Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

SPALLATION NEUTRON SOURCE (SNS) PROJECT

November 2003

EXECUTIVE SUMMARY

A Department of Energy, Office of Science review of the Spallation Neutron Source (SNS) project was conducted at Oak Ridge, Tennessee on November 4-6, 2003, at the request of Dr. Patricia M. Dehmer, Associate Director of Science for the Office of Basic Energy Sciences. The purpose of the review was to evaluate progress in all aspects of the project: technical, cost, schedule, management, and environment, safety and health. Special emphasis was given to evaluating how well the project is managing contingency, its adequacy for completing the remaining project work, and identifying areas where improvements could be made to ensure that the project is completed within the $1,411.7 million Total Project Cost (TPC).

Overall, the Committee found that the SNS project is appropriately managing the issues and can meet its Level 0 Baseline objectives: a TPC of $1,411.7 million; project completion by June 2006; and at least 1 megawatt proton beam power on target. The biggest challenge continues to be cost, and contingency management is a major concern. Contingency funds (based on the Estimate-at-Completion or EAC) have been reduced during the last six months from $44.6 million to $31.3 million with about $316 million worth of line item work in the baseline left to be costed. The Committee challenged the project to identify additional cost savings and maintain contingency above $25 million (based on the EAC) by the next DOE review. The Committee recommended that the project develop a plan for transferring staff to the SNS operating budget in FY 2006 as major subsystems are successfully commissioned.

Although the project's critical path is not presently impacted, production problems with Linac components have remained a significant cost/schedule issue. Progress on fabrication and assembly of the Drift Tube Linac (DTL) is somewhat behind schedule, but acceptable. More recently, superconducting cryomodule production has fallen behind schedule, and the project has developed and begun implementation of a recovery plan, which the Committee endorsed. Appropriate management attention at all levels has been dedicated to resolving both the DTL and cryomodule production issues.

Per a May 2003 DOE review Action Item, an End Game Plan was prepared, reviewed by DOE, and implemented in September 2003, bringing the SNS cost, schedule, and technical baselines in line with the Budget Authority funding profile in the FY 2004 Project Data Sheet and the Project Execution Plan. In part, this was accomplished by re-sequencing work in the Integrated Project Schedule that extends the overall project internal working schedule from December 2005 to March 2006, which reduces the amount of schedule contingency to about four months.

Technical and construction progress have continued to be excellent, and as of September 30, 2003, the project is 72 percent complete versus 73 percent planned. The information in DOE's Project Assessment and Reporting System accurately reflects this status. Technical milestones completed since the May 2003 DOE review included: commissioning DTL Tank #1, completion of Ring design and start of Ring installation, installation of the Target Core Vessel, and completion of the Target Systems design and R&D. In addition, beneficial occupancy of the Ring and Ring to Target Beam Transfer Service Buildings, Cooling Tower, Central Utility Building, and Linac and Ring Extraction Dumps has been accomplished. Market experience has remained good with over 95 percent of SNS procurements awarded. The project's safety record has remained outstanding with over 4.4 million work hours without a lost workday injury.

The SNS project is a multi-laboratory partnership led by the SNS Project Office in Oak Ridge, Tennessee. The partners are Argonne National Laboratory (ANL), Brookhaven National Laboratory, Lawrence Berkeley National Laboratory (LBNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Thomas Jefferson National Accelerator Facility. Relations among the SNS partner laboratories continue to be excellent and internal communications are generally good. Two of the laboratories (ANL and LBNL) have completed their original scopes of work and transitioned off of the project, except for a newly agreed upon participation of LBNL in the Linac Low Level RF work. LANL is scheduled to complete its work and transition off of the project in 2004. The new ORNL Director is very supportive of the SNS and has been actively engaged in assisting with its progress.

The SNS project was responsive to the recommendations and Action Items from the May 2003 DOE review. At this review, the Committee made 26 recommendations and assigned one Action Item (to conduct the next DOE review during May 11-13, 2004).

In summary, the Committee found that the SNS project is still on track to meet its Level 0 Baseline objectives, and SNS management is on top of the issues including those associated with production of Linac components. The biggest challenge continues to be cost, and contingency management is a major concern.

CONTENTS

Executive Summary i
1. Introduction 1
2. Technical Systems Evaluations 11
    2.1 Linac Systems (WBS 1.4) 11
    2.2 Ring Systems (WBS 1.5) 21
    2.3 Target Systems (WBS 1.6) 25
    2.4 Instrument Systems (WBS 1.7) 28
    2.5 Control Systems (WBS 1.9) 34
3. Conventional Facilities (WBS 1.8) 37
4. Accelerator Physics/Pre-Operations (WBS 1.10) 41
5. Environment, Safety and Health 45
6. Cost Estimate 47
7. Schedule and Funding 51
8. Management (WBS 1.2) 53

Appendices
A. Charge Memorandum
B. Review Participants
C. Review Agenda
D. Cost Table
E. Funding Table
F. Schedule Chart
G. Management Chart
H. Action Items
I. Glossary

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 in a Front End and accelerated to an energy of one billion electron volts (1 GeV) using a linear accelerator (Linac). The H^- beam will then be transported to an accumulator ring, where it will be injected by stripping away the electrons to leave the desired protons to be collected in the ring. Finally, the protons stored in the ring are directed in a short (under one microsecond) pulse onto a liquid mercury target at a rate of 60 pulses per second, 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 pictorial 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 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 (CF) is being handled by a commercial architect engineer/construction management (AE/CM) team (Knight-Jacobs) under a task order contract to ORNL.

The SNS conceptual design was carried out during FY 1996/1997, at a cost of about $16 million, and evaluated by a DOE review committee in June 1997 (report DOE/ER-0705). Later that same year, a DOE Independent Cost Estimate was performed. In response to

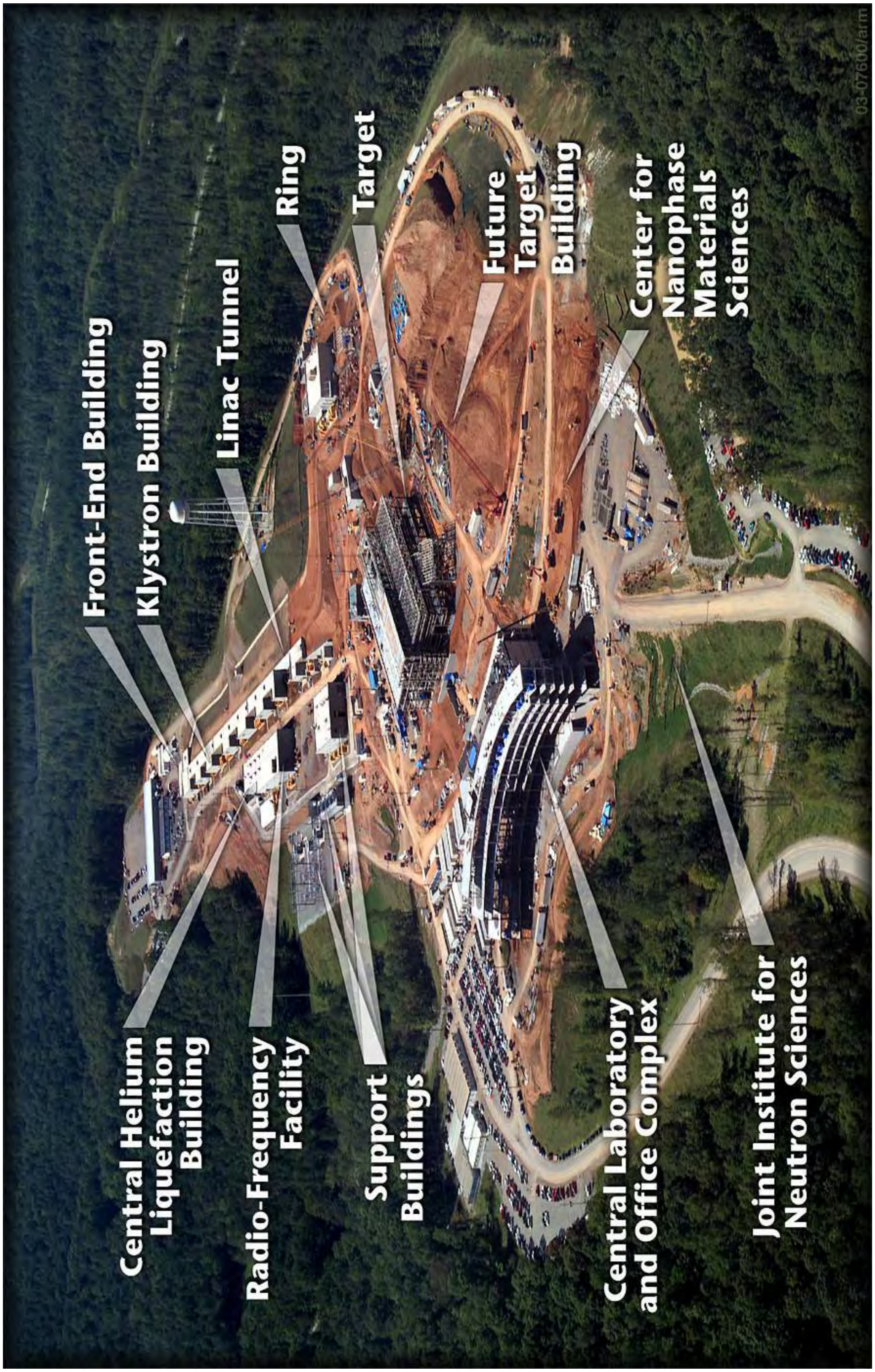


Figure 1-1. Spallation Neutron Source Facility

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 $1,266 million to $1,333 million (as spent[1]).

Critical Decision (CD) 1, Approval of Mission Need, and CD-2, Approve Performance Baseline and PEP, for the SNS were approved by the Secretary of Energy in August 1996 and December 1997, respectively. The SNS PEP, which governs how the project is managed, was most recently updated in April 2002. The Level 0 Cost and Schedule Baselines set at CD-2 comprised a TPC of $1,333 million and a seven-year design/construction schedule, with facility commissioning to occur at the end of FY 2005. The approved Level 0 Technical Baseline stipulated that the accelerator complex would be capable of producing 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 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 beginning in FY 1999. Further work was deemed necessary, however, to complete a detailed cost and schedule baseline, and to restore project contingency to at least 20 percent. A strong recommendation was made to hire a permanent Project Director as soon as possible and to continue building the Accelerator Systems Division (ASD) at ORNL.

At the start of FY 1999, the 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 (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 October 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. and Knight has since been acquired by M+W Zander, but the joint venture retains the name Knight-Jacobs). The AE/CM team is responsible for design and construction of all CF.

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

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

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

A Final Environmental Impact Statement for the SNS was issued in April 1999. On June 18, 1999, the Secretary of Energy signed the Record of Decision to proceed with construction of the SNS at ORNL on Chestnut Ridge (the preferred site). A Mitigation Action Plan (MAP) was prepared, identifying actions taken by DOE and the project to avoid or minimize environmental harm in building and operating the facility. All actions identified in the MAP have been properly implemented.

In July 1999, another DOE review was conducted for the purpose of evaluating the project's proposed technical, cost, and schedule baselines. The review committee judged the baselines to be credible and consistent with the FY 2000 Budget Request funding profile, and recommended their approval by DOE. Confidence was expressed that the new SNS project team could lead the project to success; however, the committee emphasized the need to improve LANL's management approach for the Linac and for the project team to permanently fill the lead CF position. The committee felt that the management team had moved aggressively to take full ownership of all technical, cost, and schedule aspects of the project, and defined a clear vision and a disciplined management approach.

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

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. As FY 2000 began, the project used FY 1999 uncosted obligations to continue making progress until satisfying the stated congressional conditions. In particular, DOE approved CD-3, Start Construction, on November 19, 1999, and site preparation work on Chestnut Ridge began soon thereafter. A formal groundbreaking ceremony for SNS was held on December 15, 1999. By February 2000, DOE and the project had satisfied the seven congressional conditions and all FY 2000 construction funds were released to the project. Later in FY 2000, the project managed to complete most Title I design activities, as well as nearly all site clearing, excavation, and road work.

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

Another condition imposed by Congress was that the General Accounting Office (GAO) had to certify that the total taxes and fees on SNS paid to the State of Tennessee or its counties/ municipalities would be no greater than if SNS were located in any other state that contains a DOE laboratory. In response, the Tennessee Legislature enacted a law in January 2000 to completely exempt SNS from state and local sales and use taxes (estimated at $28.3 million). This tax exemption addressed the last remaining condition in the House report, and GAO provided the necessary certification. The TPC was then reduced from $1,440 million to $1,411.7 million.

In March 2000, another DOE review was conducted for the purpose of evaluating progress in all aspects of the project: technical, cost, schedule, management, and environment, safety and health. The committee judged that the new management team was making good progress due to their demonstrated ownership of all technical, cost, and schedule aspects of the project. Cost and schedule information supported the President's FY 2001 Budget Request, and the committee expressed confidence that the project could be successfully completed as planned by June 2006 and within the $1,411.7 million TPC. The project's proposal to change the high-energy end of the Linac to a superconducting design was supported, subject to completion of necessary R&D as soon as possible, and TJNAF was added as a partner laboratory on the project. The SNS Integrated Project Schedule (IPS) was found to be resource-loaded, self-consistent and supported by detailed schedules, and the management control systems (configuration control and earned value reporting) were found to be working adequately. Previously identified issues with LANL's management approach had been resolved with their establishment of a dedicated SNS Linac Division.

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

Congress appropriated the entire requested amount for FY 2001 (minus a $512,000 rescission) and DOE provided the project with $258.9 million in construction funds and $19.1 million in operating expense funds.

In October and December 2000, a two-phase DOE review was conducted that included an initial evaluation of the SNS pre-operations plan and cost estimate. Three major issues were identified in the first review phase, two of which had to do with the potential for significant cost growth in different areas, one in CF and the other in pre-operations. It was also noted that the project was using contingency at an alarming rate. The cost growth concerns stemmed from the AE/CM's preliminary Title I design estimate for CF, which was about $80 million over the cost baseline, and an overly aggressive pre-operations staffing plan. The third issue was that the IPS was more aggressive (i.e., provided 14 months of float) than could be supported by the FY 2001 Project Data Sheet's annual Budget Authority (BA) 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 while providing a facility that meets or exceeds the capabilities defined in the Conceptual Design Report. There were significant scope reductions or deferrals in CF that included deferring a commitment to construct the Central Laboratory and Office (CLO) Building, reducing the size of the Target Building, and reducing the instrument budget from $93 million to $53 million (still more than the conceptual design level of $45 million). In addition, the last three cryomodules of the Superconducting Linac (SCL) were deleted to save money, resulting in an estimated lower Linac output energy of 840 million electron volts (MeV), while still providing a proton beam power on target capability of over 1 MW (the Level 0 Baseline parameter). The pre-operations staffing level was returned to the initial level, i.e., the minimum level necessary to commission the machine. Lastly, the IPS was re-planned to be more consistent with the BA in DOE's annual funding profile and still provide six months of schedule contingency.

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

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

In May 2001, another DOE review was conducted. Special emphasis was given to the SNS installation and commissioning plans, and there was a confirmation that project cost and schedule baselines were consistent with the President's FY 2002 Budget Request. The committee judged that the project was making satisfactory progress; that the three issues noted in the October 2000 review had been resolved; Linac energy output had been restored to 1GeV; the number of state-of-the-art instruments stood at five with a total instrument budget of $60 million; and a reduced-cost CLO Building was included. There had been a smooth transition to a new Project Director and Deputy Director since the previous review, and a search was under way to permanently fill Division Director positions for XFD and CFD. An outstanding technical concern regarding the performance of the new cryomodules led to a recommendation to establish a radio frequency (RF) test stand at TJNAF.

In the November 2001 DOE progress review, special emphasis was given to evaluating the SNS updated Estimate-to-Complete (ETC), as well as installation and commissioning plans. The committee judged that the project was continuing to make satisfactory progress and remained on track to meet its Level 0 Baseline objectives. Technical progress had been excellent since the May 2001 review, with the design baseline exceeding requirements, five Best-in-Class instruments had been baselined, RF testing capability was being established at TJNAF, and there was significant progress on component fabrication and site construction. The committee endorsed the project's proposed ETC, and a Baseline Change Proposal (BCP) was processed in December 2001 to incorporate it into the project baseline.

The May 2002 DOE progress review found that over 60 percent of all project procurements had been placed, the Front End was scheduled for shipment to ORNL in June 2002, conventional construction was progressing with some facilities nearing completion, and over 600,000 construction work-hours had been accumulated without a lost workday injury. Two areas of concern were raised by the committee that resulted in recommendations. First, there was a need for a quantitative, risk-based contingency analysis to be prepared, and second, until a definitive solution could be found for the recently identified target window pitting issue, the project should retain a solid target back-up design.

In the November 2002 DOE review, special emphasis was given to evaluating the project's decision to retain the liquid mercury target concept in the baseline, and to whether project contingency was adequate to address the risks associated with completing the SNS on schedule. The committee found that the project remained on track to meet its Level 0 Baseline objectives, and that the baseline was consistent with the FY 2003 Project Data Sheet and the PEP. The project reported that SNS was over 51 percent complete with more than 90 percent of all procurements placed. The Front End Systems had arrived in ORNL, and were being commissioned. Two problem areas had recently surfaced with the Linac, including: 1) vacuum leaks in a large fraction of the Drift Tubes supplied to LANL by a vendor required rework or rebuilding; and 2) the Low Level Radio Frequency (LLRF) Control System being developed by LANL fell seriously behind schedule and could not meet functional requirements. The committee recommended that the SNS Project Director and both Directors of ORNL and LANL become involved in a Drift Tube recovery plan, and that ORNL/SNS assume the lead role in a joint ORNL/LBNL/LANL team to resolve the LLRF problem. After a review of test results to understand the target pitting issue, the committee concurred with the project's decision to retain the liquid mercury target as the baseline design.

The FY 2001, 2002, and 2003 congressional appropriations for SNS have met the levels contained in the President's Budget Requests ($278.0 million, $291.4 million, and $225.0 million, respectively). Accordingly, the project's TEC and TPC have remained constant at $1,192.7 million and $1,411.7 million, respectively. The FY 2002 appropriation was the peak of the project's annual funding profile. The President's FY 2004 Budget Request for SNS is $143.0 million.

As of September 30, 2003, the overall project was 72 percent complete, had awarded 95 percent of procurements, and completed 92 percent of all design work, 97 percent of R&D, 70 percent of conventional construction, 66 percent of technical hardware, and 39 percent of installation. Beneficial occupancy of the Ring and Ring Target to Beam Transport (RTBT) Service Buildings, Ring and RTBT Tunnels, Cooling Tower, Central Utility Building, and Linac and Ring Extraction Dumps has been accomplished. The site has transitioned from temporary to permanent electrical power. The last two remaining major civil construction activities are the Target Building (62 percent complete) and the CLO Building (45 percent complete). The project has logged a safety record of over 2.5 million work hours without a lost work day away case. Completed technical milestones include: commissioned DTL Tank #1, continued Linac and Target installation, completed Ring design and started Ring installation, installed the Target Core Vessel, and completed Target Systems design and R&D. The overall size of the project work force, including construction workers, is about 1,100 full-time equivalents (FTEs), and has started to decline as civil construction approaches completion in March 2005 and the partner laboratories transition off of the project (as have ANL and LBNL).

1.2 Charge to the DOE Review Committee

In an August 26, 2003 memorandum (see Appendix A), Dr. Patricia M. Dehmer, Director for Basic Energy Sciences, Office of Science (SC), requested that Daniel R. Lehman, Director, Construction Management Support Division lead a review to evaluate all aspects of the project, including technical, cost, schedule, management, and ES&H. In addition, the Review Committee was asked to verify that the project's technical, cost, and schedule baselines are consistent with the current DOE-approved SNS PEP and FY 2004 Project Data Sheet. The Front End Systems (WBS 1.3) was not explicitly covered in this review because it has now been completed and installed at SNS.

1.3 Membership of the Committee

The Review Committee (see Appendix B) was chaired by Daniel R. Lehman and James R. Carney. 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 have served on one or more of the previous eleven 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 November 4-6, 2003, at Oak Ridge, Tennessee. The agenda (Appendix C) was developed with the cooperation of the SNS Project Office, DOE/SC 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 first day was devoted to project overview plenary sessions with presentations given by members of the SNS Project Office staff and a tour of the construction site. In the afternoon and on the second day, there were presentations by the partner laboratories 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 at a closeout session on the last day.

2. TECHNICAL SYSTEMS EVALUATIONS

2.1 Linac Systems (WBS 1.4)

The Linac structure is unchanged since the May 2003 DOE review. As shown in Figures 2-1and 2-2, the Linac structure is a conventional Drift Tube Linac (DTL) to 87 MeV, a Coupled Cavity Linac (CCL) from 87 to 186 MeV, a "medium-β" (β =0.61) SCL from 186 MeV to 379 MeV, and a "high- β" (β =0.81) SCL from 379 MeV to approximately 1 GeV. The medium- β SCL has 33 cavities in 11 modules and the high- β SCL has 48 cavities in 12 modules.

2.1.1 Findings

Good progress has been made since the May 2003 DOE review. The two areas that were identified as requiring particular attention in the November 2002 DOE review report and for which significant progress was reported for their remediation in the May 2003 DOE review report are now regarded as fully recovered. These items concerned hardware problems with the DTL and the LLRF Control System. A brief report of findings on these two subjects follows:

1. The manufacturing flaws in the DTL have been completely mitigated. Four tanks have been delivered to SNS. Tanks #1 and #3 are installed, aligned, and conditioned. Tanks #4 and #5 are being prepared for installation at SNS, and Tanks #2 and #6 will be shipped soon. Significant engineering and technical oversight was provided to achieve the successful remediation, and no outstanding issues remain. Tank #1 was included in a successful integrated test of all subsystems, and is expected to fully meet the project specifications, as will all the other DTL tanks. The project-wide cooperation and response have been exemplary.

2. The LLRF Control System recovery plan has been brought to a successful conclusion, and an internal SNS project committee has closed out this issue. A third generation "Field Control Module" and all support hardware have been developed, tested, accepted, and procurement for all components is underway for the full complement needed. This system was tested with beam on the radio-frequency quadrupole (RFQ) in September, and without beam in DTL Tank #3 and later in DTL Tank #1. The required amplitude and phase regulation were achieved. Again, the response to this problem has been exemplary.

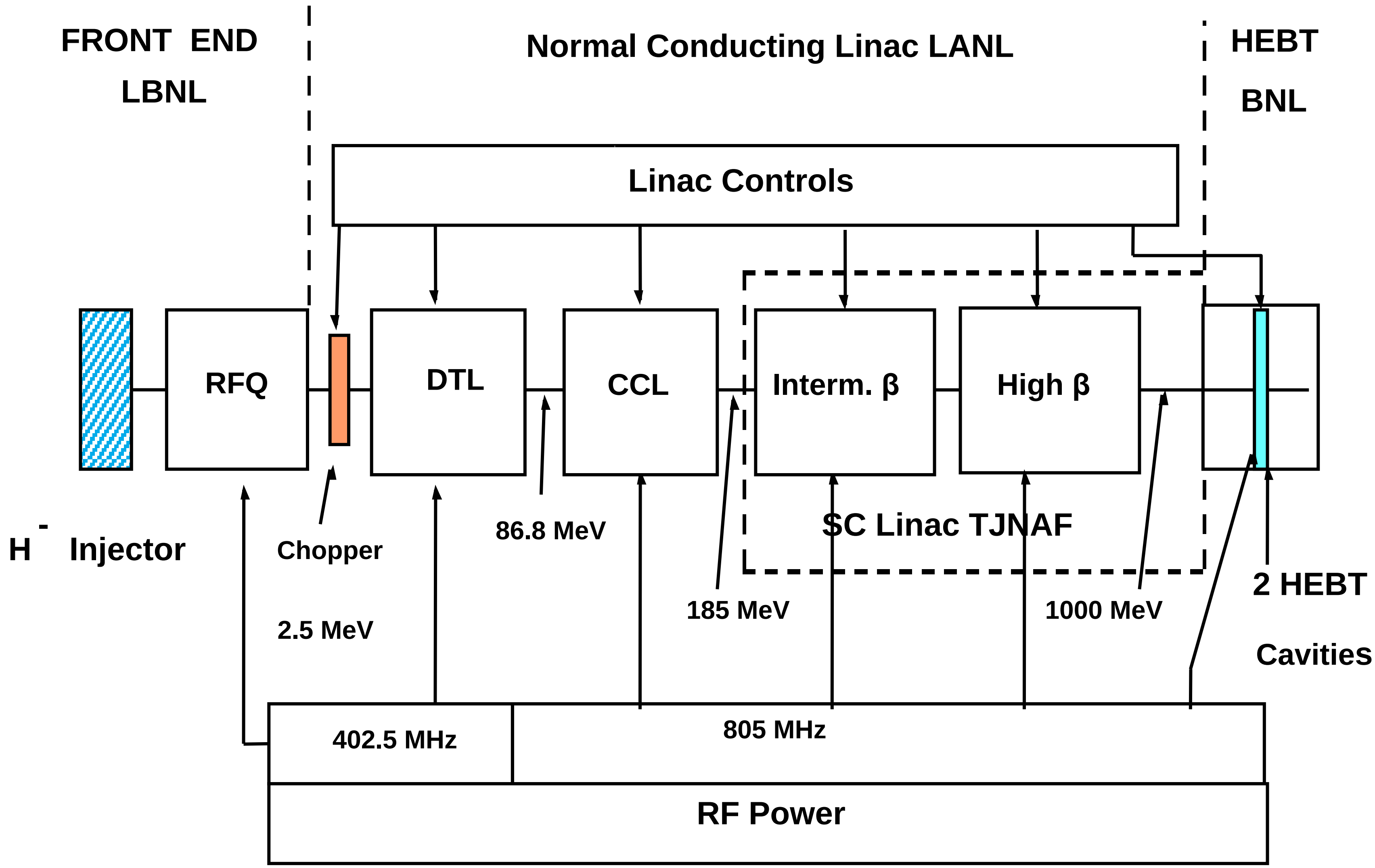


Figure 2-1. SNS Linac Configuration

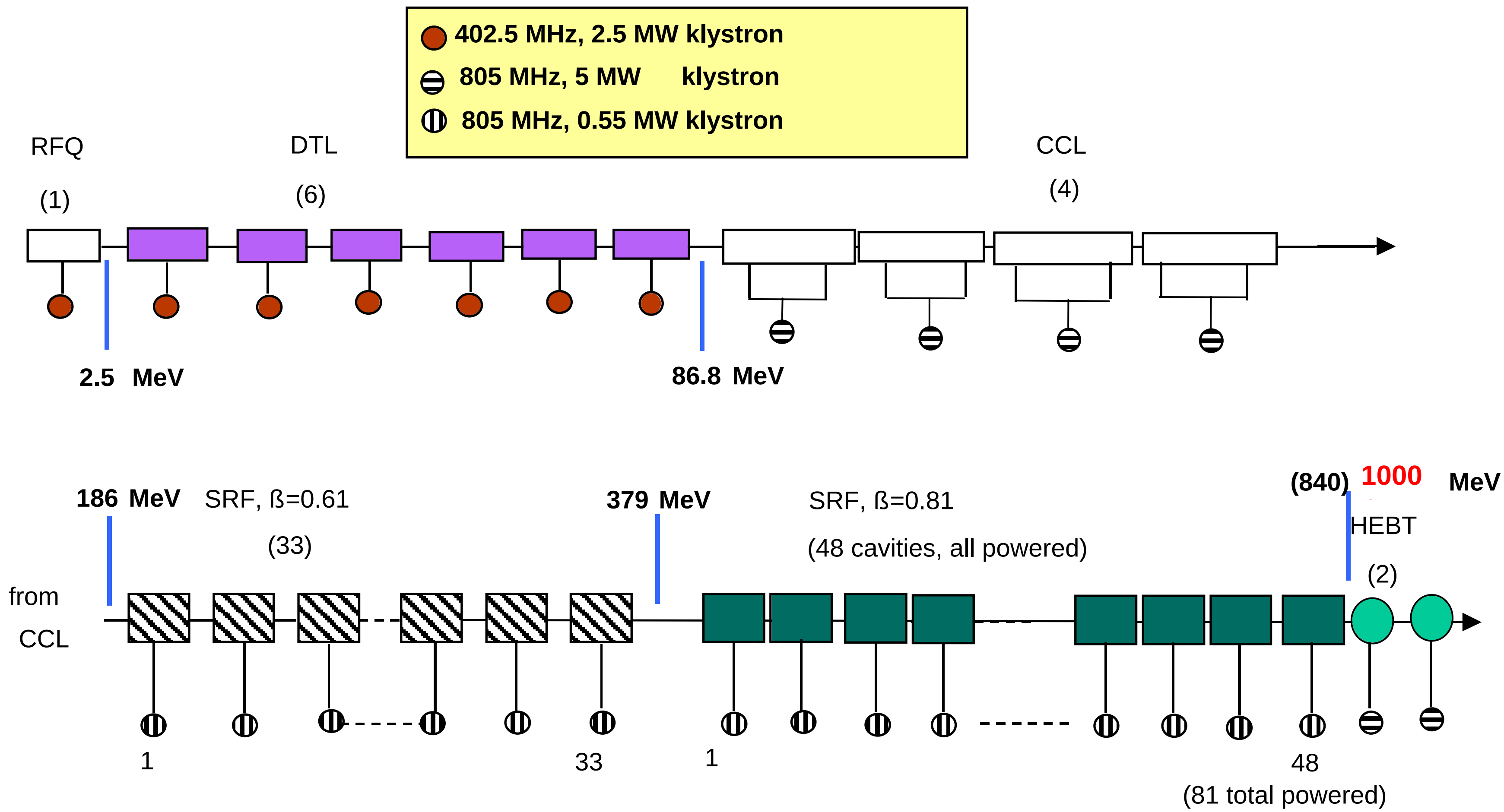


Figure 2-2. Layout of Linac RF with NC and SRF Modules

The following progress was reported and is listed here in summary fashion. The production of the DTL components is essentially complete. Some Drift Tubes housing electromagnetic dipoles and Beam Position Monitors (BPM) must still be retrofitted in otherwise completed tanks, but the DTL construction and assembly are almost complete. The first CCL module, including bridge couplers, has been built, inspected, and tuned at the manufacturer, ACCEL, in Germany. This unit will be delivered to SNS later this month for re-assembly and high-power testing in the Linac tunnel. The remaining three CCL structures continue to be produced and assembled at the subcontractor in Germany. Quality assurance and quality control processes developed during the production of the first CCL module remain in place and the remaining module production is far along, with shipping of the fourth and last CCL module forecast for March 2004. The only exception to this otherwise satisfactory report is that at the time of the May 2003 DOE review, the first of the CCL modules was expected to be shipped in late July from the vendor in Germany to SNS. This is one example of schedule slippage noted by the Committee. In this case, eight weeks of delay is attributed by SNS management primarily to tuning difficulties (now resolved).

During the May 2003 DOE review, manufacturing problems with the High Voltage Converter Modulators (HVCM) designed at LANL and built under contract by Dynapower were reported. In this instance also, a significant addition of support staff assigned from LANL to carry out daily supervision at the vendor has contributed to a most successful outcome. All 17 of the HVCM units were factory tested, accepted, and have been delivered. One of the production units is under test at LANL, where testing of the HVCM prototype has also continued. Six more HVCM units are under test at SNS. An extensive testing program, designed to accumulate 8,000 hours of running time on a production HVCM, was initially recommended in the November 2002 DOE review report, and re-endorsed in the May 2003 DOE review report. Considerable testing has now been accomplished, and some of the HVCMs have operated for significant periods of time at close to full power. This program is properly regarded as quite successful, although some of the testing of pulse width modulator controls has revealed that under certain unusual conditions potentially destructive failure of the Integrated Gate Bipolar Transistor (IGBT), a critical component of the HVCM, might occur. Pulse transformer core saturation protection should be investigated to protect the IGBTs. Though this failure mode is not apparent until pulse flattop regulation is attempted, and flattop regulation does not appear to be required, finding a solution to this problem is necessary for solid HVCM operation. This continues to justify further testing, although the HVCM in tandem with the LLRF system should provide the necessary well-regulated and conditioned RF drive required by the Linac.

Noise from the HVCM system and other sources has been a problem for diagnostic systems. Some improvements have been made, but these may not be sufficient to reduce the problem to the desired level needed for long-term noise free operation. Ripple on the transformer pulse from pulse-width modulation is being investigated and may be compensated by LLRF feed forward.

Measurements of AC harmonics from the HVCM have started. The system is six-phase without staggered phases from system to system. This may cause undue on-site harmonics.

Klystrons to power the various RF structures of the Linac continued in production at several vendors, and more deliveries have been made. A complete complement of the E2V (Marconi) 402.5 mega Hertz (MHz), 2.5 MW klystrons for the RFQ and DTL has been delivered and assembled in the Linac Gallery. A "second-source" version of the same unit is scheduled for initial delivery from Thales in late February 2004. Even more important was the delivery from Thales of an 805 MHz, 5 MW klystron (the 5 MW klystrons are required for the CCL and HEBT cavities) that was accepted at LANL. It has lower-than-specified efficiency, but this klystron has otherwise passed tests during operation at LANL, and was used to provide full power testing for other 5 MW RF components. These components, the circulator and load for the 5 MW systems, have had various failures, but at least one example of each has been accepted after modifications to RF seals and barrier windows. The 5 MW klystron is noteworthy for its demanding combination of a long pulse and high peak power (for use in the CCL portion of the Linac.) The first accepted unit is being shipped from LANL to SNS for installation in the Linac Gallery in support of high-power tests of the first CCL module. A modification of the output transition section that was specified based upon earlier operation of a failed 5 MW Thales klystron was successfully incorporated into the accepted 5 MW klystron.

Two vendors are under contract for the 550 KW klystron production. Thirty-eight units (of 81 units under order) have been delivered to date by one vendor (CPI), but the second vendor (Thales) has had only one unit (of 15) accepted at the factory. The respective orders listed above reflect a shift of eight units from the Thales order to the CPI order in response to the production difficulties at Thales. Twelve of the CPI klystrons are mounted in the Linac Gallery to be operated from a single HVCM in the near future.

Good progress has been made in superconducting RF cavity construction and in the assembly and installation of cryomodules:

1. Thirty-five medium-β cavities have been delivered, and 23 have been processed and qualified at gradients above the design specification of 10 mega Volts per meter (MV/m) in single-cavity tests.
2. Fifteen high-β cavities have been delivered, and three have been processed and qualified at gradients of more than the specified 15.6 MV/m in single cavity tests.
3. Six medium-β cryomodules have been assembled and four tested.
4. Four SCL cryomodules have been commissioned with high-power RF.
5. Three SCL cryomodules have been installed in the SNS Linac tunnel.

Several technical issues with the cryomodules noted in the May 2003 DOE review have been resolved:

1. Intermittent binding of the tuner motors was due to a vendor design change, which has been corrected.
2. Vacuum leaks in the couplers and in the end-cans have been eliminated by correcting vendor procedures.
3. Vacuum leaks in Aluminum-Magnesium seals to Niobium-Titanium flanges have been eliminated by increasing the torque on the flange bolts.

One technical issue identified at the May 2003 DOE review has not yet been resolved, namely that a "lack of reproducibility of the medium-β cavity performance in the vertical Dewar after buffered chemical polishing (BCP) and high-pressure rinsing (HPR) has existed for some time and has led to the necessity for repeated etch preparation on a number of cavities." It remains true that "the cause of this difficulty is not completely understood, but is thought to be associated with incomplete HPR, water contamination, or drying effects." The overall success rate for medium-β cavities that have passed acceptance is that 60 percent pass on initial testing, 16 percent on a second processing, 12 percent on a third, and one cavity not passing after eight attempts. The net result is that it has taken about twice as many processing cycles to produce a given number of cavities.

An external review of SNS cavity processing was held October 16 and 17, 2003, at which a number of procedural changes and equipment modifications were proposed. Several of these changes have already been implemented, and the three cavities subsequently processed have met performance goals. The remaining changes are being implemented as soon as practicable, and will be applied and evaluated over the next two or three months.

Some loss of time in cryomodule testing was due to failure of the 1 MW, 805 MHz klystron RF power supply required for these tests.

Cryoplant and transfer line fabrication and installation are almost complete. The cryoplant is rated for 2400 watts at 2.1° Kelvin (K). All refrigerator components have been delivered to SNS and installation is nearing completion, with only a modest amount of piping and wiring remaining. The helium refrigeration and distribution systems were reported in May 2003 to be on a schedule that would support operation of cryomodules within the Linac tunnel by March 2004. This operation is now reported to be delayed until approximately June 2004.

Checkout and dehydration of the cryoplant warm compressors is underway. The installation of the 4.5° K cold box will be complete within a week. Checkout is expected to start in December 2003 and require two months, followed by two months for cooldown and acceptance (the 4.5° K cold box acceptance test is to be completed in March 2004). The 2.1° K coldbox has been in place for a number of months, and piping and electrical installation are underway. The cold compressors will be installed and checked out by late December 2003 and cooldown of the 2.1° K system will begin after the 4.5° K cold box commissioning (the 2.1° K cold box acceptance test is to be completed in April 2004). Transfer line installation is complete with exception of U tubes to the modules. Transfer line cooldown will start after 4.5° K cold box acceptance. Overall system cooldown is scheduled for May 2004.

Tests of those cryomodules that will not be tested at TJNAF are scheduled to begin at SNS in August 2004. It is important that module testing not be interrupted when testing is terminated at TJNAF.

The next six to nine months will see a large amount of Linac components installed and integrated testing of systems initiated. The present schedule slips DTL and CCL installation into one another. Accumulated delays are approximately 10-12 weeks. The slip of the SCL commissioning start is from October 2004 to March 2005 (key dates are shown in Table 2-1).

Assembly, RF measurements, tuning, installation, conditioning, and systems tests of the DTL and CCL are now interwoven with each other. These activities will continue through September 2004. Two teams of eight to nine people are planned for these activities. They consist of a mechanical lead engineer, about two mechanical technicians, a vacuum lead engineer with approximately three vacuum technicians, and approximately two RF engineers or tuning experts. Both activities are supervised by a lead physicist.

Table 2-1. Key Schedule Dates

CCL 1	Installation Start	November 2003
DTL 3	Installation Start	January 2004
DTL 2-3	Commissioning Start	March 2004
CCL 1	Conditioning Start	April 2004
DTL 1-3	Commissioning Finish	May 2004
DTL 4	Installation Start	May 2004
DTL 4-6, CCL 1-3	Commissioning Start	August 2004
CCL 4	Conditioning Finish	September 2004
DTL 4-6, CCL 1-3	Commissioning Finish	September 2004
SCL medium-β	Integrated Test Start	June 2004
SCL high-β	Installation/Test Finish	February 2005
SCL	Commissioning Start	March 2005
Ring	Commissioning Start	July 2005
Beam on target	Ready Start	November 2005
CD-4		March 2006

The RF group must see to the installation and systems tests of the LLRF and RF sources. This group consists of six people in the LLRF, eight in the high-power RF, and three in the structures and tuning (these last three are employed into the DTL and CCL assembly activities).

The Linac work to be performed at LANL is now (costed and committed) 94 percent complete. At TJNAF the work is 96 percent obligated and 92 percent costed.

2.1.2 Comments

Overall, the progress on the Linac is very encouraging. There has been close coordination and working relations at all levels between ORNL, LANL, and TJNAF. This will continue to be needed as the Linac moves forward. LANL and SNS have negotiated the "End-Game" for the LANL effort, largely to be complete by March 2004.

The LLRF continues to progress very well and the reported tests remain very encouraging. At the May 2003 DOE review this observation was noted and remains true:

> "It may be time to start to consider implementation of initial operational and commissioning features. For example, how to deal with beam loading fluctuations like beam or no beam pulse to pulse, unexpected short pulses, etc. and how to implement feed forward and feedback to deal with the changes in beam intensity that can be erratic during startup."

The DTL assembly is approaching a successful conclusion. The successful production, testing, and delivery of all the HVCM units is also encouraging. System tests including potential failure modes of the IGBT are now important. The "2,000 hour" testing program of the HVCM should be continued. HVCM noise mitigation needs further investigation and possibly outside review. Power line harmonics may need further suppression for on-site harmonics.

The installation of the Linac in the tunnel and RF components in the Linac Gallery, while underway, has not yet reached full speed. The Linac and other accelerator components are not reported to be on the project critical path. The Committee did not review a resource-loaded schedule of installation and test manpower, however, it is clear that there is a great deal of work to do and difficulties in any area can slow down the schedule. The Committee was told that the addition of three people immediately would considerably relieve this situation. As new operators are being brought on, judicious selection of these people and immediate assignment to the RF group may be a way to proceed. The installation schedule must be monitored closely and action promptly taken as necessary to avoid delays on the critical path.

The risk of additional loss of time in cryomodule testing at TJNAF due to klystron failure is substantial, and could be reduced by insuring the prompt availability of a replacement 1 MW 805 MHz klystron.

The Committee commended SNS and TJNAF for holding a workshop to address problems with cavity processing and implementing the suggested changes. The effects of changes in equipment and procedures should be promptly evaluated, and further review and development, as needed, should be vigorously pursued until the production problems are resolved and all the cavities qualified. The following comment from the May 2003 DOE review report bears repeating:

> "While the difficulties with cavity surface processing are likely to be overcome soon, they are a reminder that the technology is sufficiently new that the aggressive schedule is not at this point entirely without risk. This also indicates the longer term need for a superconducting cavity facility at ORNL for processing and testing the unique cavities used by SNS. Such a facility would directly support Linac maintenance as well as enabling Linac performance upgrades and long-term R&D. The Committee noted that the SC cavity production run for SNS represents a unique opportunity for statistically meaningful comparisons of SC cavity preparation and handling techniques, and believe the project should be encouraged to support such development efforts as have no negative effect on technical risk, schedule, or costs."

The risk assessment summary identified two potential risks in the cryogenic systems: 1) transfer line leaks detected during cool down, and 2) rotating equipment failure during commissioning. It is important that commissioning and acceptance of the plant not be delayed so that the plant can be brought into operation, failures discovered, and Helium made available for cryomodule integrated testing.

If the presently reported issues are controlled promptly, then they generally need not represent a major concern and remediation of the identified issues is possible within the available financial and schedule contingency resources as estimated by SNS management.

2.1.3 Recommendations

1. Implement the recommendations of the internal and external review committees concerning production of SNS superconducting cavities and modules at TJNAF. Involve technical experts and the top management of SNS and TJNAF to minimize impacts of this problem to SNS project costs and schedule.

2. Provide access to a spare 1 MW klystron for the test bed at TJNAF.

3. Give high priority to cold tests/operation of one or more cryomodules in the Linac tunnel. Currently this is scheduled to start in June 2004 with the first availability of liquid Helium in the tunnel. All necessary efforts should be made to meet or advance the date of such tests and operation.

4. Add support as necessary for Linac installation work to avoid any further slippage of the Linac schedule.

5. Continue to closely monitor the production and performance of the 5 MW Thales klystron, 5 MW loads, and 5 MW circulators. Vigorously pursue repairs, replacement, or redesign of any 5 MW system components that fail in test.

6. Test the HVCM in the high current/low voltage configuration as soon as possible, and continue life testing. Explore pulse transformer core saturation interlocks to protect the IGBT against short circuit faults.

7. Continue to monitor the manufacturing of the CCL, and prepare for full power tests at the earliest opportunity after first item delivery.

2.2 Ring Systems (WBS 1.5)

2.2.1 Findings

There has been considerable progress in the development of the Ring Systems as demonstrated by the installation of most of the components in the High Energy Beam Transport (HEBT). There are also many Ring components delivered to ORNL awaiting installation. The ASD has control of all tunnels and buildings, and is installing technical equipment. The Committee commended BNL and ORNL for excellent work in a number of different areas as noted in the findings on each subsystem below.

The Committee was presented with the End Game Plan as reviewed and endorsed during the July 2003 DOE review. The Committee concurred that the End Game Plan, while introducing some technical and schedule risk, is a feasible solution to the funding profile problem, and provides a means of easing pressure on contingency.

Overall, the Ring Systems are doing very well with respect to the technical quality of components, cost, and schedule. The Committee saw no obstacles and was encouraged to see work on the remote handling of components in high radiation areas. Recommendations from the May 2003 DOE review have been addressed.

Vendor delivery of 21Q40, 26Q40, and 30Q44 magnets has caught up with assembly requirements, and is essentially on schedule. This is an improvement since the May 2003 DOE review. Twelve of 32 half cells have been delivered to SNS, and the first of eight doublet cells have been delivered. The extraction kicker is in fabrication, and an RFQ for the Lambertson septum magnet is in process. The other special injection/extraction magnets are complete or are in process. Magnets are on schedule to meet project milestones for beam into the HEBT, Ring, and the RTBT.

The vacuum chambers and vacuum system purchased components are also on schedule to meet project milestones. Most of the HEBT vacuum components have been installed since the May 2003 DOE review, along with many of the HEBT magnets. This was an early installation activity that is 75 percent complete and is a noteworthy accomplishment. There are settlement issues in the RTBT tunnel that are being addressed. The titanium nitride coating of vacuum system components is on-going, but is keeping pace with schedule requirements. The ring arc and straight section vacuum chambers, and the RTBT chambers, are also on schedule to meet project milestone requirements.

The HEBT and RTBT beamline collimators #1 and #2 have been completed and delivered to SNS. Outer shielding for the HEBT collimators has also been delivered. The ring adjustable collimators are in fabrication, and the remaining shielding assemblies are also in fabrication. This is good progress since the May 2003 DOE review.

Installation of ring and transport components is on schedule, including the early installation of the HEBT. Considerable effort has gone into support of infrastructure compatibility issues and installation drawing documentation. The End Game strategy will delay some cable and power supply installation.

The Committee was presented with a status of the remote handling devices for the first time, and significant progress has been made. Active handling hot spots have been identified and the requirements for remote handling appear to be well planned. The RTBT/Target interface is well defined, and is a safety critical application area for remote handling devices. Remote clamping/handling devices will also be required at collimator, window, and scraper areas due to estimated dose rates at these locations. Initial designs have been completed for all areas except the RTBT/Target interface, which has just been started. First article prototypes are complete and tested with good results for the remote vacuum clamp, the passive dump window, and the window extraction mechanism. Requirements for the remote handling mechanisms are being incorporated into the designs of the primary ring collimators and scrapers. Procurements are in process. Maintaining vacuum at these locations due to thermal cycling of components has been considered, and is not expected to be a problem. Written procedures will be prepared for the proper use of the remote handling tools, and will be certified by personnel training on the prototype devices.

The transfer of drawing documentation from BNL to the SNS Document Control Center has experienced some problems, but is proceeding.

The power supplies are in good condition and there are no outstanding problems. The 184 low-field corrector power supplies are at SNS and tested. Of the 69 medium supplies (plus eight spares), one supply has been delivered and 69 are scheduled to be delivered to ORNL in FY 2004, with eight supplies delayed until FY 2005 due to End Game Plan constraints. The first of the extraction kicker supplies is under test at BNL, with the remaining 13 units to be delivered to ORNL with only factory testing. Delivery is expected by June 2004. The main dipole supply transformers have been delivered and installed with the rectifier system to be tested by January 2004. Two of the eight production injector kicker supplies will be under test in December 2003 with the full complement delivered by October 2004.

The first RF cavity power system (cavity, power supplies, etc.) has been delivered to SNS. Delivery of all RF units to SNS is scheduled by March 2004. The responsibility for Ring RF systems at ORNL has been transferred from the power supply group to the RF group. With this reorganization, clear lines of responsibility for the Ring RF power supplies should be established. The RF system has been successfully tested.

Progress has been made in diagnostics, but not as much as in other areas. The SNS diagnostics group has focused their efforts on the diagnostics needed for Front End and DTL commissioning. This commissioning provides advantages to the Ring since there are common electronics, and some are provided by BNL, thus the experience is useful. However, there is concern because of a problem with the Beam Current Monitor (BCM) electronics that is not understood. It remains under investigation. The BNL diagnostics group has worked on beamline components (that is, hardware that will be in the vacuum system) and has made some progress on diagnostics electronics, but again this was primarily for the BCM. Other diagnostics work has been delayed by work on the Relativistic Heavy Ion Collider; however, the SNS diagnostics group has not been ready to receive diagnostics electronics, although this situation is gradually changing (see comments in Section 2.2.2).

Upon further investigation it has been determined that the Ionization Profile Monitor can be implemented with permanent magnets, thus saving funds.

2.2.2 Comments

The Committee was provided with responses to the Ring recommendations from the May 2003 DOE review. The recommendations and discussion follow:

1. *Consider ways to supplement the staffing of the SNS diagnostics group to better support installation and commissioning.* The size of the SNS diagnostics group has not been significantly increased. The project asserted that the End Game Plan reduces the pressure on the SNS diagnostics group by leveling their activity through

FY 2004 and FY 2005. This appears to be the case; however, support for diagnostics installation, integration, and commissioning has remained lean. There are further comments below on this subject.

2. *Continue to examine maintenance procedures, and spare parts issues for devices in activated areas, and identify resources for remediation.* As noted above, the project gave a presentation addressing remote handling procedures. There is good work in this area and it should be continued.

Because of the limited resources in the SNS diagnostics group, the project will need to focus its efforts on the primary Ring diagnostics (BCMs, Beam Loss Monitors (BLMs), BPMs, and foil diagnostics).

Pre-testing of all medium power supplies will be preformed at ORNL prior to installation, while the injection and extraction kickers are to be tested in place after installation with only factory testing. This lack of pre-testing of all supplies at ORNL could cause problems and delays during initial operation of the supplies. It is common not to make full-power tests of large power supplies at the factory, but the use of open-load, full-voltage, and "short circuit full current" tests may not reveal all the possible problems in the power supply. The sooner the full power test can be performed at ORNL, the more confidence in the performance of the supply.

The End Game Plan pushes a large portion of Ring Systems installation into FY 2005. After installation begins, only six months remain until the beginning of Ring commissioning. This will leave little time for system checkout. SNS personnel are aware that this introduces some risk. Most components have been thoroughly tested before delivery; however, this equipment will have been sitting in place or in storage, for up to a year and a half before being turned on for commissioning. Since the End Game Plan was put together quickly, it is likely there is an opportunity for fine tuning that will reduce the risk associated with rescheduling. The project should continue to explore these opportunities.

2.2.3 Recommendations

None.

2.3 Target Systems (WBS 1.6)

2.3.1 Findings

The project has responded positively to the previous DOE review recommendations. Three out of five Action Items were closed and the Committee agreed with the actions taken. Of the remaining two, one has a due date in the future and the other one is still being dealt with. These recommendations will be picked up below.

Excellent progress was again observed, with Title II design reviews completed and installation of the target monolith well under way. One highlight was the smooth insertion of the core vessel on October 9, 2003, which was accomplished with no difficulty at all.

Procurements continue to be generally proceeding well, with 52 out of 66 major procurements awarded. Of the remaining 14, requests for proposals (RFPs) for nine have been issued. An important decision point will be when the bids for the inner reflector plug arrive, because this is probably the most complex and difficult structure of the whole system to manufacture.

The End Game Plan resulted in shifting the date for project completion by three months and leaves the Target Systems with only one month of contingency in their schedule for installation and commissioning of all the components in the Target Maintenance Cell ("Hot Cell").

A new Estimate-at-Completion (EAC) since the May 2003 DOE review showed a cost increase in Target Systems from $106.4 million to $108.1 million, which carries a contingency of four percent on commitments and nine percent on uncommitted items. Although this contingency is marginal, there do not appear to be any major risk items that would mandate immediate action. This is because only about $7.1 million of the outstanding $25.9 million in remaining work consists of new procurements, the rest resulting from phased funding ($4.2 million), installation work ($8.1 million) and staff salaries. Furthermore, a credible recovery plan is in place for the item with the highest cost uncertainty (the inner reflector plug).

In an effort to minimize the risk from cavitation erosion caused by the pulsed proton beam impinging on the proton beam window, the project has shown that Kolsterizing, proven to be the most effective surface treatment for stainless steel, can be applied successfully to the target structure as manufactured. Furthermore, the effectiveness of diverse diagnostic sensors to detect Mercury leakage into the interstitial space between the Mercury container and the outer shroud has been successfully demonstrated as recommended at the May 2003 DOE review.

2.3.2 Comments

The project decided to go ahead with the dummy concrete shutters as a cost saving measure ($1.4 million in the short term). However, no provisions were made for handling the activated central steel plugs. This will be necessary as soon as the first of the remaining eight beam lines needs to be occupied.

A large number of items needed for remote handling and fixtures that would allow practice evolutions of key operations have been deferred in order to meet budget and schedule constraints. While this helps the project budget it constitutes a mortgage on operations, part of which may have to be paid back at an early stage if something goes wrong and may eventually lead to unwanted and possibly extended interruptions. Planning for the use of operations funds in FY 2006 must take this into account and high priority must be given to procurement of the deferred items.

While the Committee was impressed by the successful installation of the heavy inner shielding, it became obvious during the process that tolerances were so tight that welds had to be ground away from the vessel walls. The solution may not always be so easy and the project should consider allowing somewhat larger gaps to ease installation in the future.

Components successfully installed so far are passive ones not needing commissioning or testing. The team is well advised to remain vigilant during installation of active components in order to repeat their success.

XFD has been recruiting and hiring people for key positions for the transition to operations. An operations manager and a deputy are presently working with the design team. A target team leader has recently been hired and they are recruiting for a remote handling team leader.

The operations staff anticipates that the Target Systems can be run initially under the requirements of the Accelerator Safety Order rather than the Nuclear Safety Rule (10CFR830). Regardless of how this evolves, the Target Systems have been designed and built to the stricter requirements of the Nuclear Safety Rule.

The vendors for the inner reflector plug assembly have requested a two-week extension to reply to the RFP. Since this delayed the bid evaluation until after this review, there was no opportunity to verify to what extent the vendors shared the Committee's concerns about the complexity of this unit.

The project is preparing a fall-back inner-reflector plug design that is simpler, but will have reduced performance. This may be acceptable since the plug can be replaced with a more capable one in the future. Design changes this late in the project are a concern since these systems are highly coupled. The project must ensure that this change does not create problems elsewhere. There was also concern that other efforts will be diluted and the project will be distracted by this effort.

The availability of heavy water (20 tons required) at no cost to the project to cool the reflector is not yet assured. If this needs to be bought on the market, it would be a very big burden (approximately $10 million) on the project's budget. In that case it may be possible to start with light water at the expense of some neutron flux intensity, which can be recovered once heavy water becomes available. The possible dilution in the transition process is not a concern since it should be possible to drain the loop almost completely.

2.3.3 Recommendations

1. Work out, by the next DOE review, a detailed procedure for the exchange of the proton beam window and ensure that all equipment required for this procedure on the side of the RTBT is actually in ASD's plans (open recommendation from May 2003 review).

2. Complete the detailed planning, with time estimates, for the target changeout by the spring 2004 Experimental Facilities Advisory Committee meeting.

3. Establish an aggressive management and quality assurance (QA) plan for the inner reflector plug. Before signing the contract, create an integrated testing plan with the vendor to assure that all welds and components are thoroughly tested before they become inaccessible. Cryogenic components and welds should be flow tested with gas, pneumatically pressure tested, radiographed, cold tested with Nitrogen and Helium and Helium leak tested. Components and welds must be tested as many times as necessary during construction even if that requires building special fixtures. Appoint a shop liaison person and obtain agreement from the vendor for him to be present at the vendor to witness key steps (QA hold points). Adhere to the maxim of "You get what you inspect, not what you expect!"

2.4 Instrument Systems (WBS 1.7)

2.4.1 Findings

The Committee was impressed with the progress reported by the project in Instrument Systems. As discussed below, the responses to previous recommendations were deemed to be reasonable. Within the scheduling constraints controlled by CFD, the plans for achieving the baseline goals of designing, building, and installing three instruments, and having two more completed, appear to be within budget and on schedule. The responses to previous DOE review recommendations are as follows:

1. A resource-loaded integrated installation plan for core vessel and shutter inserts has been completed. The core vessel insert components are to be received by March 2004. They will be prepared by SNS staff, with installation to be performed by the CM contractor starting in July 2004. The shutter inserts are to be received by April 2004 and then prepared by SNS staff, with installation by the CM contractor beginning in August 2004.

2. Installation plans have been prepared for the first three baseline instruments; however, the recommended *integrated* installation plan is still in progress. One reason for the delay in the integrated plan is that the current goal is to begin installation of five externally-funded instruments in FY 2005, in addition to the three baseline instruments. Such a goal is justified by the increased efficiency of simultaneously installing shielding for tightly-spaced, neighboring beam lines; however, the planning for the externally-funded instruments is not yet as advanced as that for those in the baseline. Another cause for delay is the shift (since the May 2003 DOE review) in the Beneficial Occupancy Date (BOD) for the Target Building. The first major installation activities involve neutron guides; these require a climate-controlled environment that will not be available before BOD. Work outside of the Target Building proper will begin as early as January 2004.

3. A staffing plan for Instrument Systems, covering the transition from construction to operations, has been prepared in spreadsheet form. This plan has been integrated with one for the entire XFD. The plan shows a clear ramp-up of SNS labor to accomplish the instrument installation goals.

Instrument Systems has recently begun its major hardware procurements. For the $6.7 million awarded so far, the costs are 3.2 percent below the baseline estimate. With another $12.1 million of procurements to go, the initial performance suggests that cost planning has been reasonable. As part of the End-Game Plan, $6 million in procurements for baseline instruments #4 and #5 have been shifted to FY 2005 and FY 2006.

2.4.2 Comments

The start date for the bulk of the instrument installation tasks cannot be before the Target Building BOD of February 2005. The plan, as laid out by the Instrument Systems group, can be accomplished in the 13 months left in the project after that date. However, there appears to be little or no contingency left in the installation schedule. In the event that the Target Building BOD is shifted to a later date, there will be an option to work extra shifts, but this option will reduce the schedule by very little. Further delays in the BOD should be avoided if at all possible.

The overall strategy for using contract or procured labor for the construction and installation of several of the major components of the instruments is an efficient and cost-effective method for getting these instruments constructed on time and within budget. The use of large sections of poured-in-place concrete shielding by the CM contractor, for example, will save a great deal of time in shielding installation. Also, the Instrument Systems' organizational plan assigns sufficient responsibilities to bridge the many interfaces created by out-sourcing. The project has assigned an instrument scientist and an engineer to each instrument to develop the design for the instrument. In addition, they have an installation engineer who acts as coordinator for the installation of all of the instruments, and he will interface between the various vendors and the instrument scientists and engineers. Most importantly, the project has correctly identified the final authority for each individual instrument with the instrument scientist.

One area of concern may be in the number of technicians available to the project during the installation phase during FY 2005 and FY 2006. Five technicians are shown in the Instrument Systems staffing plan (two mechanical technicians, one electrical technician, one chopper technician, and one to be determined). While the project is planning to use the contract labor mentioned above in various capacities, it is felt that the number of technicians may be too small to accomplish the task. Since there will be five other instruments (not part of the SNS construction project) also starting installation in FY 2005, there will be a large number of technical tasks to complete. Given this, the project should carefully reconsider the level of technical support required in FY 2005.

The correct number of technicians needed to install the instruments will naturally come from an integrated installation plan. While the project has done a good job on producing the installation plans for the individual instruments, they should continue to work toward completing a resource-loaded integrated installation plan. Such a document will act as a guide in staffing. While producing the document, XFD should identify the resource bottlenecks in the installation process. An integrated installation plan will not only help in scheduling XFD manpower, but also will help with planning work for personnel residing within SNS, but outside of XFD. For example, the alignment crew also acts as a resource to ASD and integrated planning will help minimize unforeseen conflicts in requests for their services.

For the success of the SNS project, it is necessary to look beyond the completion of the construction project (CD-4), and to consider the staffing through pre-operations and into operations, in order to obtain user credibility. The transfer of Instrument Systems personnel from ANL to ORNL has effectively been completed, with the exception of the chopper laboratory, which must wait until space is available. Instrument Systems' administration now resides at ORNL.

An Instrument Systems staffing plan was presented by category that includes FY 2007. This plan appears to be reasonable, though there was concern about the sharp ramp-up of numbers for the both the research associates and technicians around FY 2006. The project is cautioned that filling these positions may prove difficult. On the other hand, it will be necessary that these positions be filled in a timely manner, because a large number of instruments are due for commissioning in the not-too-distant future (three in FY 2006, five in FY 2007 and two in FY 2008).

The delays in procurements for baseline instruments #4 and #5 have been planned in a sensible way to accommodate BA constraints. Nevertheless, there are concerns that the detector orders, which have long delivery times, might not arrive in time for the early project completion date. Should unspent BA be found at the end of FY 2004, the project was strongly encouraged to use it to accelerate these procurements.

The Committee was impressed by the various activities of the Instrument Systems group that are technically outside of the scope of this construction project, but are vital to the overall success of the SNS as a user facility. Besides the five instruments within the SNS baseline, there are three instruments approved by the Experimental Facilities Advisory Committee (EFAC) to be designed and built by Instrument Development Teams (IDTs) (including one with funding from Canada), five EFAC-approved instruments to be designed and built by IDTs through Basic Energy Sciences funds (the SING—SNS Instruments Next Generation project), and one more EFAC-approved instrument to be designed and built by an IDT through DOE/SC High Energy and Nuclear Physics funds. This is a total of 14 instruments to be commissioned between 2006 and 2011 (see Table 2-2). All these instruments have designated beam lines. In addition,

---

Table 2-2. SNS Instrument Status

Five Instruments in SNS Baseline (Funded within the Project TPC)

Three to be installed by CD-4

- High Resolution Backscattering Spectrometer
- Vertical Surface (Magnetism) Reflectometer
- Horizontal Surface (Liquids) Reflectometer

Two to be installed after CD-4 during low-power operations

- Extended Q-Range Small Angle Diffractometer
- Third Generation Powder Diffractometer

Three EFAC-Approved Instruments to be Designed and Built by IDTs

- Wide Angle Thermal Chopper Spectrometer (funded by BES grant to Cal Tech)
- Cold Neutron Chopper Spectrometer (funded by BES grant to Penn State)
- Vulcan Engineering Diffractometer (funded by Canada)

Five EFAC-Approved Instruments Comprising the SING Project (funded by BES)

- Ultra High Pressure Diffractometer
- High Resolution Thermal Chopper Spectrometer
- Single Crystal Diffractometer
- Disordered Materials Diffractometer
- Hybrid Spectrometer

One EFAC-Approved Instrument to be Designed/Built by IDT (funded by DOE/SC Nuclear Physics)

- Fundamental Physics Beamline (actually 2 instruments on a single beam line)

Two EFAC-Approved Instrument Proposals Awaiting Funding

- Spin Echo Spectrometer (to be funded by Germany)
- Chemical Spectrometer (funding TBD)

---

there are another two IDT instruments approved by EFAC that are working to obtain funding. Furthermore, there are another four potential IDT instruments that have been identified. This demonstrates the great interest within the user community in this project. It also means that the space for instruments within the Target Building is becoming committed, such that further new instruments may become more difficult to accommodate. In fact, the space available for further beam lines on the hydrogen moderators is quite limited.

The SNS project has recognized the need for infrastructure initiatives in the development of technologies that support the neutron scattering instruments. They have arranged workshops during 2003 involving potential users and other interested parties who can contribute in the different scientific aspects necessary for the success of the overall project. For example, a detector workshop was held in Bloomington, Indiana. Various detector projects necessary for future instruments have been identified with the lead taken in various laboratories, in addition to their own in-house development. A workshop on the use of polarized neutrons was held in Gaithersburg, Maryland, to initiate a road map for the development activities in polarized neutrons. A SNS staff person has been added in this area. A workshop on sample environment was held in Tallahassee, Florida, with a result to develop a national plan to coordinate the development of specialized sample-environment equipment, together with some standardization of instrument interfaces and communication protocols. A high-field magnet proposal is also being prepared.

In other SNS internal component development, work continues on data acquisition. It is noted that the maximum detector count rate will be the limiting factor for certain instruments, particularly the reflectometers and the small-angle scattering instrument. The first of two neutron choppers has been delivered and is currently undergoing tests at ANL.

Software, data visualization, and related computing development have been identified as crucial to both the Day 1 and longer-term success and scientific impact of the SNS. A workshop on data visualization and analysis software was held at ORNL to define the goals of data analysis software, and there is an effort to collaborate on the National Science Foundation Teragrid. As a result of this workshop a requirements document will be produced to define the modern data/software architecture that SNS will need. Various options, some components of which are contained in the DANSE (Distributed Data Analysis for Neutron Scattering Experiments) system being developed by the Angular-Range Chopper Spectrometer IDT, will be evaluated by Computer Sciences at ORNL on behalf of SNS. A team leader of scientific computation and analysis software is being sought. Discussions have taken place with the ISIS facility in the United Kingdom and the

Japanese Proton Accelerator Research Complex project in Japan on possible collaboration. It is clear that SNS is currently taking a suitably long-term and visionary view, and this should be encouraged.

There are three major challenges facing SNS with regard to software development during the transition to operations. The first challenge is to move software development and maintenance sufficiently high up the list of funding priorities so that it can be approached in the professional manner that will be required in front rank science. In the past, software development has been treated as a part-time and uncoordinated activity of instrument scientists. The second challenge is to define and then develop the necessary modern and extensible architecture that can use the future capabilities of the grid while at the same time readily incorporate the large amount of existing legacy code (and hence bringing on board the current user community). This will be the key to really exploiting the power of the SNS and its synergy with scientific computing. The third challenge is to implement (within this architecture) a basic (but complete) suite of data treatment programs for each instrument, to be available on Day 1 of operation. Without this, SNS will start with a backlog of untreated data (and unhappy users) from which it will struggle to recover. Given that first user operation is expected within four years, immediate action is required.

While SNS must have the active involvement of users and IDTs, it must be careful not to make choices that are too dominated by the well-developed views of particular groups of expert users and may not be appropriate for, or even alienate, possible future groups of new users. The expectations of biologists/life scientists for sophisticated and yet highly automated data analysis is likely to be well beyond those of current mainstream neutron users.

SNS outreach efforts thus far to the scientific user community for involvement have been most useful and future workshops should be planned. It is clear that the degree of collaboration is excellent and has resulted in the successful funding of the five SING project instruments. The Committee was also pleased to see that these efforts are also being coordinated with European and Japanese development programs.

2.4.3 Recommendation

1. Continue to refine the integrated plan for instrument installation, making adjustments for scheduling constraints such as the Target Building BOD, and provide an update at the next DOE review.

2.5 Control Systems (WBS 1.9)

2.5.1 Findings

The Control Systems effort continues to go well. The project is meeting its schedule and budget goals. In the case of the budget, the project has actually under-spent. Given the needs of the project to manage BA, funding and deliverables ($1.8 million) have been rescheduled from FY 2003/2004 to FY 2005/2006. This is expected to have no negative impact on meeting the project goals. The recommendation made at the May 2003 DOE review was satisfactorily addressed.

The Committee reviewed the SNS Risk Assessment with the Control Systems WBS Manager in the area of Control Systems, agreed with that assessment, and did not identify any further risk items.

Two technical problems worthy of note were encountered by the project in the last year. The first is the "IOC Disease," characterized by Experimental Physics Industrial Control System (EPICS) Input/Output Computers (IOC) that appear to go dead. The second is the presence of large amounts of electromagnetic noise which cause false trips in the Machine Protection System (MPS). The project reacted effectively to both problems.

The symptom of apparently dead IOCs has been seen at other laboratories, and is connected to the EPICS feature of broadcasting messages about connections when communication difficulties are encountered (these broadcasts flood the network, and do not allow the IOCs to send device data). This is a fundamental feature of the distributed nature of EPICS. The "IOC Disease" at SNS has been diagnosed as a configuration problem at the interface of IOCs to the supporting network. The specific causes of the SNS symptom have been identified, but not yet completely fixed. Much of the configuration is not done automatically, and the supporting documentation for the correct configuration is ambiguous. The project needs to confirm the correct configuration. The project also needs better tools for automatically configuring software systems, so that the correct configuration data is present at startup. The Committee noted that TJNAF and ANL's Advanced Photon Source both have EPICS with hundreds of IOCs and do not have this problem.

The MPS nuisance trip problem caused by electromagnetic noise is really a classic problem in accelerators. There are numerous noise sources (RF power systems, switching noise in magnet power supplies, even beam induced noise in some accelerators). Accelerator engineers are aware of these issues, and do their best to design in appropriate measures, but there are always a few problems that appear—usually because these problems are highly affected by the physical layout. The toolkit for fixing such problems is well known—there are numerous texts on the subject. The Controls Systems staff is working with the High Power RF, Power Supply staff to identify and mitigate noise sources, ground loops, etc. A workshop on noise mitigation was held, and some sources were identified and their noise was mitigated by as much as a factor of ten. The number of these false trips has dropped significantly, however, more work remains to be done, and as more sections of the accelerator are commissioned, new sources will probably appear. (Aside: The Committee liked the start made on the MPS post mortem analysis tool, but more work needs to be done.)

The Committee congratulated the SNS project for their success in some specific Control Systems areas: Personnel Protection System for the Front End (PPS Phase 0.4), and Cryogenics Plant Control (purifier startup). Project successes in controls-related areas include the greatly improved LLRF situation and the accelerator applications programs, programming environment, and tools.

2.5.2 Comments

Staffing appears to be reasonable. The project's Control Systems staff should include a dedicated database expert. Presently, their needs are met by part-time involvement of an expert shared with Project Management. The SNS needs to build or acquire more expertise in the area of EPICS support—at the device and IOC level, configuration management, development environment, and testing environment. The project is growing such expertise. At present, the true expertise for EPICS support is at LANL; the project has an agreement and budget for that support to continue through CD-4.

The "IOC Disease" emphasized the need for stronger configuration management and testing environment tools. The project is working on more robust tools/environment; it should investigate how these needs are met at other laboratories. This is, by now, a classic problem for large accelerator facilities, and there are numerous working examples. These tools should use the Oracle Database as the repository of the configuration data. These configuration management and testing environment tools should be the first assignment of a newly hired database expert.

2.5.3 Recommendation

1. Add a full-time database expert to the Control Systems staff by May 2004.

Intentionally Blank

3. CONVENTIONAL FACILITIES (WBS 1.8)

3.1 Findings

Since the May 2003 DOE review, progress has been maintained in construction and completion of CF activities. The project has demonstrated progress in accordance with the End Game Plan presented in July 2003, which remains consistent with the project TPC of $1,411.7 million, and the June 2006 completion.

The cost and schedule assumptions supporting the CF portion of the End Game Plan have been validated. Recommendations made in the May 2003 DOE review have been adequately addressed. The greatest risk to achieving the End Game Plan is associated with near-term activities in Target Building construction. Based on the level of integration between CFD and XFD staff, the risks are identified and appear to be well managed.

The CF EAC has increased from $366.1 million at the May 2003 DOE review to $376.9 million. Of this $10.8 million increase, $2.6 million is associated with End Game Plan schedule extensions, $4.2 million is associated with approved contract changes, and $2.6 million is associated with approved claims. CF activities appear to be on schedule, as proposed in the End Game Plan, with all CF work to be completed in March 2005.

Differential settlement has occurred at the transition between the RTBT Tunnel and Target Building. The project has determined that no repair action at the floor level is required at this time. Cosmetic and/or final repair of the joint between the two structures will occur later.

The process used to commission CF facilities and utility systems has been integrated into the overall commissioning process for the project and the test and check out data provided is in accordance with the needs of the commissioning plan.

3.2 Comments

The data that has been collected through the AE/CM regarding site construction risks support the project's approach to risk from CF activities. However, as the project transitions into closeout, leadership is still required to adequately address the needs of Target Building/Systems integration, commissioning support, and integration with ORNL. Project integration with ORNL includes: 1) the CF utility systems being monitored and controlled through the use of EPICS, 2) provision of proximity readers for access control, and 3) provision of the main telecommunication switch for the SNS.

The Committee verified that ORNL management has made the necessary commitments to deliver proximity readers and the telecommunications switch in accordance with project objectives. It is important to manage and track these commitments as an integrated element of the SNS project.

The construction site is well maintained and site management has achieved a commendable safety record with real benefit in the form of lower insurance costs and project cost savings. Work in place appears to be of high quality indicating that the CM has maintained a high site-wide standard.

Notable achievements at this review include:

- Greater than 2.5 million construction man hours, with zero lost-work-day accidents.
- Implementation of “blown” fiber optic installation methods resulting in significantly lower damage or repair required (two breaks per million installed feet).
- A 90-day subcontractor look-ahead schedule to determine the inventory of CM-furnished equipment required on site with a result of no-lost-time due to furnished equipment.

The CFD, its contractors, and the SNS project as a whole have continued to do a commendable job in assuring site safety, as well as in managing the complexities of parallel construction activities. This has been demonstrated through an excellent site safety record, excellent site management and coordination, and effective transition of completed facilities.

The differential settlement between the RTBT Tunnel and Target Building has reached approximately three inches. The modeling and assessment of this condition to date appear to support the project approach of monitoring the situation, rather than effecting repairs. No impact to operational requirements is anticipated by the project.

The integrated site infrastructure supporting the Center for Nanophase Materials Sciences, the SNS, the Joint Institute for Neutron Sciences, and any other site facilities represent a unique capability for ORNL. The project should ensure that the integrated utility systems will support SNS availability during outages, maintenance, equipment breakdowns, and loss of power scenarios given the demands of these additional facilities.

There is a potential disconnect in the End Game Plan where it shows CF staff ramping down to approximately zero in March 2005. With construction completion scheduled for the end of February 2005, and a contractual requirement to close the construction contracts within 90 days, the CF ramp down may extend into May 2005.

As noted in previous DOE review reports, and reinforced here, the leadership required to complete equipment installation and ensure the integration of the remaining CF construction activities continues to represent a project challenge. Adding the complexity of staff transitions and laboratory roll-offs will require constant attention to “completion”. The project must ensure adequate field engineering and installation coordination between CF forces and technical installation staff through the end of the project.

3.3 Recommendation

1. Work with the Target Building contractor to optimize the construction schedule to ensure the April 12, 2004, Ready for Equipment date for Hot Cell Equipment is achieved.

Intentionally Blank

4. ACCELERATOR PHYSICS/PRE-OPERATIONS (WBS 1.10)

4.1 Findings

Excellent progress was reported on the successful beam commissioning through DTL Tank #1. All diagnostics performed very well. This was a severe test not only of DTL Tank #1, but also of the ion source and Front End Systems. Transmission and emittance goals were met. There were problems uncovered, but these related to reliability rather than accelerator physics.

The ion source demonstrated a reliability of seven percent downtime during DTL Tank #1 commissioning; a further factor of 14 is needed to reach the goal of 0.5 percent. In response to a May 2003 DOE review recommendation, a “Hot Spare” ion source was equipped with a Low Energy Beam Transport (LEBT) and an emittance scanner. Besides providing a ready spare, this set-up is a fully-fledged test stand and is being used to develop high reliability operation.

During commissioning the resonant frequency of the RFQ suddenly changed by 500 kHz. This event occurred at the same time the control system experienced a major fault. Subsequent investigation did not locate the cause of the frequency shift. After retuning the RFQ, normal beam operation was restored.

The diagnostic plate emittance scanner performed well at 7.5 MeV, but needs upgrading to be able to function at the higher beam energy (40 MeV) when DTL Tank #3 is commissioned.

Neither the Medium Energy Beam Transport (MEBT) halo scrapers nor the MEBT chopper were commissioned.

The energy spreader cavity in the HEBT line was deferred and may possibly be removed from the baseline to save cost. The Committee was presented with simulation calculations using the program “Orbit” that demonstrated that even with the higher peak current resulting from the lack of energy spreading the losses were less than 0.2 percent for 1 MW operation, which is acceptable.

Excellent progress has been made in simulating the “electron cloud”. These demonstrate the beneficial effects of solenoids in the collimator regions. The efficiency of clearing electrodes as a function of voltage now appears to be understood.

A plan was presented that narrows the focus of the Ring beam diagnostic effort to assure that the most necessary diagnostics—BPM, BLM, BCM, and Foil Video systems—be available and well-tested before beam commissioning begins. It appeared that this effort may still be too diffuse, and that work on diagnostics that are not necessary for initial commissioning is continuing at a level of effort that may be putting the timely availability of the minimum necessary set at risk.

4.2 Comments

The ASD is to be congratulated for the successful commissioning of DTL Tank #1, especially on the rapid achievement of the beam parameter goals.

The “Hot Spare” ion source is to serve a dual role, both as a spare during commissioning, and as a test stand for reliability development. At this stage in the project, and considering the order-of-magnitude improvement needed in reliability, the Committee considered the latter role more important than the former.

As long as the RFQ frequency change is not understood, the Committed recommended continuous running of the RFQ at operating parameters to acquire confidence in the stability of its resonance frequency.

The emittance of the beam “core” is impressive, but it should be noted that this figure of merit is not relevant unless there is a collimation system that can select this “core”. It is highly desirable to commission the MEBT halo collimation system while the beam energy is still sufficiently low that detailed emittance data can be taken. The last chance to perform this measurement is when DTL Tank #3 is commissioned.

As result of the End Game Plan, there will be two to three months less time available for commissioning. Commissioning with a beam stop at the end of the completed DTL was eliminated. The commissioning time still seems adequate, but very little contingency remains.

The possible elimination of the energy spreader HEBT cavity from the baseline has in principle the potential of affecting the capability of operating the facility at 1 MW beam power. The quite extensive simulations that were presented indicate that 1 MW operation is still possible. These simulations should be recorded in an SNS project report. Similar reports that ensure the Level 0 Baseline requirement of 1 MW-capable operation is supported should be produced if further configuration changes are needed in the future.

The commissioning effort was severely hampered by excessive electromagnetic noise that initially caused frequent trips of the MPS and, even after significant improvement, still introduced significant noise into the signals from the BCM. The noise seems to be mainly caused by the HVCM, switching mode power supplies, and sparking in the ion source. The present effort to identify the noise sources and mitigate this problem should be continued vigorously, and established grounding and shielding practices should be used for all installations.

It is absolutely necessary that a close-to-complete set of primary beam diagnostic instrumentation and software be present, integrated into the operating systems of the Ring and associated transfer lines, and well-tested before commissioning begins on those systems. In order to assure this, the beam diagnostic effort should be more closely focused on the most important items, namely the BLM, BPM, BCM, and Foil Video systems, and if necessary, work on other beam diagnostics should be delayed.

SNS has an accomplished staff that has made excellent progress in the construction project. However, the Committee expressed concern that there is not a convincing staffing plan for morphing into a robust operating accelerator laboratory, with the possible exception of the actual accelerator operations group. There is a lot more to accelerator operations than the direct operation of the accelerator. The near-term lack of funds, in conjunction with the remote partnership mechanism may be making this challenge more difficult.

4.3 Recommendations

1. Use the Orbit code or other simulations to document and ensure that changes in the accelerator configuration continue to support the Level 0 Baseline requirement for 1 MW operational capability.

2. Install and commission the MEBT halo scraper system during the next commissioning run. This will also require upgrading the diagnostics plate emittance scanners to
40 MeV capability.

3. Continue to reduce electromagnetic noise and its impact on beam diagnostics and controls.

4. Focus the accumulator ring beam diagnostic effort on the most important diagnostic elements, namely the BLM, BPM, BCM, and Foil Video systems. This narrower focus should soon begin to meet the beam commission start date of July 2005.

5. Present a staffing plan for the eventual change from a construction project into an operating accelerator laboratory at the next DOE review. This plan should include, at a minimum, estimates of the workload of an operating SNS, including ramp-up to 1 MW operation and beyond, the required staffing level in various expert categories, and an approximate schedule and procedure for building to this required staff.

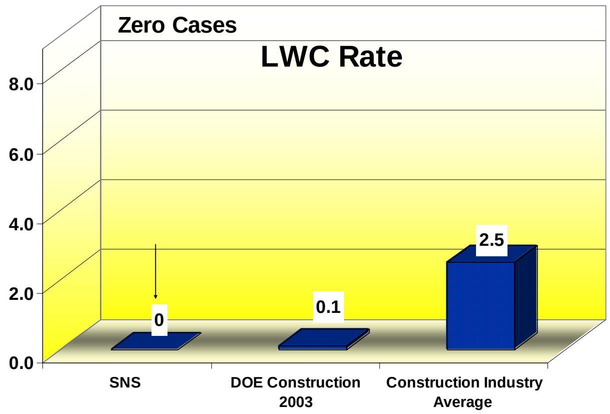
5. ENVIRONMENT, SAFETY and HEALTH

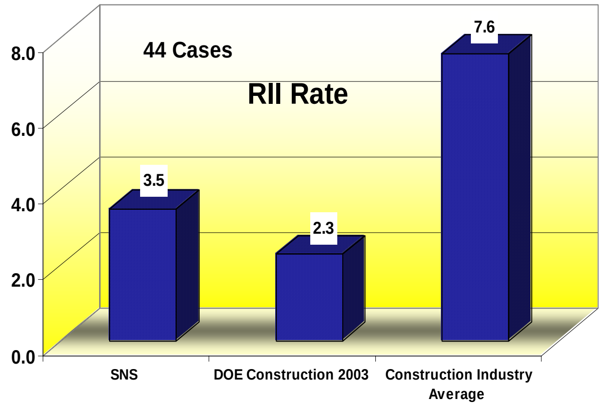
5.1 Findings and Comments

One recommendation was made during the May 2003 DOE review: *Complete the development and implementation of procedures for the lockout of each complex system prior to commissioning any of its subsystems*. The project has effectively responded to this recommendation and has a process in place to assure that lockout procedures are in place for each system with multiple energy sources prior to its energization.

The project has a Readiness Review Plan in place for operation of the accelerator and target that will enable it to be prepared for CD-4. The strategy for an Accelerator Readiness Review for operations (CD-4) and an Operational Readiness Review for the target (post CD-4), if necessary, has been developed. The individuals who have been proposed for the review committees are appropriate for this project.

Personnel safety in both construction and installation activities continues to be outstanding—2.5 million construction and 1.9 million project/installation man-hours have been worked to date without a Lost Workday Case (LWC) injury, which is a commendable accomplishment.





The project has been working successfully on improving (reducing) its Recordable Injury Incident (RII) rate since May 2003 DOE review. The scope of the field task Job Safety Analysis has been broadened to include preparatory and post-task activities. They are continuing to emphasize effective work interfaces. Since this shift in focus on recordable injuries, the construction project has enjoyed a period of 107 days without a single recordable injury case.

There are no environmental concerns by the State and Federal agencies with jurisdiction over ORNL with regard to SNS construction. The SNS project is currently working with the Tennessee Department of Environment and Conservation to have required permits in place in anticipation of facility operations.

Project management's focused attention on safety has yielded not only very low injury rates but has generated a positive working relationship between craft and management. One favorable outcome for the project has been the cooperation and suggestions to improve safe work practices by union craft personnel. They have identified safer and more efficient means of performing work. This photograph shows two cable pullers recommended by the electricians. The pullers reduce the number of individuals needed to move the cable off of the six 5,000 pound spools eliminating the potential for back and hand injuries, and reducing the need for six craft personnel who previously would have fed the cable off of the spools. These pullers also contribute to increased productivity as fewer personnel are required to force the cables through the conduit to the tunnel area below.

In summary, Integrated Safety Management Principles are being applied on the SNS project in construction and the coordination, installation, and commissioning of technical systems.

5.2 Recommendations

None.

6. COST ESTIMATE

6.1 Findings

The SNS TPC has remained unchanged since the May 2003 DOE review at $1,411.7 million. A summary of the cost estimate can be found in Appendix D. The TPC consists of a TEC of $1,192.7 million (construction line item) and $219.0 million of operating-expense funded activities (including R&D and Pre-Operations).

The actual FY 2003 costs-to-date (October 2002 through September 2003) were $292.4 million ($277.8 million for construction line item activities and $14.6 million for R&D and Pre-Operations). Cumulative costs and commitments through September 2003 were $1,055.3 million ($923.2 million for line item activities and $132.1 million for operating-expense funded activities).

The line item Budget-at-Completion (BAC) presented was $1,147.9 million. This represents an increase of $14.5 million (use of contingency) over that presented in May 2003. The total contingency remaining in the baseline TEC is $44.8 million. Also presented was an EAC of $1,161.4 million with $31.3 million remaining in contingency. Using the EAC, actual costs and commitment through September, and estimated costs and commitments for October, the project calculated a contingency of 21.8 percent. This estimate is based on the following assumptions: 1) projected costs through October 2003 are $869.2 million; 2) open commitments and awards at the end of October 2003 are $81.0 million; and 3) credit for contracts awarded but not funded or awards incrementally funded is $67.5 million.

Each of the technical subcommittees reviewed the SNS EAC and provided an independent assessment of the adequacy of that estimate for the systems reviewed. The results are summarized below. Details of these analyses are covered in the individual technical sections where applicable.

SNS management continues to use phase-funded procurements in the technical and CF portions of the project. Approximately 108 contracts with a total value of $290 million have been phase-funded. Sixty-two of these with a total value of $119 million have been completed.

The integrated cost performance module Microframe Project Manager (MPM) appears to be fully functional including cost estimates and detailed schedule baselines. The value of the performance metric is limited by frequent revisions of the baseline. However, as is appropriate for a project approaching completion, focus is shifting towards the EAC and very careful contingency management. Based on the performance reporting system, the SNS project is 72 percent complete as of the end of September 2003, as compared with 73 percent planned.

SNS provided a project risk summary, reflecting analyses performed in October 2003. The analysis identified a “maximum cost impact” of $22.3 million if all 42 identified risks were to materialize. Previously (May 2003) the “maximum cost impact” associated with identified risks totaled $41.1 million. Risks associated with the DTL, LLRF, high-power RF, and Target installation are receding. Risks associated with cryomodule delivery have increased.

The May 2003 review committee assigned the following actions: 1) prepare a comprehensive End Game Plan that resequences project activities to better match the approved funding plan; 2) conduct a DOE review of the End Game Plan.

SNS and DOE have completed these actions. The End Game Plan addresses three issues:

1. FY 2006 funding disconnects—operations funding ($75 million, approximately six months), pre-operations budgeted through late finish (June 2006), while construction is funded through early finish (December 2005).
2. Implicit schedule contingency—the December 2005 early finish asserts an aggressive schedule that outstrips the FY 2004 BA and limits some of the flexibility derived from phased contracts.
3. Cost growth—cost growth would exacerbate the funding/schedule disconnect.

The May 2003 DOE review report identified a shortfall in the projected BA for FY 2004. The cumulative BA provided only $500,000 relative to planned expenses (not including projected open commitments). The revised work plans are consistent with the approved funding profile and provide a $1.6 million buffer relative to the cumulative BA of $1,071.8 million. The revised work plan does slip the projected Early Finish date three months to March 2006 with the attendant increases in risk.

6.2 Comments

The present contingency level (using the management-derived EAC) is $31.3 million. This represents a significant reduction ($13.3 million or 30 percent) in six months from the $44.6 million contingency (using the EAC) presented during the May 2003 DOE review. An analysis of historical contingency usage does indicate a reduction in the usage rate. However, current available contingency levels are very tight, and SNS management concurred with this assessment. The Committee's discomfort was amplified by the fact that the contingency percentage reported by SNS (21.8 percent) above does not provide any contingency allowance for open commitments ($81.0 million at the end of October 2003) and contracts awarded but not funded plus phase-funded contracts ($67.5 million).

Of the $13.3 million in contingency usage since May 2003, $9.4 million was in CF. The fact that there are very few additional significant construction procurements left mitigates somewhat the concern regarding the rate of contingency usage since May 2003.

The Committee's review of the contingency included an evaluation of the risk-based contingency analysis provided by the SNS project staff. The analysis was found to be incomplete and it underestimated the cost risk facing the project. For example, the following risks were not included in the analysis:

- "Standing Army" costs in the event that the Early Finish date is exceeded.
- Residual risk associated with materials that have been delivered, but where failures are still a possibility.
- An estimate of the "unknown unknowns" component.

The Committee judged that the contingency remaining at this stage in the project is extremely tight, but adequate to complete the project within the TPC given careful management focus. With regard to the 21.8 percent contingency presented, the percentage has increased slightly as compared with that presented at the May 2003 DOE review.

The information being entered into the DOE Project Assessment Reporting System (PARS) is entirely consistent with the data being reported in the project's monthly status reports. This data is collected using the project's MPM system and appears to be fully consistent with actual physical progress. However, problems within PARS currently prevent accurate display of the information.

6.3 Recommendations

1. Present a current EAC and identify additional cost savings to meet a contingency target of $25 million (as a minimum) at the next DOE review.

2. Perform a more comprehensive risk analysis by January 1, 2004 and continue to update monthly.

Intentionally Blank

7. SCHEDULE and FUNDING

7.1 Findings

The project's current cost baseline remains at a TEC of $1,192.7 million and a TPC of $1,411.7 million, which are both specified in the Construction Project Data Sheet in the FY 2004 President's Budget Request and in the SNS PEP. The FY 2004 Data Sheet contains a BA profile (see Appendix E) of $143.0 million in FY 2004; $112.9 million in FY 2005; and $74.9 million in FY 2006. The project's planned profile for budget outlay is: $221.4 million in FY 2004; $99.1 million in FY 2005; and $52.4 million in FY 2006. The difference between the available cumulative funding (BA) and the planned cumulative obligations through the end of FY 2004 is $1.6 million. (See Section 6, Cost Estimate, for a discussion of the contingency analysis.)

The IPS is consistent with the BA funding profile cited above. This IPS includes an internal goal for an early project completion in March 2006, providing three months of project schedule contingency relative to the CD-4, Approve Start of Operations, commitment date of June 2006. There is additional one-month float within the IPS before the early finish date. Project performance continues to track well against existing DOE milestones.

The IPS (see Appendix F for summary version) is derived from the detailed schedules provided by each WBS manager. The integrated detailed schedules are comprised of 15,351 activities, 18,556 relationships, and 652 inter-project links, approximately the same as at the May 2003 DOE review. Project elements that are on or near the critical path include the Target Building and Target installation, as well as accelerator commissioning. An abbreviated IPS for the Accelerator Systems currently shows approximately 125 days of schedule contingency, exactly
50 percent of the schedule contingency shown on this same schedule at the May 2003 DOE review.

7.2 Comments

Implementation of the SNS End Game Plan allowed the project to develop a new schedule that is fully consistent with the DOE BA funding profile. The new schedule pushed back work originally planned for FY 2004, into FY 2005 and FY 2006, with the result that the IPS Early Finish date slipped three months to March 2006. This still leaves a full three months of schedule contingency before the baseline CD-4 milestone of June 2006.

In formulating the new schedule, the project has planned to leave a small buffer of $1.6 million in unallocated BA at the end of FY 2004. This represents a significant improvement over the situation as noted in the May 2003 DOE review and the Committee commended the project for continuing to plan for aggressive progress on many fronts. SNS management plans to hold back 15 percent of FY 2004 funding until much later in the year in order to maintain flexibility and ensure that the available BA is used most effectively. However, given the small size of the buffer, it is likely that contingency use over the course of FY 2004 will cause some work planned for FY 2004 to slip into the beginning of FY 2005.

The IPS identifies the Target Building (hot cell portion) and the Target Systems as comprising the project's critical path. At present, and given budget constraints, there is not much that can be done to improve upon the contractor's schedule to turn over the hot cell portion of the Target Building for the beginning of Target installation. But since this same contractor is responsible for installing the Target hardware, he has been asked to develop an integrated schedule for both sets of activities. This schedule is likely to provide the most efficient overall path for the earliest possible completion.

While the Committee recognized the importance of the Target-related work, it was clear that accelerator testing and commissioning activities are very close behind in terms of criticality. The 50 percent reduction in the IPS schedule contingency (from six months to three months) over the remaining 28 months through March 2006 is a real concern.

7.3 Recommendations

None.

8. MANAGEMENT (WBS 1.2)

8.1 Findings

Impressive progress continues to be made on the construction, technical components, and installation of the SNS project. At the end of September 2003, the SNS project was about 72 percent complete. The R&D is 97 percent complete, while the design work is 92 percent complete (the remaining work relates to the Instrument Systems). Project construction is 75 percent complete and over 95 percent of the major procurements have been awarded. Installation of the technical systems is estimated to be 39 percent complete. All of these indices represent significant progress since May 2003 DOE review. All accelerator buildings have been turned over to ASD, and DTL Tank #1 has been commissioned. Target core vessel installation has begun.

The SNS project has been very responsive to the recommendations from the May 2003 DOE review. Most notably, the project has developed an End Game Plan that was reviewed by the DOE SNS Project Office in July, and has now been implemented in the baseline. This project completion plan aligns the SNS IPS with the BA profile for the remainder of the project, with the consequence of delaying the internally driven Early Finish date by three months to March 2006, now just three months before the CD-4 milestone at the end of June 2006. The critical path in the new schedule goes through the installation of the Target hot cell and has one month contingency with respect to the early completion date.

Project cost contingency based on EAC is reported to be $31.3 million, 21.8 percent of the unobligated cost to go. This is to be compared with $44.6 million (20.2 percent) of contingency reported at the May 2003 DOE review. SNS management continues to examine possible technical adjustments, sequencing of activities, and the level of component testing to accommodate potential cost increases, with the goal of limiting the use of contingency funds. The project is continuing to transfer work and the associated risk to ORNL from the partner laboratories and examined other options to reduce contingency use and balance risk. The SNS project uses a risk analysis technique to identify and evaluate risks to the project and to determine the level of contingency that may be needed. This risk list totals to a potential need of $25 million, leaving $6 million of contingency funds to cover unknown risks.

Dr. Jeffery Wadsworth has been recently appointed as the new Director of ORNL and has established close links with the SNS project. He is fully supportive of the SNS project and realizes its importance to the DOE Office of Science. SNS and ORNL management continue to work closely to ensure that the SNS project will be integrated into ORNL when completed.

The MOA between the SNS project and the partner laboratories remains in place. This document reflects the business relationships between the SNS project and the individual partner laboratories that are required to manage the SNS project. Two of the five partner laboratories have been successfully transitioned off of the project. LBNL finished as scheduled in July 2002. Remaining instrument work has been transferred from ANL to ORNL as of September 2003. An early handoff of Linac responsibility from LANL to ORNL is planned for April 2004. Cost savings resulting from the early ANL and LANL hand-offs have been used to offset cost increases and limit contingency usage. A "lead-mentor-consult" sequence is planned for transferring knowledge from the partner laboratories to ORNL, and this seems to be working satisfactorily with the three laboratories that have or are in the process of being transitioned off.

8.2 Comments

Overall, excellent progress has been made on the SNS project. It is being managed effectively by a strong and competent team, consistent with completing the baseline project scope within the baseline TPC ($1,411.7 million) and schedule (operation in June 2006). The contingency has decreased $15 million since the May 2003 DOE review to $31 million. While the risk analysis suggests that this contingency is adequate, the rapid contingency usage is a concern and SNS management needs to remain diligent to ensure that the cost baseline is met. While the project has made concerted efforts in identifying cost savings, this remains a priority and will require continued attention.

The Committee reaffirmed its confidence in the SNS management team (see Appendix G). SNS management provided evidence that issues are identified quickly and actions are taken to resolve them. The Project Office has good communications with the partner laboratories; issues raised by them are heard and dealt with effectively. Balancing cost, schedule, and technical risk remains a significant challenge. The SNS project relationship with both the DOE Office of Basic Energy Sciences and the local DOE Project Office continues to be positive and cooperative.

Contingency remains tight, and managing it will be a challenge. A risk analysis is continually updated to identify issues. The risk analysis identifies the likelihood of the risk associated with the issues, the potential timing of the risk event, and the severity of the issue in terms of cost and schedule impact. This is an important approach, but it must be recognized that this list addresses only the "known unknowns," and that problems not on the list may arise. For example, the DTL problems were not identified on the risk list before they arose. It is also very important to keep this list up to date and aligned with the lists developed by the Level 2 WBS Managers and partner laboratories. For example, the risk list presented by BNL contains items not on the "official" project risk list.

SNS management has identified a number of engineering implementation options which, if implemented, could reduce the EAC by on the order of $7 million, generating this much additional contingency. While the facility could be completed with CD-4 performance parameters with these reductions taken, it would be desirable to include them if possible to ensure higher performance. Management is planning to defer work on the affected systems to as late a date as possible to maintain flexibility. This is a prudent strategy.

The current major challenge is the poor production yield of the medium-β SCL cavities at TJNAF. The project has responded by calling a review by a committee of independent experts, which was conducted in October 2004. TJNAF presented a plan for process improvements; the committee endorsed these and made additional recommendations. At this time, 60 percent of the recommendations have been implemented. TJNAF has responded positively, bringing considerable talent and expertise to bear, demonstrating considerable commitment to the SNS project and receiving strong management support. Continuing and significant attention will be required, however, to fully resolve this issue, and it is not guaranteed that a substantial increase in yield will be achieved. While this issue will not affect project completion, it can affect the cost of this activity. A strong scientific approach to the yield issue, in addition to continued focus on production of the cavities, is required.

The transition from construction to operations is an important element of the End Game Plan both to ensure a successful technical outcome and to manage the project costs and affect possible cost savings. The SNS management described how their organization will evolve from a construction to an operating organization with the goal of obtaining increased operational efficiency. Handoff/transition plans for the remaining partner laboratories need to be implemented with these overarching goals.

A good plan is being developed for LANL, which addresses how LANL can continue to provide technical backup on a “consulting” basis. As a result of the strong involvement by ORNL personnel in solving the DTL problems, they have developed significant technical expertise, which will speed up the full transfer of responsibility to ORNL. While the handoff plan seems to satisfy all parties, the post-handoff MOA has not yet been finalized.

Because of the need to take serious measures to control overall project costs, the committee encouraged SNS management to examine the potential savings from a faster transition at the partner laboratories than is currently planned. The project should identify key skills and technical knowledge that are necessary to bridge the transition between the partner laboratories and SNS before making hand-off decisions.

A key element to the success of the project its early completion. Increased attention on identifying mitigation activities to reduce the risk of schedule delays should be implemented, in addition to the current risk assessment study that focuses largely on cost. Delays in the schedule may result in cost growth beyond the cost of the effort to remedy the problem, which is the source of the delay. The ability to transfer staff to an operating budget when a major subsystem has been successfully commissioned and tested, but prior to CD-4, would facilitate the transition from the construction project to the operating phase.

8.3 Recommendations

1. Closely monitor the implementation of the cavity yield mitigation plan at TJNAF and conduct a follow on review by the end of January 2004.

2. Finalize plans by January 2004 for the earliest possible ramp-down of effort at the remaining partner laboratories and for transfer of technical knowledge from them to SNS at ORNL.

3. Increase focus by January 2004 on schedule issues in the risk assessment document.

4. Develop a plan by March 2004 for transferring staff to an operating budget when a major subsystem has been successfully commissioned and tested but prior to CD-4.

APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government
Department of Energy

memorandum

DATE: August 26, 2003

REPLY TO
ATTN OF: SC-10

SUBJECT: SEMI-ANNUAL DOE REVIEW OF THE SPALLATION NEUTRON SOURCE PROJECT

TO: Daniel R. Lehman, Director, SC-81

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 November 4-6, 2003. The purpose of this review is to evaluate progress in all aspects of the project: technical, cost, schedule, management, and ES&H.

The SNS project is now over two-thirds complete, and the key activities include hardware fabrication and installation of the Linac, Ring, and Target Systems, as well as construction of the Target and Central Laboratory and Office Buildings. At the previous DOE Review in May 2003, the project was tasked to develop an "End Game Plan" to ensure that SNS could be completed within the approved Budget Authority (BA) funding profile. Such a plan was prepared, reviewed, and endorsed by DOE for final development and implementation by September 30, 2003. The "End Game Plan" review also expressed concern regarding the adequacy of the remaining contingency. Hence, the November 2003 DOE review should devote special attention to evaluating contingency management and identifying areas where improvements could be made to ensure that the project is completed within the $1, 411.7 million TPC.

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 those in the FY 2004 Project Data Sheet and the current DOE-approved SNS Project Execution Plan (e.g., Total Project Cost of $1,411.7 million, and CD-4 in June 2006), and is there adequate progress to meet the baseline objectives? Is the information in the DOE Project Assessment Reporting System consistent with physical progress?

2. Is the project being managed as needed for its proper execution? Is the "End Game Plan" credible and consistent with BA funding profile constraints? Has SNS management made satisfactory progress in implementing it? Is there a reasonable plan for transitioning the SNS facility into operation?

3. Is there adequate contingency (cost and schedule) to address the risks inherent in the remaining work and is it being properly managed? Is the contingency supported by and consistent with an appropriate project-wide risk analysis?

4. Is adequate progress being made on installation and commissioning of Linac, Ring, and Target Systems? Are the installation and commissioning plans reasonable from the

standpoint of previous experience, technical logic, costs, project-wide staffing plans, and transfer of responsibilities from the partner labs?

5. Are ES&H aspects being properly addressed given the project's current stage of development? Are Integrated Safety Management Principles being followed?

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

Jeff Hoy, the SNS Program Manager, will serve as the Basic Energy Sciences point of contact for 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:
B. Weakley, SC-4
L. Dever, SC-80
J. Carney, SC-81
J. Hoy, SC-13
G. Boyd, Oak Ridge Operations Office
G. Malosh, Oak Ridge Operations Office
L. Price, Oak Ridge Operations Office
J. Wadsworth, Oak Ridge National Laboratory
T. Mason, SNS Project Office
C. Strawbridge, SNS Project Office

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review
of the
Spallation Neutron Source (SNS) Project
November 4 - 6, 2003

Daniel R. Lehman, DOE, Chairperson
James R. Carney, DOE, Co-Chairperson

SC1	SC2	SC3	SC4	SC5
		Target	Instrument	
Linac System, WBS 1.4	**Ring System, WBS 1.5**	**Systems, WBS 1.6**	**Systems, WBS 1.7**	**Control Systems, WBS 1.9**
* Dixon Bogert FNAL	* Rod Gerig, ANL	* Gunter Bauer, FZJ	* John Tranquada, BNL	* Rusty Humphrey, SLAC
Bob Diebold, consultant	Dick Cassel, SLAC	Jocy Donahue, LANL	David Mildner, NIST	
Ken Shepard, ANL	George Goeppner, ANL	Ian Thorson, TRIUMF	Robert McGreevey, ISIS	
Helen Edwards, FNAL			Greg Smith, ORNL	

SC6	SC7	SC8	SC9	SC10
Conventional	Accelerator Physics			Project
Facilities, WBS 1.8	**Pre-Operations (WBS 1.10)**	**ES&H**	**Cost and Schedule**	**Management, WBS 1.2**
* Dale Knutson, ANL	* Tom Roser, BNL	* Rich Hislop, ANL	* Jim Krupnick, LBNL	* Rich Hawryluk, PPPL
Dale Flowers, PNNL	Peter Limon, FNAL		Phil Lindquist, Cal Tech	Jim Strait, FNAL
	Rick Baartman, TRIUMF			

Observers

Pat Dehmer, DOE/SC	Les Price, DOE/ORO	Rick Korynta, DOE/TJNAF
Jeff Hoy, DOE/SC	Larry Radcliffe, DOE/ORO	Kevin Jones, LANL
Pedro Montano, DOE/SC	David Wilfert, DOE/ORO	Paul Lisowski, LANL
Kristin Bennett, DOE/SC	Beverly Kipe, DOE/ME	William Press, LANL
Mike Osinski, DOE/SC	Eugene Colton, DOE/ALB	Klaus Berkner, UC

LEGEND

SC Subcommittee
* Chairperson

Count: 27 (excluding observers)

APPENDIX C

REVIEW AGENDA

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

AGENDA

Tuesday, November 4, 2003—SNS Building, 701 Scarboro Rd., Conference Room 101

8:00 am	DOE Full Committee Executive Session .... Carney • BES Program Perspective—Charge .... Dehmer • DOE Project Director Perspective .... Price • SNS Cost Spreadsheet .... Krupnick
9:00 am	Opening Remarks • UT-Battelle Welcome .... Wadsworth • DOE Welcome .... Dehmer
9:10 am	SNS Overview .... Mason • Safety • End Game Plan • Current Challenges
10:00 am	Break
10:15 am	Project Management Overview .... Strawbridge • Construction safety and ES&H performance • Cost/schedule performance (plus DOE PARS) • Risk assessment, contingency status, estimate to complete • End Game Plan Implementation • Response to prior DOE Reviews
10:40 am	Experimental Facilities Summary .... Anderson • Status of R&D, design, and procurements • Baseline Status (cost/schedule/technical) • Target/Instrument Installation Planning and Progress • Response to prior Reviews • Current issues
11:05 am	Accelerator Systems Summary .... Holtkamp • Status of R&D, design, and procurements • Baseline status (cost/schedule/technical) • Accelerator Installation and Commissioning Planning and Progress • Response to prior Reviews • Current issues
11:35 am	Conventional Facilities Summary .... Chargin • Status of construction • Baseline status (cost/schedule/technical) • Response to prior Reviews • Current issues

12:00 pm	Lunch
12:45 pm	Parallel Subcommittee Presentations/Discussions
	• Accelerator Systems .... Holtkamp/STLs
	• Conventional Facilities .... Chargin/Staff
	• Experimental Facilities .... Anderson/STLs (Management/Cost & Schedule/ES&H Subcommittees meet with above subcommittees)
3:30 pm	Site Tour
5:00 pm	DOE Subcommittee Executive Sessions
5:15 pm	DOE Executive Session .... Carney
6:30 pm	Adjourn

Wednesday, November 5, 2003

8:00 a.m.	Subcommittee Breakout Discussions
9:00 a.m.	Management Subcommittee .... Wadsworth/Mason/Strawbridge/ Boudwin/SNS Division Directors
11:00 am	Cost/Schedule Subcommittee .... Herron/Staff
12:00 pm	Lunch
1:00 pm	Continue Subcommittee Breakout Discussions
2:30 pm	DOE Subcommittee Executive Sessions
4:00 pm	DOE Full Committee Executive Session .... Carney

Thursday, November 6, 2003

8:30 am	Subcommittee Working Sessions
10:00 am	DOE Full Committee Executive Session Closeout Dry Run .... Carney
11:30 pm	Lunch
12:30 pm	Closeout with DOE and SNS Management .... Carney
1:30 pm	Adjourn

APPENDIX D

COST TABLE

Cost Baseline

Cost Baseline

WBS	Description	November 2003 Review Baseline (BAC) $M Revision 449	May 2003 Review EAC $M	End Game Plan EAC $M	November 2003 Review EAC $M
1.2	Project Support	75.6	76.0	76.0	75.9
1.3	Front End Systems	20.8	20.8	20.8	20.8
1.4	Linac Systems	313.2	307.7	308.2	314.6
1.5	Ring and Transfer Systems	141.2	147.6	148.2	142.1
1.6	Target Systems	106.5	106.8	107.5	108.1
1.7	Instrument Systems	63.3	63.4	63.8	63.3
1.8	Conventional Facilities	367.5	366.1	373.7	376.9
1.9	Integrated Controls	59.6	59.7	59.7	59.6
BAC		1,147.9	1,148.1	1,157.9	1,161.4
Total Contingency		44.8	44.6 20.2%*	34.8 20.4%**	31.3 21.8%***
	TEC	1,192.7	1,192.7	1,192.7	1,192.7
	R&D	101.9	101.2	101.2	101.9
	Pre-Operations	117.1	117.8	117.8	117.1
	TPC	1,411.7	1,411.7	1,411.7	1,411.7

*Based on EAC and estimated costs and awards through 4/30/03

**Based on EAC and estimated costs and awards through 6/30/03

***Based on EAC and estimated costs and awards through 10/31/03

APPENDIX E

FUNDING TABLE

SNS Budget Authority (BA) Profile

(Actual Year thousands of dollars)

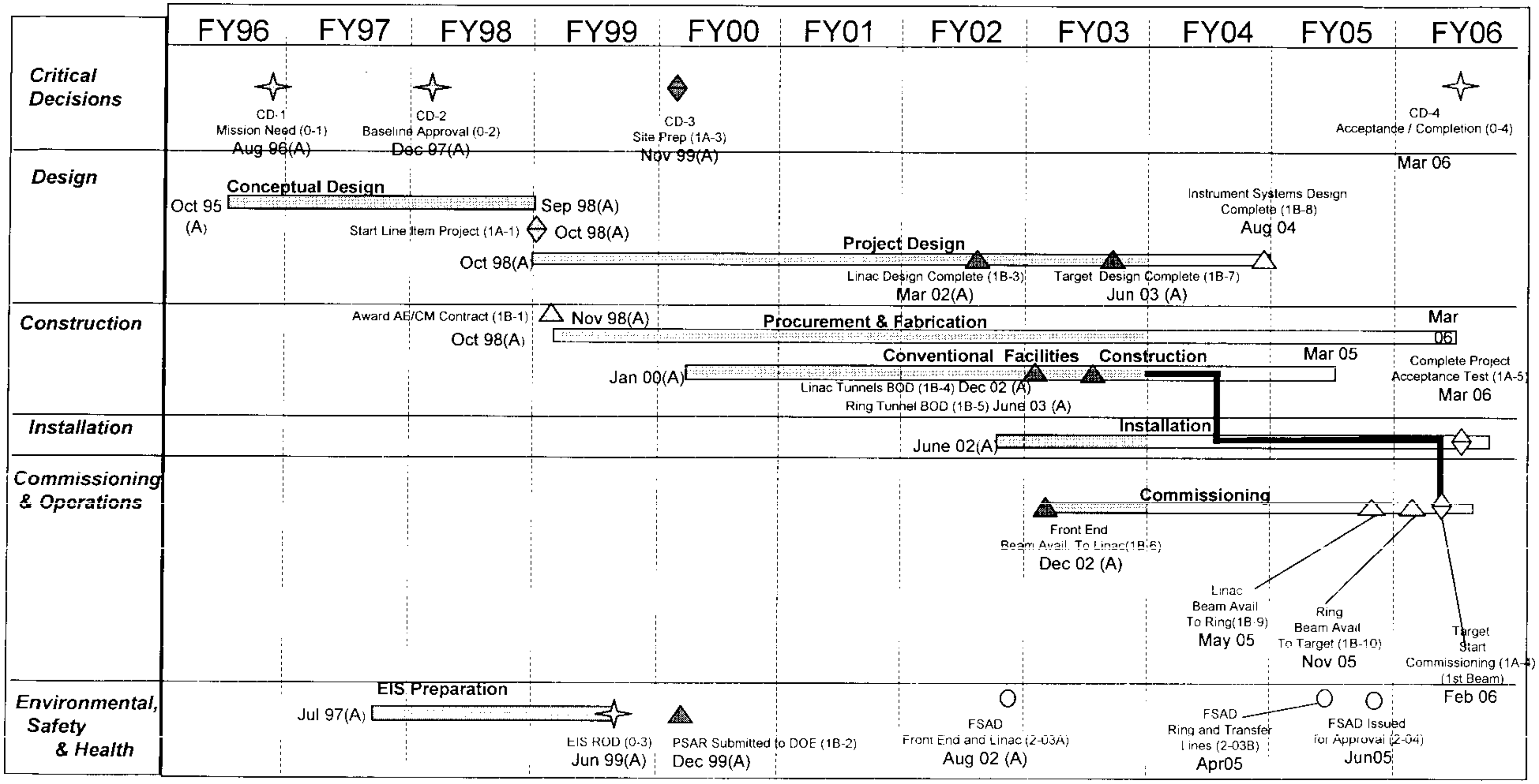
	Prior Years	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	Total
Construction Line Item		101,400	100,000	258,929	276,300	210,571	124,600	79,800	41,100	1,192,700
Operating Expense	38,578	28,600	17,900	19,059	15,100	14,441	18,397	33,100	33,825	219,000
Total BA	38,578	130,000	117,900	277,988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

Funding profile from President's FY 2004 Budget Request

APPENDIX F

SCHEDULE CHART

SNS On Track for Early Finish in March 06



Legend

(A) Actual Date Completed

Critical Path

Level 0 Milestone Early Finish Date

Level 1A Milestone Early Finish Date

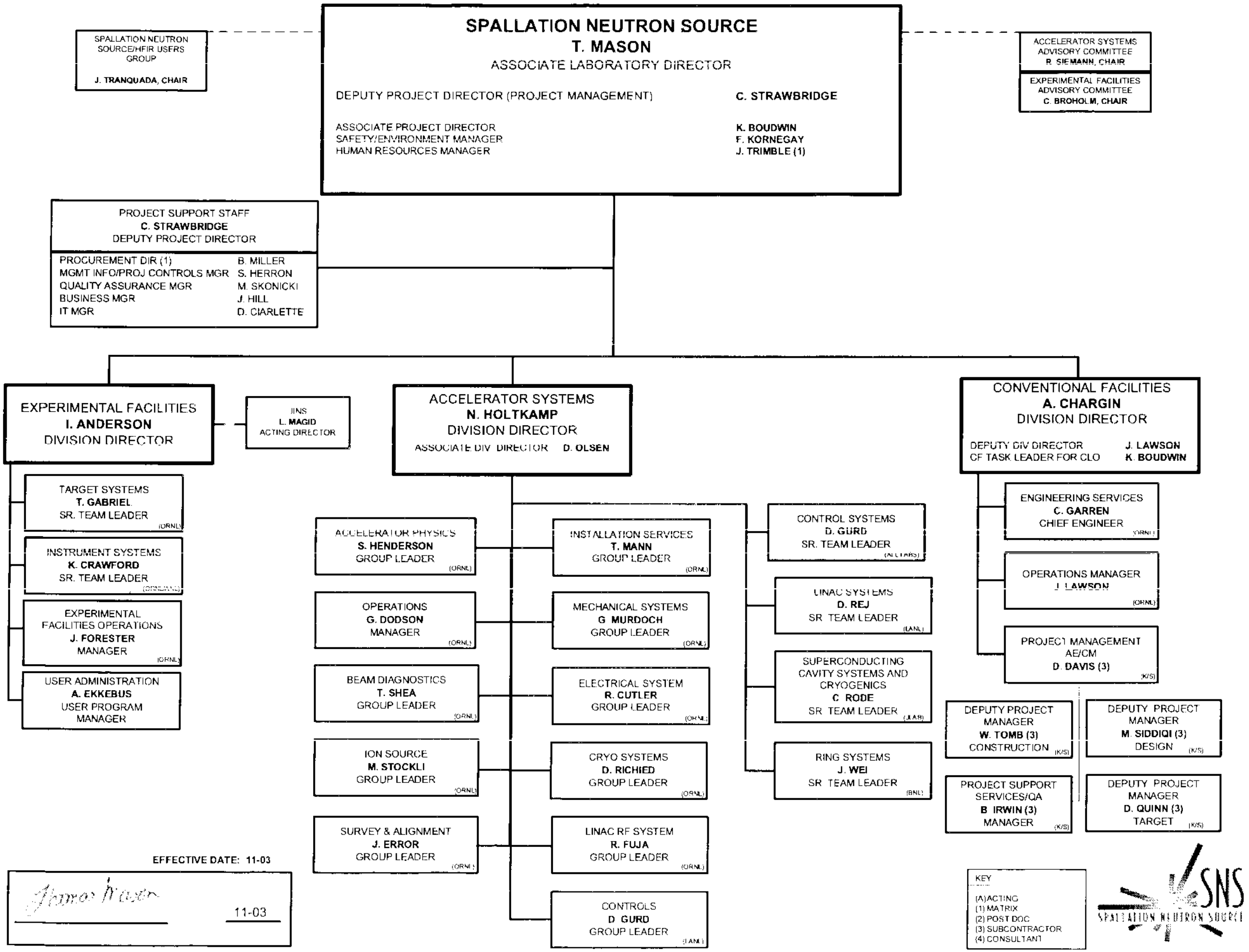
Level 1B Milestone Early Finish Date

Level 2 Milestone Early Finish Date

DOE-SC Review
November 4-6, 2003

APPENDIX G

MANAGEMENT CHART


SPALLATION NEUTRON SOURCE
T. MASON
ASSOCIATE LABORATORY DIRECTOR
DEPUTY PROJECT DIRECTOR (PROJECT MANAGEMENT) C. STRAWBRIDGE
ASSOCIATE PROJECT DIRECTOR K. BOUDWIN
SAFETY/ENVIRONMENT MANAGER F. KORNEGAY
HUMAN RESOURCES MANAGER J. TRIMBLE (1)
SPALLATION NEUTRON SOURCE/HFIR USERS GROUP
J. TRANQUADA, CHAIR
ACCELERATOR SYSTEMS ADVISORY COMMITTEE
R. SIEMANN, CHAIR
EXPERIMENTAL FACILITIES ADVISORY COMMITTEE
C. BROHOLM, CHAIR
PROJECT SUPPORT STAFF
C. STRAWBRIDGE
DEPUTY PROJECT DIRECTOR
PROCUREMENT DIR (1) B. MILLER
MGMT INFO/PROJ CONTROLS MGR S. HERRON
QUALITY ASSURANCE MGR M. SKONICKI
BUSINESS MGR J. HILL
IT MGR D. CIARLETTE
EXPERIMENTAL FACILITIES
I. ANDERSON
DIVISION DIRECTOR
JINS
L. MAGID
ACTING DIRECTOR
TARGET SYSTEMS
T. GABRIEL
SR. TEAM LEADER (ORNL)
INSTRUMENT SYSTEMS
K. CRAWFORD
SR. TEAM LEADER
EXPERIMENTAL FACILITIES OPERATIONS
J. FORESTER
MANAGER (ORNL)
USER ADMINISTRATION
A. EKKEBUS
USER PROGRAM MANAGER
ACCELERATOR SYSTEMS
N. HOLTKAMP
DIVISION DIRECTOR
ASSOCIATE DIV DIRECTOR D. OLSEN
ACCELERATOR PHYSICS
S. HENDERSON
GROUP LEADER (ORNL)
OPERATIONS
G. DODSON
MANAGER (ORNL)
BEAM DIAGNOSTICS
T. SHEA
GROUP LEADER (ORNL)
ION SOURCE
M. STOCKLI
GROUP LEADER (ORNL)
SURVEY & ALIGNMENT
J. ERROR
GROUP LEADER (ORNL)
INSTALLATION SERVICES
T. MANN
GROUP LEADER (ORNL)
MECHANICAL SYSTEMS
G. MURDOCH
GROUP LEADER (ORNL)
ELECTRICAL SYSTEM
R. CUTLER
GROUP LEADER (ORNL)
CRYO SYSTEMS
D. RICHIED
GROUP LEADER (ORNL)
LINAC RF SYSTEM
R. FUJA
GROUP LEADER (ORNL)
CONTROLS
D. GURD
GROUP LEADER (LANL)
CONTROL SYSTEMS
D. GURD
SR. TEAM LEADER
LINAC SYSTEMS
D. REJ
SR TEAM LEADER (LANL)
SUPERCONDUCTING CAVITY SYSTEMS AND CRYOGENICS
C. RODE
SR TEAM LEADER (JLAB)
RING SYSTEMS
J. WEI
SR TEAM LEADER (BNL)
CONVENTIONAL FACILITIES
A. CHARGIN
DIVISION DIRECTOR
DEPUTY DIV DIRECTOR J. LAWSON
CF TASK LEADER FOR CLO K. BOUDWIN
ENGINEERING SERVICES
C. GARREN
CHIEF ENGINEER (ORNL)
OPERATIONS MANAGER
J. LAWSON (ORNL)
PROJECT MANAGEMENT
AE/CM
D. DAVIS (3) (K/S)
DEPUTY PROJECT MANAGER
W. TOMB (3)
CONSTRUCTION (K/S)
DEPUTY PROJECT MANAGER
M. SIDDIQI (3)
DESIGN (K/S)
PROJECT SUPPORT SERVICES/QA
B. IRWIN (3)
MANAGER (K/S)
DEPUTY PROJECT MANAGER
D. QUINN (3)
TARGET (K/S)
EFFECTIVE DATE: 11-03
11-03
KEY
(A) ACTING
(1) MATRIX
(2) POST DOC
(3) SUBCONTRACTOR
(4) CONSULTANT
SNS
SPALLATION NEUTRON SOURCE

APPENDIX H

ACTION ITEMS

Action Items
Resulting from the November 2003
Department of Energy Review of the

Spallation Neutron Source

Action	Responsibility	Due Date
1. Conduct a Semi-Annual Project Status Review	DOE-SC	May 11-13, 2003

Carl N. Strawbridge
Deputy Director
Spallation Neutron Source
Oak Ridge National Laboratory

Lester K. Price
SNS Project Director
Oak Ridge Operations Office
U.S. Department of Energy

Jeffrey C. Hoy
SNS Program Manager
Office of Basic Energy Sciences
U.S. Department of Energy

Thomas E. Mason
Associate Laboratory Director
Spallation Neutron Source
Oak Ridge National Laboratory

James R. Carney
Review Co-Chairman
Office of Science
U.S. Department of Energy

Patricia M. Dehmer
Director
Office of Basic Energy Sciences
U.S. Department of Energy

Jeffrey Wadsworth
Director
Oak Ridge National Laboratory

APPENDIX I

GLOSSARY

GLOSSARY

AE/CM	Architect Engineer/Construction Manager
ANL	Argonne National Laboratory
ASD	Accelerator Systems Division
BAC	Budget-at-Completion
BCM	Beam Current Monitor
BCP	buffered chemical polishing
BLM	beam loss monitors
BNL	Brookhaven National Laboratory
BO	budget obligation
BOD	Beneficial Occupancy Dates
BPM	Beam Position Monitor
CF	Conventional Facilities
CCL	Cavity Coupled Linac
CD	Critical Decision
CFD	Conventional Facilities Division
CLO	Central Laboratory and Office Building
CPI	Communications and Power Industries; or Cost Performance Index
DANSE	Distributed Data Analysis for Neutron Scattering Experiments
DOE	U.S. Department of Energy
DTL	Drift Tube Linac
EAC	Estimate-at-Completion
EFAC	Experimental Facilities Advisory Committee
EPICS	Experimental Physics Industrial Control System
ES&H	environment, safety, and health
ETC	Estimate-to-Complete
GAO	General Accounting Office
GeV	billion electron volts
H^-	negatively-charged hydrogen ions
HB	High Beta
HEBT	High Energy Beam Transport
HPR	high pressure rinsing
HVCM	high voltage converter modulators
IDT	Instrument Development Teams
IGBT	Integrated Gated Bipolar Transistor
IOC	Input/Output computers
IPS	Integrated Project Schedule
JLab	Thomas Jefferson National Accelerator Facility

J-PARC	Japanese Proton Accelerator Research Company
K	Kelvin
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LEBT	Low Energy Beam Transport
Linac	linear accelerator
LLRF	Low Level Radio Frequency
LWC	lost workday case
M&O	Management and Operations
MAP	Mitigation Action Plan
MB	Medium Beta
MEBT	Medium Energy Beam Transport
MeV	Million Electron Volts
MHz	mega Hertz
MOA	Memorandum of Agreement
MPM	Microframe Project Manager
MPS	Machine Protection System
MV/m	mega Volts per meter
MW	million watts
ORNL	Oak Ridge National Laboratory
PARS	Project Assessment Reporting System
PEP	Project Execution Plan
QA	Quality Assurance
QC	Quality Control
R&D	research and development
RATS	Receiving, Assembly, Test and Storage
RF	radio frequency
RFP	request for proposals
RFQ	radio frequency quardrupole
RII	Recordabel Injury Incident
RTBT	Ring to Target Beam Transport
SC	Department of Energy Office of Science
SCL	superconducting linac
SING	SNS Instruments Next Generation
SNS	Spallation Neutron Source
TEC	Total Estimated Cost
TPC	Total Project Cost
XFD	Experimental Facilities Division