division Director, and Procurement Manager). 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 (world-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 projects 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 Project Execution Plan, and is also included by reference in the laboratories' management and operation contracts. The latter step has 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. By the end of 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 contractor (Burns & Roe) who then conducted such a review during September through November 1999. The final

Burns & Roe 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 had to certify that the total taxes and fees on SNS paid to the State of Tennessee or its counties and 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 General Accounting Office provided the necessary certification.

In April 2000, the management and operation contract for ORNL was turned over from Lockheed Martin Energy Research to a limited liability partnership between 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 $258.929 million in construction funds and $19.059 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 Title I design estimate for conventional facilities, which was about $80 million over budget, and an overly aggressive pre-operations staffing plan. The third issue was that the SNS Integrated Project Schedule (IPS) required more Budget Authority 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 and reducing the size of the Target Building, and the Instrument budget was reduced from $93 million to $53 million (which was still more than the conceptual design level of $45 million). In addition, the last three cryomodules of the superconducting Linac 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 Integrated Project Schedule was re-planned to be consistent with the Budget Authority in DOE's annual funding profile, still provide six months of schedule contingency, and retain the project completion date of June 2006.

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 Level 1 Baseline Change Proposal was approved by DOE that: added a reduced-scope CLO Building back into the project; set the instrument budget at $60 million to provide for at least five instruments plus design of common components for future instruments; relaxed certain DOE milestones to conform with the revised IPS; and removed the energy specification for Linac output energy (while retaining the proton beam power on target requirement of $\geq$ 1 MW). The pre-operations cost estimate was such that there would be no change in Total Estimated Cost or the TPC.

In February 2001, Dr. Moncton 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, Dr. Thomas Mason (formerly the SNS Experimental Facilities Division Director) 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 within the neutron scattering research community.

1.2 Charge to the DOE Review Committee

In a March 2, 2001 memorandum (see Appendix A), Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences, Office of Science, requested that Daniel R. Lehman, Director, Construction Management Support Division lead a review to evaluate all aspects of progress on SNS, including technical, cost, schedule, management, and ES&H, with a special emphasis on plans for installation and commissioning. The review scope also included verification that the project's cost and schedule baselines are consistent with the President's FY 2002 Budget Request to Congress.

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 six DOE review committees. The Committee was organized into ten subcommittees, each assigned to evaluate a particular aspect of the project corresponding to members' areas of expertise.

1.4 The Review Process

The review was accomplished during May 15-17, 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 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.

2. TECHNICAL SYSTEMS EVALUATIONS

2.1 Accelerator Physics

2.1.1 Findings

The progress in understanding the physics throughout the SNS accelerator complex is impressive (see Figure 2-1 for a block diagram of the SNS Front End and Linac configuration). The SNS team has carefully considered recommendations given at the fall 2000 DOE review. It was a pleasure to observe good collaboration between the ORNL, LANL, BNL, and LBNL groups in accelerator physics studies. This collaboration has now been extended to experimental beam dynamics studies.

The Ion Source has demonstrated good reproducibility at a level of 50 milli Amperes (mA). However, reliability has not yet been demonstrated. For the Radio Frequency Quadrupole (RFQ), simulations are done by restoration of the input distribution from experimental data. This input distribution is shared with collaborators and used for end-to-end simulations. Beam halo is generated by the RFQ and Medium Energy Beam Transport (MEBT).

Good progress has been made in beam dynamics simulations for the Linac using several different multi-particle codes. A comparison was made between five different codes and reasonable consistency was established in beam dimensions, even up to the 7 sigma level.

The baseline of the superconducting Linac (SCL) has been changed, with fewer high-$ superconducting radio frequency (SRF) cavities and higher accelerating gradients. This produced several new tasks to be analyzed by the SNS accelerator physics group. The new results of the SRF cavities' performance are impressive. If peak electric fields higher than 35 mega Volts per meter (MV/m) are achieved, the plan is to raise the beam energy and lower the beam current, since this makes achieving the design beam power easier. However, energies higher than 1.05 GeV would require a Ring upgrade.

The Proton Storage Ring (PSR) instability is still not understood to a level where the performance limit of the SNS can be predicted with complete confidence. However, extremely impressive advances have been made in understanding impedance-generated beam halo in the Ring.

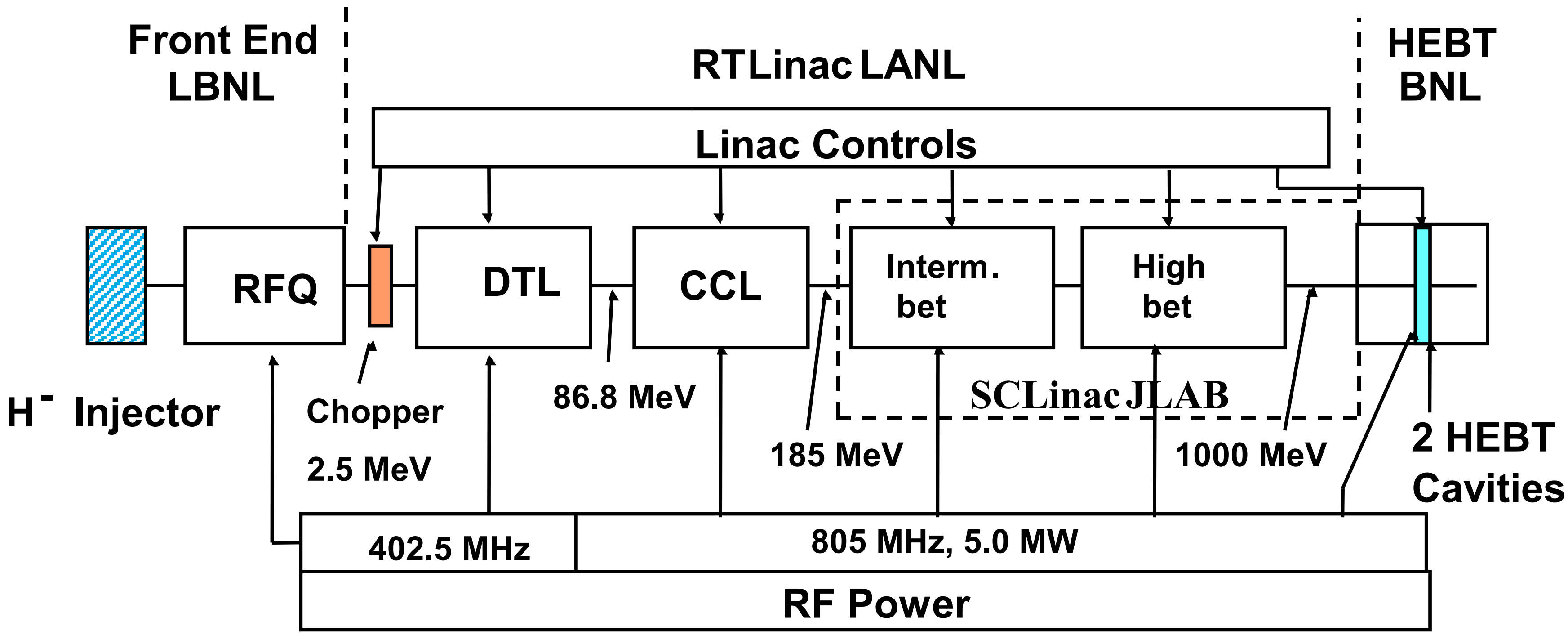


Figure 2-1. SC Linac Configuration

2.1.2 Comments

The achievement of full design performance of the Front End at LBNL by confirming it with detailed studies of beam parameters is very important for successful on-site commissioning. Measurements of the beam halo to a level of 10^{-3} or lower are very desirable. After the beam has been formed by the Front End System, it is still at a sufficiently low energy that it can be scraped to reduce the 100 percent emittance. Not collimating it at this stage is a missed opportunity.

In order to achieve 1 GeV beam energy, the SRF cavities should run at a synchronous phase of around –20 degrees. This is lower than the previous design and shrinks the longitudinal acceptance. It is therefore difficult to be confident with the new phase setting of the SRF section prior to a detailed error analysis. The beam dynamics simulations have not been done in the presence of a full set of misalignments and errors of accelerating and focusing fields in the new baseline design of the Linac.

It appears that detailed analysis of the beam dynamics throughout the Linac during the transient caused by the beam loading has not yet been done. This can be an appreciable perturbation to the beam in the SRF section.

The projected beam diagnostics system is sufficient for the commissioning goal of 100 kW. However, there is concern about the diagnostics for the beam physics studies necessary to achieve the peak design intensity. There is no beam instrumentation for studying the beam halo both in transverse and longitudinal phase spaces. The resolution and dynamic range of existing devices are not likely sufficient. Without detailed experimental beam physics studies, the achievement of the design level of relative beam losses looks problematic. Foil or laser stripping of the H^- beam produces electrons and protons that can be used to obtain beam parameters instead of analyzing the high intensity H^- beam. The further development of diagnostics such as the "laser wire" should to be encouraged.

Work has started for the study of possible scenarios of commissioning the SRF cavities with beam. Time- and cost-saving effective beam tuning procedures can be developed if experts from the existing and operational ion Linac facilities are involved.

LANL management has funded a study of the PSR instability. Their primary concern, however, is to achieve reliable high-intensity operation of the PSR. This is not the same as the primary concern of the SNS, which should be to develop an experimentally verified model.

2.1.3 Recommendations

1. Evaluate, by fall 2001, the benefits that would accrue from collimating the beam to a smaller 100 percent emittance before it is injected into the Linac.

2. Prepare, by April 2002, a diagnostic system in the Medium Energy Beam Transport for beam parameter measurements in a dynamic range of greater than three orders of magnitude, for measuring transverse halo and demonstrating beam gap cleanliness.

3. Perform beam dynamics studies, by fall 2001, that include misalignments and errors for the baseline design of the superconducting Linac with the new synchronous phase setting. Take into account realistic accelerating field errors including errors during the transient caused by beam loading.

4. Develop a program for experimental beam studies, by fall 2001, with the goal of achieving peak design intensity, with relative beam losses commensurate with that specified for the ultimate beam power.

5. Maintain active involvement in the studies of the Proton Storage Ring instability, with the goal of understanding it.

2.2 Front End Systems (WBS 1.3)

2.2.1 Findings

The project has made significant progress on Front End Systems since the fall 2000 DOE review in the following areas:

- Solving Cesiation problems with the Ion Source,
- Accelerating beam through Module 1 of the RFQ,
- Achieving 50 mA average beam current from the Ion Source,

- Integrating ORNL personnel into the effort at LBNL, and
- Studying Ion Source RF antennae coatings.

The project has made good progress against the first recommendation from the fall 2000 DOE review and reasonable progress against the second recommendation as follows:

1. Aggressively pursue demonstration of required beam performance. At the fall 2000 DOE review, LBNL had been unable to reproduce earlier Ion Source operating results. In the intervening time, they have established a clearer understanding of the source Cesiation process, and overcome several other lesser problems. The Ion Source can now be routinely run at 35 mA and achieve average beam currents as high as 50 mA. The first module of the RFQ has been installed and beam has been accelerated through it. These accomplishments demonstrate a substantial level of progress toward establishing Front End Systems performance.

2. Give priority to completing an installation plan and revise the installation estimates accordingly. Good progress toward the definition of installation and commissioning tasks has been made. Substantial agreement between ORNL and LBNL concerning installation responsibilities has been achieved. However, the completed installation plan has yet to be completed, and a revised cost estimate is not yet available.

The current schedule shows one day of schedule contingency against the milestone to deliver beam to the Drift Tube Linac (DTL) on December 26, 2002. The reported negative contingency of 55 days toward total project completion was found to be an artifact of an improper update of the DTL/Front End Systems schedule linking.

Three Project Change Requests are being prepared. Unless some mitigating action is taken, those Project Change Requests will increase the Budget-at-Completion for the Front End Systems by $1.68 million. This represents slightly more than an eight percent increase in overall cost.

Significant progress has been made in understanding coating failures on the Ion Source RF Antennae. The final solution to this problem represents the greatest remaining technical challenge for reliable Ion Source performance. A second challenge occurs as one increases the Ion Source current from 35 to 50 mA. At the higher ion currents, anomalous electron currents sometimes occur. This problem is not fully understood, but two potential improvements are envisioned.

Three individuals from the SNS Accelerator Systems Division at Oak Ridge have begun spending substantial time at LBNL. They have contributed greatly to the effort at LBNL and facilitated significant support from ORNL ceramics experts in an attempt to solve the Ion Source antennae problems. SNS Accelerator Systems Division staff have also supported commissioning the RFQ, and helped provide planning and documentation crucial to the process of transferring the Front End Systems to SNS.

The majority of components yet to be received at LBNL are associated with the MEBT. If progress continues as expected, the installed MEBT will be available for first beam in February 2002. The fourth module of the RFQ is expected to be delivered on July 23, 2001. The completed RFQ is expected to be fully installed and ready to produce beam in early November 2001. The 2.5 MeV Diagnostic Assembly is expected to be available in December 2001.

2.2.2 Comments

The significant presence of SNS Accelerator Systems Division personnel at LBNL has been a very positive impact on the SNS Front End Systems effort. The people currently spending time at LBNL are focused primarily on the Ion Source and Low Energy Beam Transport (LEBT). In the fall of 2001, the effort would benefit from more attention on the RFQ and MEBT.

Over the past couple years, the Front End Systems schedule has slowly slipped at a nearly constant rate. Currently, the remaining schedule contingency is down to one day. The upcoming schedule has limited beam-testing time for the RFQ and MEBT. The schedule is success oriented and no time is allotted for overcoming significant future problems. Although the overall schedule does allow significant time to improve Front End Systems operation once it is installed at SNS, the schedule at LBNL is very tight.

The complexity of the MEBT represents the next significant technical challenge to Front End Systems performance. The short time allotted for MEBT testing at LBNL will increase the risk that final testing and any potential MEBT modifications will have to be performed at SNS, after shipping from LBNL in June 2002.

If approved without any mitigating actions, the in-process Project Change Requests will increase the Estimate-to-Complete by nearly 20 percent. The installation budget has yet to be rebaselined, and prudence would dictate at least a ten percent contingency reserve at this point in the Front End Systems effort. There is no budget for an extended effort to overcome potential MEBT problems at LBNL.

2.2.3 Recommendations

1. Aggressively pursue demonstration of Radio Frequency Quadrupoles and Medium Energy Beam Transport performance. Examine the Front End Systems schedule to see if the MEBT testing with beam can be accelerated. Take any reasonable actions needed to achieve earlier testing or at a minimum to prevent any further schedule erosion.

2. Verify availability of equipment yet to be delivered by partner laboratories. Verify that the equipment needed from them and components yet to be delivered from Front End Systems vendors will, in fact, arrive as currently scheduled.

3. Complete the installation plan, and perform a bottoms-up estimate of the installation as planned by October 1, 2001. Account for the proper participation of both SNS Accelerator Systems Division and LBNL. [See also recommendations in Section 7, Installation and Pre-Operations.]

2.3 Linac Systems (WBS 1.4)

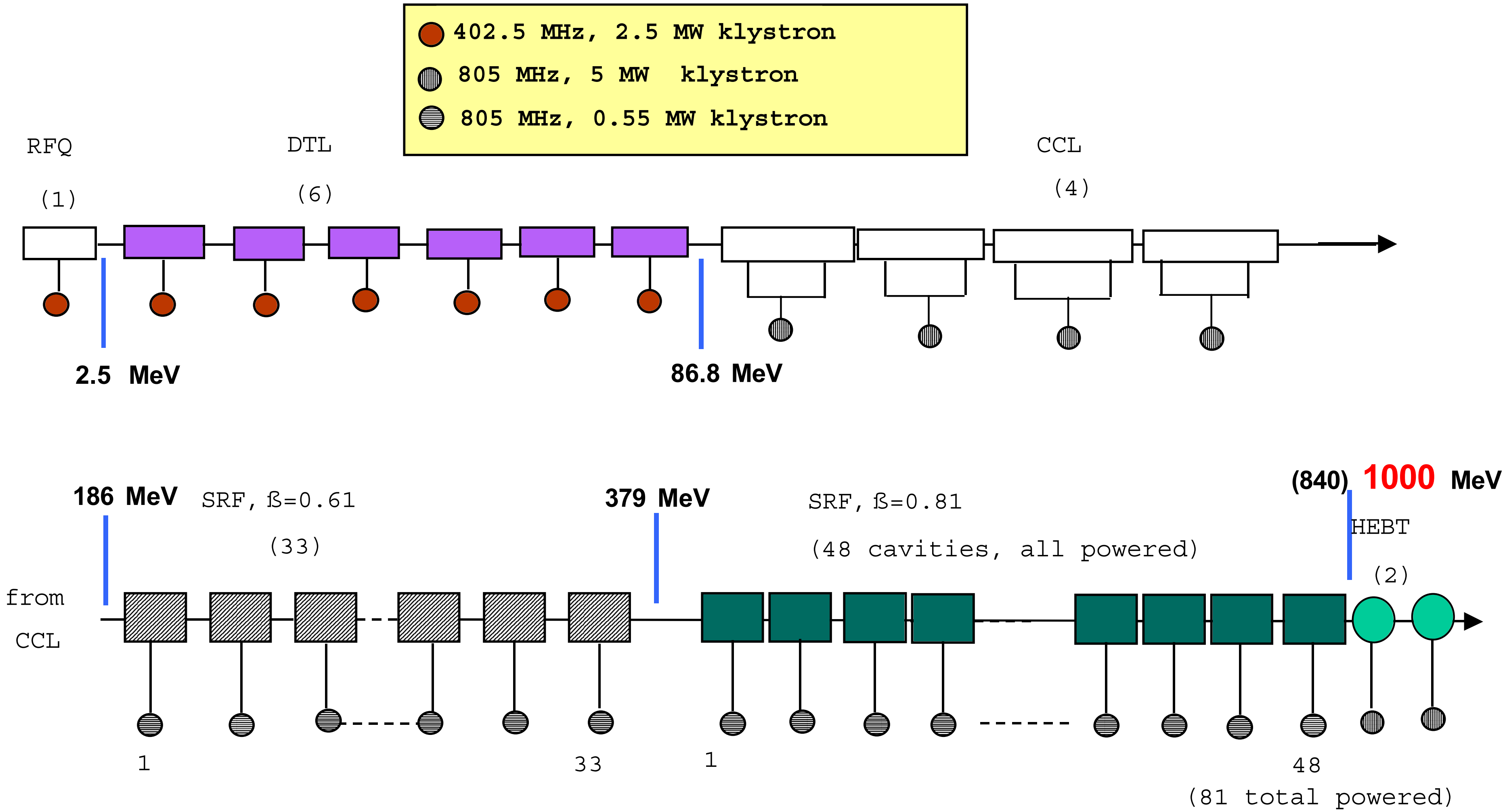
2.3.1 Linac Overview

2.3.1.1 Findings

As shown in Figure 2-2, the Linac structure is a conventional DTL to 87 MeV, a Cavity Coupled Linac (CCL) from 87 MeV to 186 MeV, a “medium-$” ($=0.61) SCL from 186 MeV to 379 MeV, and a “high-$” ($=0.81) SCL from 379 MeV to approximately 1 GeV. The medium-$ SCL has 33 cavities in 11 modules and the high-$ SCL has 48 cavities in 12 modules.

Work on end-to-end beam simulations has continued and progress has been made in support of the new design specifications outlined above. Also, the simulations have been made with higher numbers of simulated particles than the results presented at the previous DOE review.

Layout of Linac RF with NC and SRF Modules



Work on the DTL and CCL designs has made good progress. The designs for the DTL are sufficiently advanced for production orders to be placed. The CCL cold model work was completed, although the bridge couplers involved more iterations than had been anticipated. Using the cold models, the designs were firmed up and the production of the hot model was begun. The hot model is behind the schedule proposed six months ago. The power supply for the hot model is ready, and the testing of the hot model will begin in the next few months.

Significant positive results were reported with respect to the RF modulators based upon the integrated gate bipolar transistor switching technology that has been developed at LANL for the SNS. In summary, the modulator has been successfully demonstrated, and the procurement may begin after a planned final design review. The plan is to place approximately four subcontracts for the major subcomponents of the integrated gate bipolar transistor modulators, and for LANL and ORNL to do the final assembly at SNS.

Orders for both the 2.5 MW and 5 MW klystrons used for the conventional Linac and the 550 kW klystrons for the SCL have been placed at multiple vendors, thereby reducing exposure to non-performance, using phase-funded contracts. The contracts have been placed at favorable prices. In all, the project reported that 49 percent of the conventional Linac and RF equipment is under contract as either firm or phased commitments, or fixed price options. This is an encouraging development, since the pricing uncertainties are rapidly being removed.

Mechanical engineering and design has continued, and is completed in those areas where vendor proposals have been or are now being solicited. In the SCL warm sections (the area between cryomodules where quadrupoles and instrumentation are inserted), an order was recently issued to suspend engineering so that the technical specifications could reviewed. This action was taken to potentially reduce the technical complications revealed in the preliminary designs, that could in turn, potentially reduce the costs associated with the warm section insertion.

Cooperation between LANL and TJNAF staff has continued at a high level, and the project continues to benefit from the joint specifications and the coherent and constructive team approach.

Both LANL and TJNAF management teams reported to the Committee on their perspective of the direction of the preparations for hand-off of the installation and commissioning responsibilities to ORNL. In the case of TJNAF, satisfaction exists that a significant team (reported as approximately ten full-time equivalents or FTEs) will work with and learn about the cryomodules in tandem with the assembly and testing of the cryomodules at TJNAF, and this staff should be able to assume responsibility later at SNS. LANL management reported a more pessimistic assessment. LANL believes that it is necessary to specify seven ORNL SNS people to go to LANL for a time estimated at typically nine months to become familiar with the seven principle areas (DTL, CCL, high-power RF, high-voltage converter modulator, low-level RF, Linac physics and commissioning, and Linac diagnostics). LANL management reported an impression that SNS management was presently reluctant to make such a commitment at this time.

LANL management believes that there needs to be a definition for success for the Linac, that is a project definition of acceptance testing procedures for the Linac subsystems as part of the hand-off from LANL to the SNS Accelerator Systems Division at Oak Ridge. It was also observed that the stated goal of 95 percent operational reliability appears not to be actively pursued by the SNS management, and is perceived as having substantially lower priority than cost and schedule considerations.

2.3.1.2 Comments

Very good progress has continued since the fall 2000 DOE review. The Committee noted the favorable procurement experience, and the relatively high percentage of procurements with pricing now locked into firm contracts, firm phased-funding commitments, or firm options. It was also reassuring to see the high quality of the management staff at LANL and TJNAF respectively, and the good nature of the working relationship between the respective management teams. The Committee appreciated the constructive effort of these teams in the review process.

All levels of SNS management and LANL and TJNAF management should continue to develop plans for installation and commissioning. The commitment of SNS Project Office staff to this effort is clearly necessary as equipment is built at the partner laboratories. SNS Accelerator Systems Division technical staff need to spend extended time at LANL and TJNAF so that the SNS project will have the necessary knowledge of the Linac Systems.

SNS management should focus more attention to addressing incomplete actions on recommendations from previous reviews. In the case of items such as the hot model, it is clear that early action is being advocated by LANL. In the case of providing an RF system for TJNAF, the Committee did not accept the statement by SNS management in the "response to recommendations" summary document that the 20 kW system provided at TJNAF is sufficient to either meet the sense of the recommendation or to meet the cryomodule testing needs.

A credible effort has been made over the last six months to maintain the existing baseline cost, and to provide a schedule for completion that is consistent with the funding profile. Continued attention should be directed at maintaining the existing baseline and completing the plan and cost estimate for Linac installation and commissioning activities.

2.3.1.3 Recommendations

1. Define the acceptance test criteria for Linac subsystems as they are to be handed-off to SNS Accelerator Systems Division (as soon as possible, but no later than the time of the next DOE review.)

2. Define the Linac installation and commissioning activities, their costs, and who has what roles and responsibilities by October 1, 2001.

3. Develop a plan for the exchange of technical personnel that ensures the transfer of relevant information for the various Linac subsystems.

4. Complete the hot module tests of the Cavity Coupled Linac and finalize the Cavity Coupled Linac design.

5. Keep firmly in mind the required reliability of the Linac, and where possible, facilitate the eventual upgrade potential of the facility.

2.3.2 Superconducting Linac

2.3.2.1 Findings

The design specifications for the SCL structure have changed in one significant respect since the October 2000 (Phase I) DOE review. The number of "high-$" powered cavities has been reduced from 59 to 48 by deleting the last three cryomodules. This was done as part of the re-baselining activity that followed the previous review to remove unnecessary scope, across the entire project, to preserve the baseline TPC. As first proposed, this reduction reduced the output energy of the Linac to approximately 840 MeV. Subsequent to this action, and in response to R&D studies of the ability of “electropolished” cryostructures to support a higher peak electric field (35 MV/m rather than 27.5 MV/m), a decision was taken to specify a 1 GeV Linac, but at a relatively reduced beam power of 1.44 MW. This important decision was adopted through the change request process and the facility is being designed for 1 GeV, not 840 MeV. SNS management has stated that it accepts the fact that the higher gradient design is still under development and test, and that the fall-back position (which of course is more expensive) is to achieve 1 GeV by adding back the three missing cryomodules and associated RF power (klystrons, modulators, and power supplies.)

Prototype cavity work has made good progress since the fall 2000 DOE review. The high-$, six-cell prototype cavity achieved accelerating field gradients well above the original design gradient of 12 MV/m. Numerical modeling has provided an understanding of the excessive Lorenz force detuning in the medium-$ prototype, and enabled a design fix which should reduce the shift to an acceptable level once the cavity is enclosed in an integral helium vessel.

The excellent performance of the prototype cavities and the potential for using an improved processing technology provide a basis for increasing the cavity performance goal from the original 27.5 MV/m to 35 MV/m peak surface electric field.

Both LANL and TJNAF management expressed concern about the need for SNS project management to commit to a RF system at TJNAF capable of full-power/full-repetition rate/full-duty factor tests of cryomodules as soon as the first item is produced. This is projected as being required in February 2002. Although represented as important for even the originally specified 27.5 MV/m gradient modules, it is regarded as critical for the development and performance verification of the 35 MV/m gradient modules. Given that the rest of the project depends on the performance of the higher gradient modules, both LANL and TJNAF management stressed the importance of a timely solution to this issue. This appears to require a specific solution using existing equipment from elsewhere to the extent possible, since the first production item of the LANL modulators is not expected prior to mid-summer 2002, perhaps six months after the cryomodule testing at the higher gradients is expected to begin.

An analysis of the effects of beam-excited higher-order modes has been completed both for cavity modes and for beam-pipe trapped modes. A higher-order modes coupler has been designed, prototyped, tested, and shown to provide adequate damping of these modes. Prototype fundamental power couplers have been completed and conditioned at room temperature up to 550 kW.

Design of the refrigeration system has been completed and procurements are on schedule. Cryomodule design has been nominally completed, and 12 of 17 major procurements have been awarded. Production cryomodule assembly is scheduled to begin on May 1, 2002.

Overall, the work assigned to TJNAF is well along, with 16 percent of the budget already spent on actual costs and 32 percent in placed contracts.

2.3.2.2 Comments

Very good progress in design, prototyping, and procurement has been made since the fall 2000 DOE review. SCL systems are generally on track and on schedule.

The decision to assume a successful development of high-gradient high-$ cryomodules is an ambitious attempt to preserve the baseline technical performance of the SNS at a lower cost under reasonable projections of achievable technical capabilities. SNS management is aware that if this strategy fails, then the project would have to bear the expense of adding back the deleted cryomodules, klystrons, and modulators. The Committee concurred that this approach is a reasonable risk with a favorable payback if successful. However, the timely completion of the full cryomodule development program will be delayed, threatening the production schedule if a 1 MW, 60 Hz, full-duty-cycle RF power source is not available to test the prototype cryomodule at TJNAF, beginning in February of 2002. The need for this RF source was first identified 18 months ago, and was identified as a priority item in the previous DOE review.

The decision to increase the design gradient of the SCL cavities seems warranted by the good progress with the prototype cavities, and by the availability of improved technology, such as electropolishing.

The present design of the SNS depends on achieving 1 GeV beam energy. In particular, the Ring is being designed for this energy. The proposed increased SCL cavity operating gradient is, when scaled for frequency, substantially higher than that attained at the Deutsch

Electron Synchrotron's Tera eV Energy Superconducting Linear Accelerator Test Facility. Achieving it in routine operation may well require development of appropriate cavity processing and cryomodule assembly techniques. Also, the increased gradient will place increased demands on ancillary systems. Given these facts, full-power, full-duty-cycle tests of the cryomodule assembly assume an even more critical importance.

2.3.2.3 Recommendations

1. Plan and fund the timely delivery of an RF system at TJNAF that will have the capability for full-power/repetition-rate/duty-factor tests of the cryomodules. This RF system is required when the first cryomodule is ready for tests, currently projected as February 2002. (This recommendation is also an Action Item—see Appendix I.)

2. Consider, in a timely and careful manner, all useful possibilities for R&D to enhance and ensure the probability of achieving operational 35 MV/m peak gradients.

2.4 Ring Systems (WBS 1.5)

2.4.1 Findings

SNS is committed to 1 GeV at machine turn-on, either by higher gradients in the SCL cavities, or by finding the funds to restore the deleted cryomodules and RF power.

The BNL staff working on the SNS has been reduced from 130 to 91 people while retaining the FTE level at 75. This is a good step. There remains a difference between BNL and the SNS Project Office in planning for Ring Systems hand-off over the next four years.

There are a large number of accelerator physicists (nearly ten) at BNL working on the SNS. There is also a minimum of 5.7 FTE-years of accelerator physicists in the SNS Accelerator Systems Division working on the Ring. This number seems excessive for a system that is essentially designed.

SNS management reported the partner laboratories are now comfortable with the "lead-mentor-consult" process. This is essentially true with respect to the Ring. The issue is in the detailed planning on a case-by-case basis. Progress is being made and both laboratories agree that the process is working. Mechanical interfaces are being defined and issues are being addressed in a timely manner.

As WBS 1.5 saves money (via favorable procurements, or otherwise), it is authorized to use these funds to proceed with chromaticity sextupole design and construction. Both ORNL and BNL expect to have chromaticity control in place for Ring turn-on.

The Accelerator Systems Division hired a low-level RF engineer who will spend time at BNL. This is an encouraging example of the policy to place Accelerator Systems Division staff at partner laboratories to gain expertise in areas that presently lack experience.

The schedule showed that the Ring is late by four to six weeks, primarily due to diagnostics. However, the Committee agreed with the project that this presents minimal schedule risk overall. The Committee did not suggest any changes to the Ring baseline cost estimate.

Good progress has been made in a number of technical areas. For example, about 70 percent of all the magnets needed for the injection lines and the Ring are under contract and scheduled for delivery during October 2001. The other 30 percent are either prototyped, or their design is complete and they are ready for prototyping. The cost of the magnets that are under contract is close to the estimate. In Vacuum Systems, about 90 percent of the design is complete and many of the components are on order. The costs of the vacuum components that are on order are under the baseline estimate. The stripping foil changer is designed and several critical aspects have been tested. The changer is in the process of being built, and a special diamond foil is being researched at ORNL.

In the area of collimators, the preliminary design for revised parameters for stripper foil location in the High Energy Beam Transport (HEBT) is underway, and the beam tube is being redefined. For the Ring, moveable collimator parameters and a preliminary design review have been completed. Detailed design is underway for moveable collimators and the absorber chamber design has been defined. The design of the first Ring to Target Beam Transport (RTBT) line collimator has been completed. A request for proposal (RFP) is out for first article absorber assembly with phased procurement options for all HEBT, Ring, and RTBT passive absorber assemblies. Moveable work shield components have been fabricated, and final assembly is underway.

An order for the 160 corrector power supplies has been placed with a vendor, Danfysik, and the first article injection kicker power supply is being fabricated. An RFP for 68 medium power supplies is ready to be issued in June. The Ring main bending magnet supply has yet to be specified. All of the power supplies will be controlled by a controller developed by BNL, which will make operation and maintenance much more convenient.

The RF power supplies are based on conventional tube (radio transmitter type) amplifiers. SNS has the manpower to install and operate the RF supply.

A small prototype kicker was tested to determine the beam impedance of a new design. The resulting beam impedance was not reduced as much as expected but still may be sufficient. The first thyratron-driven extraction kicker has been designed and parts are being ordered. The extraction kickers will be supplied and commissioned by BNL due to their complexity.

In the area of commissioning, a group is being formed at SNS to measure the magnets, test the power supplies, complete the installation drawings, manage installation, and perform installation test and preoperational tests on the Ring power system. With close cooperation from BNL, this team should be able to accomplish these tasks. Commissioning and installation activities are further addressed in Section 7.

2.4.2 Comments

The Receiving, Acceptance, Test, and Storage (RATS) building is a very positive addition and will be instrumental in the equipment hand-off process. Many of the earlier concerns expressed by BNL have been addressed, particularly with respect to direct current magnets and power supplies.

A mock-up of the Ring tunnel has been built and is being used to make final determinations of outstanding issues. A particular issue that must be addressed is whether an alcove is needed at the location of the cable chase.

The kicker impedance problem should be pursued further. The impedance seen by the beam can be troublesome for a high intensity beam. Further refinements of the present design should be developed, or new concepts should be pursued to improve its performance, or a contingency plan should be devised in case of problems.

An R&D program as proposed at the kicker design review should be funded to design a solid-state extraction kicker. (This will be the last kicker of this rise time and pulse width that is made with thyratrons.) Solid-state designs will be cheaper, smaller, more reliable, and enable formation of a better pulse shape.

Based on the lifetime and failure rate of present thyratrons, the availability of a thyratron-based extraction kicker may be less than the required 99 percent. The overall availability of the 250 power supplies (including the kickers) in the Ring using standard industrial grade supplies may be as low as 97 percent.

A way needs to be found to procure long-lead spare parts for equipment such as power supplies. With the relatively large number of power supplies, failures of components will occur and they will need to be repaired without delay.

It appears that no consideration has been given to the effect of the pulsing klystron modulator load on the power lines, and in turn, the power lines' effect on the Ring power supply regulation. There is a pulsed load of approximately 100 mega Volt Amperes (MVA) on a substation transformer of approximately 60 MVA capacity with no separation of loads or active pulse-load compensation. This potential problem needs investigation.

In previous DOE reviews, the funding profile for WBS 1.5 was not commonly understood between BNL and the SNS Project Office. This time, however, both are working to similar numbers.

Aside from several cost and equipment hand-off issues, working relations between the Ring Team and the SNS Project are good.

2.4.3 Recommendations

1. Include the chromaticity sextupoles in the Ring technical scope. The decision to build the sextupoles must be made now so that they can be included on the girders when they are initially installed in the tunnel.

2. Develop a plan, by the next DOE review, for the final transfer of effort from BNL to SNS Accelerator Systems Division.

3. Renegotiate Appendix C of the Project Execution Plan, or whatever document is appropriate, so that all interfaces and responsibilities are well defined. This should be accomplished by the next DOE review.

2.5 Target Systems (WBS 1.6) and Instrument Systems (WBS 1.7)

2.5.1 Findings

The project is making good progress in all aspects of Target Systems. It has responded positively to the recommendations and comments given in previous DOE reviews. Ten percent of all procurement orders have been placed, and costs are 14 percent higher than the original vendor quotes, that is, well below contingency level.

Target Systems is fully staffed, and although there are no issues, funding for the transition into pre-operations is still a concern. The IPS early finish date has been moved in accordance with a recommendation from the fall 2000 DOE review, which had a cost impact of about $840 K.

Tests on the Target Test Facility are still in progress. Major items, such as remote disconnecting and reconnecting of mercury lines, are still pending. Cavitation problems discovered in the mercury pipe work are about to be rectified with minor impact on cost and no impact on schedule.

Only one building extension outside the Target Hall has been prepared (for the backscattering instrument). A similar need will eventually arise for others beyond the five instruments included in the project baseline scope.

The instrument budget has been scaled up again to $60 million, which can provide five best-in-class instruments, three of which have already been baselined with designs that are well advanced. These five instruments will span many, but not all, of the scientific areas originally addressed, and in addition will open up new scientific possibilities in the areas they do address. The Instrument Systems Senior Team Leader assured the Committee that he is quite confident that with adequate Budget Authority for Instrument Systems in FY 2002 and FY 2003, all five instruments can be operational at the time user operation of SNS will begin. The Committee concurred with this view.

Scope transferred to Target Systems from Conventional Facilities and Ring Systems has increased the WBS 1.6 baseline cost. Not all of the increase is compensated by reductions in the other WBS areas. Several Project Change Requests are pending, which together with the recent changes, will increase the cost baseline of Target Systems by about 2.5 percent. This is not a serious concern at the present stage of the project.

2.5.2 Comments

The Committee was pleased with the recent increase in computer power to boost predictive capabilities in neutronic performance and shielding design. This will enable the project to generate important data in a timely fashion.

R&D is, with minor exceptions, coming to an end. The main unresolved issue is the effect of simultaneous irradiation and stress on the solid metal—liquid metal interface. It may dictate short operational lifetimes for the initial target shells (radiation damage less than five displacements per atom), which is expensive.

The Target design was switched from mechanical to hydraulic drives for the beam shutters. This has some advantages, but it is not without problems. An effort should be made to enable shorter opening and closing times than the two minutes presently envisaged. However, careful control must be exercised in setting the neutron optical shutter inserts down on their alignment fixtures in order to avoid damage from shocks or fatigue. Early tests and development work are, therefore, highly desirable. This would mean early procurement of one hydraulic gear and associated control software.

The three supercritical hydrogen (H_2) moderators, which used to be in series, will now be supplied from independent cryogenic lines. This is a highly welcome move, which will improve operational reliability and performance. Its cost impact has not yet been fully quantified.

The Committee supported the decision to restore the Linac energy to 1 GeV with an option to go to 1.3 GeV at a later stage. The project should take this into account in optimizing the position of the target relative to the moderators, and should retain enough flexibility to adjust to a change at a later time. The prospect for achieving a beam current of 1.4 mA at 1 GeV is very appealing, however, this should not be allowed to consume contingency funds that could otherwise be used to increase the number of instruments.

Linac and Ring exit beam dumps must be able to accept full-power single pulses to support the project's accelerator commissioning plans. The Committee was not able to verify that the Ring exit dump is capable of this as presently planned. The project should pay due attention to this question. Since the Linac and Ring extraction beam dumps are inadequate for more than 7.5 kW operation of the accelerator system, eventual problems related to high-power operation of the accelerator may delay the beginning of user operation.

In this context, the question of how the performance of the facility will be ramped up to full specifications is important. Only a preliminary (optimistic) plan has been shown by the project. [Note: Even one-third of full specified power will make SNS the world leader in pulsed spallation sources, but only if adequately equipped with user facilities.] Instrument commissioning including shielding verification can happen only after the SNS Operational Readiness Review which is anticipated to take place about six months after CD-4, Approve Start of Operations—now scheduled for June 2006. At that point, at least the first five instruments should be ready for full-power commissioning.

The Committee noted that the scope of the first three instruments has been downgraded to meet budgetary constraints. Although this is recoverable at a later stage, the Committee is concerned that, in their present configuration, these instruments will be barely acceptable for user operation. Resources should be redirected as necessary to bring the powder diffractometer to a state of design comparable with that of the other four instruments. The goal should be to have all five instruments ready for neutrons at, or shortly after, the SNS Operational Readiness Review.

Coverage of momentum-energy (Q-T) space should be taken into account when deciding on the priority of follow-on instruments. The project should generate a diagram showing what can be reached with neutrons in principle, and how this space is covered by the planned instruments. In addition, emphasis should be placed on special sample environment instruments to draw full benefit from the superior source properties of SNS.

The Instrument Systems Team currently has only one software expert. This is clearly inadequate and SNS management should give priority attention to increasing the level of instrument software staff.

The reduction in floor space in the Target Hall will affect logistics of preparation for experiments. This is probably not recoverable due to the need for foundations. Careful planning of experiment logistics will be required to define and minimize the impact.

Planning for installation of instruments has started, but it is difficult to see how empty beam lines between installed instruments will be filled. The problem is that instruments not only require a definite footprint on the floor, but also need to view a certain moderator. There is no flexibility to choose the moderator viewed by a given beam line. Without an early concept for the full suite of instruments to be installed, this will lead to difficulties.

The Instrument Systems Team is planning on using the Target Building before its beneficial occupancy date to prepare for certain instrument installations. This may be very problematic and should be coordinated carefully with Conventional Facilities to avoid conflicts.

The cost and schedule performance indicators for Instrument Systems caused the Committee some concern. SNS management explained that this was due to changes that needed to be made in the schedule so that the budget and schedule are consistent. The project believes that this inconsistency will be rectified soon. Progress of Instrument Systems is such that a more detailed look at their technical, cost and schedule planning seems appropriate at the next DOE review. Hot cell and handling issues have not received the same attention from the Committee as other aspects of the project. This should also be addressed in the next DOE review.

2.5.3 Recommendations

1. Select an Experimental Facilities Division Director with comprehensive experience in neutron scattering within the next four months.

2. The Experimental Facilities Division Director and the Instrument Systems Senior Team Leader should work together to avoid any further reduction in instrument budget, and to secure timely completion of a useful suite of instruments for the beginning of user operations immediately after the SNS Operational Readiness Review.

3. Experimental Facilities and Accelerator Systems Divisions should work together to certify that the requirements for minimum beam size and maximum current density on the Target can be met and will not be violated under any circumstances. This is crucial to the integrity of the Target and the safety of the facility.

4. Plan for timely testing of the target module and mercury piping final designs on the Target Test Facility prior to installation at SNS.

2.6 Control Systems (WBS 1.9)

2.6.1 Findings

The project has a well-coordinated team approach in Control Systems across the partner laboratories. This is a truly excellent accomplishment. The Beam Diagnostic Systems effort is following a similar team building approach. The planned staffing of WBS 1.9 for construction and operations looks correct. The budget similarly appears to be correct, and the team is generally meeting their schedule milestones -- very well done.

The staffing for the Accelerator Systems Division Application Programming Team is low, as noted in the findings of the March 2000 DOE review. From the Committee's experience, the staffing requirement is for professional software engineers (although accelerator physics experience is helpful).

2.3.1 Comments

The Committee reviewed: the SNS Timing System, Machine and Personnel Protection Systems, Cable Planning and Coordination, Rack Factory, Network System Design, Conventional Facilities Controls, and Controls Project Management and Organization including interfaces with Beam Diagnostics and Accelerator Systems Application Programming. The general conclusion was that excellent progress is being made in all these areas.

Recommendations were made in previous DOE reviews that the project should investigate the utility and cost effectiveness of a Cable Planning and Coordination Team, and a Rack Factory. The project has done so, and is in the process of implementing both recommendations. Both of these recommendations have involved coordination effort from the Controls Group.

The Control System Network design is proceeding well. This effort is consuming a large amount of time from the Controls Group Lead Engineer, whose efforts are being augmented by the ORNL Computing Information and Networking Division. This collaboration is excellent. The size of the design team should be increased somewhat, so that the Controls Group Lead Engineer can devote more of his time to other areas.

The project has vacillated on the use of Experimental Physics and Industrial Control Systems (EPICS) for the Conventional Facilities controls. At present, the project is committed to using EPICS and the Committee would like to reiterate its support of this choice.

The Controls Group is supporting laboratory space in both the Scarboro Building and the RATS facility. The Committee felt that this support should include distribution of timing signals from a common source to both facilities. This requires the use of a few dedicated fibers between the two facilities out of the presently existing fiber links. This will give the project useful experience in running the timing system as a production facility over a distributed topology.

2.6.3 Recommendation

1. Evaluate the level of staff in the Applications Programming Group to develop the programs to meet the functional requirements of commissioning and early operations. This should include estimates for both the construction and pre-operations phases and should be completed by October 1, 2001.

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3. CONVENTIONAL FACILITIES (WBS 1.8)

3.1 Findings

Since the fall 2000 DOE review, Conventional Facilities (CF) progress has been maintained in design and construction at the site, and the project completed a detailed scope review. Title I and II design are well underway with overall CF design progress at 75 percent complete. Procurement actions supporting construction are approximately 28 percent complete and site construction progress is about 11 percent complete. Progress is acceptable and the temporary hold that DOE placed on construction package awards last November resulted in a four to six week delay from the presented baseline schedule. The revised cost and schedule baseline, and the associated planned use of contingency estimates, are supported by the project Budget Authority funding profile.

The CF team in concert with the entire SNS project staff have done a commendable job in identifying cost reduction items and reaching cost targets for CF scope. The Committee found that approximately $77 million in CF scope reductions have been identified and incorporated in the Title I estimate (Revision 2) dated April 16, 2001. Overall, recommendations from the fall 2000 DOE review have been adequately addressed.

The Committee reviewed the Front End Concrete Construction package as a certified-for-construction example for WBS element 1.8.3.1. Design documents are being prepared as a total integrated design that includes approved drawings and specifications for the specific scope of work being bid. Taken in concert with the unit price procurements already in place, and the flow-down of requirements to the construction contractor, the Committee found that the project has reached a level of maturity necessary to support major construction activities.

The next seven months of the project represent the period of highest risk for CF cost and schedule due to the issues caused by award of contracts, field construction, commissioning plans, and equipment installation integration occurring concurrently. It is important to note that some of the scope reduction items may resurface on the project as unacceptable loss of functionality (i.e., auditorium, cafeteria, furniture, and casework) when these issues are revisited at a later date.

The principal changes in the project since the fall DOE review can be summarized as follows:

- The CF (WBS 1.8) cost baseline is currently $307.5 million. This is a $7.2 million increase compared to the October 2000 baseline.

- The Title I cost estimate for CF activities is complete and documented in SNS Title I Cost Estimate (Revision 2) dated April 16, 2001. The cost estimate supports the CF cost baseline.

- The project presented a Budget Obligation profile, construction sequencing plan, CF schedule, and budget that were self-consistent and reflect the project Budget Authority.

- Title III costs have been moved from Engineering, Design and Inspection (EDI) to construction. Per DOE Guide 430.1-1A Chapters 6 and 25, Title III should be part of EDI costs. This should be corrected in time to support the next DOE review.

The March 2001 CF Cost Performance Index (CPI) of 1.01 and Schedule Performance Index (SPI) of 0.90 indicate reasonable progress using a defensible baseline. Information presented during the review indicated that April 2001 SPI data will show improvement.

3.2 Comments

The Committee acknowleged the tremendous effort of the CF team in aggressively moving forward with design and site construction activities. Completion of Title I design has provided a more accurate estimate from which credible scope reduction efforts can proceed.

To assess readiness for construction, the CF team was interviewed on the topics of procurement, site logistics, procedures, labor relations, schedule, and staffing. The team appeared to be well prepared to begin large-scale conventional construction activities.

The AE/CM has pre-qualified bidders, established unit price contracts/purchase orders, and is staffed to proceed through the bid and award phase. The AE/CM is well aware of the intense procurement schedule over the next five months and believes they are prepared to support the activity. The CF Team has developed a more detailed working document to track these procurements from design completion through contract award. This detailed document can be traced through the Master Schedule to the IPS and these documents appear to be consistent with each other to within a four week period.

Plans have been developed to address site general conditions (e.g., trailers, trash, toilets), site staging, storage, access, etc. These plans are comprehensive to the extent feasible. Commissioning data is missing from these plans and this represents a source of potential conflict. The team has done a good job in taking proactive steps to anticipate ready-for-equipment milestones and commissioning activities in this planning, but has no commissioning and installation plan against which to validate these assumptions.

Standard procedures and processes are in place to control and manage the volume of paperwork necessary to execute construction (e.g., addenda, RFI, change orders, submittals). A CF project execution plan and quality assurance plan have been developed; inspection plans are complete through the civil phase of the work and are awaiting further design completion for the remainder of the plans to be developed. The staff has been trained in these plans and procedures, and the training extends beyond on-site personnel to include remote personnel (i.e., AE offices in San Francisco).

A Project Labor Agreement is in place for this work. The CM is active with local labor to ensure an adequate labor supply for the project. The labor agreement as written considers the integrated site and the multiple sources of labor for the project.

Sequencing has been developed for the work and is driving the packaging of activities to optimize equipment and contractors' craft resources on site. The Committee reviewed the design, procurement, and construction start schedules. These schedules appeared to be self-consistent to within four weeks. The work load required by the current schedule is significant as numerous design reviews, procurement package releases, pre-bid meetings, bid analysis/award meetings, and contractor mobilizations will occur over the next seven months to maintain the IPS early finish dates.

A review of CF staffing indicated that the CM has fully staffed the construction team (less one key individual), and the SNS Project Office CF team appeared to be fully staffed within two to three positions. Personnel changes are underway to optimize the skill mix as the work moves from design into construction. An ongoing staff issue is the open CF Division Director position. This position should be filled immediately as this is a critical time for leadership in CF activities.

The current SNS project philosophy regarding contingency use is to accelerate or defer scheduled work during and between adjacent fiscal years to utilize all available Budget Authority in the current fiscal year. By design, this results in little or no uncosted obligations at the end of the fiscal year. This practice meets the objectives of the project, but does not represent traditional best practice in project management. The highly concurrent approach to construction and equipment installation may drive a more aggressive allocation process than that currently in use. The Committee discussed a recommendation to manage contingency based on addressing unknowns rather than accelerating or decelerating known work scope. During full construction, with overlapping equipment installation and commissioning activities, experience indicates that there will be unknowns that must be addressed through contingency allocations that are not currently planned.

As noted in previous reviews and reinforced here: 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.

3.3 Recommendations

1. Fill the Conventional Facilities Division Director position immediately.

2. Prepare an equipment integration, installation, commissioning, and start-up plan that includes the interface constraints of site construction activities with ready-for-equipment criteria and hand-offs from site contractors by the next DOE review.

4. ENVIRONMENT, SAFETY and HEALTH

The SNS Environment, Safety, and Health (ES&H) team addressed the areas of project safety analysis and documentation, construction safety management, and quality assurance (QA). ES&H is receiving appropriate attention for the current and near-term stages of project development. The project has implemented an effective construction safety program, as demonstrated by its outstanding safety experience to date. Plans to augment staff throughout the project as construction activities increase in volume and complexity have been established to maintain a best-in-class construction safety record on the project. There are several coordination issues that require resolution in regard to approval of the Final Safety Analysis Report (FSAR) for the Target and implementation of some QA practices.

4.1 Findings

ES&H considerations are well integrated into project activities. This is attributed to DOE, SNS, and CM senior management's commitment to safety and their clearly communicated expectations of the project safety program.

Safety and environmental documentation has been well executed for this stage of the project. The processes of tracking identified project safety deficiencies through the "Commitment Tracking System" for issues identified during external safety reviews and the "Corrective Action Tracking System" for internal safety observations are excellent mechanisms to assure that no issues are overlooked or forgotten.

The project has done an excellent job of developing safety related documentation, and there is a well-defined plan for the development and approval of future safety documentation. The Preliminary Safety Analysis Document (PSAD) for the accelerator, that was first approved in 2000, is scheduled to be upgraded to a Final Safety Assessment Document (FSAD) for the Front End Building, Linac Tunnel, and Klystron Gallery (FELK) in 2002. An Accelerator Safety Envelope for the FELK will also be completed in 2002. An FSAD Accelerator Safety Envelope that includes the Ring will be approved in 2005.

As an accelerator-based Radiological Facility, an Accelerator Readiness Review for commissioning will be conducted prior to the start of accelerator commissioning activities. A Commissioning Program Plan will be presented at this Accelerator Readiness Review in accordance with the requirements defined in DOE Order 420.2A (Safety of Accelerator Facilities). The plan will describe the readiness assessment process to be followed prior to each stage of commissioning.

Regarding the documentation for the start-up of the Nuclear Facility, the plans are for a two-step phased approach (see Figure 4-1). The Preliminary Safety Analysis Report (PSAR), approved in February 2000, identified the Target as a Category 2 Nuclear Facility, based upon the expected radionuclide inventory of the Target after some weeks of full-power (2 MW, 60 pulses per second) operation. During early stages of commissioning and operation (low-power operation), the radiological inventory of the Target will be such that it is not a Nuclear Facility, but considered a Radiological Facility. The requirements for startup of a Nuclear Facility are given in DOE Order 425.1B (Startup and Restart of Nuclear Facilities).

Consistent with the requirements of the DOE Order and the planned operation (Radiological Facility, then Nuclear Facility), SNS plans to conduct the following readiness reviews. First, a readiness assessment will be conducted for starting up the Target as a Radiological (below Category 3) Facility. This will allow the Target to be run (i.e., “beam on target”) for the pre-operational testing mentioned above. As part of the preparation for the readiness assessment, SNS will start to document their training and maintenance plans, which are also required documents for an operating Nuclear Facility. The phased approach will allow the SNS to develop administrative processes that are based on experience, and should take full advantage of the graded approach philosophy. Further, completion of the readiness assessment will allow SNS to commission the Target and move to CD-4, Approve Start of Operations.

After commissioning, SNS will prepare and conduct an Operational Readiness Review that will permit the start of Nuclear Facility operations (Category 3, first, and Category 2 eventually). During the period of hot operations (pre-operation and commissioning), SNS can refine their calculations to determine when the inventory will grow to Category 3 and 2 levels. Further, procedures, training plans, and other documentation can be revised based on this experience. A Startup Notification Report is required prior to an Operational Readiness Review. Based on discussions with DOE, SNS will prepare the Startup Notification Report about one year before the Operational Readiness Review.

The design of the Accelerator and Target Systems is continuing to evolve as research and development results are evaluated, and additional experience and knowledge is gained. Since

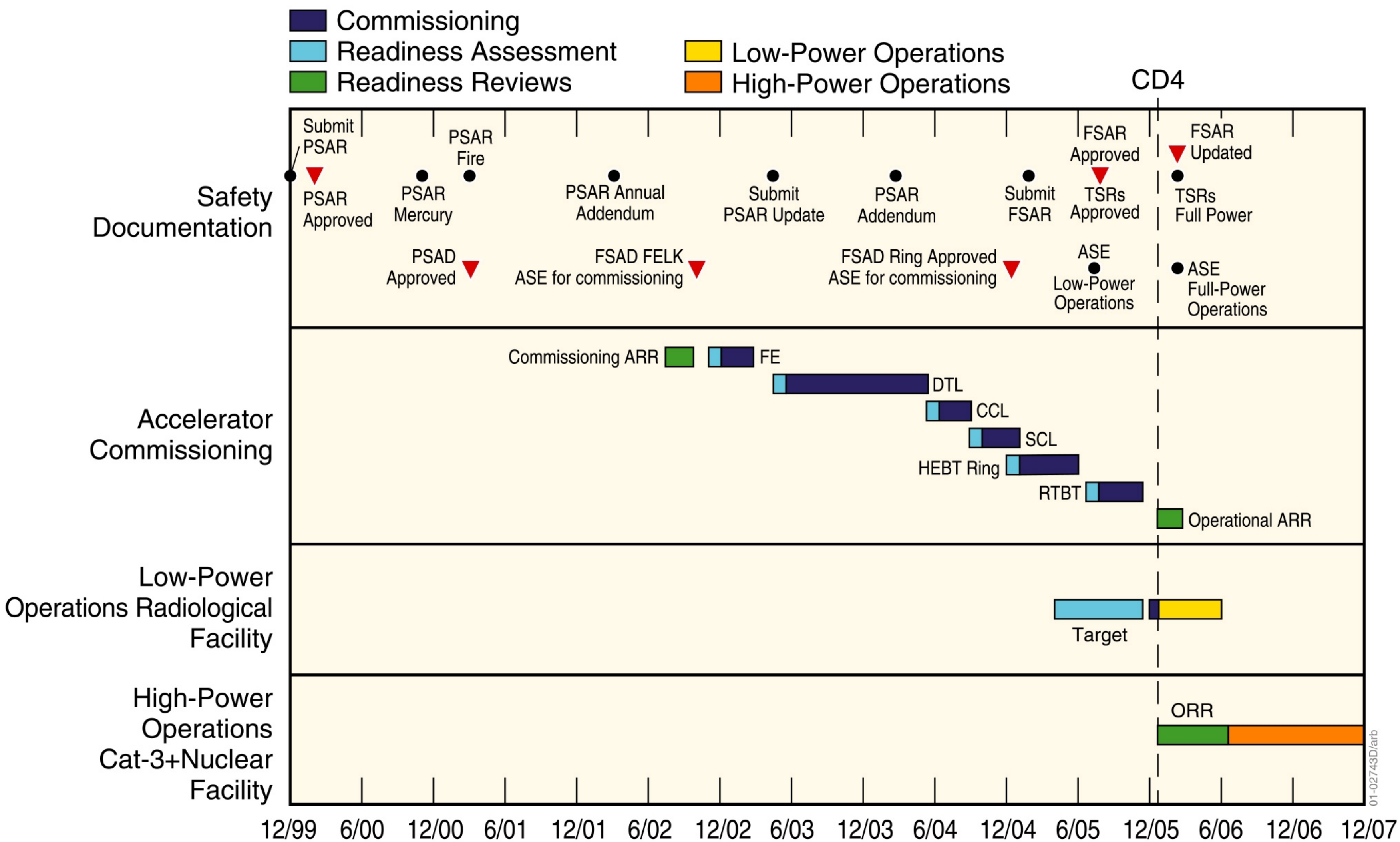

Figure 4-1. SNS Commissioning Strategy

safety basis documentation, consisting of a PSAD and a PSAR, have been completed and approved, it is important that any design changes, especially those that may affect the safety basis, are reflected in subsequent updates to those safety basis documents.

Design Control Documents and System Requirement Documents are routinely reviewed as part of the approval process by the SNS ES&H Manager. Given that these documents identify changes to technical systems, by including the safety department in the approval chain, safety issues can be identified and analyzed, and controls incorporated into project safety planning and documentation. ES&H personnel evaluate the changes using a process similar to the Unreviewed Safety Question and Issue processes used in operational nuclear and accelerator facilities. That is, they evaluate whether the design change has the potential to create a new accident/consequence, or change the probability/consequence from a currently analyzed accident scenario. As appropriate, the changes are integrated into the planned PSAR/PSAD updates, and the operations personnel are involved in the development of the safety basis documents. This process will enable the project to continue their excellent record of addressing ES&H issues and hazards, and ensure that the selected resolutions are fully and optimally integrated into facility safety planning.

In March 2001, a PSAR update report was prepared, and part of that report summarized the changes made to the design, and how those changes affected the safety basis. The report is not a full update of the PSAR, but rather it focuses on the changes since the PSAR was approved. The current plan is to prepare another updated report for the PSAR in about one year, then a formal update to the PSAR in 2003 that will incorporate the changes documented in the update reports. It is expected that the 2003 PSAR will be modified, as appropriate, and then submitted as the FSAR. The Technical Safety Requirement document will be developed, first for low-power and subsequently for Category 2 Nuclear Facility operations, after the FSAR has been submitted to DOE. The sequence is very appropriate.

The plans for testing and validating the physical systems, structures, and components for the Target as they are received and assembled were evaluated. Subsystems testing for the Target is planned for August 2003 through March 2005, and testing of integrated systems in the period April 2005 through September 2005. No specific testing plans have been established at this point, nor was it expected that they would be developed at this stage of the project. In the absence of specific testing plans, it was difficult to establish whether the time allotted will be sufficient to conduct the necessary pre-operational tests given the planned resources. This should be evaluated in more depth in 2002.

The project has been subject to close scrutiny by both state (Tennessee) and Federal environmental agencies since its inception. The SNS ES&H organization has effectively addressed their concerns. The proposed SNS practice of receiving all chemicals destined for the project at a single site, monitoring waste minimization, and recycling of construction debris will ensure that the project maintains a positive environmental protection posture.

Policies and practices being implemented by the CM's management are resulting in a world-class safety program. Injury experience based on 256,000 manhours worked to date shows zero lost work days, zero identified environmental insults, and zero reportable injuries/lost workdays at partner laboratories.

COMPARISON WITH DOE & INDUSTRY EXPERIENCE		
	Lost Work Day Rate	Recordable Injury Rate
Spallation Neutron Source	0	1.56
Department of Energy	2.3	4.2
U.S. Heavy Construction Industry	4.8	7.9

The CM currently has a full-time safety professional on staff, which is adequate at this stage of construction. He has authority to hire more safety personnel over the next three months, and more as the project grows.

The SNS QA office has direct responsibility for the Experimental Facilities, Accelerator Systems, the partner laboratories, and oversight of CF and AE/CM activities. The QA team is in place and staffed. The QA Manager has direct experience in a similar position at ANL's Advanced Photon Source. Additional QA support is available from ORNL services and from outside services on a contract-as-needed basis. The project is in the early stages of procuring about $750 million of goods and services, and whether the current staff is adequate to support this effort remains to be seen.

QA program development started in earnest a year-and-a-half ago. Project QA plans and procedures have been developed, and training and familiarization of project staff are well underway. Good working relationships have been forged with the partner laboratories. The QA program is currently focusing on assessing the effectiveness of partner laboratory QA program implementation and compliance with the overall project QA requirements. Three reviews have been completed to date (ANL, LBNL, and AE/CM).

The SNS QA team has a balanced approach to the QA program implementation, and is sensitive to requirements that could increase costs unnecessarily. Good working relationships appear to have been established with project line management and technical teams, this being most evident in Target Systems.

A key QA process in use at SNS is the Acceptance Criteria Listing. The Acceptance Criteria Listing defines responsibilities for component, subsystem, and system performance tests and verifications. It incorporates other test plans and procedures without adding excessive documentation, and is a record of verification results including non-conformance and corrective actions. Additionally, it provides an effective interface between the technical personnel and the QA staff. The Acceptance Criteria Listing process is in the early stages of implementation with its use most evident in Target Systems. It appears to be a good process and should be firmly established throughout the project.

Controls system software (including safety systems), which comes from a variety of sources, is used in all of the systems. Software development and use span nearly all the organizational elements.

4.2 Comments

There were no issues or weaknesses identified from the review of project safety analysis and documentation, construction safety management, and QA. The stepped approach to completing the startup documentation of the Target is a great idea. The readiness assessment process is simpler and more appropriate for Radiological Facility operations than the Operational Readiness Review process. Further, the experience gained in the readiness assessment process and the subsequent facility operations will facilitate the Operational Readiness Review process. SNS should continue to work with the DOE Oak Ridge Operations Office to: 1) get official "buy-in" from DOE for the stepped approach for startup discussed above; 2) determine whether Operational Readiness Review approval will be delegated to the Operations Office (or maintained in DOE Headquarters); and 3) ensure that DOE is kept aware of the readiness assessment/ Operational Readiness Review progress, as they have been doing.

The specific plans for subsystems testing and integrated systems testing should be evaluated in more depth during the next DOE review.

Further, someone in the Experimental Facilities Division, knowledgeable about the planned operations of the Target, should be involved in the development of systems/processes being completed for the Linac such that those systems/processes are strong enough to include the needs of the Target. This can be accomplished by hiring an ES&H "coordinator" for the Experimental Facilities Division, similar to the position that currently exists in Accelerator Systems Division.

Given the importance of software to project success, more QA attention should be given to documentation and evaluation of reliability for software developed specifically by the project. It is suggested that the project address Control Systems software as a specific element in the QA Plan.

The project should evaluate the level of quality assurance oversight being applied to the Accelerator Systems Division/Experimental Facilities Division efforts with that applied to CF to ensure that the efforts are consistent with each other, and appropriate for the risk involved. Currently, the QA Manager's organization has a dual role—to provide QA support (e.g., reviewing documents and designs), and oversight (including partner laboratories) to the activities of the three SNS Divisions (Accelerator Systems, Experimental Facilities, and Conventional Facilities).

Finally, the project should consider developing a QA library that is a central repository of key documents and records, other than the QA plans, procedures, and guides currently maintained on the SNS Web Site.

4.3 Recommendations

1. DOE must establish a mechanism for agreeing with the proposed SNS plan for a stepped readiness assessment of the Target (i.e., complete a readiness assessment first for operation as a Radiological Facility, and then complete an Operational Readiness Review for operation as a Nuclear Facility).

2. Identify qualified reviewers for readiness reviews and assessments, and a review schedule within the next year.

3. Staff an experienced construction safety oversight position for the SNS Project Office now, before construction site activities accelerate further.

4. Review and update project QA procedures on a regular basis (at least annually).

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5. COST ESTIMATE

5.1 Findings

The SNS Total Project Cost (TPC) has remained unchanged at $1,411.7 million since the fall 2000 DOE review. 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 R&D and pre-operations activities.

The actual FY 2001 costs and commitments through April 2001 amount to $203.2 million ($187.9 million for line item activities, and $15.3 million for R&D and pre-operations activities). Cumulative costs and commitments through April 2001 amounted to $389.7 million ($331.9 million for line item activities and $57.8 million for R&D and pre-operations activities).

As of the end of April 2001, contingency was reported to be $170.5 million or 25 percent of the Estimate-to-Complete (ETC), which was $692.2 million.

5.2 Comments

The contingency presented at the October 2000 (Phase I) DOE review was $167.2 million (20 percent of the ETC). The project agreed with the recommendation from that review that this level of contingency was dangerously low for a stage of the project when all Title II design activities had yet to be completed. During fall and winter 2000, SNS management actively pursued a reassessment of the cost estimate (but not a bottoms-up ETC) to identify possible scope reductions and/or savings that could be applied to increase contingency funds. As a result of this exercise, the project was able to significantly increase the contingency percentage. The Committee found that the current estimated contingency level of $170.5 million (25 percent of the ETC) is adequate for this stage of the project. However, there are a number of draft and pending change orders that, if and when implemented, will reduce the contingency percentage. The Committee was not presented with a complete list of known or likely changes, but it is estimated that these changes could reduce contingency by as much as $10 million.

The project recently initiated a standardized approach and format for addressing monthly management projections of an Estimate-at-Completion (EAC). These assessments occur as part of the periodic (approximately four to six weeks) cost and schedule performance review meetings with the project Senior Team Leaders. DOE project management staff routinely participate in these reviews. The format appears to adequately address the necessary items (e.g., current Budget-at-Completion, EAC projections from the Microframe Project Manager database, approved Project Change Requests not yet implemented, and other potential changes) needed to permit the Senior Team Leaders and SNS management to address their current EAC assessment. The Committee found this to be a good proactive approach to forecasting future trends.

The current ETC reported by the project is merely the arithmetic difference between the Budget-at-Completion and the Actual Cost of Work Performed. With the exception of CF, the project has not performed a bottoms-up ETC since July 1999.

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.

5.3 Recommendation

1. Prepare a bottoms-up Estimate-to-Complete for the entire project and implement as a new baseline by the next DOE review.

6. SCHEDULE and FUNDING

6.1 Findings

The project's current cost baseline is 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. As indicated in Appendix E, the FY 2002 Budget Request contains a Budget Authority funding profile of: $278.0 million in FY 2001, $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.

SNS has established a new IPS that is consistent with the Budget Authority funding profile cited above. The IPS calls for an internal goal for project completion of December 2005. This provides six months of project schedule contingency relative to the CD-4 commitment of June 2006. No Level 0 milestones were changed; Level 1 and Level 2 milestones have been adjusted to accommodate the new schedule. The IPS assumes that contingency is distributed throughout the duration of the project, with most of the available contingency allocated to the outyears. The project is currently running approximately one month behind the early finish dates in the baseline schedule; it was approximately three weeks behind at the beginning of this fiscal year.

The Project Summary Schedule (see Appendix F) is derived from the detailed schedules provided by each Senior Team Leader. The current integrated detailed schedules are comprised of approximately 11,000 activities and 16,000 relationships (of which 196 are inter-project links that tie activities among the individual partner laboratory schedules). Project elements that are on or near the critical path include: Front End Systems, DTL, CCL, SCL, Ring components, Target installation, ready-for-equipment and beneficial occupancy in some buildings, and commissioning.

The SNS Change Control Process was reviewed by an independent panel of experienced consultants in January 2001. The results of the review were presented, as were a series of process improvements implemented during the last few months. Data was shown that indicated that the average time between generation of a Project Change Request and its implementation after approval has been reduced. The SNS Project Office plans to make additional modifications to the process, including a possible re-examination of both approval threshold levels and the number of change control boards. However, as noted above, the Committee heard conflicting information and was not presented with a complete list of known or likely Project Change Requests, nor total costs.

The integrated cost performance module (Microframe Project Manager) has been implemented, with start-up in November 2000. It now appears to be fully functional, including both the cost estimate and detailed schedule baselines. Project staff continue to maintain the Cost Estimate Database in parallel with the Microframe Project Manager system. Since this is essentially a duplication of effort, they propose to retire the Cost Estimate Database. The Committee supported this decision.

The technical baseline control systems appear to be extensive. SNS Project Office staff has made an effort to streamline the document control process. The Committee encouraged further simplification in this area.

6.2 Comments

The new baseline schedule is consistent with the overall funding envelope. While it assumes distribution of contingency over the life of the project, no contingency remains for FY 2001 and approximately nine percent is allocated for FY 2002. This approach to contingency management keeps the pressure on both cost and schedule performance. It is likely, however, that actual contingency needs will exceed the near-term contingency available, with some resultant slip in schedule as the only recourse. The budget obligations are being effectively tracked and managed against available Budget Authority, 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. In particular, the project intends to make several buildings available for initial installation of equipment (ready-for-equipment) prior to completion (beneficial occupancy). Although this method of accomplishment is certainly viable, significant detailed planning must be accomplished in order to mitigate potential interferences, understand any cost impacts due to introduced inefficiencies, and mitigate risk.

Critical path (or near critical path) activities are distributed among many areas of the project, indicating that resources have been distributed appropriately throughout the project. FY 2001 and FY 2002 activities that are schedule drivers include the Front End Systems and Conventional Facilities work.

7. INSTALLATION and PRE-OPERATIONS

7.1 Findings

This section addresses both component installation (a construction-funded activity) and pre-operations (an operating-funded activity). The latter topic includes accelerator commissioning, as well as planning for initial facility operations.

The planning by SNS, as established six months ago, to transfer the installation and commissioning efforts from the other partner laboratories to ORNL has advanced significantly, but it is still an ongoing activity. The installation and commissioning group established at SNS is very aware of their task and it is proceeding rapidly. The plan is reasonable and logical, and the details have been discussed with the partner laboratories who feel that the communications with SNS on installation and commissioning has greatly improved since the fall 2000 DOE review. Nonetheless, much work remains to complete this effort. Since installation and commissioning start after the conventional construction has finished, careful coordination is needed to make the schedules match.

The main reason for increasing the staff of the Accelerator Systems Division is to have an experienced and viable group of people at ORNL to operate the accelerators at SNS. The final size of the staff is therefore related to the anticipated size of the operating staff after completion of the project. The plan is for Accelerator Systems Division to reach 174 people by 2006 (CD-4), and a level of 230 people around 2008. Given the phased commissioning of SNS, the projected staffing level leading to 174 people in FY 2006 should be adequate. The proposal for first year operations following commissioning was not presented.

The concept of phased commissioning starting at the Front End and working downstream is very good. It will train the operations staff and set real milestones for many groups. The accelerator progress will benefit greatly. The installation plan of the Target Monolith has been well planned and represents significant work.

The Committee found that the setup for component testing and acceptance tests in the RATS facility should work as planned if nearby extra storage is acquired.

7.2 Comments

Planning for the Front End tests next year is well advanced, but needs to be verified to ensure consistency with conventional construction plans. The same comment applies to early Linac tests shortly thereafter.

The detailed delivery schedule dates for several components are not finalized. These dates are needed to make an integrated installation schedule of the overall project to minimize interference. Installation and commissioning are interleaved. A detailed plan of both should be developed to make full progress.

The “lead-mentor-consult” idea for installation and commissioning can be made to work well, but the Committee had concerns that funds at the end of the project may limit the mentor-consult component.

The installation plans involving Davis-Bacon workers could change with time and should be managed carefully. The source of tools for the installation workers should be specified. In addition, it is important to identify potential delays in the target installation sequence as many large components are installed in series and substantial delays are possible.

The Committee advised that it is important to develop an online accelerator physics model from the Front End to the Target for commissioning with beam data, and also to perform software application code dry runs before commissioning starts.

Lastly, SNS should develop staffing and budget requirements for the first full year of operation after most partner laboratory commissioning staff have returned home.

7.3 Recommendations

1. Identify a position with overall authority over SNS commissioning by the next DOE review.

2. Finalize the resource-loaded SNS installation and commissioning plan prior to the next DOE review and prior to conventional construction bid and award. The ready-for-equipment dates must be in the bid packages. [This recommendation is also an

Action Item—see Appendix I.]

3. Complete in detail the installation scope to be transferred from the partner laboratories to SNS Accelerator Systems Division, including a bottoms-up budgetary estimate before the next DOE review.

4. Write detailed "hand-off" component-boundary documents for each accelerator area including component lists, system checks, databases, and control software before the next DOE review.

5. Reserve some contingency funds for hardware rework discovered during commissioning.

6. Resolve the time overlap between installation of the Instruments and completing construction of the Instrument Hall by the next DOE review.

7. Develop remote commissioning of the SNS accelerator using off-site commissioners to maximize the use of the partner laboratories' expertise.

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8. MANAGEMENT (WBS 1.2)

8.1 Findings

A significant change has been made in the management of the SNS project since the fall 2000 DOE review. A new SNS Project Director, Deputy Project Director, and Accelerator Systems Division Director were selected and are fully functioning in their new positions. The SNS Director and the SNS Deputy Director held important management positions within the SNS project before their selection. In addition, the SNS Project Director is an internationally known neutron scientist with close ties to neutron user community.

Significant technical progress is continuing to be made on the project. By the end of March 2001, the overall project was about 22 percent complete with 56 percent of the design work finished and 82 percent of the R&D completed. Full-scale construction work is underway. Project contingency is almost 25 percent of the ETC ($170.5 million) with about five months of schedule contingency remaining (about eight percent). The project plans to spend or commit all of the $278.0 million in FY 2001 funds. Another $291.4 million has been requested for FY 2002.

ORNL management, led by the ORNL Director, continues to demonstrate significant support for the SNS project. Integration of the SNS project into the parent ORNL organization is ongoing. This integration is expected to facilitate the development of the SNS Research Program and provide cost efficiencies for shared resources.

Changes have also occurred in the size of the SNS Project Office staff. The staffing level was reduced from 69 to 57 FTEs. The project has simplified some of the project control and reporting requirements to meet the needs of the new management.

FY 2001 is the peak staffing year for the partner laboratories, and some roll-off of their staff has already begun. Detailed planning for the hand-off of responsibility from the partner laboratories to the SNS organization at ORNL is continuing.

The Memorandum of Agreement (MOA) between the SNS Project Office and the partner laboratories is being revised. This document reflects the business relationships required to manage the SNS project. The MOA is part of the Project Execution Plan, which defines the roles and responsibilities of all the SNS participants.

8.2 Comments

The transition to a new SNS Director and Deputy Director has been smooth. Communication among the new SNS Director, SNS partner laboratories, and DOE has been very good. Two key SNS management positions are currently vacant: an Experimental Facilities Division Director and a Conventional Facilities Division Director. The lead SNS management team members have limited prior experience on large scientific projects outside of SNS. While this is the third management team to be assigned to the SNS project, each team has made a significant contribution to its progress. Based on actions taken so far, the present SNS management team has gained the confidence of both ORNL and DOE management.

Projected contingency levels are satisfactory, but tight. Project cost and schedule status has been satisfactory (less than ten percent variances). Approximately $10 million in possible change orders are proposed and in process for the Change Control Board. Timeliness for resolving change control actions has been steadily improving.

The SNS project last performed a comprehensive, bottoms-up ETC in FY 1999. With the transition from design to construction and installation, the project should complete a bottoms-up ETC and implement it as the new baseline (see Section 5 recommendation). The SNS project will need to ensure that systems are in place to assess risk and evaluate alternatives concerning issues that could come up in the development of a revised ETC.

Project management systems are in place to provide adequate information to manage the project. A competent project team exists and the project is being adequately managed. The multiple laboratory partnering arrangement continues to present coordination challenges, as well as technical benefits. Installation and commissioning plans should be expeditiously completed to ensure that the coordination issues that typically arise during project transitions are minimized. These plans must therefore contain the details for the hand-off of components and systems, and identify positions that will ensure that strong leadership is exercised over installation and commissioning (see Section 7 recommendations 1-4).

With some exceptions listed in the respective technical sections of this report, the SNS project has been responsive to issues and recommendations identified at previous DOE reviews. Major issues from the fall 2000 DOE review have been addressed. The Conventional Facilities cost estimate has been contained at $307 million. The project instrument budget is consistent with original project commitments and allocated budget. The IPS is consistent with the Budget Authority funding profile and includes a six-month schedule contingency (with about five months left). The pre-operations cost estimate fits within the $1,411.7 million TPC.

The project's relationship with the State of Tennessee remains good, and SNS is viewed positively in Congress (as reflected by the FY 2001 appropriation).

The project cost estimate requires that the partner laboratories' staff rolls off of the project in a timely manner as assigned work is completed. Continued communication with the partner laboratories is needed to ensure that an orderly hand-off of knowledge and responsibilities occurs.

The SNS project should continue to pursue potential cost savings. This includes reductions in overhead accounts, potential savings in the project support functions, and efficiencies in project reporting. The project should identify priorities for any unspent contingency amounts for the next DOE review.

The SNS project baselines are consistent with the President's FY 2002 Budget Request of $291.4 million. Adequate plans are in place to expend the requested funding. The FY 2002 budget is only a modest increase from the current year's funding level. Project procurement experience has been good. Some recent bulk buys in the Conventional Facilities area represent notable cost savings. Nonetheless, SNS management will need to maintain very tight cost and schedule control in order to successfully achieve CD-4, Approve Start of Operations.

8.3 Recommendation

1. Prepare an estimate of the annual operating costs for the SNS facility by the next DOE review.

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(08-89) (EFG 07-90)

MAR 12 2001

MAR 14 REC'D

MAR 14 2001

United States Government — Department of Energy

Memorandum

DATE: MAR 2 2001

REPLY TO THE ATTN OF: SC-13

SUBJECT: A REQUEST TO ORGANIZE AND LEAD AN OFFICE OF SCIENCE SEMI-ANNUAL STATUS REVIEW OF SNS

TO: Daniel R. Lehman, Director, Construction Management Support Division

I would like to request that you organize and lead an Office of Science (SC) semi-annual status review of the Spallation Neutron Source (SNS) project in Oak Ridge, Tennessee, during May 15 - 17, 2001. The purpose of this review is to evaluate progress in all aspects of the project: technical, cost, schedule, management, and ES&H. In addition, the review committee should verify that the project's cost and schedule baselines are consistent with the President's FY 2002 Budget Request.

Beginning this spring, the SNS project plans to commence large-scale conventional construction activities at the Oak Ridge site. It is therefore important for the Department to confirm that conventional facilities design is sufficiently mature as the project begins making this major commitment of funds to the construction of SNS buildings and tunnels.

In addition, the December session of the last SC review recommended that the installation and commissioning plans, that were then in preliminary form, be completed and reviewed in more depth at the spring 2001 review.

In carrying out its charge, the review committee should respond to the following questions:

1. Are the project's cost, schedule, and technical baselines consistent with the President's FY 2002 Budget Request?

2. Is the project making adequate progress on all fronts to meet the baseline objectives?

3. Is the project being managed as needed for its proper execution?

4. Are the project's management systems functioning adequately to control cost, schedule, technical interfaces, and provide for configuration management?

5. Are the installation and commissioning plans reasonable from the standpoint of technical logic, costs, SNS staff buildup, and handoff of responsibilities from the partner labs?

6. Are the plans to commence large-scale construction of conventional facilities reasonable?

Distributed by W. J. Madia ✓

DATE 3-12-01

Akers ✓
Beierschmitt
Boykins ✓
Branham ✓
Debban ✓
Evans ✓
Gilliland ✓
Haerer ✓
Harris ✓
Mason ✓
Porter ✓
Preston ✓
Riedinger ✓
Roberto ✓
Smith ✓
Stair ✓
Turner ✓

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7. Are ES&H aspects being properly addressed given the project's current stage of development?

8. Has the project responded appropriately to recommendations from prior DOE/SC reviews?

Jeff Hoy, the SNS Program Manager, will work closely with you as necessary to plan and carry out this review. I would appreciate receiving your committee's report within 60 days of the review's conclusion.

Patricia M. Dehmer
Associate Director of Science
for the Office of Basic Energy Sciences

cc:
J. Decker, SC-1
M. Johnson, SC-2
L. Dever, SC-1
B. Weakley, SC-4
J. Turi, SC-80
J. Carney, SC-81
J. Hoy, SC-13
E. Cumesty, Oak Ridge Operations Office
G. Malosh, Oak Ridge Operations Office
L. Price, Oak Ridge Operations Office
W. Madia, Oak Ridge National Laboratory
T. Mason, SNS Project Office
C. Strawbridge, SNS Project Office

Department of Energy Review
of the
Spallation Neutron Source (SNS) Project
May 15-17, 2001

Daniel R. Lehman, DOE, Chairman
James R. Carney, DOE, Assistant Chairman

Support
Casey Clark, DOE/SC

SC1 Accelerator Physics	SC2 Front End, WBS 1.3 Control Systems, WBS 1.9	SC3 Linac System, WBS 1.4	SC4 Ring System, WBS 1.5	SC5 Installation Pre-Operations
* Rick Baartman, TRIUMF	* Ben Prichard, Jr., LANL	* Dixon Bogert, Fermilab	* Rod Gerig, ANL	* John Seeman, SLAC
Peter Ostroumov, ANL	Rusty Humphrey, SLAC	Bob Diebold, consultant	Richard Cassel, SLAC	Sheklar Mishra, Fermilab
		Ken Shepard, ANL	Mike May, Fermilab	Tom Roser, BNL

SC6 Conventional Facilities, WBS 1.8	SC7 Cost and Schedule	SC8 Project Management, WBS 1.2	SC9 ES&H	SC10 Target Systems, WBS 1.6 Instrument Systems, WBS 1.7
* Dale Knutson, PNNL	* Jim Krupnick, LBNL	* Bob Wunderlich, DOE/CH	* Rich Hislop, ANL	* Gunter Bauer, PSI
Dale Flowers, PNNL	Mike Osinski, DOE/SC	Klaus Berkner, LBNL	Arnold Clobes, LLNL	Gian Felcher, ANL
Greg Pitonak, DOE/PAO	Ralph Patterson, LLNL	Ed Moses, LLNL	Adam Cohen, ANL	Costas Stassis, Ames
Valerie Roberts, LLNL	Bob Simmons, PPPL			

Observers

Pat Dehmer, DOE/SC	Tara Elmore, DOE/IG	Andrew Gable, DOE/Argonne
Iran Thomas, DOE/SC	Eric Fowler, DOE/IG	Jeff Bostock, NRC
Jeff Hoy, DOE/SC	Dawnya Hathaway, DOE/IG	Lance Haworth, NSF
Bill Oosterhuis, DOE/SC	Debbie Solmonson, DOE/IG	Thomas Weber, NSF
Dennis Wilson, DOE/SC	David Treacy, DOE/OECM	Bob Marianelli, OSTP
Les Price, DOE/ORO	Mike Butler, DOE/BHG	Edward Keen, U. of California
Frank Chen, DOE/EH		

LEGEND
SC Subcommittee
* Chairperson

Count: 33 (excluding observers)

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Department of Energy Review
of the
Spallation Neutron Source (SNS) Project

DRAFT AGENDA

<u>Tuesday, May 15, 2001—SNS Building, 701 Scarboro Rd., Conference Room 101</u>

8:00 a.m.	DOE Full Committee Executive Session	Lehman
	– BES Program Perspective—Charge	Dehmer
	– DOE/ORO Perspective	Price
9:00 a.m.	Opening Remarks	
	– UT-Battelle Welcome	Madia
	– DOE Welcome	Dehmer
9:10 a.m.	SNS Overview	Mason
	– Management transition	
	– Baselines and FY 2002 Budget Request	
	– Re-baseline summary	
10:00 a.m.	Break	
10:15 a.m.	Project Management Overview	Strawbridge
	• Progress to technical/cost/schedule baseline objectives	
	• Cost/schedule performance	
	• Project management systems	
	• Construction safety and ES&H performance	
	• Reponse to prior DOE Reviews	
	• Installation and commissioning	
10:45 a.m.	Experimental Facilities Summary	Gabriel
	• Status of R&D and design	
	• Summary and implementation of re-baseline	
	• Installation and commissioning plans	
11:00 a.m.	Accelerator Systems Summary	Holtkamp
	• Status of R&D and design	
	• Summary and implementation of re-baseline	
	• Installation and commissioning plans	
11:30 a.m.	Conventional Facilities Summary	Chargin
	• Implementation of re-baseline	
	• Design progress	
	• Construction Plans	
12:00 p.m.	Lunch	
12:45 p.m.	Site tour	

1:45 p.m. Parallel Subcommittee Presentations/Discussions
- Accelerator Systems (SC1-5)..Holtkamp/STLs
- Conventional Facilities (SC6)...Chargin/Staff
- Experimental Facilities (SC5, SC10).................................Gabriel/STLs

(Management/Cost & Schedule/ES&H Subcommittees (SC7-9) meet with above subcommittees)

4:45 p.m. DOE Subcommittee Executive Session
5:00 p.m. DOE Executive Session ....Lehman
6:30 p.m. Adjourn

Wednesday, May 16, 2001

8:00 a.m. Continue Parallel Subcommittee Presentations/Discussions
- Accelerator Systems..Holtkamp/STLs
- Experimental Facilities ....Gabriel/STLs
- Conventional Facilities ....Chargin/Staff

(Management/Cost/Schedule/ES&H (SC7-9) meet with others until 9:00 am)

9:00 a.m. Cost/Schedule Subcommittee (SC7)..........................Boudwin/Herron/Staff
9:00 a.m. Management Subcommittee (SC8) ....Mason/Strawbridge
SNS Division Directors
12:00 p.m. Lunch
2:30 p.m. DOE Subcommittee Executive Session
3:00 p.m. DOE Full Committee Executive Session

Thursday, May 17, 2001

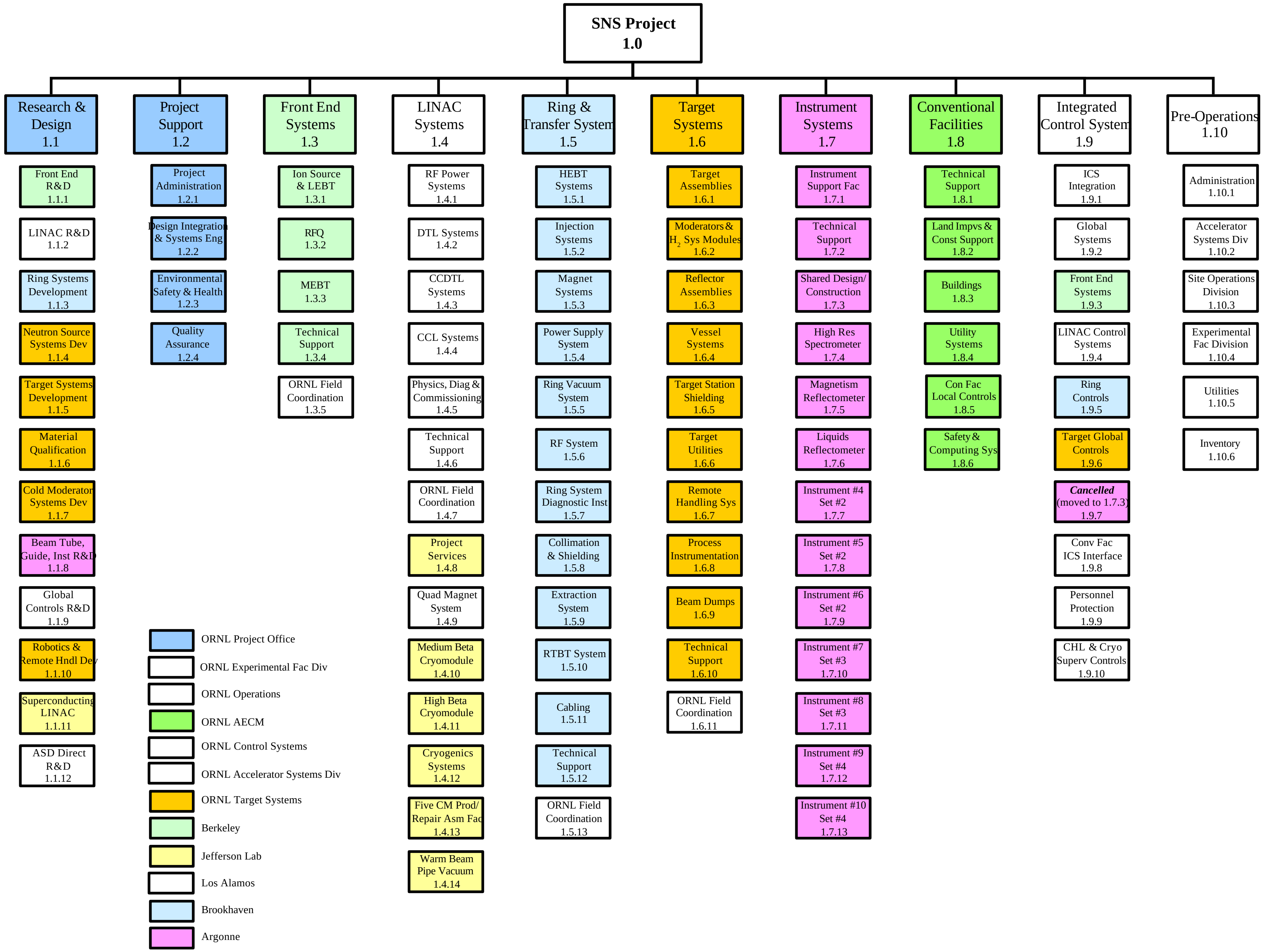
8:30 a.m. Subcommittee Working Sessions
10:00 a.m. DOE Full Committee Executive Session Closeout Dry Run
12:00 p.m. Lunch
1:30 p.m. Closeout with DOE and SNS Management
2:30 p.m. Adjourn

Cost Baseline

WBS	Item	10/00 Baseline $M		May Review Baseline* $M	
1.2	Project Support	75.5		75.3	
1.3	Front End	19.2		19.3	
1.4	Linac Systems	256.8		264.3	
1.5	Ring and Transfer System	130.5		145.3	
1.6	Target Systems	91.9		93.0	
1.7	Instrument Systems	93.0		60.0	
1.8	Conventional Facilities	300.3		307.5	
1.9	Integrated Control	58.3		57.5	
	BAC	1025.5		1,022.2	
	Contingency	167.2	20.2%**	170.5	24.6%**
	TEC	1,192.7		1,192.7	
	R&D	108.0		103.7	
	Pre-Ops	111.0		115.3	
	TPC	1,411.7		1,411.7	
	EDIA		47.5%		35.1%

*Rev. 193.

**Based on ETC of $692.2M (estimated costs & commitments through April 2001).


SNS Project 1.0
Research & Design 1.1
Front End R&D 1.1.1
LINAC R&D 1.1.2
Ring Systems Development 1.1.3
Neutron Source Systems Dev 1.1.4
Target Systems Development 1.1.5
Material Qualification 1.1.6
Cold Moderator Systems Dev 1.1.7
Beam Tube, Guide, Inst R&D 1.1.8
Global Controls R&D 1.1.9
Robotics & Remote Hndl Dev 1.1.10
Superconducting LINAC 1.1.11
ASD Direct R&D 1.1.12
Project Support 1.2
Project Administration 1.2.1
Design Integration & Systems Eng 1.2.2
Environmental Safety & Health 1.2.3
Quality Assurance 1.2.4
Front End Systems 1.3
Ion Source & LEBT 1.3.1
RFQ 1.3.2
MEBT 1.3.3
Technical Support 1.3.4
ORNL Field Coordination 1.3.5
LINAC Systems 1.4
RF Power Systems 1.4.1
DTL Systems 1.4.2
CCDTL Systems 1.4.3
CCL Systems 1.4.4
Physics, Diag & Commissioning 1.4.5
Technical Support 1.4.6
ORNL Field Coordination 1.4.7
Project Services 1.4.8
Quad Magnet System 1.4.9
Medium Beta Cryomodule 1.4.10
High Beta Cryomodule 1.4.11
Cryogenics Systems 1.4.12
Five CM Prod/ Repair Asm Fac 1.4.13
Warm Beam Pipe Vacuum 1.4.14
Ring & Transfer System 1.5
HEBT Systems 1.5.1
Injection Systems 1.5.2
Magnet Systems 1.5.3
Power Supply System 1.5.4
Ring Vacuum System 1.5.5
RF System 1.5.6
Ring System Diagnostic Inst 1.5.7
Collimation & Shielding 1.5.8
Extraction System 1.5.9
RTBT System 1.5.10
Cabling 1.5.11
Technical Support 1.5.12
ORNL Field Coordination 1.5.13
Target Systems 1.6
Target Assemblies 1.6.1
Moderators & H2 Sys Modules 1.6.2
Reflector Assemblies 1.6.3
Vessel Systems 1.6.4
Target Station Shielding 1.6.5
Target Utilities 1.6.6
Remote Handling Sys 1.6.7
Process Instrumentation 1.6.8
Beam Dumps 1.6.9
Technical Support 1.6.10
ORNL Field Coordination 1.6.11
Instrument Systems 1.7
Instrument Support Fac 1.7.1
Technical Support 1.7.2
Shared Design/ Construction 1.7.3
High Res Spectrometer 1.7.4
Magnetism Reflectometer 1.7.5
Liquids Reflectometer 1.7.6
Instrument #4 Set #2 1.7.7
Instrument #5 Set #2 1.7.8
Instrument #6 Set #2 1.7.9
Instrument #7 Set #3 1.7.10
Instrument #8 Set #3 1.7.11
Instrument #9 Set #4 1.7.12
Instrument #10 Set #4 1.7.13
Conventional Facilities 1.8
Technical Support 1.8.1
Land Impvs & Const Support 1.8.2
Buildings 1.8.3
Utility Systems 1.8.4
Con Fac Local Controls 1.8.5
Safety & Computing Sys 1.8.6
Integrated Control System 1.9
ICS Integration 1.9.1
Global Systems 1.9.2
Front End Systems 1.9.3
LINAC Control Systems 1.9.4
Ring Controls 1.9.5
Target Global Controls 1.9.6
Cancelled (moved to 1.7.3) 1.9.7
Conv Fac ICS Interface 1.9.8
Personnel Protection 1.9.9
CHL & Cryo Superv Controls 1.9.10
Pre-Operations 1.10
Administration 1.10.1
Accelerator Systems Div 1.10.2
Site Operations Division 1.10.3
Experimental Fac Division 1.10.4
Utilities 1.10.5
Inventory 1.10.6
ORNL Project Office
ORNL Experimental Fac Div
ORNL Operations
ORNL AECM
ORNL Control Systems
ORNL Accelerator Systems Div
ORNL Target Systems
Berkeley
Jefferson Lab
Los Alamos
Brookhaven
Argonne

SNS Budget Authority (BA) Profile

(Actual Year thousands of dollars)

	Prior Years	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
Construction Line Item		101,400	100,000	258,929	276,300	210,571	124,600	79,800	41,100	1,192,700
Operating Expense	38,578	28,600	17,900	19,059	15,100	14,441	18,397	33,100	33,825	219,000
Total BA	38,578	130,000	117,900	277,988	291,400	225,012	142,997	112,900	74,925	1,411,700

Funding profile from President's FY 2002 Budget Request

Spallation Neutron Source Funding Profiles

(Actual Year thousands of dollars)

	BA Profile									
	Prior Years	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
Line Item		101,400	100,000	261,900	290,200	222,400	131,400	81,600	31,100	1,220,000
Tax on Line Item			0	2,400	8,500	8,000	6,600	1,800		27,300
New Line Item		101,400	100,000	259,500	281,700	214,400	124,800	79,800	31,100	1,192,700

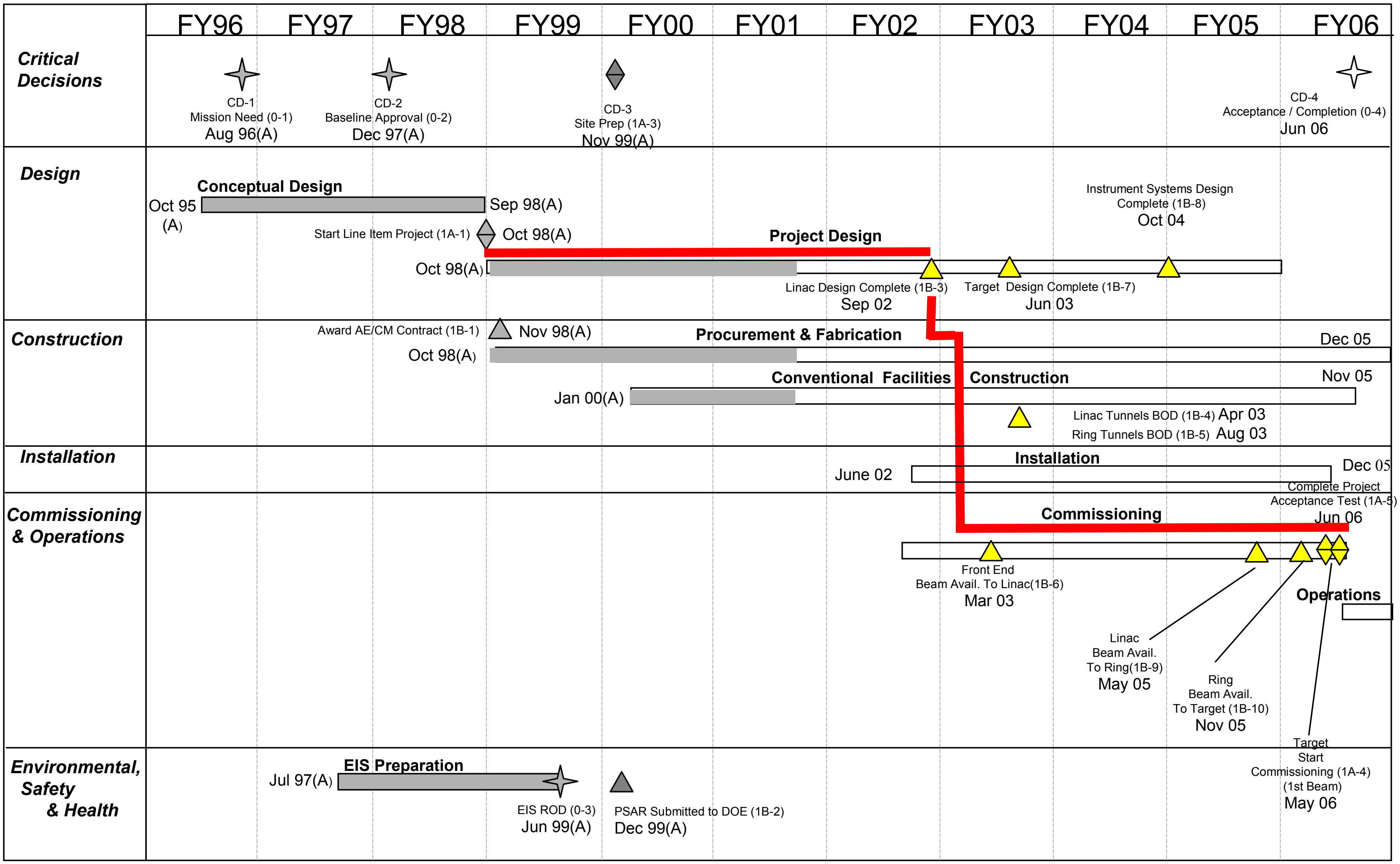
	BO Profile									
	Prior Years	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
Line Item		37,140	133,960	249,900	289,100	224,400	142,800	91,600	51,100	1,220,000
Tax on Line Item				2,400	8,500	8,000	6,600	1,800		27,300
New Line Item		37,140	133,960	247,500	280,600	216,400	136,200	89,800	51,100	1,192,700

Spallation Neutron Source Funding Profiles

(Actual Year thousands of dollars)

Profile supporting the proposed new FY 2001 Data Sheet

	BA/BO Profile								
	Prior Years	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**Total**
R&D		27,800	17,000	16,200	5,400	3,700	2,600			72,700
Tax on R&D				100						100
New R&D		27,800	17,000	16,100	5,400	3,700	2,600	0	0	72,600
Pre-Ops		800	900	2,900	4,400	6,400	16,000	33,400	44,000	108,800
Tax on Pre-Ops					100	200	200	300	100	900
New Pre-Ops		800	900	2,900	4,300	6,200	15,800	33,100	43,900	107,900
Total BA/BO	38,500	28,600	17,900	19,000	9,700	9,900	18,400	33,100	43,900	219,000

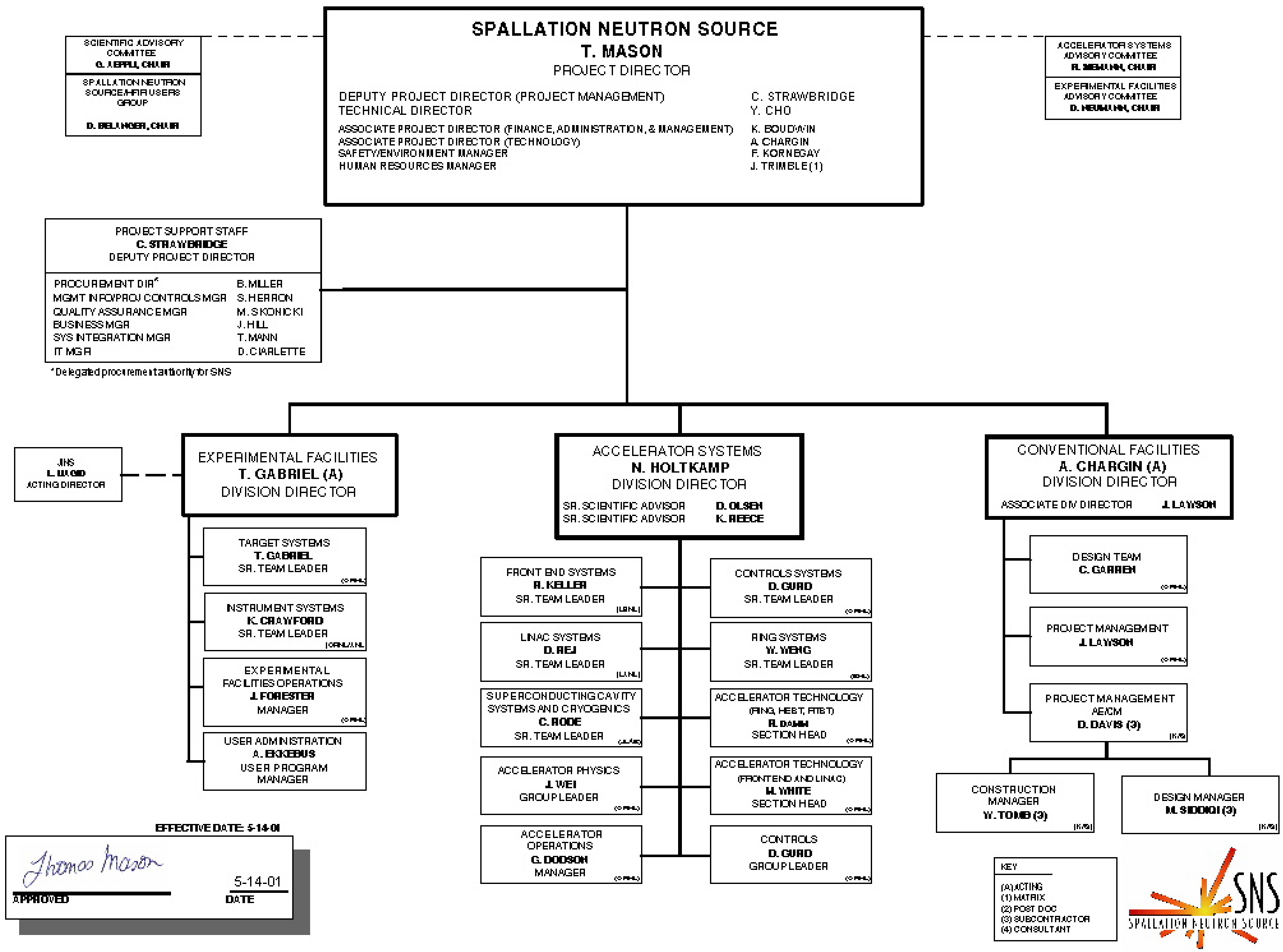


Legend

- (A) Actual Date
- Completed
- Critical Path
- Level 0 Milestones
- Level 1A Milestones
- Level 1B Milestones

Spallation Neutron Source
Project Summary Schedule
MAY 2001

SNS Project Organization



GLOSSARY

β	beta (particle velocity divided by speed of light)
H^-	negatively-charged hydrogen ions
Q-ω	momentum energy
AE/CM	Architect Engineer/Construction Manager
ANL	Argonne National Laboratory
BNL	Brookhaven National Laboratory
CCL	Cavity Coupled Linac
CD	Critical Decision
CF	Conventional Facilities
CPI	Cost Performance Index
DOE	U.S. Department of Energy
DTL	Drift Tube Linac
EAC	Estimate-at-Completion
EDI	Engineering, Design and Inspection
EPICS	Experimental Physics and Industrial Control System
ES&H	environment, safety, and health
ETC	Estimate-to-Complete
FELK	Front End, Linac Tunnel, and Klystron Gallery
FTE	full time equivalent
FSAD	Final Safety Assessment Document
FSAR	Final Safety Analysis Report
FY	fiscal year
GAO	General Accounting Office
GeV	billion electron volts
HEBT	High Energy Beam Transport
IPS	Integrated Project Schedule
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LEBT	Low Energy Beam Transport
Linac	linear accelerator

mA	milli Ampere
MAP	Mitigation Action Plan
MEBT	Medium Energy Beam Transport
MeV	million electron volts
MOA	Memorandum of Agreement
MVA	mega Volt Ampere
MV/m	mega Volts per meter
MW	million watts
ORNL	Oak Ridge National Laboratory
PEP	Project Execution Plan
PSAD	Preliminary Safety Assessment Document
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
R&D	research and development
RATS	Receiving, Assembly, Test and Storage
RF	radio frequency
RFQ	radio frequency quadrupole
RFP	request for proposals
RTBT	Ring to Target Beam Transport
SCL	superconducting linac
SNS	Spallation Neutron Source
SPI	Schedule Performance Index
SRF	superconducting radio frequency
TEC	Total Estimated Cost
TJNAF	Thomas Jefferson National Accelerator Facility
TPC	Total Project Cost
WBS	Work Breakdown Structure

Action Items

Resulting from the May 2001
Department of Energy Review of the

Spallation Neutron Source

Action	Responsibility	Due Date
1. Plan and fund the timely delivery of an RF system for full tests of cryomodules at TJNAF.	SNS	ASAP
2. Conduct a Semi-Annual Project Status Review	DOE/SNS	November 6-8, 2001
3. Complete the installation and commissioning plans by the next SC Review.	SNS	November 2001

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