Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

SPALLATION NEUTRON SOURCE (SNS) PROJECT

November 2002

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science review of the Spallation Neutron Source (SNS) project was conducted at Oak Ridge, Tennessee during November 13-15, 2002, at the request of Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences, Office of Science. The purpose of the review was to evaluate progress in all aspects of the project: technical, cost, schedule, management, and ES&H. Special emphasis was given to evaluating SNS management's decision to retain the liquid mercury target concept in the baseline and whether project contingency is adequate to address the risks associated with completing SNS on schedule.

Overall, the Committee found that the SNS project is progressing well to meet its Level 0 Baseline objectives: Total Project Cost (TPC) of $1,411.7 million; project completion by June 2006; and greater than or equal to 1 megawatt proton beam power on target. The project's cost, schedule, and technical baselines are consistent with the FY 2003 Project Data Sheet and the Project Execution Plan. Technical and construction progress have continued to be excellent, and as of October 31, 2002, the project is 51.1 percent complete (versus 52.0 percent planned). The information in DOE's Project Assessment and Reporting System accurately reflects this status. Over 90 percent of all procurements have been placed under contract and market experience has been good (eight percent over the baseline estimate to date). The Front End was shipped from Lawrence Berkeley National Laboratory to the SNS site and installed on schedule and within budget during summer 2002; commissioning has just begun. Other accelerator components are continuing to arrive in Oak Ridge.

In the area of Conventional Facilities, the last two major procurements have been awarded (for the Target Building general construction and the Central Laboratory and Office Building), and most of the accelerator related structures are nearing completion. These construction activities (over 1,500,000 work-hours to date) have been accomplished without a lost workday injury. Integrated Safety Management principles are being followed. With certain exceptions, the recommendations from the May 2002 DOE review have been implemented.

The SNS project is a multi-laboratory partnership led by the SNS Project Office in Oak Ridge, Tennessee. The partners are Argonne National Laboratory, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory (LBNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Thomas Jefferson National Accelerator Facility (TJNAF). Relations among the SNS partner laboratories continue to be excellent and internal communications are generally good. Integration activities among the three SNS Divisions (Accelerator Systems, Experimental Facilities, and Conventional Facilities) are improving. There have been no changes in key project management positions.

The project is managing to an Integrated Project Schedule with an early finish date of December 2005, which provides six months of schedule contingency. While the Committee expressed confidence that the project could be completed on schedule and within the TPC, it again urged SNS management to judiciously conserve contingency funds (currently 20.4 percent of the remaining work). As noted in nearly all previous DOE reviews, the project contingency level is considered to be tight. The risk-based contingency analysis prepared by the project should be used as the basis for a formal risk management plan. The Committee recommended that the project provide monthly updates of the risk analysis to the Federal Project Manager, including a realistic Estimate-at-Completion and potential demands on contingency. Cost estimates and schedules for installation and commissioning were found to be reasonable, but should be updated by the next DOE review.

Although overall Linac progress has been satisfactory, two significant problem areas have developed in recent months: 1) vacuum leaks in a large fraction of the Drift Tubes supplied to LANL by a vendor will require 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. Based on the September SNS Accelerator Systems Advisory Committee review, primary responsibility for the LLRF task has been removed from LANL. Under ORNL leadership, LANL and LBNL are cooperating to develop a LLRF solution based on the LBNL approach used for Front End commissioning. Since the project had not completed a recovery plan for the Drift Tube problem, the Committee urged them to do so promptly and assigned an action item for the plan to be provided to DOE by January 1, 2003. It was also recommended that the SNS Project Director and Laboratory Directors for ORNL and LANL be personally involved in the plan's execution. While neither of these problems is considered to be a high technical risk, there is a potentially serious schedule risk unless management focuses the necessary resources to reach timely solutions.

Due to target window pitting concerns noted at the May 2002 DOE review, SNS management planned to reach a decision by October 2002 on whether to retain the liquid mercury target concept in the project baseline. Based on the results of intensive R&D, the project is confident that the current target wall material (cold-worked 316 stainless steel) has adequate lifetime to meet baseline objectives, i.e., several weeks operation at 1 megawatt. In addition, by implementing mitigations identified as part of the R&D program (e.g., surface hardening and/or shock reducing gas bubbles), there are very good prospects for reducing the pitting damage to the point where it is not the lifetime limiting mechanism. The timeline for implementing additional mitigations is long-term; the initial target would not require replacement until at least 2008 given the power profile of early SNS operations. Accordingly, SNS management decided to retain the liquid mercury target in the project baseline design. The Committee concurred with this decision.

In summary, the Committee found that the SNS project is still on track to meet its Level 0 Baseline objectives, and management is cognizant of the issues. As always, the Committee cautioned the project not to be complacent given the challenges ahead in the Linac, in accelerator installation and commissioning, in conserving contingency, and in safely completing conventional construction.

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1. INTRODUCTION

1.1 Background

When completed in 2006, the Spallation Neutron Source (SNS) will be the world's foremost neutron scattering facility. It will be an important scientific tool for basic research in materials science, life sciences, chemistry, solid state and nuclear physics, earth and environmental sciences, and engineering sciences. The design calls for a beam of negatively-charged hydrogen ions (H^-) to be generated and accelerated to an energy of one billion electron volts (1 GeV) using a linear accelerator (Linac). The H^- beam will then be transported to an accumulator ring, where it will be injected by stripping away the electrons to leave the desired protons and bunching them into a short (under one microsecond) pulse 60 times per second. Finally, the proton beam will be directed onto a liquid mercury target, where pulses of neutrons will be created through spallation reactions of the protons with the mercury nuclei. Inside the Target Building, the emerging neutrons will be slowed or moderated and channeled through beamlines to instrumented experimental areas where users will carry out their research. Figure 1-1 shows a 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 indicated in Figure 1-1, and defined in the SNS Project Execution Plan (PEP), each laboratory is responsible for a specific scope of work. Design and construction management of the conventional facilities is being handled by a commercial architect engineer/construction management (AE/CM) team (Zander-Jacobs) under a task order contract to ORNL.

A Final Environmental Impact Statement (FEIS) for the SNS was issued in April 1999. On June 18, 1999, the Secretary of Energy signed the Record of Decision to proceed with construction of the SNS at ORNL 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 are being properly implemented.

Figure 1-1. The Spallation Neutron Source

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

Critical Decision (CD) 1, Approval of Mission Need, and CD-2, Approval of Preliminary Baseline Range, for the SNS were approved by the Secretary of Energy in August 1996 and December 1997, respectively. The SNS PEP, which governs how the project is managed, was initially approved by the Secretary at the time of CD-2, and 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 produce a proton beam on target of $\geq$ 1 megawatt (MW). Receiving $23 million in FY 1998, the project carried out advanced conceptual design and further R&D activities in anticipation of starting Title I design in FY 1999.

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

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

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

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

At a DOE review of the SNS project in January 1999, the review committee determined that the SNS collaboration was continuing to work well together, and technical progress was generally good, however the baselines were still not judged to be ready for DOE approval. The main reason was lack of technical leadership and project-wide ownership by the relatively inexperienced SNS Project Office management team then at 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 parameters were revised to include an average proton beam power on target of up to 2 MW, enhanced ("Best-in-Class") instruments, and expanded laboratory and office space for users and staff.

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

In order to strengthen the commitment among the partner laboratories, the 1998 inter-laboratory Memorandum of Agreement (MOA) was revised, and signed by the laboratory directors in October 1999. It replaced the original MOA in the SNS PEP, and is also included by reference in the laboratories' management and operations (M&O) contracts. The latter step had the effect of making the MOA a legally binding agreement 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. The project was able to make continued progress, however, by using uncosted obligations remaining from FY 1999 while efforts were made to satisfy these conditions. In particular, DOE approved CD-3, Start Construction, on November 5, 1999, and site preparation work on Chestnut Ridge began soon thereafter. A formal groundbreaking ceremony for SNS was held on December 15, 1999. By February 2000, DOE and the project had satisfied the seven congressional conditions and all FY 2000 construction funds were released to the project. Later in FY 2000, the project managed to complete most Title I design activities, as well as nearly all site clearing, excavation, and road work.

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

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

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

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

In October and December 2000, a two-phase DOE review was conducted that included an initial evaluation of the SNS pre-operations plan and cost estimate. Three major issues were identified in the first review phase, two of which had to do with the potential for significant cost growth in different areas, one in 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 Integrated Project Schedule (IPS) required more Budget Authority (BA) than that contained in the FY 2001 Project Data Sheet's annual funding profile.

SNS management took immediate steps to resolve these issues, and by December, the committee found that the project had developed workable plans to address them. The overall approach to dealing with the cost concerns involved value engineering and selective scope reductions that still allowed the project to meet its Level 0 Baseline objectives. There were significant scope reductions in CF that included deleting the Central Laboratory and Office (CLO) Building (while retaining a minimum level of functionality) and reducing the size of the Target Building, and the instrument budget was reduced from $93 million to $53 million (still more than the conceptual design level of $45 million). In addition, the last three cryomodules of the Superconducting Linac (SCL) were deleted to save money, resulting in a lower Linac output energy of 840 MeV, while still providing a proton beam power on target of over 1 MW. The pre-operations staffing level was reduced to the minimum level necessary to commission the machine. Lastly, the IPS was re-planned to be consistent with the BA in DOE's annual funding profile and still provide 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, a reduced-scope CLO was retained in the baseline; the instrument budget was adjusted to $60 million to provide for at least five best-in-class instruments plus design of common components for future instruments; certain DOE milestones were relaxed to conform with the revised IPS; and the energy specification for Linac output energy was 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) or TPC.

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

The FY 2001 and 2002 congressional appropriations for SNS have met the levels contained in the President's Budget Requests ($278.0 million and $291.4 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 is the peak of the project's annual funding profile. The President's FY 2003 Budget Request ($225.0 million) was still under consideration by Congress at the time of the November 2002 DOE Review. In the meantime, the project is being funded under Continuing Resolutions at the higher FY 2002 rate so there have not been any adverse impacts. Both the House and Senate marks support the FY 2003 Budget Request funding level for SNS.

During FY 2001-2002, construction activities at the Chestnut Ridge site have included extensive structural work on the Front End Building, Linac and Ring Tunnels, Klystron Hall, Target Building foundation, and site utilities and support buildings. In fact, the Front End Building is now essentially complete. As of September 30, 2002, the overall project was 51 percent complete, had awarded nearly $450 million in procurements, completed 84 percent of all design work, 43 percent of conventional construction, and 94 percent of all R&D. The last two large CF procurements (Target Building general construction and CLO Building) were awarded in July 2002. The Front End System was delivered by LBNL to ORNL, installed at the site, and commissioning begun. Other technical components have continued to arrive in Oak Ridge at the Receiving, Assembly, Test and Storage (RATS) Building I on Union Valley Road and at RATS II on the SNS construction site. The overall size of the project work force, including construction workers, exceeds 1,000 full-time equivalents (FTE), which is near its peak level.

1.2 Charge to the DOE Review Committee

In an August 21, 2002 memorandum (see Appendix A), Dr. Patricia M. Dehmer, SC's Associate Director for Basic Energy Sciences (BES), 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 2003 Project Data Sheet.

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 served on one or more of the previous nine DOE review Committees. The Committee was organized into eleven subcommittees, each assigned to evaluate a particular aspect of the line item project corresponding to members' areas of expertise.

1.4 The Review Process

The Review was accomplished during November 13-15, 2002, 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 morning of the first day was devoted to project overview plenary sessions with presentations given by members of the SNS Project Office staff. 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. A tour of the construction site was conducted at the end of the first day. 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 Accelerator Physics

2.1.1 Findings

The Front End System has been transferred from LBNL to ORNL and commissioning at ORNL started October 31, 2002. LBNL demonstrated 50 milli Amperes (mA) at the exit of the Medium Energy Beam Transport (MEBT). This is a remarkable achievement given that the required intensity is 38 mA. The emittance goal has also been achieved, but at 33 mA, somewhat less than nominally. Impressive round-the-clock operation has been demonstrated. The MEBT chopping system and the MEBT halo suppression system have not yet been demonstrated. However, these things are in the recommissioning plans.

Partially chopped bunches have been simulated and these simulations show that they stay within the Linac acceptance criteria and so should pose no threat to Linac operation at full intensity.

There are no plans to characterize the beam at the exit of MEBT in all six phase space dimensions. This was a cost-saving decision made early on in the project. As a result, it is not possible to generate better distributions for end-to-end simulations than those that are obtained by tracking the measured direct current (DC) emittance in the Low Energy Beam Transport (LEBT) through the Radio Frequency Quadrupole (RFQ) and the MEBT.

There has been excellent progress on the “laser wire” profile monitors. These can be used to measure beam halo in the linac online, and moreover Front End commissioning plans include using the laser wire to measure the amount of beam in the gap. This answers a recommendation of the May 2002 DOE review.

The extraction kicker in the Ring has had a design modification that reduces its beam coupling impedance by a factor of two.

Excellent progress was shown of simulations and analytical calculations relating to instabilities in the Ring. These show that the Ring is stable up to design intensity for all known and understood instability sources. Moreover, there is hardware in the baseline for both Landau and active damping.

The LANL Proton Storage Ring (PSR) instability is still not in the category of understood instabilities, since the measured variation of threshold with bunch length is not in agreement with simulations or analytic calculations. In terms of electron production, there has been good progress in measuring and evaluating secondary electron yield for the Ti-N plated vacuum chamber material, with and without electron scrubbing.

2.1.2 Comments

There is no specification in the parameter list for beam pulse flatness. Since local intensity affects matching, lack of flatness can result in large projected emittance growth. The ion source has demonstrated flatness of intensity during a macropulse to the level of a few percent, which is probably sufficient, but there is no mechanism for maintaining flatness.

The parameter list specifies expected root mean square (RMS) emittances. This is not always a useful specification, since small halo can drastically change the RMS emittance, and the halo can be scraped in some cases, especially at low energy.

The commissioning team should use the opportunity afforded by the Drift Tube Linac (DTL) delay to more fully characterize the beam from MEBT, and to measure the efficacy of the beam halo suppression system.

Lacking a fuller understanding of the PSR instability, it is advisable to use all possible means to reduce electron generation in the SNS Ring. The proposed clearing electrode at the stripping foil and solenoids in the collimator straights should go ahead, as recommended by the Accelerator Systems Advisory Committee (ASAC) review of September 2002.

2.2 Front End Systems (WBS 1.3)

The Front End commissioning program was successfully completed on schedule at LBNL on May 31, 2002. All major beam parameters were achieved. This included a 50-mA beam current, which exceeded the 38-mA requirement by approximately 30 percent. The Front End was disassembled and shipped to Oak Ridge by July 15, 2002, as scheduled. The Front End was re-assembled at Oak Ridge, recommissioning started on October 29, 2002, and an Ion Source beam of 30 mA was extracted. The Front End Systems subproject at LBNL was formally closed out in September 2002 within budget and on schedule.

2.2.1 Findings and Comments

The Front End is complete. The Ion Source, LEBT, RFQ, and MEBT have been assembled in the SNS Front End Building and recommissioning has begun. The Front End Team has done a good job—well done.

2.3 Linac Systems (WBS 1.4)

The Linac structure is unchanged since the May 2002 DOE review. As shown in Figures 2-1 and 2-2, the Linac structure is a conventional DTL to 87 million electron volts (MeV), a cavity coupled 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.

2.3.1 Findings

Good progress has been made in many areas since the May 2002 DOE review. In two areas, however, problems have been identified that were not fully apparent at the time of the May review.

A number of serious hardware problems became apparent in May following the delivery of the first DTL section, Tank #3. An adequate and appropriate recovery plan is not yet in place.

The DTL section first assembled at LANL (Tank #3), was shipped to SNS-ORNL. Sometime after receipt, leaks were found in Tank #3, both in the body and in the drift tube sections. In subsequent investigations, it has been determined that similar flaws exist in components destined for other DTL tanks.

Three major problems found in the DTL drift tubes include: 1) vacuum leaks in the electron beam welds at the ends of the tubes; 2) electroplating of some of the tube ends that makes it impossible to reweld the ends; and 3) damage to the permanent magnets in the drift tubes from errors in the control of the electron beam. In addition, about 25 percent of all Tank #1 and Tank #3 tubes have vacuum to water passage leaks. For DTL Tank #1, 47 of the 59 tubes have been damaged and must be rebuilt. For DTL Tank #3, 29 of 33 tubes must be repaired or rebuilt. It is believed that the tubes with only vacuum leaks can be repaired by machining a groove and welding in a ring in the area of the bad weld.

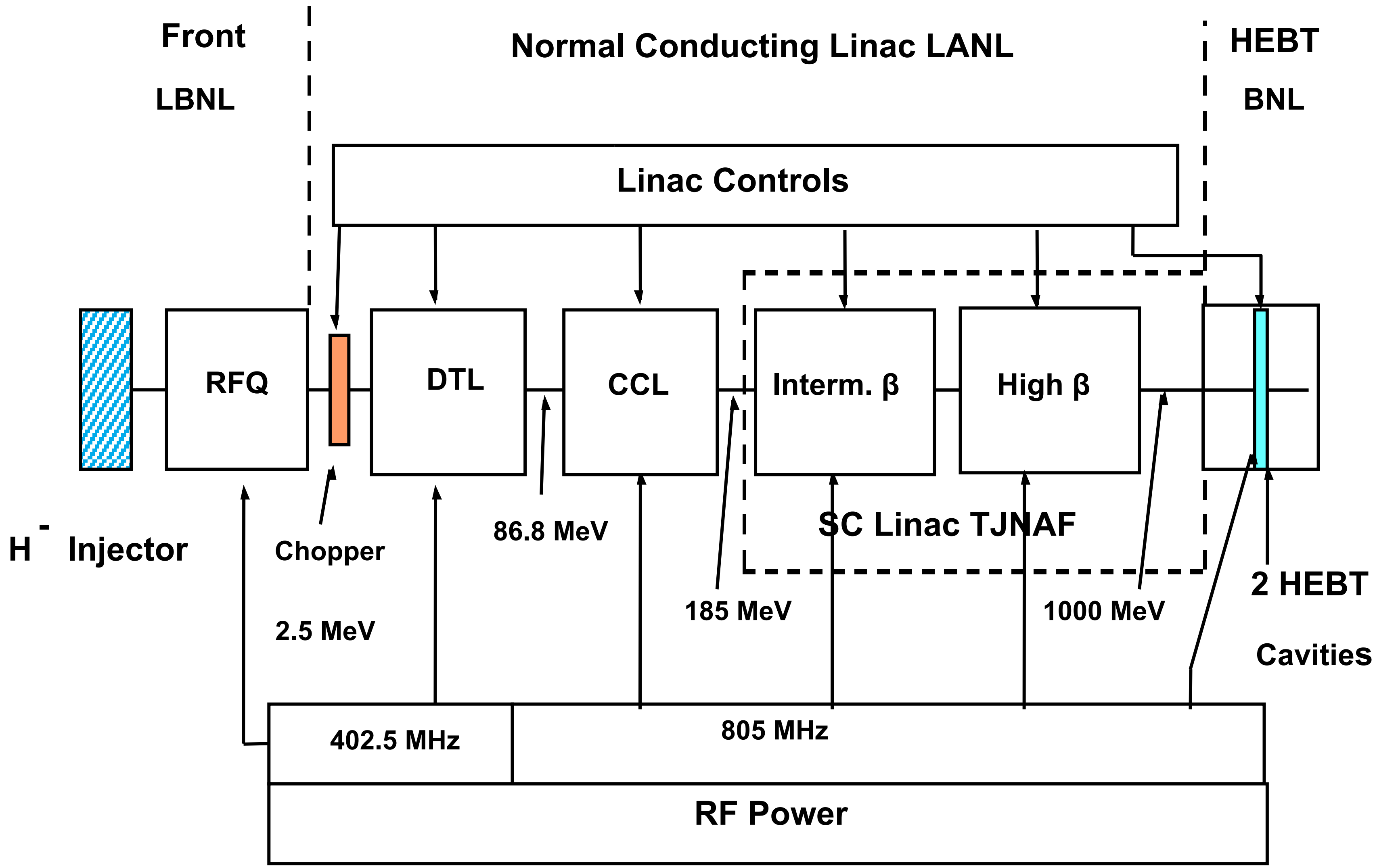

Figure 2-1. **SNS Linac Configuration**

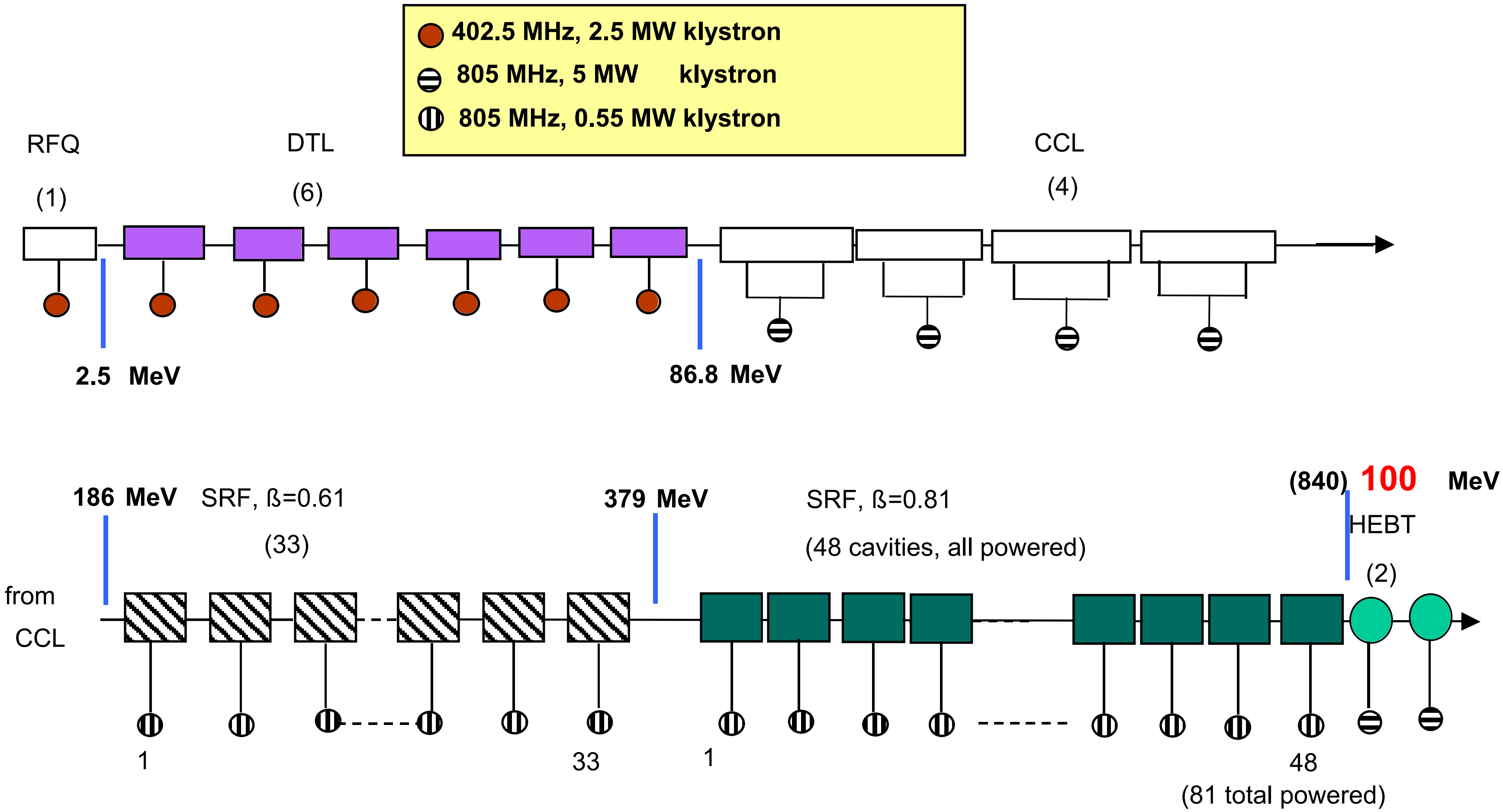
402.5 MHz, 2.5 MW klystron
805 MHz, 5 MW klystron
805 MHz, 0.55 MW klystron
RFQ
(1)
DTL
(6)
CCL
(4)
2.5 MeV
86.8 MeV
186 MeV
SRF, ß=0.61
(33)
379 MeV
SRF, ß=0.81
(48 cavities, all powered)
(840) 100 MeV
HEBT
(2)
from
CCL
1
33
1
48
(81 total powered)

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

A plan and schedule for the drift tube repair and rebuild program are being developed, but they do not presently exist. The plan must incorporate parallel fabrication lines to meet the schedule. DTL commissioning in the IPS is scheduled to start May 22, 2003. With the present single fabrication line it is expected that Tank #3 tubes can be delivered by the end of February 2003 and Tank #1 tubes by mid-May 2003. This latter date is about two months late relative to needed delivery to meet the nominal commissioning date.

The second problem area concerns the Low Level Radio Frequency (LLRF) control system for the Linac. The Integrated Cryomodule Test at TJNAF in September 2002 was a first test with high power hardware for the LANL LLRF system. The test required that a number of systems be integrated: SCL cavity modules, high power RF, timing, controls, and LLRF. A priority of the test was a demonstration of phase and amplitude feedback control. The LLRF system was not ready and could not provide closed loop control. Subsequent to this time, ASAC and a special LLRF review committee looked at the status of the LLRF system and recommended bringing together resources of all partner laboratories with oversight responsibility at ONRL. A SNS LLRF Development and Production Plan has since been developed. This plan provides an integrated approach to the LLRF system based on LBNL's LLRF system that was successfully used to commission the Front End. Key milestones include testing the present LBNL system on the cryomodule at TJNAF in January 2003, and testing the new design full capacity prototype control board at TJNAF in May-June 2003. This system would then be available for commissioning DTL Tank #1 in June 2003.

Significant progress was reported in other areas. The CCL structure continues to be produced and assembled at the subcontractor in Germany. The first of the CCL modules, designed and managed by LANL, will be available for radio frequency power tests at SNS-ORNL in January 2004.

The prototype cryomodule has been assembled with three medium-β cavities. A number of tests have been successfully completed and have proven the designs of several major subsystems:

1. All three cavities, together with associated tuners and couplers, could be operated at accelerating gradients above the design goal of E_{peak} = 27.5 mega Volts per meter (MV/m) and quality factor of 5×10^9.
2. The power couplers for each cavity have been operated at full power.
3. Lorenz-force detuning of all cavities in pulsed operation is within acceptable limits.
4. Microphonic-induced detuning of all cavities was found to be sufficiently small to indicate this is unlikely to be an operational problem.
5. The piezo tuner system was tested in pulsed operation, and proved capable of reducing Lorenz-force detuning by a factor of three.

The assembled cryomodule was recycled to room temperature, loaded on a truck and "road-tested" to determine the effects of mechanical stress from transportation, and cooled down again and found to have suffered no ill effects; therefore, establishing the feasibility of transporting fully assembled cryomodules from TJNAF to ORNL. However, the Committee noted that one of the cavities has a strong field unflatness. This will need to be monitored on production cavities. Design and construction of the refrigeration system is basically complete. Most major elements, except for the 2° K cold box, have been delivered to ORNL, and installation is in progress. Installation of the transfer lines and valve boxes is also in progress.

Seven medium-β production cryo cavities have been received at TJNAF, and further deliveries are expected at a rate of four cavities per month. Medium-β cryomodule production has begun and many components are already complete. Procurement of cavities and cryomodule elements, and preparation for production assembly of cavities and cryomodules continues to proceed on schedule. All component orders have been placed. Electropolishing equipment has been delivered and installed.

Klystrons to power the various RF structures of the Linac are in production at several vendors, and some deliveries have been made. Klystrons and converter modulators for the DTL have been installed in the Klystron Gallery. Tests of a significant number of production converter modulators/power supplies at the commercial vendor, Dynapower, are scheduled in the near future, with delivery to follow. The DTL klystrons are being manufactured at E2V (formerly Marconi) and five units have been delivered and a sixth accepted. The 5 MW klystrons for the CCL are being manufactured at Thales, and the first unit is now scheduled for factory acceptance. The first vendor for the SCL klystrons, Communications and Power Industries (CPI), has delivered three units.

The prototype converter modulator built by LANL has operated without failure over the last seven months, and has accumulated over 600 hours of operation with a Marconi 2.5 MW klystron. Higher power tests will use the first 5 MW klystron when it is delivered from Thales.

2.3.2 Comments

Overall, the progress on the Linac is satisfactory. The two problem areas are disappointing, but neither is irreparable, nor should they detract from the significant work accomplished and reported to the Committee.

The project-wide response to the belated realization of inadequate LLRF progress (hardware, software, and specification) was appropriate. The scale of the problem is significant, and the delay has been very unfortunate. The direction outlined in the "SNS Low Level RF Development and Production Plan" and the accompanying document "Low Level RF Control System Requirements for RFQ, Linac, and HEBT" is appropriate and the leadership assigned is competent to provide the necessary guidance. Adequate personnel to support the effort has been assigned or promised.

The project-wide response to the required repair of the DTL Tanks #1 and #3 has not yet produced a complete recovery plan that can be reviewed. Recognition by upper management at SNS-ORNL and LANL that a problem does exist has produced a commitment on both sides to the immediate addition of staff assigned to understand and mitigate the impacts of the problems, and to organize the remediation effort. Initial reviews to assess the difficulties have occurred, and a follow-on review is planned in early December 2002. Staff responsible for the remediation at LANL indicated a desire to identify and implement acceptable technical fixes while holding schedule impacts to acceptable minimums without sacrificing technical scope or reliability. The Committee concluded that the extent of the technical difficulties leading to the problems will be determined in the immediate future, and an appropriate plan will be developed, contractual requirements identified, and repair work started prior to the project's December 2002 ad hoc review. Senior management at LANL and SNS-ORNL have promised the remediation managers all necessary assistance on an "on-demand" basis. The identification of the production problems leading to the manufacturing difficulties appears to be well along, and the repair of some items is underway, although without a completely reviewed and accepted remediation plan. Therefore, it is not readily possible to accept assertions as to the final cost or schedule impacts at this time.

Completion of the closed loop testing of the prototype cryomodule with LLRF is critical.

The Committee also repeated its earlier observation that the modulator developed at LANL and planned for the Linac klystron systems has many unusual or unique features. It is encouraging that the prototype system has accumulated significant operating time, because testing of these modulators is critical. Long-term testing should be executed not only on the prototype, but more importantly, on production units.

The Committee commended the project for its open loop tests to date of the prototype cryomodule. The considerable variation in mechanical properties between cavities observed in the prototype cryomodule indicates that similar tests of the production cryomodules are warranted, both to provide feedback for the production process and also to insure that electro-mechanical properties and behavior of all cavities stay within acceptable ranges.

The project should provide for assembly of the repaired DTL drift tubes into DTL Tanks #1 and #3 under clean conditions.

Cost and schedule issues do not generally represent a major concern except in the few particular areas noted.

2.3.3 Recommendations

1. Urgently develop, review, approve, and implement a realistic and sound plan for the repair of Drift Tube Linac Tanks #1 and #3. Provide this plan to the project's external review scheduled for early December. Adjust, as necessary, the schedule for DTL installation and commissioning.

2. Provide the priority, resources, and expertise required to carry out the DTL recovery plan in a reliable and highly expeditious manner. SNS project management must maintain close oversight and control. Continue immediate repairs and modifications to the fabrication sequence. Give the DTL Project Engineer all necessary support, including a team that can provide a quality product in a timely way.

3. Keep the ORNL and LANL Laboratory Directors informed of the status and needs of the DTL effort on a weekly basis.

4. Expeditiously carry out the LLRF Development and Production Plan with close management attention. Maintain vigilance to emphasize the development of only essential requirements and to meet the milestones.

5. Ensure full participation of SNS personnel in the testing of production cryomodules and RF controls at TJNAF. Tests should include demonstration of phase and amplitude control of a cryomodule in pulsed operation at full gradient for a significant time using the initial LLRF system (January 2003) and the final LLRF control board (May/June 2003).

6. Maintain the close coordination and working relations at all levels between ORNL, LANL, and TJNAF necessary to successfully fabricate, install, and commission the Linac.

7. Continue to closely monitor production of the klystrons and other high power RF components, as well as the production and testing of the superconducting cavities.

8. Initiate life-tests of a production modulator unit before the next DOE review, with a goal of achieving at least 8,000 operating hours.

2.4 Ring Systems (WBS 1.5)

2.4.1 Findings

There has been very good progress in many different areas in the Ring. The Committee commended BNL and ORNL for excellent work in a number of different areas as noted in overviews on each subsystem below. The first fully assembled half cell has been delivered from BNL to ORNL.

Ring Systems are on schedule and components should be ready as indicated in the IPS. Costs to date are tracking the budget estimates. The components that have been received are meeting the requirements for the project technical baseline.

The Committee was shown a set of recommendations from the September 2002 ASAC review along with the project's corresponding responses. The concerns involve changing the magnets in the Ionization Profile Monitor from permanent to electro-magnets, taking some steps to mitigate electron cloud generation and lowering the machine impedance of the extraction kicker.

All Ring magnets are now on order. BNL has procured the remainder of the one-of-a-kind magnets. The need for dipole shimming and remeasurement was identified, and shimming and remeasurement of the dipoles have been completed. The dipoles now meet specifications at 1.0 GeV, and are acceptable for 1.3 GeV. It is not yet known if Ring quadrupoles will meet RMS specifications. It is clear that in order to meet specifications, all quadrupoles need to be measured. In the case of one quadrupole type, magnets not meeting Ring specifications will be used in the beamlines. In other cases, shimming may be needed. The delivery schedule does not appear to be impacted. A second magnet measurement station has been installed. BNL appears to have found an acceptable solution to the magnet coil copper-to-stainless steel water fitting leak problem, but further testing of this design needs to be done.

All of the standard vacuum hardware components have been placed on order, except for residual gas analyzers. Many of these items are in the RATS I Building, and testing of these is in progress. This quality assurance step is commendable and should continue. Purchase orders for the vacuum chambers are on-going, but these are not currently a pacing item nor is the TiN coating.

BNL understands the associated issues related to secondary electron yield, TiN surface outgassing, and the effects of beam scrubbing (should that conditioning process become necessary). However, the necessary high throughput pumps to deal with the vacuum pressure rise are not presently included in the design, although there is provision for retrofitting to the vacuum chambers. The chambers could possibly be baked out in-situ, but would require a significant effort and cost expenditure to provide this capability. The present approach to these problems is acceptable, but there is some risk to vacuum system performance in the presence of outgassing and beam scrubbing.

Collimator design and fabrication is in process. Collimator locations in the Ring have been finalized. Delivery of these should not be a problem, and in fact the Ring to Target Beam Transport (RTBT) collimator has been delivered to ORNL.

All of the 283 power supplies for the Ring are under contract and scheduled for delivery in accordance with the baseline. Forty of the 231 low-field corrector power supplies have been received and are under test. The first article of the medium-range power supplies is due in December 2002 with the remainder arriving in 2003. The remainder of supplies, the majority of which are one-of-a-kind (e.g., kicker, main dipole supply) are also due for delivery in 2003 and are on schedule. All of the supplies will be controlled by the Power Supply Interface (PSI) through the machine control system. The prototype extraction kicker has been tested and is under contract (build-to-print) in close collaboration with BNL. The first RF cavity and power supplies have been tested with three cavities shipped by the first quarter 2003.

Per a recommendation from the May 2002 DOE review, the Committee received a comprehensive description of the diagnostic systems of the Ring and associated beamlines. Specifications and design work are progressing well. The project has used a diagnostics advisory group that has provided considerable input and whose recommendations have been seriously considered. The Committee judged the complement of diagnostics to be sufficient and necessary to meet the project technical baseline.

2.4.2 Comments

The project presented responses to the Ring recommendations from the May 2002 DOE review. The recommendations and discussion follow:

1. Address the recommendation from the November 2001 review concerning spares in high radiation areas, concentrating on the development of procedures and tooling for rapid, low-exposure replacements in high radiation areas.

It is evident that work has been done in this area. However, it is not complete. Many spares have now been included in the baseline, and more are planned. The Committee would like to see additional work in regard to planning for rapid, low-exposure replacements in high radiation areas.

2. Present, at the next DOE review a specific report on all Ring diagnostics.

   Completed.

3. Collect, at ORNL, all component and subsystem drawings from the partner laboratories and include them in the Document Control Center (DCC) in preparation for installation.

   Progress has been made in this area, but more needs to be done. This recommendation was also in the installation section, and is repeated in that section.

4. Create a complete set of installation documents (e.g., drawings) in support of installation.

   Progress has been made in this area, but more needs to be done. This recommendation was also in the installation section, and is repeated in that section.

The solutions to ASAC recommendations, presented at this review, should be implemented.

BNL has two different plans for magnet measurement: a minimal plan and a full plan. The minimal plan allows for only Ring quadrupole measurement, without sorting and measurement of chicane magnets and septa. The full plan allows for measurement, shimming (if needed), sorting of quadrupoles, and measurement of sextupoles and correctors.

A concern was expressed in the area of diagnostics by both BNL and ORNL. When scope was transferred from BNL to ORNL to install and commission Ring components, the agreement included the responsibility for the diagnostics components. This responsibility now belongs to SNS ASD. However, because of the flat effort profile, ASD does not have the manpower to do this work. The Committee has a recommendation that this should be addressed.

The Committee strongly suggested that a test be performed on the long-term reliability of the revised magnet coil water fitting design, to include a closed loop deionized water flow circuit, and a static deionized water corrosion test.

High throughput pumps can be added to the Ring vacuum system that will mitigate the vacuum pressure increases associated with surface outgassing and beam scrubbing for the electron cloud (PSR) instability. The cost estimate for this should be developed.

The vacuum interface between the Linac and the HEBT is well defined and has been accommodated in the BNL designs. However, the vacuum interface to the target area is not well defined at this time.

The RATS I facility is impressive. Magnet measurement activity, vacuum component testing, and DTL assembly and vacuum checkout is underway in the building. The use of “travelers” was evident and this is commendable. There are many components and assemblies in the building, but this area could result in a potential delay unless detailed “in” and “out” material flow schedules are prepared and maintained. The resident SNS quality assurance station and personnel is a wise investment, providing for immediate on-the-spot answers to quality assurance issues that will inevitably arise there.

BNL has an SNS-audited and approved quality assurance plan (September 2001). Acceptance criteria on procurements, and production travelers, have been integrated into magnet fabrication and assembly. This attention to quality assurance is commendable and should continue. A bar code tracking system is being developed to keep track of components and assemblies, integrated with the DCC drawing database and inspection data, and available as an on-line resource to technical and operations staff. This effort should be aggressively continued.

All 87 of the large power supplies (excluding extraction kicker) are placed with a single vender with delivery by fourth quarter 2003. Tracking these procurements will be essential to ensure timely deliveries of power supplies. All power supplies should be tested before final installation on site (whenever practical). Factory testing is often not sufficient to establish supply performance criteria, as well as establishing control parameters. A spare transformer should be procured to improve availability of the Main Ring Power Supply.

2.4.3 Recommendations

1. Present at the next DOE review, a plan for timely acceptance testing, installation, and commissioning of Ring diagnostics.

2. Present at the next DOE review, a solution for implementing the full magnet measurement plan.

2.5 Target Systems (WBS 1.6)

2.5.1 Findings

General progress in Target Systems is excellent, construction work is well under way with some critical tasks (e.g., alignment of the base plate/associated tie rods) having already been accomplished successfully.

The project has been working hard and is successfully coping with recent difficulties on the technical level. The effort staged to provide a basis for the target concept decision scheduled for October 15, 2002 was outstanding and deserves a special commendation. In this context the project made excellent use of international collaborative efforts, thus optimizing the use of their own resources.

On October 15, 2002 the project decided to retain the concept of a flowing liquid mercury target, based on: 1) the generally acknowledged advantages of such a target that led the project to adopt this concept in the first place; 2) evidence resulting from an intense research effort indicating that the goal of achieving at least two weeks of service life at 1 MW beam power can be reached (less than 50 microns erosion of cold-worked 316LN stainless steel); and 3) prospects of achieving significantly longer service life at 1 MW by developing techniques to mitigate the effects of pressure waves, identified in exploratory research.

The present SNS design for the target unit foresees a double-walled container with a narrow gap in which flowing mercury cools the proton entrance window. Such narrow gaps with one wall facing vacuum or gas atmosphere have been found to be particularly prone to cavitation-erosion.

The project proposes to counteract this problem initially by making the outer wall thicker for more stiffness and extra material that can be eroded away without posing a risk during low power operation at start-up. As a later option, water cooling of this gap by a separate loop is under study. Only those installations that cannot be retrofitted at a later stage are planned to be implemented initially for this loop.

Target Systems currently shows a negative variance of ten and five percent respectively in schedule and cost. Credible arguments were made that Target Systems will recover from the current delays, mostly associated with the mercury vs solid target decision, the mercury pump fabrication running behind schedule, and the outer reflector assembly, without affecting important project milestones.

The Committee noted, however, that the installation schedule is extremely tight and the present plan of working one shift per day may not be realistic. Additional schedule problems could result from delays in other project elements, especially CF. Recovering from these delays will cause an additional burden on contingency.

2.5.2 Comments

The Committee basically concurred with the decision in favor of retaining the mercury target concept in the project baseline design and noted that:

- Although not yet comprehensive, a basic understanding of the mechanisms leading to cavitation-erosion by mercury under pulsed pressure input has evolved.
- Experimental evidence exists that (at least in the absence of irradiation) certain surface treatments can delay the onset of significant mass removal and thereby enhance the resistance to cavitation-erosion of cold worked 316LN stainless steel, the base material chosen by the project for the target container.
- The alternative of a solid target, although probably feasible for 1 MW pulsed-beam power, is by no means without problems (e.g., decay heat removal after shutdown). In the event of a later beam power upgrade, it becomes increasingly more difficult and less neutron-efficient, which would partly offset the benefits of the upgrade.

Concerns remain, however, because in-beam tests have only been carried out at very low integrated beam input. While the pitting damage observed appears very similar to that generated in off-beam tests, it is by no means clear that off-beam tests are fully representative. Concurrent effects such as irradiation damage or enhanced liquid metal embrittlement cannot be excluded, although in the absence of radiation the latter is not expected to occur in the present system (mercury and 316LN stainless steel). Options to carry out high integrated current tests (e.g., at the ISOLDE On-Line Isotope Mass Separator at CERN) have not yet been pursued.

Furthermore, the current density in the Weapons Neutron Research (WNR) facility tests was varied by varying the total current, i.e. energy input. The question of whether the volume (in which the pressure build-up occurs) has an effect was not studied at all. This volume will be much larger at SNS than in the WNR tests.

At present, Target Systems is protecting an overrun of $1.9 million over the Estimate-at-Completion (EAC) of $104.2 million. This includes $270 K listed for field survey results from transfer of scope without budget and should not be charged to Target Systems. In addition, Target Systems has identified probable cost increases of $2.8 million for steel shielding and installation. The Committee agreed that these increases are likely. A manipulator remote decontamination glovebox ($500 K) can be deferred to the operations phase with acceptable risk.

With regard to potential near-term savings identified by the project, the Committee had the following comments:

- Elimination of spares for moderators and the inner reflector plug will defer cost to the operating phase, but may be acceptable ($1.778 million).
- Reducing the component test program poses a significant increase of schedule risk and is not recommended.
- Use of dummy shutters in nine beam lines (near-term savings $1.2 million) will result in a long-term cost increase, and is likely to increase burden on instrumentation and waste storage and disposal. The Committee encouraged the project to reassess the anticipated long-term savings.

In the Committee's assessment, the revised EAC for Target Systems is $107.1 million.

2.5.3 Recommendations

1. Assure that the entire design of Target Systems is fully consistent with routine 1 MW operation before placing any relevant procurement requests.

2. Make arrangements to stay abreast of ongoing efforts in the field of high-power target development for future enhancements of SNS Target performance.

2.6 Instrument Systems (WBS 1.7)

2.6.1 Findings

The Instrument Systems team continues to make good progress on all tasks. In particular, the efforts towards the baseline goals of designing, building, and installing three Best-in-Class instruments, and having two more ready for installation, remain within budget and on schedule.

The responses to the two recommendations from the May 2002 DOE review are quite satisfactory, as explained below.

In response to the first recommendation to evaluate costs associated with core vessel inserts, it has reported that the incremental cost for an optimized insert over a blank insert is $35 K for a single-beam insert. Procurements for the inserts are underway, with the inclusion of options for optimized inserts that can be exercised within the next six months. These options are relevant for approved Instrument Development Team (IDT) instruments with identified funding (not part of the TPC). Buying appropriate inserts now for installation in 2004 with IDT money will, at no cost to the SNS construction project, save the IDTs and the future SNS operations budget considerable money and time associated with the removal and disposal of highly-activated blank inserts after SNS project completion in 2006. It was also pointed out to the Committee that there is an opportunity, within the next 12 months or so, to include the procurement of poured-in-place concrete shielding for several IDT instruments with the procurement for the SNS instruments. The cost per instrument would be reduced by taking advantage of the efficiency of having all shielding poured at one time by a single contractor.

In response to the second recommendation, management has prepared an initial plan for the necessary adjustments in the staffing profile for transitioning from construction to commissioning, and eventually to support of a user program. The future staff requirements have been identified and are being taken into account in hiring considerations. More broadly within the XFD, some transfers of engineering and design personnel from Target Systems to Instrument Systems have begun, taking advantage of outside funding from new IDTs.

Beyond the five baseline instruments in the TPC, there are now eight neutron scattering IDTs and one fundamental physics team whose instrument concepts have been approved by the Experimental Facilities Advisory Committee (EFAC). Of the maximum of 24 instruments possible, 14 are now approved by EFAC and 12 of those are funded (see Table 2-1). This success means that future instruments will be both limited by moderator availability and floor space constraints.

The mechanical design of the core inserts, main shutters, and guide system is quite advanced and very good overall. Procedures for installation and alignment are in place and seem logical. Critical issues, such as radiation heating and neutron window stresses have been thoroughly analyzed by calculation and finite-element modeling. The results were consistent with appropriate safety codes and good engineering practice.

The procurement has been made for the guide systems for four instruments, with guide procurement for the fifth to proceed as soon as BA allows. Costs of these initial procurements have been within estimates, which is an excellent start. The major procurements for the rest of the instrument components are scheduled to occur in the next nine months.

Table 2-1. 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)

Four EFAC-Approved Instruments to be Designed and Built by IDTs (funded by BES)

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

Two EFAC-Approved Instruments to be Designed and Built by IDTs (funding TBD)

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

Two Instrument Proposals Being Developed for EFAC Approval

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

The data acquisition development is presently making adequate progress. The hardware design appears satisfactory and is being put together for testing. Instrument software development is underway, though much work is required. A second software specialist will be joining the team soon. It is expected that the team will eventually reach five FTEs.

The detectors required for the first four instruments have been identified. A detector scheme for the fifth baseline instrument has been tentatively identified, though some development work is necessary and in progress. The present detector plans should lead to world-class performance; nevertheless, it is recognized that the development of new detector technology will be necessary for instruments such as the reflectometers and the single-crystal diffractometer to take full advantage of the high-power source. The Committee endorsed the participation of Instrument Systems personnel in collaborative investigations of advanced concepts with other national laboratories.

The Committee was presented with adequate preplanning for instrument commissioning. The instrumentation team has considered the instrument acceptance criteria in terms of both operational readiness at Critical Decision 4, Approve Start of Operation, and data quality assurance during the commissioning phase. Plans include preparing standard samples for testing instrument performance, reliability, and reproducibility. As presented in the white paper, "The Spallation Neutron Source: Operational Aspects and Reliability in the Transition from Commissioning to Fully Committed User Operation" (SNS 102000000-TR0004-R00), there should be adequate time for instrument testing during the accelerator commissioning phase, with a goal of beginning a user program in FY 2007.

The possibility of a neutron optics test station at ORNL's High Flux Isotope Reactor (HFIR) has receded to 2004, and indeed this might not become a reality in time for useful tests. The test station was to be used for two reasons: 1) to test neutron optical components and ideas (including quality assurance on neutron guides); and 2) to test data acquisition systems (DAS). If the test station is not forthcoming in time, the optical components can be tested at ANL's Intense Pulsed Neutron Source (IPNS) or at the National Institute of Standards and Technology, with the DAS testing at IPNS.

Although it is outside the scope of the DOE review, the Committee noted that the User Administration is doing a good job of interacting with and growing the neutron scattering user community. The American Conference on Neutron Scattering, held last June in Knoxville, was co-sponsored by the SNS-HFIR User Group, received tremendous support from SNS staff, and attracted 400 participants. Several workshops have already been held. Others are being planned to advertise the scientific capabilities of and the opportunities at the SNS, and to educate potential new users. Related workshops planned for the near future involve the Cold Neutron Chopper Spectrometer instrument, the Angular-Range Chopper Spectrometer IDT effort on data analysis software, and a national collaboration on advanced detector development. The next Joint Institute for Neutron Sciences workshop will be held in March 2003 on "Neutrons in Chemistry and Earth Sciences".

2.6.2 Comments

One engineering issue discussed was the design of the seal between the neutron windows and the core vessel and/or shutter optical elements. Many metal-to-metal configurations were tested and most failed to form a satisfactory seal. A solution that should be considered is a metal "C-ring". These are used in much the same manner as an elastomeric O-ring, but are impervious to radiation damage and thermal cycling. Many companies make these (for example, Perkin Elmer makes them in custom shapes, cross sections, and coatings—they also carry an inventory of stock sizes). By supplying parameters such as gland geometry, pressure direction, and seal environment, a customer can get a quote on a custom seal in reasonable quantities.

The awards for the neutron guides for four instruments have been made, however, no spare guides are included in the procurement packages. While the glass is encased in a steel shell, dropping one accidentally would likely result in a broken guide. With a total of roughly 300 guides to be handled and installed, an accident-free installation process poses a considerable challenge. (In addition, radiation damage to the reflective coatings on elements close to the moderator may reduce effectiveness after some period of service.) The procurement of some number of spare guides could mitigate the installation risk. Evaluation of such an option is highly recommended.

The guide suspension system was clearly explained. The support system is sufficiently robust and addresses the six degrees of freedom of the guide. One issue that should be considered is the buckling deflection of a guide train when it is evacuated. The guides are joined to one another with a silicone caulk, resulting in a joint that is elastic with respect to bending. With a guide train that may be on the order of 50 meters in length, with a joint every half-meter, the effective slenderness ratio may be quite high. The axial compression on an evacuated guide with a cross section of 10 by 12 cm would approach 300 pounds. It would seem worthwhile to perform a calculation or modeling exercise to determine whether the present design for the alignment yokes offers sufficient constraint to prevent unacceptable deflections when the guide train is evacuated.

The film thickness for the various neutron windows was optimized to maximize neutron transmission while safeguarding against a failure. Calculations and finite element analyses were properly used for this purpose, however, the only material considered was AL6061T6. Other materials exist that may result in better neutron transmission at equal factors of safety, two examples being magnesium (AZ31B) and beryllium. Consideration of such options is advisable.

An important issue concerns the installation of the core vessel inserts that requires collaboration between Target Systems and Instrument Systems. Accurate installation is important because the vessel inserts determine the beam center lines relative to the Target moderators. The beam line shutters are placed relative to the core vessel inserts, and the shutter inserts include the initial sections of instrument optics. (In at least one case, a core vessel insert includes a neutron guide.) The inserts impact the alignment of the downstream neutron guides. The Committee found that the engineering staff has developed adequate plans for the alignment of the guides within the inserts. This should not be a problem provided that the Target and Instrument Systems staff understand each others' concerns.

The significance of the insert installation issue is recognized by the project, and a workshop on this issue has been organized for January 2003, to be attended by the relevant staff members of both Target and Instrument Systems. This should provide the opportunity for both teams to make sure that their plans and expectations are compatible. The finalization of these plans and relevant procurement are expected by summer 2003, with the start of the installation of the core vessel inserts scheduled for March 2004. This operation is expected to take about three months, and will be followed by installation of the shutters and inserts in late-summer 2004. Given the progress in instrument design and procurements and outside funding of new instruments, it is time to revisit the plan for instrument installation.

2.6.3 Recommendations

1. Communicate to funding agents the opportunity for large cost and time savings enabled by design and procurement of core vessel and shutter inserts, and of poured-in-place shielding, within the next 6 to 12 months. This opportunity applies to those Experimental Systems Advisory Committee-approved Instrument Development Team instruments with identified funding.

2. Prepare an integrated installation plan for core vessel and shutter inserts by November 2003.

3. Revise the integrated installation plan for instruments by November 2003.

2.7 Control Systems (WBS 1.9)

2.7.1 Findings

The Control Systems effort is in excellent shape. The cost and schedule variances are currently less than five percent for both cost and schedule. The team has met the project's goal of having working systems available for checkout and commissioning of the Front End Systems delivered by LBNL. Working systems here include communication networks, Experimental Physics and Industrial Control System (EPICS) software on work stations with server support, a temporary control room, Input/Output Controllers, Timing System, Machine Protection System, Personnel Protection System (PPS), etc. As noted by the project, "As soon as AC voltage is available, people want networks. So far, we've been there."

The Control Systems effort is well managed, and the team is anticipated to meet their schedule and cost baselines. The Global Control System is a reasonably low-risk effort at this point. The installation and commissioning plans are reasonable, but the Committee expressed concern (see comment below) on the impact of the late delivery of the DTL Tank #3 components.

The PPS team has done well with their first installation and certification effort. Especially noteworthy is that the Accelerator Readiness Review (ARR) approved their effort. Having done their preparation well and passed this milestone, the team is now familiar with the ARR process.

2.7.2 Comments

The late delivery of DTL Tank #3, coupled with the project commitment to hold the start date for DTL commissioning, has shortened the time available for checkout of control equipment and software for this portion of the Linac from three months to approximately two weeks. The Central Systems team believes (and the Committee concurred) that there is a significant risk that this shorter time period will not be adequate for checkout. Thus, the checkout process could stretch into the commissioning effort, resulting in parallel efforts on commissioning and checkout. The project is understaffed for pre-operations support for Controls Systems. The present level of staffing is approximately 18 FTE-years.

2.7.3 Recommendation

1. Review the pre-operations budget for Controls Systems and present a plan to show there is adequate support from the controls team to meet pre-operations goals at the next DOE review.

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3. CONVENTIONAL FACILITIES (WBS 1.8)

3.1 Findings

Since the May 2002 DOE review, expected progress has been maintained in design and construction at the site. The project has demonstrated significant achievement of planned activities and has reached 100 percent design complete for CF as scheduled. The Committee found that in general, CF activities are on or ahead of schedule with the exception of site-wide final utilities and the Target Building substructure. Neither of these two schedule deficiencies currently affects critical path activities and adequate work-around plans have been initiated. The project Estimate to Complete (ETC) is based on defensible technical information supported through procurement actions with overall CF progress approximately 53 percent complete through September 2002.

The CF EAC has increased from $323.6 million at the May review to $345.1 million. Of this $21.6 million increase, $14.4 million is associated with the award of the CLO and Target Buildings' general construction contracts. The balance is associated with field changes in construction. The EAC presented at this review represents a cumulative cost growth of 12.6 percent since the May 2001 baseline review. Given the complexity of integrating 54 contracts and the issues of parallel design and construction, this represents excellent performance to date.

The project is entering a high-risk, high-complexity phase of CF now that the Target and CLO Building construction contracts are awarded and will be completed simultaneously. The project is well positioned to accomplish this phase and has reallocated engineering and construction site oversight resources to address the complexity. However, the project must continue to focus on CF performance.

The project remains on track to deliver against the cost and schedule baseline. The CF cumulative cost performance index (CPI) of 0.94 and schedule performance index (SPI) of 0.98 accurately reflect performance in the field.

The CF procurement strategy has continued to result in significant benefit to the SNS project with a savings of $1 million on the CLO and Target Building procurements. The project has adequately dealt with the potential increase in risk from this strategy and has done a commendable job bringing CF procurement issues to closure.

The project incentive plan for transition and closeout of CF contract activity is effective and has resulted in a lower risk profile for closure activities. A notable practice was identified that ties 20 percent of the AE/CM incentive fee to a 90-day window for final files transfer and closeout. Of 54 contracts, 13 have been closed to date with little or no outstanding issues or concern.

The construction site continues to be well maintained and site management has achieved a commendable safety record in excess of 1.5 million man-hours with no lost workday cases. Work in place appears to be of high quality in all respects indicating that the Construction Manager has established a high site-wide standard. Also notable is the continued high level of commitment displayed by senior SNS management. In addition, the on-site first aid station is appreciated by contractor staff, and has proven to be cost effective and provide performance benefits.

The SNS project continues to use an Integrated Systems approach in a distributed team relationship. However, accountability and ownership for the integration outcomes remains difficult to see and understand.

The level of management discipline displayed in the Front End building turn-over uncovered interface and integration issues such as overhead work interference and workplace cleanliness issues. These issues were addressed, however, there is no evidence to suggest that this level of integration is sufficient for accomplishing the remainder of the project.

The May 2002 DOE review recommendation regarding seismic design issues was resolved but resulted in approximately $500 K in unplanned additional Title III costs.

The previous integration recommendation was addressed through improvements in roles and expectations, and a more formal procurement interface. However at the end of the project, all design and installation media need to be integrated seamlessly. This requires constant attention to ensure a systematic approach and integrated delivery of the SNS.

3.2 Comments

Ready for equipment (RFE) dates are no longer an issue in the accelerator complex where Beneficial Occupancy Dates (BOD) are now being used. However, installation activities in the Target Building are still heavily dependent on RFE dates. CF activities remain ahead of all other project installation activities and can support commissioning as planned.

As noted in previous DOE reviews, and reinforced here, equipment installation poses a continuing issue as BOD and equipment installation occur in parallel with construction. The project must continue to focus on ensuring adequate field engineering and installation coordination between CF forces and technical installation staff.

The CFD and XFD coordination has improved through collocation at the site, and by the addition of qualified site engineering (AE/CM) resources for Target Building construction. This has helped to minimize the potential risks associated with Target Building construction through improved teamwork and communication among all project participants.

Lessons learned from the Front End installation have identified areas of project improvement, most of which are addressed by not turning over the construction site until after beneficial occupancy conditions have been achieved. However, a few issues remain such as dust control, which could be addressed by finishing areas of site grading and providing surface cover. CFD should consider ways to more effectively support cleanliness criteria and minimize the impacts of routine personnel traffic through areas turned over for installation.

The SNS user and operational model has not been adequately refined to understand the impact on current CF activities. Examples of areas where impact could occur are associated with security and access expectations such as prox cards or keys, badging and training infrastructure requirements, and the fundamental expectations of integration with the ORNL site infrastructure requiring additional labor commitments. The operational model of the SNS should be further developed to help understand the site infrastructure/integration requirements and identify possible impacts to current CF planning.

3.3 Recommendations

1. Implement the lessons learned from the Front End facility occupancy and more effectively address the comments regarding Conventional Facilities Division, the Accelerator Systems Division, and the Experimental Facilities Division integration during installation by the next DOE review.

2. Refine the SNS user and operational model to more clearly understand the site infrastructure/integration requirements and the potential impact on current CF planning.

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4. PRE-OPERATIONS/OPERATIONS PLANNING (WBS 1.10)

4.1 Findings

The SNS project is about 50 percent complete and most of the major orders have been placed. The project has started receiving hardware at SNS from the partner laboratories. The installation and commissioning phase of the accelerator has started. The project plans to finish by December 2005 leaving about six months of schedule contingency to meet the CD-4 milestone of June 2006. The installation and commissioning schedules are based on the early finish date.

The SNS project is to be congratulated for the successful installation and timely start of commissioning of the Front End Systems, which exceeded its design goal intensity by 30 percent at LBNL. Staff from several partner laboratories participated in the recommissioning of the Front End Systems at SNS.

Based on the poor experience of the Front End Systems installation under RFE conditions, the project decided to require BOD in all future accelerator installations. The DTL installation milestone has been delayed by vendor manufacturing problems. SNS management believes that this delay will not impact the commissioning of the Linac. The Linac's LLRF system has encountered problems at a serious level. SNS management has taken ownership of this part of the Linac and is getting help from other partner laboratories (e.g., LBNL).

The first half-cell of the Ring has been delivered to SNS and is awaiting installation. Ring dipoles and quadrupoles have been shimmed to cure the field variations between magnets. There is a plan to sort these magnets during installation.

In partial completion of the May 2002 DOE review recommendations, significant progress has been made in collecting documentation and drawings from the partner laboratories. These drawings are critical to installation. Installation drawings are being prepared and are now required before installation can start. The Installation team is undertaking a quality assurance audit of the document and drawing policy.

In response to a May 2002 DOE review recommendation, a resource-loaded installation schedule was presented. It showed large variations in required installation labor during FY 2003 as a result of the delayed delivery of the DTL. It will be a useful tool for load-leveling and in the future will help to take into account delays in delivery of the accelerator components and take advantage of availability of downstream hardware.

SNS has adopted a unified control system based on EPICS. Although requiring a significant effort, it will have a great payoff during commissioning. A relational database system has been developed to capture accelerator information during construction. A total of 16 FTEs were removed from the Pre-Operations budget of Control Systems (WBS 1.9). This could have a significant impact on Pre-Operations. There is a plan to move the Pre-Operations effort from the temporary control room in the Front End Building to a central control room in the CLO Building.

The number of accelerator physicists, beam diagnostics physicists, and operators in the Pre-Operation Plan for SNS is low. Partner laboratories will have delivered their hardware and ramped down their staff earlier than the commissioning of their portions of the accelerator complex. SNS had support of LBNL and other partner laboratories in commissioning the Front End. The Committee expressed concern that this support may not be there for the other commissioning efforts.

Front-End commissioning at SNS is requiring substantial participation from SNS, LANL, and BNL staff. More than ten physicists are participating in the commissioning effort, which is now entering its fifth week. This large commissioning team was needed even though the system was first fully commissioned at LBNL because modifications (improvements) were made to almost all systems during commissioning, and the commissioning plan is evolving as needed. The physics ideas behind these changes are sound. The commissioning schedule is interleaved with installation of equipment items downstream in the tunnel. There is a plan to use 90 shifts of beam commissioning effort in order to complete Front End commissioning by January 2003.

All commissioning efforts are planned to be conducted in series. The same staff moves from one segment to another immediately downstream. This assumes that the upstream segment runs with minimal supervision from the operations staff. In reality, more operations staff may be required for continued operation of the upstream segment.

4.2 Comments

DTL and LLRF delays leave little schedule contingency for accomplishing installation and commissioning activities by the early finish date. Due to the DTL delay, the installation labor plan needs to be updated. Flexibility in labor, funding, schedule, and testing of equipment will be needed at all levels to respond effectively to future changes in component deliveries.

There is very little schedule contingency left for installation. Accelerator components, after the necessary testing, should be installed as soon as they become available and once enclosures and buildings have reached their BODs.

During commissioning, technical support will be needed to fix components and operate those parts of the machine that have already been commissioned.

Participation of the partner laboratories in commissioning should be supported by SNS management. This would be facilitated by providing them with remote access to the control system.

The control room move could have a significant impact on schedule. SNS should keep both control rooms operational during the transition period.

4.3 Recommendations

1. Collect all component and subsystem documentations and drawings at ORNL, including all native files from the partner laboratories, and include them in the Document Control Center by the next DOE review.

2. Create a complete set of installation documents (i.e., drawings) in support of installation.

3. Update the resource-loaded installation schedule taking into account the delay in the DTL delivery and present it at the next DOE review.

4. Update the resource-loaded commissioning schedule including pre-operations staffing, technical support, and operational spares, and present it at the next DOE review.

5. Develop a data-logger for live accelerator data capture during commissioning and operation.

6. Provide a clean environment in the areas where technical equipment is being installed.

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5. ENVIRONMENT, SAFETY and HEALTH

5.1 Findings and Comments

Recommendations from the May 2002 DOE review have been satisfactorily addressed.

Integrated Safety Management principles are being applied on the project. The level of safety expected and being practiced at the SNS is appropriate and effective given the project's current stage of development.

Safety appears to be receiving due consideration in the coordination, installation, and commissioning of technical systems. Project management is not resting in this area, but is in the process of placing increased expectations on the safety performance of their personnel through adopting safety observation practices and making enhancements to their work coordination process.

Management of the construction activities is such that the level of safety being achieved at the SNS is "World Class". SNS management safety expectations and the CM's rigorous adherence and implementation of these expectations have resulted in the project achieving over 1.5 million hours worked without a lost time incident to date.

The tradesmen's realization that they are the direct beneficiaries of the safety program and the positive working relationship that the CM has developed with local unions have resulted in strong field support for the safety program. The CM subcontractors appear to have reached a safety culture level that could be labeled as "Interdependent". Interdependent is described as: 1) cooperation within and across teams; 2) peer's keeper; 3) organizational pride; and 4) teams fully engaged in goal setting and improvements.

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6. COST ESTIMATE

6.1 Findings

The SNS Total Project Cost (TPC) has remained unchanged at $1,411.7 million. A summary of the cost estimate can be found in Appendix D. The TPC is comprised 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 2002 costs (October 2001 through September 2002) were $267.9 million ($252.1 million for construction line item activities, and $15.8 million for R&D and pre-operations activities). Cumulative costs and commitments through September 2002 were $831.2 million ($713.7 million for line item activities, and $117.5 million for R&D and pre-operations.)

Following recommendations from the November 2001 DOE review, SNS has instituted a process for maintaining “bottoms-up” ETC in a phased approach over a cycle of 12 to 15 months. The ETCs for WBS elements 1.4 (Linac Systems), 1.7 (Instrument Systems), and 1.8 (Conventional Facilities) were updated in detail for this review. The second phase is scheduled to begin in January 2003 for WBS elements 1.5 (Ring Systems), 1.6 (Target Systems), 1.7 (Control Systems), and 1.2 (Project Support). SNS management also maintains an estimate that provides a top-level view, accounts for in-process change requests, and is reported each month.

The budget at completion (BAC) presented was $1,117.2 million. This represents an increase of $29.1 million (use of contingency) over that presented in May 2002. The total contingency remaining in the TEC is $75.5 million.

Using the baseline (BAC) and costs, and commitment actuals through October 2002, the project calculated a contingency of 24.2 percent. This estimate is based on the following assumptions:

- Projected costs through October 2002 are $744.0 million;
- Open commitments at the end of October 2002 are $114.4 million;
- Credit for contracts awarded but not funded is $110.4 million; and
- Five percent contingency on both funded and non-funded contract commitments is $12.9 million.

The project also provided a contingency assessment based on the EAC that includes $8.2 million of pending calls on contingency identified by SNS management. Based on the EAC, the contingency figure is 20.4 percent.

Each of the technical subcommittees reviewed the SNS ETC and provided an independent assessment of the adequacy of that estimate for the subsystems reviewed. While there were some differences between the Committee's EAC and the SNS EAC at the subsystem level, there was no significant aggregate impact. Details of these analyses are covered in the individual technical sections.

SNS management continues to use phase-funded procurements in the technical and CF portions of the project. Approximately 98 contracts with a total value of $267.9 million have been phase-funded. Fifty-four of those with a total value of $105.6 million have been completed.

The integrated cost performance module (Microframe Project Manager) appears to be fully functional including cost estimates and detailed schedule baselines. Based on this performance reporting system, the SNS project is 51 percent complete.

The project performed a risk-based contingency analysis in response to recommendations provided in the May 2002 DOE review report. The project controls staff presented the process used, and the results of this "bottoms-up" detailed risk analysis.

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 Microframe Project Manager system and appears fully consistent with actual physical progress.

6.2 Comments

The Committee agreed that performing a "rolling ETC" is a sensible approach that will produce a new set of ETCs for the next DOE review. Given the Committee's concerns about likely cost growth for installation, DTL, Target Systems, and LLRF, there should be new estimates for these elements.

The present contingency level is $75.5 million. This represents a significant reduction ($29.1 million or 28 percent) in six months from the $104.6 million contingency level presented in May 2002. In addition, SNS management has identified $8.2 million of pending Project Change

Requests (PCRs) that could result in calls on the remaining contingency. Since the May 2002 DOE review, cost baseline changes were primarily driven by contract award experience, and increases in the CF cost baseline dominate ($19.9 million, including $14.4 million for the CLO and Target Building general contractor awards and $5.5 million for contract modifications). The next largest contributor is Linac Systems at $4.7 million reflecting revised estimates. The fact that there are very few additional major construction packages planned mitigates somewhat the concern regarding the rate of contingency usage since the May 2002 DOE review.

As presented at the May review, SNS established top-down, uniform project-wide contingency levels equal to ten percent for design and project management; 15 percent on construction, equipment procurement, and fabrication; and 20 percent on installation, testing, and commissioning. While SNS management assured the Committee that they had analyzed key risk areas and were confident that contingency was adequate to manage those risks, the May 2002 DOE review committee requested a quantitative, risk-based analysis for this review.

In accordance with this recommendation, project staff performed a risk-based contingency analysis. The approach used by the SNS project to prepare this risk assessment was as follows:

- The Level 2 WBS Managers (e.g., Linac, Ring, Target etc.) were requested to identify potential risk items for their areas of responsibility.
- The WBS Managers identified factors for probability of occurrence, technical consequence, and schedule consequence, as well as the cost or schedule impact.
- This information was forwarded to the SNS Project Office.
- SNS management filtered the data based on their experience and expertise.
- Risk items were summarized for each major subsystem and grouped in the categories of high, moderate, or low risk. The totals for low risk items were increased to reflect unknown and unforeseeable issues.

The Committee judged that the project's contingency analysis represents a good start and should be used as the basis of a formal risk management plan. The Committee endorsed the SNS Project Office's stated intent to manage risk on a "continuing basis". If done carefully and with full participation and buy-in from the partner laboratories, such efforts will eliminate the need for a semi-annual bottoms-up assessment.

The project's calculation of 24.2 percent for contingency relative to the value of work yet to be committed and accomplished is based on the current BAC. The Committee felt that a contingency calculation of 20.4 percent based on the EAC, including the $8.2 million of pending calls on contingency identified by SNS management, is more realistic.

As the project prepares for its latter phases of installation and commissioning while carrying a shrinking pool of contingency funds, it becomes even more important to carefully manage risk. The project should report on the results of this effort regularly.

Given the contingency remaining at this stage in the project, the Committee judged that the current TPC is adequate to complete the project.

6.3 Recommendations

1. Provide a monthly status update of the risk analysis and plans to the Federal Project Manager, including a realistic Estimate at Completion and potential draws on contingency.

2. Perform updated Estimates-to-Complete by the next DOE review for Ring and Transfer Systems, Target Systems, all installation and commissioning activities, DTL, LLRF, and Control Systems.

7. SCHEDULE and FUNDING

7.1 Findings

The project's current cost baseline remains at a TEC of $1,192.7 million and a TPC of $1,411.7 million, which are both specified in the FY 2003 President's Budget Request and in the SNS Project Execution Plan. The FY 2003 Budget Request contains a BA profile (see Appendix E) of: $225.0 million in FY 2003; $143.0 million in FY 2004; $112.9 million in FY 2005; and $74.9 million in FY 2006. The project's planned profile for budget obligations (BO) is: $341.8 million in FY 2003; $181.1 million in FY 2004; $77.9 million in FY 2005; and $40.7 million in FY 2006. The difference between the available cumulative funding (BA) and the planned cumulative obligations (BO) through the end of FY 2004 is $6.3 million. (See Section 6, Cost Estimate, for a discussion of the contingency analysis.)

The IPS (see Appendix F for a summary version) is consistent with the BA funding profile cited above. The IPS calls for an internal goal for project completion of December 2005, providing six months of project schedule contingency relative to the CD-4, Start of Operations, commitment date of June 2006. Project performance continues to track well against existing DOE milestones, although there has been a significant reduction in schedule contingency for several Linac items including the DTL and LLRF.

The IPS is derived from the detailed schedules provided by each Level 2 WBS Manager. The integrated detailed schedules are comprised of 14,482 activities and 19,079 relationships, approximately the same as the May 2002 DOE review. Project elements that are on or near the critical path include the commissioning sequence for the DTL, CCL, SCL, Ring, Target installation, and commissioning.

7.2 Comments

The proposed schedule is consistent with the overall funding profile. The project's financial obligations are being effectively tracked and managed against available BA, with phased-funding of contracts used as an effective tool for maximizing flexibility. While the Committee judged that the small reservoir of unplanned BA in FY 2004 is unlikely to have a significant impact on the overall project schedule, it may result in some activities or obligations being slipped into FY 2005. This issue should be revisited during future DOE reviews.

Critical path (or near critical path) activities are distributed among many areas of the project, indicating that resources have been distributed appropriately across all WBS elements.

As highlighted in the technical sections, the Committee had significant concerns about the reduction in schedule contingency since the May 2002 DOE review in several of the Level 2 WBS schedules including the Linac, Target, and overall Installation. These schedules should be revised in the light of the "recovery" plans being formalized over the next two months.

As noted in previous DOE reviews, the project's early finish goal of December 2005 will likely be difficult to achieve. While the project recognizes the risk of having only $6.3 million in excess spending capacity relative to authorized BA at the end of FY 2004, SNS management believes, based on past experience, that they will be able to maintain schedule within the funding constraints. In addition, there were three areas of particular schedule risk that were discussed during this review including the DTL schedule, the LLRF schedule, and the Target installation schedule. The project recognizes these risks and has initiated mitigation plans to recover the schedule.

Given the five months of schedule contingency on overall accelerator commissioning, and the additional six months of contingency on Target commissioning, the Committee judged that the baseline CD-4, Approve Start of Construction, date of June 2006 is reasonably achievable.

7.3 Recommendation

1. Update all installation and commissioning schedules by the next DOE review.

8. MANAGEMENT (WBS 1.2)

8.1 Findings

The SNS management team (see Appendix G) is in place and is effectively managing the project. The SNS management team is effectively coordinating with and integrating a multi-laboratory project, and it has a good working relationship with DOE.

BNL management has yet to provide the SNS Project Office with a plan for transitioning their personnel to other projects when work on SNS is completed.

In the last six months, issues were identified with the delivery of a satisfactory LLRF systems by LANL. SNS has reorganized a team of ORNL, LBNL, and LANL staff to design and build a new system in two stages.

The scheduled installation of the DTL has been delayed by approximately nine months due to fabrication and testing problems. This could impact the commissioning date by two or more months. These problems were identified on delivery of the initial DTL Tank (#3) to Oak Ridge in June 2002. The SNS/LANL management team is working on a DTL recovery plan.

8.2 Comments

A lack of transition planning for BNL staff after their completion of tasks for the project is expected to lead to personnel uncertainty and morale issues in the near future. These issues are expected to lead to loss of productivity and pressure on SNS management to exceed their staffing plan.

The Committee supported the recommendations of the LLRF Advisory Board chaired by Tom Shea and encouraged continued proactive management intervention to get the LLRF effort back on track.

The project has responded appropriately to the May 2002 recommendation on integration, but the Committee urged the project to bolster and make more systematic their ever increasing integration efforts.

The successful production of the drift tubes that meet all functional requirements is an enabling component of the Linac commissioning schedule. The project should develop an aggressive schedule consistent with low technical risk that has sufficient time for installation and checkout.

The Committee judged that the test plans for the DTL, including first article testing, were inadequate, and was concerned that this shortcoming may extend to other subsystems.

In a collaborative project environment with multiple laboratory participation, project management needs to implement quantifiable milestones early in new work scope to effectively measure progress.

8.3 Recommendations

1. Within the next three months, BNL should develop a plan for BNL personnel transitioning off of the SNS project that is consistent with the needs of the SNS project.

2. Senior ORNL and LANL management, including the Laboratory Directors, need to be involved and apprised on a weekly basis on the progress of the DTL recovery plan. Sufficient resources and personnel expertise should be made available to fulfill the recovery plan.

3. Confirm that major procurement actions meet SNS project requirements for test plans, including first article testing.