Department of Energy

External Independent Review of

Center for Nanophase Materials Sciences
DOE Project No. 03-R-312
at the
Oak Ridge National Laboratory
Oak Ridge, TN

FINAL REPORT

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EXTERNAL INDEPENDENT PROJECT REVIEW OF THE CENTER FOR NANOPHASE MATERIALS SCIENCES AT Oak Ridge National Laboratory

SECTION 1 - EXECUTIVE SUMMARY

1.1 INTRODUCTION

Credible reviews of projects are an expectation of Congress, the Office of Management and Budget, local stakeholders, tribal nations, and the U.S. Department of Energy (DOE). The National Research Council Report, *Assessing the Need for Independent Project Reviews in the Department of Energy*, February 1998, provides guidance on the scope, purpose, and content of External Independent Reviews (EIRs) for DOE individual construction, environmental restoration, and privatization projects. Pursuant to DOE Order 413.3, a performance baseline EIR shall be performed on all construction projects over $5M prior to Critical Decision 2 (CD-2)- Approve Performance Baseline, and on all environmental restoration (ER) projects over $5M prior to Critical Decision 2/3 (CD-2/3) – Approve Performance Baseline/Start Field Work. EIRs for such projects are to include an Independent Cost Review (ICR). An ICR is used primarily to verify project cost and schedule estimates and to support the CD-2, CD-2/3 process in establishing project performance baselines.

The EIR is a detailed review of the entire project. Its purpose is to: ensure readiness to proceed to a subsequent project phase, ensure orderly and mutually supportive progress of various project efforts, confirm functional integration of project products and efforts or organizational components, enable identification and resolution of issues at the earliest time, lowest level, and lowest cost, support event-based decisions, and control risk. It is intended to validate the proposed technical, cost, and schedule baseline, and assesses the overall status of the project management and control system. The review confirms project accomplishments, illuminates deficiencies, and provides pertinent objective information for management evaluation.

EIRs are conducted by reviewers outside of DOE and selected by DOE's Office of Engineering and Construction Management (OECM). The team assembled by JUPITER for this EIR/ICR of the Center for Nanophase Materials Sciences (CNMS) at Oak Ridge National Laboratory (ORNL) consisted of six individuals, skilled and experienced in cost estimating, scheduling and planning, management, applicable technical disciplines, and environmental regulatory matters. The JUPITER EIR/ICR Team performed a detailed review of the entire project: cost, schedule, technical, management, and external factors.

1.2 SUMMARY OF FINDINGS

JUPITER conducted an EIR/ICR of the CNMS Project in July 2002. The findings and recommendations described in this report of that review resulted from interviews with project managers, project personnel, and responsible and related senior management, as well as examining project documents. Guidance provided in the OECM report, "Independent Review Procedure," May 14, 2001, was followed in conducting this EIR/ICR and in writing this report.

As per the DOE approved Final Review Plan, dated July 19, 2002, the areas examined by the EIR/ICR Team were:

- Cost
- Schedule
- Scope/Technical
- Management, Planning, and Control
- External Factors

In the view of the EIR/ICR Team, the CNMS Project is a high-quality project with an appropriately defined scope. The project is closely aligned to the Office of Basic Energy Sciences (BES) mission and has developed well-defined scientific thrusts that are at the forefront of nanotechnology research. The project is being well managed and has developed an appropriate approach to accomplishing its scope. The design documents developed to this point seem appropriate and sufficiently comprehensive. The management and technical staff are aware of what needs to be accomplished, and seem to be fully aware of the implications of the very tight schedule under which they are working. The cost estimate, as checked by the ICR, is reasonable and realistic. Further, the EIR/ICR Team noted a significant number of positive observations on the project team activities, several of which were associated with the project's interactions with the Spallation Neutron Source (SNS).

The EIR/ICR Team made six essential findings, five findings, and a number of observations in the course of their review. In the opinion of the EIR/ICR Team, the CNMS Project will be ready for CD-2 once the deficiencies noted in the essential findings are remedied. Moreover, during the course of the review, the EIR/ICR Team observed that the project was already addressing some of these deficiencies, particularly those related to documentation. Finally, in the view of the EIR/ICR Team, all the essential findings, while requiring appropriate remedy prior to proceeding to CD-2, can be addressed quickly.

The essential findings, findings, and suggested remedies are briefly noted below. A complete discussion is provided in the body of this report, along with observations (positive and improvement areas) noted by the EIR/ICR Team.

1.2.1 Cost

Essential Finding: Escalation included in the cost estimate did not use the best process and was based on fiscal year (FY) 03, rather than FY04 guidance.

Recommendations: Use the latest DOE escalation rates.

Use Primavera to apply escalation to a spending pattern based on a resource loaded and costed schedule, taking care not to apply escalation where it has already been included in the base numbers.

Illustrate how escalation was applied to the Construction Manager Furnished Equipment and Materials (CMFE) items in the estimate.

Essential Finding: Life Cycle Costs (LCC) have not been developed for the total project.

Recommendation: Prepare an LCC estimate to cover all acquisition costs, operating and maintenance costs, assumed future rehab or expansion costs (if any), and decommissioning costs. Update the LCC as necessary to reflect significant changes, e.g., addition/deletion of major technical equipment, building size changes, and significant changes in recurring operating costs such as utilities, security, etc.

1.2.2 Schedule

Essential Finding: The current schedule has not been cost and resource loaded.

Recommendation: Develop a fully integrated resource and cost loaded Critical Path Method Schedule from design through commissioning including technical equipment, construction, design, design support, project management, Title III, other project cost (OPC) activities, demobilization, etc. The revised schedule should be independently reviewed.

Finding: The current summary level project schedule is incomplete because it does not include some major project activities, e.g., Title III, Project Management, Design Support, OPC activities, commissioning, etc.

Recommendations: Add all appropriate project activities to the summary level project schedule.

- Display the technical equipment schedule by activities that comprise the Level II WBS 2.1, i.e., Equipment, Procurement, Installation, Test and Checkout, Technical Design Support and Project Management.
- Display the conventional facilities schedule by activities that comprise the Level II WBS 2.2, i.e., Design, Construction, Project Management, Design Support, Construction Management Construction Support, and Title III services.
- Add OPC elements such as CDR/VE Study, Scientific Scope Development, ES&H Documentation and Engineering Support.
- Add key events and milestones as appropriate to a summary level project schedule.

1.2.3 Scope/Technical

Essential Finding: The ES&H Plan at the UT-Battelle level has not been formally adopted.

Recommendation: The SNS Architect-Engineer/Construction Manager's (AE/CM) ES&H Plan should be formally adopted as the ES&H plan for the CNMS Project by UT-Battelle.

Finding: Analysis supporting design decisions was not well documented.

Recommendation: Review project technical decisions and provide supporting documentation for all major issues used in the design decision-making process. At a minimum, this should include all analyses performed by external consultants. These analyses must detail all primary methods, assumptions, data sources, lessons learned, and key experience based knowledge and show how the parameters impact the equipment and building requirements, as well as major sources of risk and error.

Finding: There is no system in place to ensure that the building systems are designed, installed, functionally tested and capable of being operated and maintained according to UT-Battelle's operational needs and ensure the building systems meet UT-Battelle's needs.

Recommendation: Implement a commissioning plan for the CNMS and establish a Commissioning Authority. Include the cost of commissioning in the cost estimate.

1.2.4 Management, Planning and Control

Essential Finding: The Project Execution Plan (PEP) has not been finalized.

Recommendation: Secure approval of the PEP prior to CD-2, but after incorporating EIR Team suggestions discussed in Section 3.4.3.

Essential Finding: An overarching Quality Assurance (QA) Plan at the UT-Battelle level, which covers both equipment for the CNMS and construction of the CNMS, has not been established.

Recommendation: An overarching QA Plan at the UT-Battelle level, that encompasses the SNS AE/CM's QA Plan and the technical equipment QA plan should be formalized for the CNMS Project by UT-Battelle. Within this plan, the independence of the QA organizations should be clearly delineated.

Finding: The level of detail and specificity in the Risk Assessment should be increased.

Recommendation: Revise the Risk Assessment/Plan to incorporate more detail and specificity on the aforementioned risks and on any other risks that the project team may identify.

Finding: A system to review the constructibility, buildability, and bidability of the design has not been put in place.

Recommendation: Implement a Constructibility Review Process starting at this preliminary stage of the project and continuing throughout project development.

1.2.5 External Factors

No findings or essential findings were made.

EXTERNAL INDEPENDENT PROJECT REVIEW OF THE
CENTER FOR NANOPHASE MATERIALS SCIENCES PROJECT
AT
Oak Ridge National Laboratory

SECTION 2 – PROJECT REVIEW INFORMATION

During the past two years, the Office of Engineering and Construction Management (OECM) conducted External Independent Reviews of most of its FY1999 and FY2000 new starts to provide the Program Office with feed-back on the status of projects. The reports summarizing these Reviews have followed a standard format to provide the Department with valuable data from which projects can be compared to improve the management process and provide feedback to Congress and the Operations/Field Offices.

In a 1998 report on DOE projects, the National Research Council stated that the Independent Project Review will provide an objective, rigorous review and document and process audit of the project scope, underlying assumptions regarding technology, the cost and schedule baselines, and the acquisition and program management strategies and practices employed by the Department to manage and control program technical requirements, cost, and schedule baselines.[1]

The purpose of this Independent Review Process is to ensure rigorous and systematic Reviews of Projects at key stages in the Project life cycle. This Review Process provides a standard methodology and report format for Independent Reviews of DOE Projects. Independent Reviews are performed by personnel having no direct role or interest in the execution or outcome of the Project being reviewed.

2.1 DESCRIPTION OF PROJECT

The Center for Nanophase Materials Sciences (CNMS) will establish a nanoscale science research center at ORNL. This research center will integrate nanoscale science research with neutron science, synthesis science, and theory/modeling/simulation of nanophase materials, bringing together four areas where the United States has clear national research needs. The facility will be co-located with the Spallation Neutron Source (SNS) complex and will house ORNL staff members and visiting scientists from academia and industry. The construction of the CNMS coincides with the latter phases of SNS construction. This close coupling yields potential cost, schedule, and quality of services benefits, but is also a source of risk to the CNMS if not carefully managed.

The scope of this project is to construct and outfit the Center for Nanophase Materials Sciences. The total gross area of the new building will be approximately 80,000 square feet, providing state-of-the-art clean rooms, and general laboratories for sample preparation, fabrication and analysis. Initial equipment for nanoscale materials research such as surface analysis equipment and nanofabrication facilities are included in the CNMS Project. The engineering effort includes preliminary and final design. The project also includes procurement of experimental capital equipment and construction of facilities.

An architect-engineer operating under a fixed price subcontract will design the CNMS. A fixed-price construction contractor, administered by the ORNL operating contractor, will construct the facility. Procurement of research capital equipment will be performed by the ORNL operating contractor. Project and construction management, inspection, coordination, utility tie-ins, testing and checkout witnessing, and acceptance will be performed by the ORNL operating contractor.

[1] *Assessing the Need for Independent Project Reviews in the Department of Energy*, National Research Council, National Academy Press, 1998.

2.2 PROJECT BUDGETS AND MILESTONES

2.2.1 Construction and Related Schedule Milestones

Cost Milestones (in thousands of dollars) from the FY 2003 Congressional Project Data Sheet (CPDS)		
Total Estimated Costs		**Totals**
Design	$2,500	
Construction	$61,500	
Total Facility Costs		$64,000
Other Project Costs		
Conceptual design costs	$150	
NEPA documentation costs	$5	
Other project-related costs	$845	
Total Other Project Costs		$1,000
Total Project Cost		**$65,000**

Schedule Milestones: Schedule data are taken from the Draft PEP.

Milestone Description	Completion Date
CD-0 (Approve Mission Need)	June 2001 (A)
Approve Acquisition Execution Plan	February 2002 (A)
CD-1 (Approve Preliminary Baseline Range)	February 2002 (A)
Start Title I Design of Conventional Facilities	March 2002 (A)
Approve Baseline Technical Equipment List	August 2002
CD-2 (Approve Performance Baseline)	August 2002
Complete Title II Design of Conventional Facilities	November 2002
CD-3 (Approve Start of Construction)	February 2003
Award Conventional Facilities Construction Contract	April 2003
Beneficial Occupancy of Conventional Facilities	November 2004
CD-4a (Approve Start of Initial Equipment Operation)	December 2004
Complete Installation of Technical Equipment	September 2006
CD-4b (Approve Start of Full Operations)	September 2006

(A) - Actual

Funding Profiles – Schedule of Project Funding (in thousands of dollars) from the FY 2003 CPDS.

	Prior Years	FY 02	FY 03	FY 04	FY 05	FY 06	Total
Facility Cost:							
Design	0	$1,500	1,000	0	0	0	$2,500
Construction	0	0	$24,000	$20,000	$17,500	0	$61,500
Total Facility Cost	0	$1,500	$25,000	$20,000	$17,500	0	$64,000
Other Project Costs:							0
Conceptual Design	$150	0	0	0	0	0	$150
NEPA Documentation	$5	0	0	0	0	0	$5
Other project-related costs	0	$220	$100	$250	$175	$100	$845
Total Other Project Cost	$155	$220	$100	$250	$175	$100	$1,000
Total Project Costs	$155	$1,720	$25,100	$20,250	$17,675	$100	$65,000

2.3 REVIEW PROCESS

The JUPITER EIR/ICR Team performed a detailed review of the entire project: cost, schedule, technical, management, and external factors. The following sections describe the review process, including the review schedule, the Team members and assignments, project personnel interviewed, and documents reviewed.

2.3.1 Date and Place

Document Review, July 8 - 19, 2002
On site Review, July 22 - 26, 2002, Oak Ridge, TN

Team Member	Cost	Schedule	Management Planning	Scope/ Technical	External Factors
S. Moore*			**X**	**X**	**X**
K Hudson**	**X**	**X**	**X**		
J. Bader				**X**	**X**
W. Davies	**X**	**X**			
G. Malafsky				**X**	
L. Ross	**X**	**X**		**X**	

*Team Leader **Cost Lead

2.3.2 Project Participants/Personnel Interviewed

David Arakawa	Federal Project Manager	ArakawaDK@ornl.gov	865 576-6811
Linda Horton	CNMS Project Manager	HortonLL@ornl.gov	865 574-5081
Jeff Hoy	DOE BES	Jeff.Hoy@Science.doe.gov	301 903-4924
Kathlyn Boudwin	DOE/SNS	BoudwinKJ@ornl.gov	865 241-4134
Tony Chargin	SNS CF Director	CharginA@sns.gov	865 241-3358
Regina Chung	DOE/ORNL	ChungJ@ornl.gov	865 576-9902
James Cranston	KJ JV Design Mgr	CranstonJR@sns.gov	865 241-9416
Carol Cromwell	ORNL	CromwellCJ@ornl.gov	865 574-6065
R.A. Davis	AE/CM Proj. Mgr.	DavisRA@ornl.gov	865 241-5615
Tom Etheridge	ORNL Eng Div Dir	EtheridgeJT@ornl.gov	865 574-0115
Gary Hart	Estimator1	HartGC@ornl.gov	865 241-9430
Bob Irwin	Mgr., Proj. Support Svcs.	IrwinR@ornl.gov	865 241-9435
Rick Kasica	ORNL	KasicaRJ@ornl.gov	865 574-7257
Frank Kornegay	ES&H	FCK@ornl.gov	865 574-6688
Jamie Lollar	Estimator	LollarJ@sns.gov	865 241-3307
Douglas Lowndes	CNMS Facility Director	LowndesDH@ornl.gov	865-574-6306
Thomas Mason	ALD for the SNS	MasonT@sns.gov	865 241-1499
Jerry Mikeal	Scheduler	MikealJH@ornl.gov	865 241-7591
Barry Miller	CNMS Procurement	MillerBR@ornl.gov	865 241-3005
Johnny Moore	DOE/ORNL	MooreJO@ornl.gov	865 576-3536
Randy Ogle	ES&H	URO@ornl.gov	865 574-5744
Les Price	ORNL/SNS	PriceLK@ornl.gov	865 576-0730
Jim Roberto	ALD for Physical Sciences	RobertoJB@ornl.gov	865 574-4750
Gerald Scott	UT-B Proj. Controls	GLS@ornl.gov	865 576-0514
Mike Skonicki	SNS QA Mgr	SkonickiMH@sns.gov	865 241-3618
Jack Stellern	CNMS CF Proj. Mgr	StellernJL@ornl.gov	865 574-6434
David Wilfert	DOE/SNS	WilfertDK@ornl.gov	865 576-2673

2.3.3 Review Team Members

The EIR/ICR Team consists of experienced personnel from JUPITER Corporation and subcontractors, approved by DOE. A resume for each Review Team Member is provided in Appendix B.

2.3.4 Documentation Reviewed

During the course of the review, the Team reviewed many project documents and reference material. Some documents were provided prior to the on-site review. Additional documents and recent updates of previously provided documents were provided to the Team while they were on-site. A list of documents reviewed during the course of the Review is provided in Appendix C.

2.3.5 Meetings

The on-site review commenced on the morning of July 22, 2002, and concluded with the outbrief on the morning of July 26, 2002. At the initial on-site meeting, the EIR/ICR Team leader explained the process that would be used to conduct the review. After this initial briefing, the ORNL project manager provided an overview of the CNMS Project. Interviews of project personnel, including the Federal Project Manager (FPM) and the ORNL project manager, were conducted at the SNS offices in Oak Ridge, TN. Discussions were also held with the Associate Laboratory Directors responsible for the CNMS and for the SNS. The Lines of Inquiry (LOIs) contained in the approved EIR plan, dated July 19, 2002, provided points of departure for the interviews. The EIR/ICR Team toured the SNS project site on the first afternoon. In addition, the EIR/ICR Team members reviewing cost and schedule met separately with project cost estimators and managers responsible for developing project costs and schedules. These meetings took place on July 23, 24, and 25. The following is the schedule of the team's activities:

Date	Time	Location	Activity/Review Topics
Mon., July 22	8 – 3	SNS Office	Kickoff Meeting – Key Managers & EIR Team – Introductions & Presentations by Team & Project
	3 – 5	SNS Site	Site Tour
Tues., July 23	8 – 10	SNS Office	Cost/Schedule – Overview
	10 – 12		Scope / Technical
	1 – 5		Management, Planning, & Control
	10 – 5		Cost/Schedule Details – separate meetings
Wed., July 24	8 – 12	SNS Office	External Factors
	1 – 5		Scope / Technical
	8-5		Cost/Schedule Details – separate meetings
Thurs., July 25	8 – 5	SNS Office	EIR Team Workday Follow-up discussions as needed
Fri., July 26	8 – 9:00	SNS Office	Outbrief – Key Managers

EXTERNAL INDEPENDENT PROJECT REVIEW OF THE CENTER FOR NANOPHASE MATERIALS SCIENCES PROJECT AT Oak Ridge National Laboratory

SECTION 3 – PROJECT REVIEW FINDINGS AND RECOMMENDATIONS

3.1 COST

3.1.1 Cost Estimate/Project Funding

The EIR/ICR Team reviewed the detailed cost estimate and associated backup materials. Compared to the ICR, the Total Project Cost (TPC) is assessed to be reasonable (Refer to Appendix D for details and discussions). It was noted that unit rates in the estimate are higher than might be expected for commercial projects. However, since the unit rates are based on recent experience at the SNS site, they are valid and credible for the purposes of estimating the cost of CNMS construction. An evaluation of possible reasons for these higher costs is not within the scope and resources of the EIR. As a result, the EIR/ICR Team did not explore this topic further.

In the opinion of the EIR Team, some elements of the project's cost estimate need to be addressed prior to CD-2 to enhance the estimate's realism. Different project participants prepared major components of the cost estimate (e.g., Design, Conventional Construction, Technical Equipment, Other Project Costs (OPC), etc.). The estimates for technical equipment, labor to support the technical equipment (i.e., procurement, design support, installation, and test and acceptance), and OPC were prepared by and/or under the guidance of the CMNS Project Director/Technical Equipment Project Director. Estimates for construction, construction support, and construction management, among other items, were prepared under the direction of the Conventional Facilities Project Director.

Two essential findings and one observation was made, which are discussed below.

Essential Finding: Escalation included in the cost estimate did not use the best process and was based on FY03, rather than FY04 guidance.

Escalation was not calculated using a spending pattern derived from a schedule because a resource and cost loaded schedule has not been developed. Instead, escalation was calculated to the mid-point of construction and to the anticipated delivery date for technical equipment.

Subsequent to escalation calculations by the project, DOE issued new rates. The project used the escalation rates available to them at the time to develop a construction factor and an equipment factor.

Escalation was applied to OPC and technical equipment support labor costs, both of which already included escalation.

The construction escalation factor was applied in a way that is not clear whether items with built-in escalation, i.e., CMFE, were escalated again.

Recommendations: Use the latest DOE escalation rates.

Use Primavera to apply escalation to a spending pattern based on a resource loaded and costed schedule, taking care not to apply escalation where it has already been included in the base numbers.

Illustrate how escalation was applied to the CMFE items in the estimate.

Essential Finding: Life Cycle Costs (LCC) have not been developed for the total project.

Life Cycle Cost Analyses have been prepared only for elements associated with project elements included in the VE study. However, a total LCC for the facility has not been prepared.

Recommendation: Prepare an LCC estimate to cover all acquisition costs, operating and maintenance costs, assumed future rehab or expansion costs (if any), and decommissioning costs. Update the LCC as necessary to reflect significant changes, e.g., addition/deletion of major technical equipment, building size changes, and significant changes in recurring operating costs such as utilities, security, etc.

Observation: The Work Breakdown Structure (WBS) used to develop the cost estimate is not at a sufficient level to be used for project controls and tracking estimate evolution.

The cost estimates were not prepared in accordance with a WBS that is at a sufficient level of detail to be used for project controls and tracking estimate evolution. (Also refer to discussion in 4.2.1 Scheduling)

The conventional construction estimate is by CSI categories, and costs are displayed at the lowest existing WBS level (Level 3). The technical equipment estimate was estimated by each major piece of equipment one level below the lowest existing WBS (Level 3). Technical equipment support personnel costs for procurement, installation, test and checkout, design support and project management were estimated by accounts that roll directly to their respective Level 3 WBS element.

On award of fixed price contracts to construction sub-contractors, project personnel plan to accept the subcontractors' schedule of values to track and control their work. The subcontractors' schedule of values may or may not match the current construction estimate's CSI. The Project plans to track equipment and related personnel costs using appropriate account numbers, which will be established in the future.

At this stage of project development, a more detailed WBS would help the CNMS Project team measure technical and schedule performance as well as cost. By dividing the total project into successively smaller WBS entities, the CNMS Project Team will ensure that all required tasks are identified in terms of technical performance goals. The team can also verify that all work identified to the WBS during planning, design, construction and commissioning actually contributes to the project objectives.

A more detailed WBS can also provide a common framework for tracking the evolution of estimates (e.g., conceptual estimates, preliminary design estimates, and detailed design estimates). The WBS can provide a framework for life cycle cost estimates.

Furthermore, the schedules were not developed by WBS elements for construction or by the pieces of equipment or the personnel costs that comprise the Technical Equipment WBS[2]. In addition, the schedules were not resource loaded or costed. (See discussion in Schedule Section 4.2.)

Recommendation: Further refine the current construction WBS (currently one element) to at least two additional levels. Include those levels in the WBS dictionary.

Positive Observation: Estimating and scheduling personnel made very good use of recent actual experience.

[2] Except that currently the entirety of the equipment effort is in the schedule as one WBS element.

Estimating and scheduling personnel used recent experience from SNS to develop cost adjustment factors for the cost database, for sources of actual cost data, to prepare sanity check construction estimates, and to assist in the preparation of the project's construction schedule.

Positive Observation: Good documentation of technical equipment was furnished.

Documentation of the technical equipment consisted of a comprehensive spreadsheet listing the technical equipment, live and dead weights, utility requirements, equipment size, and final building location. The equipment cost estimate included vendor supplied installation labor and was obtained from recent procurement documents, vendor contacts, or current catalog prices.

The technical equipment cost estimates have been continually updated by obtaining new vendor quotations. Most vendor quotes are less than one month old. Since approximately half of the equipment is unavoidably foreign sourced, these updates have captured recent changes in currency valuations. In addition, ORNL used their knowledge and experience of equipment costs from previous programs to adjust cost estimates to make them more realistic.

3.1.2 Cost Risk Analysis

The EIR/ICR Team reviewed project cost risk, including risk identification and estimation of potential cost and schedule impacts of risk. There were no essential findings. However, the EIR/ICR Team did make one observations as indicated below.

Observation: Future management attention to risk elements, risk management, and contingency is not codified.

Recommendation: Include language to the PEP and/or the Risk Mitigation Assessment and Plan documents to provide regular, periodic review of risk elements including their relationship to remaining contingency and the status of the risks and management activities.

Positive Observation: The project's risks derived from their Risk Assessment process were fully considered in developing the project's contingency. In addition, both cost and schedule impacts are included in the contingency.

3.2 SCHEDULE

3.2.1 Project Schedule

The EIR/ICR Team reviewed the completeness and realism of the project schedule for the design and construction phases of the project schedule. One essential finding and one finding were made and are discussed below.

Essential Finding: The current schedule has not been cost and resource loaded.

This project is capital and time intensive. At this stage, the project is dynamic, changing from the beginning through the ending. Not only are there direct expenditures, there are expensive, time dependent costs such as technical equipment, personnel charges, and overheads. A fully integrated resource and cost loaded Critical Path Method Schedule will assist in managing both direct and time-related costs. Particular attention needs to be paid to project activities that have SNS activities as predecessors.

Another benefit of a CPM schedule at this project stage is it provides all team members the opportunity to adjust to changed conditions, to determine impact to the completion date caused by unforeseen events, and to implement risk management strategies using "what if" situations. Also, it enables efficient cash

flow management. A detailed schedule at the current project stage will facilitate the coordination of the Central Laboratory and Office and other projects, contractors, and work elements.

Recommendation: Develop a fully integrated resource and cost loaded Critical Path Method Schedule from design through commissioning including technical equipment, construction, design, design support, project management, Title III, OPC activities, demobilization, etc. The revised schedule should be independently reviewed.

Finding: The current summary level project schedule is incomplete because it does not include some major project activities, e.g., Title III, Project Management, Design Support, OPC activities, commissioning, etc.

The detailed construction schedule does not include demobilization or adequate milestones. In addition, key events/milestones have not been identified, such as interactions with SNS, dry-in, foundations, clean room, mechanical, steel, etc.

The current summary level project schedule for technical equipment does not distinguish between equipment and technical support labor.

The detailed equipment schedule information does not indicate actions and milestones by each piece of equipment by procurement activities, receipt, installation, etc.

Recommendations: Add all appropriate project activities to the summary level project schedule.

- Display the technical equipment schedule by activities that comprise the Level II WBS 2.1, i.e., Equipment, Procurement, Installation, Test and Checkout, Technical Design Support and Project Management.
- Display the conventional facilities schedule by activities that comprise the Level II WBS 2.2, i.e., Design, Construction, Project Management, Design Support, Construction Management Construction Support, and Title III services.
- Add OPC elements such as CDR/VE Study, Scientific Scope Development, ES&H Documentation and Engineering Support.
- Add key events and milestones as appropriate to a summary level project schedule.

Add key events and milestones, such as dry-in, foundations, clean room, mechanical, steel, foundations, and integrate equipment delivery/installation to the existing construction schedule. Add key events for individual equipment items, such as procurement, inspection, installation, test and acceptance to the preliminary technical equipment schedule.

3.3 SCOPE/TECHNICAL

3.3.1 Solution Alternatives

The EIR/ICR Team reviewed systems engineering and alternatives analysis.

3.3.2 Solution Requirements

The EIR/ICR Team reviewed functional & performance requirements, site location, site characterization, waste characterization, waste acceptance criteria, hazard analysis, hazard classification, safety documentation, safeguards and security, ES&H management planning, emergency preparedness, NEPA documentation, and civil, structural, and architectural requirements. There were one essential finding and two positive observations, which are discussed below.

Essential Finding: The ES&H Plan at the UT-Battelle level has not been formally adopted.

The CNMS Project intends to utilize the successful ES&H Plan developed by the SNS AE/CM (Knight-Jacobs). This approach allows the CNMS to avoid the cost of developing an independent ES&H Plan, ensures a common approach to ES&H on the SNS site, and provides a cadre of construction workers and firms with experience in working under its guidelines. As a result, this approach is cost-effective and appropriate. However, the CNMS Project (e.g., UT-Battelle) has not formally adopted the AE/CM's ES&H Plan as the guiding plan for the CNMS Project.

Recommendation: The SNS AE/CM's ES&H Plan should be formally adopted as the ES&H plan for the CNMS Project by UT-Battelle.

Positive Observation: A good process has been used for identification of functions of the Center and equipment to fulfill the functions

The process of holding two workshops with the future user community, analyzing and reducing the input from the workshops to a set of required functions to meet the Center's Mission, and the further analyses of equipment needed to fulfill the functions, all while staying within a carefully constructed budget, has been an exemplary process. Attention to selection of proven equipment for the initial period of Center operation will also be helpful in assuring ease of initial operation.

Positive Observation: The CNMS is strongly aligned with the DOE Basic Energy Sciences (BES) mission and strategy and with the National Nanotechnology Initiative (NNI).

The CNMS technical mission and approach were developed with a conscious effort to align the project with the larger DOE Basic Energy Sciences and the Federal Government's NNI programs. CNMS is one of five planned Nanotechnology research centers to be built by DOE BES at existing DOE laboratories. The BES Advisory Committee (BESAC) reviewed all the plans and promoted an open dialogue with the planned scientific user community, as well as a combined portfolio approach to the five centers. This is an excellent approach, especially in early program phases. This approach has clearly helped create a focused research plan.

3.3.3 Solution Design

The EIR Team reviewed the project design basis; design criteria; technology needs identified and demonstrated; trade-off/optimization studies; plot plan; process flow diagrams; layout drawings and equipment list; piping and instrumentation diagrams; mechanical (piping), instrumental and electrical; long lead/critical equipment and materials; design completion; design reviews; interface planning and control; operating, maintenance, and reliability concepts; and reliability, availability, and maintainability analysis. There was one finding made, which is discussed below.

Finding: Analysis supporting design decisions was not well documented.

There is a lack of documentation of the analyses to support conclusions used in specifying design decisions in several areas. This does not imply that the design decisions are wrong or that poor analysis underlies the design work. Rather, it highlights that a full written record of the methods, data,

assumptions, and knowledge base used to make the analysis and decisions must exist in the projects formal documentation.

For example, consider the analysis by Vibration Engineering Consultants on the required thickness of the concrete slab underneath sensitive equipment in the clean room. The only formal documentation provided is a short memorandum describing the consultant's conclusions that an eight-inch thick slab is needed. When a request was made for supporting analysis, the consultant simply supplied two graphs showing the measured stiffness of four and eight inch slabs. There was no analysis showing how these basic values impact the projected requirements and environment of the CNMS. This is inadequate and creates a serious risk of relying on opinion rather than substantiated analysis, even if the analysis entails a great deal of personal experience and knowledge.

Recommendation: Review project technical decisions and provide supporting documentation for all major issues used in the design decision-making process. At a minimum, this should include all analyses performed by external consultants. These analyses must detail all primary methods, assumptions, data sources, lessons learned, and key experience based knowledge and show how the parameters impact the equipment and building requirements, as well as major sources of risk and error.

Positive Observation: The design for the CNMS building provides both a good integration of identified research needs and appropriate flexibility for modifications to meet future needs.

The CNMS design shows a very good attention to the needs of the researchers by incorporating them into the building's design requirements. An example is the covered walkway between the CNMS and SNS. The chief benefits include the ability to move samples between various facilities (Central Lab and Office Building (CLO), the target building, and CNMS) in a controlled, protected environment and to provide alternate paths for the protected movement and transfer of sensitive equipment. The covered walkway may also facilitate informal exchanges between researchers in the CLO and the CNMS.

Considerable use of ORNL staff experience in modifying research facilities has been put to use in thinking through the design of the Center building from the viewpoint of future flexibility. Layouts and designs have incorporated features to facilitate ease of future modifications to building functions as new uses and operations are identified. For example, the development of requirements for the elevator and access to the Laboratories specifically included provisions for future changes of equipment.

Positive Observation: Multiple assessments of technical equipment needs were used to refine technical equipment plan.

Technical equipment items and cost have been refined through multiple reviews. In particular, a second workshop of researchers was held to assess and prioritize the choice of technical equipment in conjunction with assessing and prioritizing projected research thrusts to meet DOE BESAC science objectives. The first workshop was held in October 2001 and the second workshop in June 2002. The technical equipment list changed significantly with items deleted, added, and modified. This process increases the likelihood that the proper mix of equipment is purchased and that high-quality and productive research can begin quickly after the facility is constructed.

3.3.4 Solutions Preparation for Next Phase

The EIR/ICR Team reviewed transition and startup planning, pollution prevention and waste minimization, transportation requirements, loading/unloading/storage facility requirements, training requirements, processing/production plan/schedule, and operations plans and procedures. The Review Team made one finding, which is described below.

Finding: There is no system in place to ensure that the building systems are designed, installed, functionally tested and capable of being operated and maintained

according to UT-Battelle's operational needs and ensure the building systems meet UT-Battelle's needs.

A commissioning plan provides a documented pathway to the ensuring that the goal of establishing fully functional and integrated systems in a facility is met. Emphasis is placed on documenting the scope of UT-Battelle's program and the design intent and ensuring the proper transfer of ideas and design concepts from the construction project to operations. For example, a plan should require that the building operation and maintenance personnel be provided with full system training and receive documentation on how the system was designed, installed, and intended to operate. The commissioning process is also used to achieve quality from the start, in addition to inspecting for quality or modifying the system after the facility is occupied.

A Commissioning Authority is part of the building process from this preliminary design stage. This authority represents the facility owner from the project program to occupancy and the first year of occupancy. Include the cost of commissioning in the cost estimate

Recommendation: Implement a commissioning plan for the CNMS and establish a Commissioning Authority. Include the cost of commissioning in the cost estimate.

Positive Observation: The development of a 10 year "Long Range Plan" by the Project Management Team to mesh with the flexible design of the Center is an example of the attention to an overall strategic thought process with regard to the continuing growth and evolution of the Center developed by the Project Management.

3.4 MANAGEMENT, PLANNING, AND CONTROL

3.4.1 Mission Need/Objectives

The LOIs under the Management, Planning and Control review topic of Mission Need / Objectives provided by OCEM address the context of the project within the mission and objectives of the site and overall DOE program. The EIR/ICR had no essential findings or findings in this area, but did make one positive observation.

Positive Observation: The CNMS has developed well-defined scientific thrusts at the forefront of Nanotechnology research.

The CNMS has well-defined scientific thrusts in soft materials (e.g. organic polymers, biological films), hard materials (e.g. electron correlation and magnetism in nanoparticles), and theory (e.g. synthesis, electrodynamics) that have been refined by extensively including researchers in the program planning. These areas are at the forefront of Nanotechnology research and require the substantial experimental and theoretical resources envisioned for the CNMS and SNS to advance the state-of-the-art.

3.4.2 Team/Management Issues (Integrated Project Team [IPT])

The EIR/ICR Team reviewed the role of an IPT with respect to this project. The EIR/ICR Team made no essential findings or findings. Two observations were made, which are discussed below.

Observation: No Responsibility Assignment Matrix (RAM) was included in the PEP.

At a minimum, a RAM provides at-a-glance information on project participants, project activities, and participants' areas of responsibility and/or authority. Developing a RAM helps ensure that all project management activities are identified, assigned, and communicated.

Recommendation: A RAM for the CNMS Project should be developed and included in the PEP.

Observation: The Project Manager currently has dual responsibility on the CNMS Project.

At present, the Project Manager serves as both the overall CNMS Project Manager and Project Manager for Technical Equipment. As Construction approaches it is recommended that responsibility for the Technical Equipment be given to someone else from within the Project organization. The complexities of this project, particularly with regard to managing the SNS interface will require a full time Project Management commitment.

Recommendation: It would be good practice to start planning for that event now by growing one or more candidates for the Technical Equipment Project Manager position.

3.4.3 Documents/Requirements

The EIR/ICR Team reviewed project documentation and other requirements of DOE O 413.3, including the status and adequacy of the PEP, the efficacy of the project's acquisition plan, the project's configuration management program, the project's management tools, and the use of value engineering in design development. The EIR/ICR Team made one essential finding, and one observation, which are discussed below.

Essential Finding: The PEP has not been finalized.

Anticipating comments on the PEP from the EIR Team, the CNMS Project Team made a conscious decision not to pursue approval of draft PEP prior to the on-site visit. The expressed intention of the CNMS Project Team is to obtain approval of the PEP after incorporating EIR Team comments and prior to CD-2. This approach appears to eliminate duplicative approvals.

Recommendation: Secure approval of the PEP prior to CD-2, but after incorporating EIR Team suggestions discussed in the following observation.

Observation: The level of detail included in the PEP should be increased.

The PEP could be strengthened substantially by including additional details. Subjects which should be covered include: management of the interface between SNS and CNMS during Construction; inclusion of a Responsibilities Assignment Matrix; the independence of the Quality Assurance organization including an explanation that the solid reporting lines from QA to the Project Manager are for the purpose of indicating the functional flow of information only and do not indicate a formal reporting relationship and an expanded Organization Chart to indicate all key personnel. The functions of key personnel should describe each individual's Functional Responsibility, Level of Authority and major Interfaces.

The description of the Management Organizations and Responsibilities should be strengthened drawing on the descriptions given in the "Charter for the Integrated Project Management Team", dated July 18, 2002 and from the "Implementation Plan for Construction of the Center for Nanophase Materials Sciences at the Spallation Neutron Source Site", dated April 24, 2002, Rev. 0.

Recommendation: Increase the level of detail included in the PEP.

Positive Observation: The review of SNS and CNMS for safety on a synergistic accident scenario basis was commendable.

3.4.4 Project Risk Analysis/Mitigation

The EIR/ICR Team reviewed procedures for identification, reduction, and mitigation of risk, and the project's quality assurance program. The EIR/ICR Team did make one essential finding and two findings, which are discussed below.

Essential Finding: An overarching Quality Assurance Plan at the UT-Battelle level, which covers both equipment for the CNMS and construction of the CNMS, has not been established.

The CNMS Project intends to utilize the SNS Conventional Facilities QA Plan developed by the SNS AE/CM (Knight-Jacobs) for construction of the CNMS building. This approach allows the CNMS to avoid the cost of developing an independent QA Plan for construction, ensures a common approach to construction QA on the SNS site, and provides a cadre of construction workers and firms with experience in working under its guidelines. Separately, UT-Battelle has developed a QA plan for the procurement of technical equipment for CNMS. However, an overarching QA Plan for the entire CNMS Project has not been formalized.

The independence of the UT-Battelle and Knight-Jacobs Quality Control organizations should be clearly stated.

Recommendation: An overarching QA Plan at the UT-Battelle level, that encompasses the SNS AE/CM's QA Plan and the technical equipment QA plan should be formalized for the CNMS Project by UT-Battelle. Within this plan, the independence of the QA organizations should be clearly delineated.

Finding: The level of detail and specificity in the Risk Assessment should be increased.

Several project risks were identified by the EIR Team that were not specifically addressed in the Risk Assessment/Plan. These risks include:

- Technical Equipment Cost Risks
- Effects from potential SNS budget shortfalls
- CLO construction delays
- Contingency for CNMS Operations

The technical equipment cost estimate is based on current vendor quotes that have recently updated and compared to published price lists. In addition, the costs have been adjusted by incorporating ORNL experience with similar equipment in other projects. This work has produced a very good baseline cost estimate. However, risks are associated with this baseline estimate from the inevitable delay in procuring the equipment, the reliance on foreign equipment manufacturers, and the inherent uncertainty in marketplace. ORNL has included these factors in their baseline cost estimates.

Risks are also associated with the phasing of construction of the SNS and the CNMS. These risks arise from the possibility of delay in the construction of the SNS, which might in turn delaying the construction of the CNMS with a resulting increase in cost. The possible causes of delay in SNS construction range from a stretch-out in funding to simple site construction delays.

The Risk Assessment Plan should also provide for periodic reassessment of the identified risks and review of emerging risks. The Plan should also provide for the summarization of any future actions taken to mitigate or remove the cause of any imminent Risk and their level of success.

Recommendation: Revise the Risk Assessment/Plan to incorporate more detail and specificity on the aforementioned risks and on any other risks that the project team may identify.

Finding: A system to review the constructibility, buildability, and bidability of the design has not been put in place.

A constructibility, buildability, and bidability review ensures that the project design incorporates clear and feasible construction techniques. Several constructibility reviews should be incorporated into the project

planning and development. The combination of the reviews makes up the Constructibility Review Process. Bidability should be part of the Constructibility Review Process and consist of a review of the contract documents to identify errors, omissions and conflicts in the plans, specifications and bid item schedule. Bidability reviews will identify uncertainty and minimize unquantified risks to the bidder.

The Final Design stage review at 100% is intended to fully define the project for construction. It comprises the full design of all the detailed components of the project and the production of all documents for construction including the technical specification and a complete set of drawings. This also could be a "Redicheck."

Waiting to conduct constructibility reviews in the late stages of design is not effective. By project end, significant resources have been expended in developing the design. Plan changes at this late stage are costly to implement, have a significant effect on the project schedule and may conflict with long established approved schedules, costs and risks. It is imperative that independent of the Design team, knowledgeable construction people are involved early in the review.

Recommendation: Implement a Constructibility Review Process starting at this preliminary stage of the project and continuing throughout project development.

3.5 EXTERNAL FACTORS

3.5.1 Site Integration

The EIR/ICR Team reviewed inter-site and on-site coordination issues as well as the possible effects of this project on other projects and facilities coordination efforts with other facilities at ORNL, especially the SNS. There were no essential findings or findings, but one positive observation was noted which is discussed below.

Positive Observation: The CNMS Project gains tremendous advantages from it proximity to the SNS Project.

The CNMS Project is integrally associated with the SNS Project. The building itself will be located on the SNS campus, the SNS will be an integral tool for the research performed at CNMS, and the SNS AE/CM will be the AE/CM for CNMS. The SNS is a $1.4B project, and the CNMS Project gains tremendous advantages from its association with SNS.

SNS support organizations are being used to support the CNMS. These organizations include procurement, quality assurance, ES&H support, information technology, and design engineering. CNMS pays only for its usage of this infrastructure and avoids the costs of developing it. Because the SNS is such a large project, the depth of these support organizations is far greater than the CNMS would have been able to afford on its own. Using existing support organization also minimizes the problems usually associated with project startup.

CNMS may also benefit from having a cadre of construction contractors and subcontractors that are experienced in working on the SNS site under the direction of the AE/CM. This will likely reduce mobilization and startup costs and may provide additional benefits during construction itself. The current schedule for SNS and CNMS construction shows excellent opportunities to phase construction workers from other SNS buildings to the CNMS construction.

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APPENDIX A – ACRONYMS AND ABBREVIATIONS

AE/CM	Architect-Engineer/Construction Manager
BES	Office of Basic Energy Sciences
BESAC	BES Advisory Committee
CD-2	Critical Decision 2
CLO	Central Lab and Office Building
CMFE	Construction Manager Furnished Equipment and Materials
CNMS	Center for Nanophase Materials Science
CPDS	Congressional Project Data Sheet
DOE	Department of Energy
EIR	External Independent Review
ES&H	Environment, Safety, and Health
FPM	Federal Project Manager
FY	Fiscal Year
ICR	Independent Cost Review
IPT	Integrated Project Team
LCC	Life Cycle Costs
LOI	Lines of Inquiry
NNI	National Nanotechnology Initiative
NSRC	Nanoscale Science Research Center
OECM	Office of Engineering and Construction Management
OPC	Other Project Costs
ORNL	Oak Ridge National Laboratory
PEP	Project Execution Plan
QA	Quality Assurance
SNS	Spallation Neutron Source
TEC	Total Estimated Cost
TPC	Total Project Costs
WBS	Work Breakdown Structure

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APPENDIX B - REVIEW TEAM BACKGROUND

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EDUCATION

M.S. Nuclear Physics, University of South Carolina, 1986
B.S., Math and Physics, University of South Carolina, 1982

EXPERIENCE SUMMARY

Mr. Moore has more than seventeen years of experience supporting nuclear, environmental, and project management programs for the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission, as well as private corporations. He has a wide range of experience in the design, development, and implementation of scientific databases, especially those related to waste and materials management.

Mr. Moore has participated in more than ten independent evaluations of DOE construction and management projects under the authority of Public Law 105-62, Conference Report H.R.105-271, and DOE Order 413.3. These evaluations provide an independent assessment of project progress and status prior to critical decisions in the project life. For the DOE Office of Contract Reform and Privatization, Mr. Moore led a study of best practices and lessons learned related to contract transition at DOE sites. He also reviewed draft Requests for Proposals for major DOE procurements (Yucca Mountain Project and the Hanford Waste Treatment Plant Project). The RFP reviews were focused on evaluating risk allocation, the use of cost-effective contracting methods, and technical completeness.

Mr. Moore provided support to the U.S. Nuclear Regulatory Commission (NRC) for the development of the National Sealed Source and Device Registry (NSS&DR) System. This support included detailed data modeling, database development, the creation of data conversion routines to support database migration, and the development and coding of an object-oriented application, and implementation and documentation of the application at the NRC.

Mr. Moore managed and supported a broad range of technical projects for DOE's Office of Environmental Management, including technical and administrative support to the Waste Management Information System (WMIS), public participation support to the DOE EM Road Show, DOE's Technology Information Exchange (TIE) Program, and development of a regulatory compliance guide for transportation of radioactive materials. Mr. Moore was the principal investigator in the development of the Characteristics Database (CDB) System for the DOE Office of Civilian Radioactive Waste Management (OCRWM).

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EDUCATION

M.A., Health Promotion Counseling, Trinity College, 1995
B.S., Management Technology, University of Maryland, 1980

EXPERIENCE SUMMARY

Ms. Hudson has twenty-five years experience working with all levels of management to evaluate the realism of budgets for efforts ranging from local projects to national programs. She served throughout all Operations Offices in the Department of Energy in conducting project readiness reviews, independent cost estimates, and economic/cost analyses of weapons systems, environmental management activities, and nuclear power generating concepts. She was program manager of cost management activities, worked on development of assessment techniques and methods, and development of statistical cost analysis models. She managed large, diverse teams of engineers, economists, and costs analysts with annual budgets between $3 million and $5 million.

Her past experience includes developing approach for and managing a team of engineering, accounting, and management experts for assessment of cost management practices across the Department of Energy. She served as senior cost analyst for the review of complex, costly, and innovative construction and fabrication projects and nuclear weapon's systems, which resulted in many millions of dollars of savings to the Federal Government. She served as a cost analyst for the independent review of nuclear research projects, which were innovative and posed complex cost analysis problems. She has also served as staff assistant to two directors of the National Bureau of Standards.

Ms. Hudson is a member of the Society for Cost Estimating and Analysis and a Past Member of Board of Directors of the International Society of Parametric Analysis. She has received many awards including: U.S. Corps of Engineers Jury for Selection of the USACE Cost Engineer of the Year, 1995, 1996, and 1997, Exceptional Service Award, U.S. Federal Government, 1994, and Best Speakers Award and Award for Significant Contributions from the International Society for Parametric Analysis. Ms. Hudson has several publications on parametric methods and cost quality management.

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EDUCATION

B.S., Chemical Engineering, Auburn University, 1961

EXPERIENCE SUMMARY

Mr. Davies specializes in Cost Engineering, Estimating, and Scheduling of construction projects. He advises private industry and governmental agencies in reviewing and evaluating project construction, startup, and operation schedules and cost estimates. He prepares construction estimates and schedules of proposed commercial and industrial facilities as well as definitive estimates of completed designs prior to release for construction. He acts as client agent in reviewing construction plans and schedules to assure the design is followed and completion dates can be achieved.

Mr. Davies has over 25 years experience in Estimating, Scheduling, and Cost Engineering of projects in the nuclear fuel cycle. He has successfully completed assignments at most of the DOE field locations as well as for private industries involved in the nuclear field. He has held responsible positions such as Manager of Estimating for the Advanced Technology Division of a large construction company; Manager of Technical Services, responsible for scheduling, estimating, and cost control on a multi-billion dollar project for a commercial client; and Field Construction Engineer for a major chemical company.

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EXPERIENCE SUMMARY

Mr. Bader's experience includes managing a nuclear medical-research project, overseeing facilities design and construction. He has conducted numerous program/project reviews and has extensive knowledge about design, construction, management and operations of R&D, materials production and power plants.

As a Senior Project Director for Fluor Daniel at the Hanford site, Mr. Bader led a team of managers, professionals and workers in developing a seven-year strategic plan to double the percentage of the annual billion dollar budget applied to actual cleanup and closure activities at the DOE Hanford Site. A major focus was revising the philosophy and application of maintenance and operating procedures for the non-nuclear facilities and systems. He also authored a Hanford site-wide "Critical Self-Assessment" of Fluor Daniel's architectural, engineering, construction, construction management, operations, and maintenance performance. The Assessment was prepared in response to Congressional and State concern over Fluor's initial performance. The final report included recommended actions to resolve performance problems uncovered in the review.

Mr. Bader initiated Fluor's Washington, DC program office supporting the DOE Weapons Complex Reconfiguration Program. Under Mr. Bader's planning, direction, and oversight, Fluor performed design and construction management activities related to a "safer, more modern, more environmentally benign" Weapons Complex. The DC Office provided regulatory and compliance, master scheduling, systems engineering and integration, and support activities to Defense Programs for eight projects over 10 years.

As member of a team comprised of Fluor Senior Project Directors in the government sector, Mr. Bader researched, wrote, published, communicated, and supported training and implementation of Fluor's project management policies and procedures. Research involved in-depth analysis of aerospace and DoD program acquisition systems. Phased training and implementation began with projects in excess of $100 million and ended with corporate-wide deployment. Processes for value engineering, trade analysis, project execution planning, project management planning, systems requirements documentation, roadmapping, and earned value management were evaluated, documented, piloted and implemented.

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EXPERIENCE SUMMARY

Dr. Malafsky has over 20 years of experience in research and development, technology analysis, science and technology program review, and program management in projects ranging from basic science to industrial equipment in the fields of: Knowledge Management; distributed Command and Control; software engineering; Nanotechnology; Microelectromechanical systems (MEMS); surface physics; modeling & simulation; semiconductor processing; and sensors. He was a research scientist at the Naval Research Laboratory in Washington, DC and then worked for Science Applications International Corporation in McLean, VA. Earlier, he worked for Perkin-Elmer and Branson/IPC developing semiconductor manufacturing processes and systems.

Dr. Malafsky is currently a consultant leading a firm specializing in identifying, assessing, and designing systems that effectively employ advanced technologies. He works for a variety of customers in the R&D sponsor community as a technology advisor and technical program reviewer, such as DARPA and the Office of Naval Research. Also, he leads efforts for government and industry clients as a system architect and independent reviewer developing programs and systems that effectively mesh technology and business processes. His technical expertise allows him to avoid common missteps and exploit R&D and industry Lessons Learned to implement successful solutions using new technology.

He is a technology advisor and reviewer for R&D programs, such as MEMS and Nanotechnology, peer-peer mobile information fusion, and text analysis programs. He recently was the lead technical reviewer for a large Congressional appropriation for a MEMS and Nanotechnology program. Also, he is a technology advisor and innovation strategist to the Office of Naval Research on using emerging and mature technologies to rapidly solve Fleet problems.

He is a recognized expert in the use of advanced IT for Knowledge Management, and is the lead technical architect on several enterprise KM system projects. In particular, he concentrates on ensuring that IT tools are used to facilitate people's effective work flow by bridging the fields of human factors, cognitive science, IT, and organizational dynamics. He regularly lectures on the ability of state-of-the-art search engines and IT tools to solve the information glut and precision retrieval challenges. Also, he is the principal investigator on advanced search engine methods using automated metadata classification techniques.

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EDUCATION

M.S., Mechanical Engineering. Trinity College, 1984
B.A., Political Science and Public Relations, University of Charleston, 1971

EXPERIENCE SUMMARY

Mr. Ross is a Project/Cost Engineer with considerable experience in all aspects of project management, including design, estimation, and construction. Additionally, he has led the engineering and construction of multiple cleanrooms for government and commercial clients. Mr., Ross provides consulting services and analyses in cost estimating, CPM scheduling, contract administration, project controls, critical path delay, liability, issue and defective work investigations, and damages calculations.

Currently, Mr. Ross is developing an independent cost estimate for the mechanical, electrical and plumbing systems modernization within the U.S. Supreme Court Building and is providing design review services of the mechanical, plumbing and swing space modernization of the United Nations building. He has provided project management services on numerous assignments in both an oversight capacity and as project manager and lead estimator. Performed consulting services and analyses in cost estimating, CPM scheduling, contract administration, project controls, critical path delay, liability, issue and defective work investigations, and damages calculations.

Mr. Ross provided project management support for an Department of Defense contract, including engineering, procurement and construction management of a chemical and biological instrument calibration cleanroom at the Army Research Laboratory at the Edgewood Area of Aberdeen Proving Grounds. Project included modernization of mechanical and electrical systems. Temperature and humidity tolerances were less than one percent.

Mr. Ross coordinated and managed all aspects of construction projects including design and construction management of two new Class 10,000 pharmaceutical cleanroom for Australian National Laboratories in Columbia, MD.

Mr. Ross prepared specifications, technical plans, and construction designs for government and industrial contract projects including construction documentation review and construction management of a 5,000 s.f. chemical research cleanroom for FMC Corporation in Curtis Bay, MD.

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APPENDIX C – LIST OF DOCUMENTATION REVIEWED

DOCUMENT CONTROL #	DOCUMENT TITLE	DATE	AUTHOR

167-134-001, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Drawing Index, May 31, 2002.

167-134-002, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Site Plans & Drawings, May 31, 2002.

167-134-003, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Building Plans & Drawings, May 31, 2002.

167-134-004, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Structural Plans & Drawings, May 31, 2002.

167-134-005, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Mechanical Plans & Drawings, May 31, 2002.

167-134-006, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Landscape Plans & Drawings, May 31, 2002.

167-134-007, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Piping Plans & Drawings, May 31, 2002.

167-134-008, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Electrical Plans & Drawings, May 31, 2002.

167-134-009, Knight-Jacobs Joint Venture, Center for Nanophase Materials Sciences, 100% Title I Design Submittal, Landscape Lighting Plans and Drawings, May 31, 2002.

167-134-010 UT-Battelle, Preliminary Project Execution Plan for the Center for Nanophase Materials Sciences, X-OE-902, February 22, 2002.

167-134-011, 03-R-312, Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, Oak Ridge, Tennessee

167-134-012, Center for Nanophase Materials Sciences Conceptual Design Report, X-OE-904, November 29, 2001.

167-134-013, Center for Nanophase Materials Sciences Conceptual Design Report Addendum, January 9, 2002.

167-134-014, Systems Requirements Document for the Center for Nanophase Materials Sciences, X-OE-905, Rev. 1, February 19, 2002.

167-134-015, Basis of Design, Center for Nanophase Materials Sciences Building, Project Number F5-2681-00 (DRAFT), May 31, 2002.

167-134-016, D.D. Skinner, National Environmental Policy Act (NEPA) Review of Project: FY 2002 Physical Sciences Directorate Line Item Project, Center for Nanophase Materials Sciences: Relocation and Modifications, November 29, 2001.

167-134-017, UT-Battelle, Risk Assessment/Plan, X-OE-922, June 9, 2002.

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EXTERNAL INDEPENDENT PROJECT REVIEW OF THE CENTER FOR NANOPHASE MATERIALS SCIENCES PROJECT AT Oak Ridge National Laboratory

APPENDIX D – INDEPENDENT COST REVIEW

EXECUTIVE SUMMARY

The Independent Cost Review (ICR) team performed an in-depth analysis of 65% of the costs of the ORNL TPC.

The ICR Total Project Cost (TPC) at $63,236,098 is within the accepted range of –5% and +10% (or 2.7%) of the ORNL estimate for the Center for Nanophase Materials Sciences (CNMS) at $64,999,840.

However, the ICR OPC is significantly higher at $1,415,681 vis a vis the project OPC at $1,000,000. See discussion below.

The summary results of the ICR Total Estimated Cost (TEC) and OPC compared to the Project TEC and OPC are attached.

The following actions are suggested to help ensure the reasonableness and realism of the Project estimate.

- Use the most recent DOE escalation rates.
- Calculate escalation based on an expenditure pattern derived from Primavera.
- Ensure that escalation is not double applied where commodity, building equipment, technical equipment support costs, and OPC contain escalation.
- Deconstruct, document, and review project adders that contain multiple project features, e.g., mobilization and demobilization, labor productivity, material costs, escalation, etc., and ensure their realism and appropriate application .
- Ensure that TEC for technical equipment does not include ORNL costs for support tasks and for testing and documentation. It is assumed that the vendors will test the equipment and provide manuals. However, ORNL will likely review the test plans, have additional on-site final tests and inspections of the equipment and vendors' work, and accept/reject the vendors test results.

GROUND RULES AND ASSUMPTIONS

The following major assumptions and qualifications form the basis of the ICR:

- Scope of the estimate matches the ORNL Title I 30% design.
- No technical or building equipment will be engineered, i.e., it can be purchased off-the-shelf.
- DOE Guide 430.1-1 was followed.
- Existing bulk purchase agreements with vendors will result in savings that are being realized for the SNS project.
- Existing procurement building equipment with vendors will result in savings that are being realized for the SNS project.
- Project costs are in base 2002-year dollars and escalated using DOE January 2001 escalation rates for construction. However, note that they were double applied to OPCs.
- The CNMS will be located at Oak Ridge National Laboratory adjacent to the SNS.
- The CNMS will be operated by ORNL.
- There are no land acquisition costs or transfer costs.
- There are no site interface costs.

- The CNMS construction and technical equipment schedules are adequate for long lead procurements.
- The project schedules for construction and technical equipment are adequate.
- Costs of tariffs and fees for foreign procurements are excluded.
- Construction of CNMS construction will not be adversely affected by other SNS construction work.

TECHNIQUES AND METHODS

The ICR was prepared using the CNMS Title I design drawing package, design criteria, CNMS Title I Design – 30% detailed estimates. Other detail includes estimating data obtained from similar DOE and private industry projects, Means 2002 Construction Database, Richardson estimating manual, and the expert opinion and engineering judgment based on the estimating experience of three senior estimators. In addition, DOE guidelines published in DOE Guide 430.1-1 were employed frequently as a development basis for the check estimate and this ICR. .

The ICR Team reviewed the CNMS Title I 30% Design and cost estimates and schedules to verify that the CNMS costs and durations accurately reflect the Scope of Work Design Criteria. This effort included examination of the following:

- Site Layout
- General Arrangement Drawings
- Buildings Plans and Elevations
- Equipment Lists
- Sections, and Elevations
- Construction Package Definitions
- Equipment Quotations
- Basis of Cost Estimate
- WBS and WBS dictionary

The ICR was organized in the same format as the Project estimate, using the same Work Breakdown Structure (WBS) and/or Construction Specifications Institute (CSI) coding to facilitate comparison of the estimates.

The ICR Team used techniques as described below:

- **Bottoms-up Technique**—A work statement and set of drawings or specifications was used to “take off” material quantities required to perform each discrete task performed in accomplishing a given operation or producing an equipment component. From these quantities, direct labor, equipment, and overhead costs were derived and added. This technique was used as the level of detail increases during project development.

- **Parametric Estimating Technique**— The DOE INSITE parametric estimating model was used to help develop the contingency estimate. The INSITE percentages were adjusted where appropriate to account for existing bulk materials purchase agreements and Construction Manager Furnished Equipment that will benefit CNMS and reduce the project cost risk.

- **Sampling Technique**—The team identified key cost drivers, i.e., major estimate elements with significant impacts on the Total Estimated Cost (TEC). The key drivers identified for the CNMS include:
  - Structures
  - Technical equipment
  - Site work
  - Mechanical and electrical

- Design and engineering
- Project and design management
- Escalation
- Contingency

The team reviewed these major cost drivers by:

- Calculating bulk material take-offs and assigning costs
- Analyzing installation rates for equipment
- Developing allowances for miscellaneous activities
- Analyzing indirect and distributable costs
- Analyzing schedule durations, interfaces, and resource loading
- Developing escalation costs
- Developing project contingencies
- The costs rolled-up to the WBS level were compared to the costs in the estimate

- **Factor-Ratio Technique** - OPC factor ratios developed from DOE projects were used to check the limits of the estimates and actuals to date for the CNMS OPC. The factor-ratio was applied to the ICR estimate for TEC without contingency. The OPC elements were compared to the OPC/TEC guidance in DOE G 430.1-1 adjusted to reflect testing and documentation that will be done by the technical equipment vendors. No estimate was made for work that has been completed, e.g., CDR, VE, NEPA and ES&H.

FINDINGS AND RECOMMENDATIONS

Project personnel used the most current escalation rates available to them at the time of preparation of the estimate. However, those rates changed shortly before the EIR team arrived.

Recommendation: Use the most recent DOE escalation rates.

Escalation was calculated based on mid-point of construction and start of equipment fabrication.

Recommendation: Calculate escalation based on an expenditure pattern derived from Primavera.

Agreements for Construction Manager Furnished Equipment are priced through the current fiscal year and agreements for purchase for bulk materials are assumed to be available through the SNS project. Also, labor for the project's OPC elements contained escalation, but escalation was applied again.

Recommendation: Ensure that escalation is not double applied where commodity, building equipment, technical equipment support costs, and OPC contain escalation.

The CNMS direct estimate included adders such as 35% labor productivity and 24.5% CM indirects. It was not clear where and how these multipliers were applied.

Recommendation: Deconstruct, document, and review project adders that contain multiple project features, e.g., mobilization and demobilization, labor productivity, material handling markups, escalation, etc., and ensure their realism and appropriate application.

The CNMS estimate included labor unit costs for piping and electrical materials that the ICR team could not support, even with the 35% productivity adder. The electrical substation and distribution equipment costs were higher that our experience would support.

Recommendation: Review the backup for and application of these entries.

It is assumed that the vendors will test the equipment and provide equipment manuals. However, ORNL will likely review the test plans, have additional on-site final tests and inspections of the equipment and vendors' work, and accept/reject the vendors test results.

Recommendation: Ensure that TEC for technical equipment does not include ORNL personnel costs for support tasks and for testing and documentation.

Ensure that day-to-day non-project operating budgets are not being used for OPC support activities.

Attachment A: Summary Comparison Sheets

CENTER FOR NANOPHASE MATERIALS SCIENCES (CNMS)
TABLE 1

RECAST PROJECT ESTIMATE

Category	Labor	Bulk Mat'l	Equipment	Const Eq	Sub Cont.	Total	%	Escall.	% ESC	O/H	%	Sales Tax		Contingency	Total
Engineering															
Title 1&2	1,900,000					1,900,000							10.5	200,000	2,100,000
Title 3	285,714					285,714	5	14,286					15	45,000	345,000
AE/CM design supt	250,000					250,000									250,000
Sub-total Engr.	**2,435,714**					**2,435,714**	**5**	**14,286**	**0**	**0**		**0**		**245,000**	**2,695,000**
Directs	6,183,243	7,215,405	3,732,352	190,805	4,047,357	21,369,162	5	1,068,458		697,538	6	813,484	19	4,598,018	28,546,660
Tech. Equip.	280,000		19,451,000			19,731,000	6	1,349,031		666,002	7	1,361,570	16	3,638,497	26,746,100
Sub-toral Directs	**6,463,243**	**7,215,405**	**23,183,352**	**190,805**	**4,047,357**	**41,100,162**		**2,417,489**		**1,363,540**		**2,175,054**		**8,236,515**	**55,292,760**
T/E Proc. Supt	280,000					280,000	6	17,360							297,360
T/E Test & C.O.	280,000					280,000	6	17,360							297,360
T/E Design Supt	280,000					280,000	6	17,360							297,360
CNMS Proj Dir.	706,215					706,215	6	43,785							750,000
Proj. Mgmt	476,190					476,190	5	23,810					15	75,000	575,000
Const. Mgmt	1,714,286					1,714,286	5	85,714					15	270,000	2,070,000
UTB Const. Supt	1,428,571					1,428,571	5	71,429					15	225,000	1,725,000
Total Field Cost	**11,628,505**	**7,215,405**	**23,183,352**	**190,805**	**4,047,357**	**46,265,424**		**2,694,307**		**1,363,540**		**2,175,054**		**8,806,515**	**61,304,840**
Total Est. Cost	**14,064,219**	**7,215,405**	**23,183,352**	**190,805**	**4,047,357**	**48,701,138**	**5**	**2,708,593**		**1,363,540**		**2,175,054**		**9,051,515**	**63,999,840**
Other Project Costs															
CDR/VE study	384,000					384,000									384,000
Scientfic Scope Dev.	275,000					275,000									275,000
ES&H Docum.	266,000					266,000									266,000
Engr. Supt.	75,000					75,000									75,000
Total OPC	**1,000,000**	**0**	**0**	**0**	**0**	**1,000,000**		**0**		**0**		**0**		**0**	**1,000,000**
Total Project Cost	**15,064,219**	**7,215,405**	**23,183,352**	**190,805**	**4,047,357**	**49,701,138**		**2,708,593**		**1,363,540**		**2,175,054**		**9,051,515**	**64,999,840**

CENTER FOR NANOPHASE MATERIALS SCIENCES (CNMS)

TABLE 2

EXTERNAL INDEPENDENT COST REVIEW (ICR)

Category	Labor	Bulk. Mat'l	Equipment	Constr. Eq.	Sub Cont.	Total	%	Ecall.	%	O/H	%	Sales Tax	%	Contingency	Total
Engineering															
Title 1&2	1,900,000					1,900,000							9.6	200,000	2,100,000
Title 3	285,714					285,714		11,714					7.2	44,614	342,042
AE/CM Design Supt	250,000					250,000							7.2	18,000	268,000
Sub-total	**2,435,714**					**2,435,714**		**11,714**						**262,614**	**2,710,042**
Directs	5,892,100	7,016,000	3,732,352	190,805	4,047,357	20,878,614	4	916,712	3	626,358	7	782,684	17	3,944,742	27,149,110
Tech Equip	280,000		19,451,000			19,731,000	5.2	1,131,146		730,512	7	1,361,570	13	2,984,050	25,938,278
Total Directs	**6,172,100**	**7,016,000**	**23,183,352**	**190,805**	**4,047,357**	**40,609,614**		**2,047,858**		**1,356,870**		**2,144,254**		**6,928,792**	**53,087,388**
T/E Proc Supt.	280,000					280,000		14,560					11.5	33,875	328,435
T/E Test & C.O.	280,000					280,000		14,560					11.5	33,875	328,435
T/E Design Supt.	280,000					280,000		14,560					11.5	33,875	328,435
NMSC Proj. Dir.	706,215					706,215		36,723					11.5	85,440	828,378
Proj. Mgmt	476,190					476,190		19,524					11.5	65,630	561,344
Const. Mgmt	1,714,286					1,714,286		70,286					11.5	205,225	1,989,797
UTB Const Supt.	1,428,571					1,428,571		58,571					11.5	171,021	1,658,163
Total field Cost	**11,337,362**	**7,016,000**	**23,183,352**	**190,805**	**4,047,357**	**45,774,876**		**2,276,642**		**1,356,870**		**2,144,254**		**7,557,733**	**59,110,375**
	13,773,076	**7,016,000**	**23,183,352**	**190,805**	**4,047,357**	**48,210,590**		**2,288,356**		**1,356,870**		**2,144,254**		**7,820,347**	**61,820,417**
OPC	1,415,681					1,415,681									1,415,681
CDR/VE study															
Scientific Scope Dev.															
ES&H Docum.															
Engr. Supt.															
Total OPC	1,415,681					1,415,681									1,415,681
T0tal Project Cost	**15,188,757**	**7,016,000**	**23,183,352**	**190,805**	**4,047,357**	**49,626,271**		**2,288,356**		**1,356,870**		**2,144,254**		**7,820,347**	**63,236,098**

EXTERNAL INDEPENDENT PROJECT REVIEW OF THE
CENTER FOR NANOPHASE MATERIALS SCIENCES Project
AT
Oak Ridge National Laboratory

APPENDIX E – LINES OF INQUIRY

Cost Estimate

a) Has a preliminary baseline cost estimate been developed and formally approved by DOE, and is it used as the basis for the Cost Baseline?
b) Is the preliminary baseline cost estimate a reasonable approximation of Total Project Costs, and does it cover all phases of the project?
c) Has the preliminary baseline cost estimate been prepared in accordance with DOE requirements?
d) Are preliminary estimate bases fully documented and traceable and has all supporting backup information been collected, organized and made available in a central file or location?
e) Are all major estimate assumptions, especially those affecting major cost drivers, fully documented and explained?
f) Are estimate exclusions or qualifications clearly documented?
g) Are estimated costs time-phased and escalated using current DOE escalation rates?
h) Have preliminary funding requirements been defined, and is the project timeline in compliance with the DOE budget timeline/process?
i) Does the required budget documentation, including Project Data Sheets (where required), reflect current project cost and schedule estimates/forecasts?
j) Is the preliminary funding profile based on quantified resource requirements derived from the cost estimate, time-phased through integration with the project baseline schedule?
k) Is the preliminary funding profile based on full consideration of available or expected budget or funding levels for the project?
l) Has the impact of any projected funding shortfalls been assessed, and management strategies, developed to accommodate those shortfalls, been considered and incorporated in the project plan?
m) Are all of the preceding requirements documented in the project record?
n) Have the project Life Cycle Costs (LCC) been rough-order-of-magnitude estimated, including relevant assumptions, bases of estimate, qualifications and exclusions?
o) Does LCC include the estimated cost for all government commitments that result from execution of this project, including downstream projects/facilities and eventual disposition of the facilities constructed for this project?
p) Does the LCC estimate meet the requirements of Office of Management and Budget directives and DOE orders and guidance?
q) Are the LCC of competing projects, or alternative strategies estimated and documented on a comparable basis?

Cost Risk Analysis

a) Has a risk assessment been conducted on the preliminary baseline cost estimate?
b) What risks have been identified?
c) What mitigation plans have been implemented to address, reduce and/or eliminate this risk?
d) Does the preliminary baseline cost estimate include sufficient contingency allowances, based on identified risks, and developed in accordance with DOE guidance?
e) In addition to any deterministic contingency analyses that may have been developed, has a probabilistic risk analysis been performed?
f) Are the assumptions, rationale and methodology used to perform the probabilistic analysis fully explained?
g) Does the cost risk analysis build on, and is it tied to, the Project Risk Management Plan?
h) Have risk mitigation costs been included in the baseline cost estimate if appropriate, or addressed by the risk analysis model?
i) Are costs related to schedule contingency included in the risk analysis model?

j) Has the confidence level of the baseline cost estimate been clearly stated and explained?
k) Are all of the preceding requirements documented in the project record?

Cost Reviews/Lessons Learned

a) In addition to any internal cost estimate reviews, have the baseline preliminary cost and schedule estimates been subjected to an independent review by an organization not directly involved with the project? (ICE,ICR, IPR, as required)?
b) Has the independent review been documented, including the techniques used and type of review performed?
c) Have the results, findings and recommendation of the independent review been reconciled with the preliminary cost and schedule estimate, and cost and schedule changes been incorporated?

Future Cost Forecast

a) Are cost forecasts being developed in accordance with project procedures?
b) Is the forecast of cost at completion a reasonable projection based on the status of the project and experience to-date?
c) Is a detailed preliminary baseline cost estimate prepared and approved covering all costs for the work scope to be accomplished during the next phase of the project (i.e., the efforts needed to successfully complete the prerequisites for the next Critical Decision)?
d) Are preliminary baseline cost estimates defensible with an appropriate level of supporting detail and documentation?

Project Schedule

a) Has a preliminary schedule been developed and approved by DOE, consistent with regulatory milestones, that is used as the basis for the Schedule Baseline?
b) Is the preliminary schedule at a level of development expected for the current project stage?
c) Is the baseline preliminary schedule a reasonable layout of all project activities for all phases of the project, and at a level of development expected for the project stage?
d) Are all project activities included in the preliminary schedule consistent with the WBS (Work Breakdown Structure)?
e) Is the preliminary schedule prepared in accordance with DOE guidance and practices?
f) Is the preliminary schedule activity-based and does it include milestones, reasonable durations and acceptable logic?
g) Are lower level schedules developed and tiered to support the baseline schedule and/or Project Master Schedule?
h) Are project specific conditions included in the schedule?
i) Are all project schedule assumptions defined?
j) Is an acceptable software package being used that is compatible (preferably matching) between the client and contractor?
k) Is the preliminary schedule resource loaded, considering critical resources, and consistent with the funding profile?
l) Is the resource loading documented and reasonable, considering such elements as ramp-up, lead times, constraints, etc?

Schedule Milestone/Critical Path

a) Are milestones included at each level of the preliminary project schedule to establish a baseline and indicate significant progress against the work to be completed?
b) Are stakeholder and regulatory milestones included as appropriate?
c) Are milestones tiered to support project decisions, performance, approvals, etc?
d) Is a milestone dictionary provided which defines the requirements for successful completion?
e) Is an appropriate number of milestones included to control the project?
f) Is a preliminary Critical Path defined?
g) Are near-Critical Path activities identified and has a sensitivity analysis been conducted?
h) Are schedule management practices properly focused on Critical Path and Near-Critical Path activities?

Schedule Risk Analysis

a) Has a risk assessment been conducted on the baseline preliminary schedule and appropriate time contingency added as required?
b) Are the assumptions, rationale, and methodology used in the analysis documented?
c) What risks have been identified?
d) What mitigation plans have been implemented to address, reduce and/or eliminate this risk?

Future Schedule Forecast

a) Do schedule forecasts reflect actual performance to date, and projections?
b) Is a detailed schedule prepared and approved for activities to be accomplished during the next construction phase of the project (i.e. the efforts needed to successfully complete the prerequisites for the next Critical Decision)?
c) Is the "next phase" schedule defendable with an appropriate level of supporting detail and documentation?

Solutions Alternatives

a) Is systems engineering being been used to transform mission operational requirements or remediation requirements into system architecture, performance parameters, and design details?
b) Is the systems engineering process viewed as a hierarchy that begins with the definition of a need, progresses through a baseline and ends with verification that the need is met, including interfaces, fit, and completeness?
c) Is the application of systems engineering tailored to the project's needs and has it been documented?
d) What alternatives/solutions have been identified and analyzed?
e) Do the viable alternatives best address the mission need, and support the DOE Strategic Plan?
f) Does the Alternatives Analysis include comparisons of LCC, Feasibility (including Technology Development requirements), Stakeholder values, Safety, Regulatory Compliance, and other factors, as appropriate? Did the analysis justify the selected solution?
g) Are the preferred option(s) identified and justified?

Solutions Requirements

a) Are functional and performance requirements for the project documented, approved (by users, key stakeholders, and DOE program office as appropriate), and under configuration control?
b) Is the geographical location of the proposed project defined and approved?
c) Is the decision making process for site selection documented and appropriate?
d) Has the site selection process considered all viable options, and have relative strengths and weaknesses of alternate sites locations been assessed and documented?
e) Has the assessment of site specific requirements been initiated/completed?
f) Have survey and soil test evaluations of the proposed site been initiated/completed, to a level appropriate for the current project phase?
g) Is the investigation and development of site-specific characteristics complete, to a level appropriate for the current project phase and clearly documented? (For example. Limited soil borings or samples may have been taken.)
h) Are waste and materials, if present sufficiently characterized to identify appropriate disposal alternatives?
i) Have soil samples been taken and evaluated to identify the presence of any hazardous substances (both radiological and chemical)?
j) Have necessary plans and actions been taken to confirm conditions, prepare documents and perform the discovery action, including resolving surveillance and monitoring activities and safety considerations?
k) Is the on-site Waste Acceptance Criteria (WAC) documented, approved, and included in the design requirements for the project?
l) Are the waste packaging requirements identified, documented and included in the project design?
m) Are all outstanding modifications to the WAC requirements addressed and reconciled, or are plans in place to resolve these issues?

n) Has the required hazards analysis been completed and reflected in the current design?
o) Does the analysis address all significant risks (chemical, nuclear/radiological, industrial, etc.) associated with the project, as well as the operation of the completed project?
p) Has the hazard classification been defined, completed and approved?
q) Are results of the hazard classification incorporated in the technical baseline?
r) Is the required nuclear and chemical safety documentation complete and approved, in accordance with DOE orders?
s) Is the required Safety Analysis input completed?
t) Are Safety Analysis requirements developed along with the design, and are proper considerations for a safety envelope "designed in?"
u) Are safety issues resolved, and results incorporated into the necessary design documentation in support of Safety Documentation, or are plans in place to resolve these issues?
v) Are safeguard and security requirements identified and documented, including vulnerability analysis and verification, and incorporated into detailed design drawings and specifications?
w) Are security approaches and potential requirements documented to aid in development of safeguard and security plans?
x) Are environmental, safety and health (ES&H) requirements, as delineated in Federal, DOE, State, Site and Local laws and regulations, included in the facility and process design requirements?
y) Are any exceptions to ES&H requirements documented, justified and approved?
z) Is the Integrated Safety Management System (ISMS) implementation planned, to a level appropriate for the current project phase, in accordance with DOE Orders?
aa) Are Safety Plans for integrating safety management (including fire, occupational, radiological, industrial hygiene, etc.) completed, thorough and an integral part of the design effort?
bb) Are the requirements, methodology, and responsibility for ES&H activities clearly communicated?
cc) Are specialized issues and considerations for emergency preparedness adequately identified and documented?
dd) Is emergency preparedness planning complete, to a level appropriate for the current project phase, including coordination with site and external emergency response organizations, as appropriate?
ee) Has emergency planning for post-construction been initiated?
ff) Have National Environmental Policy Act (NEPA) activities, including NEPA strategy and requirements, been completed and are they compliant with DOE Orders, as necessary?
gg) Are architectural requirements, civil/structural requirements, seismic and other natural phenomena design requirements documented?

Solutions Design

a) Has the project design basis been developed and reviewed, including appropriate level of approval from users, key stakeholders, site management, and DOE?
b) Does the project design basis clearly define key performance expectations and provide a sound framework for subsequent design activities?
c) Has the design basis been subject to peer review by appropriate technical experts?
d) Have all necessary requirements and guidelines that govern the design of the project (such as, but not limited to Regulations, DOE Orders, Local, State and National Codes and Standards, and DOE and Contractor engineering Standards) been identified, reviewed by users, approved and integrated into the project design?
e) Have all identified requirements and guidelines that govern design of the project been reviewed by users, and have appropriate disciplines and criteria been approved?
f) Has availability of new technology for the project been evaluated, including benefits and risks?
g) Are the technology development requirements for each the selected alternative identified and documented?
h) Has new technology been investigated and tested to a level appropriate for the current project phase?
i) Has any new technology been determined to meet project objectives (technical, cost and schedule)?
j) Has the maturity of any new technology to be used on the project been evaluated and factored into risk analyses?

k) Are trade-off studies performed as needed to reach a reasonable level of project risk consistent with project phase and overall project cost/schedule?
l) Are these trade-off studies a part of conceptual and later design phases to optimize the design of the selected alternative?
m) Do the studies include alternative design and process control and optimization approaches with consideration of technical safety requirements?
n) Is the plot plan complete to a level appropriate for the current project phase, showing the location of the project in relation to adjoining facilities?
o) Does the initial final plot plan include items such as, but not limited to: Plant grid system with coordinates, Unit limits, gates, fences, off-site facilities, tank farms, roads and access ways, rail facilities, green space, buildings, major pipe racks, laydown areas, construction/fabrication areas and major utilities?
p) Are the Process Flow Diagrams (PFD) completed to a level appropriate for the current project phase, and completed and annotated with material balances for the design basis?
q) Do drawings include all major equipment items, and flows of materials to and from the major equipment items?
r) Are layout and major equipment location/arrangement drawings that identify locations of each item of equipment complete to a level appropriate for the current project phase?
s) Have all appropriate parties affected by equipment placement (operations, maintenance, etc.) had the opportunity to provide input and review the layout?
t) Is the facility, systems and major component equipment list complete to a level appropriate for the current project phase?
u) Are the P&IDs complete, to a level appropriate for the current project phase?
v) Do the P&IDs include all changes identified from preliminary hazards analysis (PHA), and maintenance and operations reviews, as necessary?
w) Have comprehensive reviews been performed, including (but not limited to) Safety Analysis Reports, maintenance and operations requirements, and final construction and fabrication details reviews?
x) Are process/mechanical design requirements for construction (including, but not limited to: Mechanical Design Requirements, Mechanical Equipment List, Piping Specialty Items List, Piping System Criteria, Valve List with tag numbers, Tie-in List for all piping tie-ins-ins to existing lines, Piping stress analysis, Specifications (design, performance, manufacturing, material, and code requirements), Utility Flow Diagrams, Utility Sources with Supply Conditions) complete to a level appropriate for the current project phase completely defined?
y) Are Instrument and Electrical requirements for construction (including, but not limited to Electrical Area Classifications, Substation Requirements, Electrical Design Requirements, Electrical One-Line Diagrams, Substation Design, Instrument Index, Logic Diagrams, and Instrument and Electrical Specifications) completely defined complete to a level appropriate for the current project phase?
z) Are all long lead/critical engineered equipment and/or materials fully specified, bid, and tabulated, as completely as possible for the current project phase, to support the project schedule?
aa) Are design reviews appropriate to the project phase (Conceptual, preliminary and final) been conducted and performed by a multi-functional team and, if appropriate, external experts utilized?
bb) Have system interfaces (consistent with System Design Descriptions) been identified and defined?
cc) If necessary, has an Interface Control Plan been completed, to a level appropriate for the current project phase?
dd) Are the Operating, Maintenance and Reliability concepts documented, approved and appropriately incorporated into the design, to a level appropriate for the current project phase?
ee) Has a Reliability, Availability and Maintainability review been initiated/completed, if appropriate, and the results incorporated into the technical baseline?

Solutions Preparation for Next Phase

a) Does the project strategy address critical issues for transition from construction to startup/testing to operations?
b) Has the initial (draft) start-up plan been developed/finalized?
c) Has a detailed waste minimization/pollution prevention plan for the project and operations phases been completed for selected design/project scope, as necessary?

d) Has an implementation plan for design, operational, and mitigation features that will minimize wastes and prevent pollution been initiated/completed, including cost estimate?
e) Have Transportation requirements (including those necessary for nuclear and hazardous materials) been fully addressed)?
f) Has the list of requirements been initiated, identifying raw materials to be unloaded and stored, products to be loaded along with their specifications, and cranes and/or remote handling equipment for the installation/removal or operation of process equipment?
g) Have training requirements been considered, defined, planned and/or scheduled?
h) Are the Processing, Production Plan and Schedules (PPPS) complete, to a level appropriate for the current project phase, and available?
i) Are equipment and material needs for processing and production, including availability and reliability defined?
j) Have operating plans and procedures, and development plans, including operating procedures that reference technical specifications and administrative limits, being initiated as necessary?

Mission Need/Objectives

a) Has a project mission need statement been created and approved?
b) Does the project mission need statement demonstrate that the project supports the execution of, and that the project need relates to, the Program Strategic Plan goals and objectives, as well as the DOE Strategic Plan?
c) Is the project in compliance with the site/complex strategic plan?
d) Are the Mission needs reassessed after major changes in the program, at budget submission and at Critical Decisions?
e) Are the changes to the project need/project mission being documented?
f) What is the "definition of success" for this project? (i.e. what constitutes a successful outcome for this project? This may be a broad or top-level definition at this phase of the project)
g) What is the cost/effect (good and/or bad) of NOT undertaking and completing this project? (i.e. What will happen if we don't do this project?)
h) Have the customer's needs and expectations been fully identified? What are the customer's needs and expectations?
i) Have the project objectives been developed taking into full account the customer's needs and expectations?
j) What are the project objectives?
k) Are the project objectives measurable?
l) What are the requirements for success?
m) Do these requirements fully meet the customer's needs and expectations?
n) Has the Conceptual Design Report (CDR) been finalized, reviewed and approved by the Contractor and DOE?
o) Have the project's performance parameters been identified and documented?
p) What are the project performance parameters?
q) Are the performance parameters realistic? Are we trying to do too much at once/not enough?

Team/Management Issues (Integrated Project Team (IPT))

a) What background/experiences of the project manager/director demonstrates his/her ability to successfully manage this project?
b) Does the project manager have a full understanding of the project and it's relation to the mission need?
c) Does the project manager have a full understanding of the project objectives?
d) Has a chartering mechanism been developed and implemented to formally recognize the existence of the project?
e) Does the charter empower and hold the Project Manager responsible and accountable for ensuring successful project completion?
f) Is the project organization in place, well-defined and functional? (i.e. Who is responsible for what?)
g) Is the project authority well-defined? Who has authority over what decisions?

h) Is there a fully Integrated Project Team (IPT) supported by representatives from budgetary, financial, procurement, information resource management, value management, contractors and others as needed?
i) Is the IPT formally chartered?
j) Who are the appointed team members, and what roles/positions and responsibilities do they hold?
k) Is there team alignment, or consensus, on the project objectives? Is there team alignment behind the project priorities?
l) Does the IPT understand the project mission need?
m) Does the IPT understand the project objectives?
n) Has the IPT developed the project objectives into appropriate, measurable "requirements for success"?
o) Is there consensus on what the parameters of performance for the project will be?
p) Is the IPT well-informed on the project status?
q) How does the IPT communicate?

Documents/Requirements

a) Has an Acquisition Strategy/Plan been developed and approved in accordance with DOE requirements/orders?
b) Are the acquisition strategy and plans sufficient to accomplish the project using a tailored approach?
c) Has the PEP been developed, finalized and approved in accordance with DOE requirements/orders?
d) Is the PEP the primary agreement on project planning and objectives between all parties? Does the PEP establish roles and responsibilities and define how the project will be executed, including tailoring general requirements and processes to the specifics of the project?
e) Have accurate Project Data Sheets (PDS) been prepared, using cost and schedule baselines, and approved as appropriate?
f) Has an acceptable process been established to review and approve proposed changes to cost, schedule, and technical baselines, to determine impact of changes?
g) Have Baseline Change Control Boards (BCCB) been established at appropriate levels of the organization? Have thresholds for each level been defined, and are appropriate procedures in place?
h) Is a functioning project control system in place for managing project baselines using earned value techniques, variance analysis, contingency/ reserve management and effective reporting, in accordance with DOE orders and guidelines?
i) Has a project Work Breakdown Structure (WBS) been established that reflects all parts of the project plan through completion?
j) Has the WBS dictionary been completed, including detailed Statements of Work (SOWs), all project schedule and cost directly aligned with WBS structure, and deliverables defined?
k) Have the Resources required for the next phase (time, people, money, technology, etc.) been identified and are they available?
l) Has a configuration management program been established and is it functioning to ensure consistency among requirements, criteria, design, existing facilities, physical configuration, and interfaces within project documents?
m) Is a value engineering program complying with DOE Orders in place, in which qualified personnel have analyzed appropriate project functions using accepted industry techniques, with the aim of improving performance, reliability, quality, safety and life cycle costs of products, systems or procedures?
n) Has the value engineering analyses been documented in a formal report? Has the analysis provided unbiased, outside opinion and senior expertise as inputs to the design process and an independent review of concept, design, and schedule?
o) Have all measures been taken to minimize project cost and maximize the return on investment for delivering the project? Have these measurements been documented and has the cost savings realized been quantified?
p) Have Project criteria been re-evaluated when value engineering analyses have determined them to have poor value or a high cost-to worth ratio?
q) Is the project being accomplished in accordance with the established DOE Project Acquisition Process, including Critical Decision and Energy Systems Acquisition Advisory Boards (ESAAB)?

r) Is a funds management system in place to ensure funds are allocated to support the project baseline elements for the current fiscal year?
s) Is a funds management system in place to periodically review the annual costs to ensure that the annual funding will not be exceeded?
t) Are Reviews (including EIRs and IPRs) and assessments performed (for the current phase) and are the findings, assessments, and recommendations documented and presented to appropriate levels of management?
u) Is a Corrective Action Plan system in place and being tracked/managed as necessary?
v) Are appropriate reviews and self-assessments planned and conducted as an integral part of the project, based on project complexity, duration and critical decision points?
w) Have "Lessons Learned/Recommendations" from independent assessments performed on this and/or similar projects been reviewed and implemented as appropriate?
x) Are Procurement packages being developed in accordance with the procurement strategy?
y) Are there Contractor selection processes and procedures in place?
z) Do the Procurement packages reflect all requirements for security, safety and environmental considerations, and pass on appropriate responsibilities to contractors and subcontractors?
aa) Do the Procurement packages include reasonable incentives for performance, where appropriate, to attract top-tier contractors.
bb) Are the necessary project management tools and procedures (such as clear roles and responsibilities, customer expectations, Budget, PEP, WBS, etc.) in place to ensure that the necessary Design, Scope and Plan products are delivered when needed?

Project Risk Analysis/Mitigation

a) What things will/could affect the stability of the Project Need?
b) What things will/could affect the success of the project?
c) Is a complete list available of the critical facts/factors and circumstances that would affect project outcome if changed?
d) Are the assumptions used to develop these critical factors appropriate? Have they been approved by appropriate parties?
e) Are the project assumptions reflected in technical/cost/ schedule baselines and risk management plans?
f) What is being done to mitigate the identified project risk?
g) Has a Risk management plan been developed, included an Acquisition Plan and/or PEP as appropriate? Is a risk mitigation strategy in place?
h) Is project risk an accurate and complete estimate of probability and severity of cost, schedule and other impacts associated with uncertainties in the project, including a time frame in which these risks are expected to occur?
i) What risks have been identified?
j) Are risks tracked, reported, and controlled?
k) Has it been demonstrated, through the required Design submittals, that the project need out-weighs the identified project risk?
l) Has a Quality Assurance (QA) program been established and documented?
m) Have QA factors, including standards, specifications, and limitations been identified?
n) Is a Quality Control (QC) and QA oversight organization in place and functional?

Site Integration

a) Have all key inter-site coordination issues been identified, addressed and resolved, or are plans in place to accomplish resolution?
b) Have all key on-site coordination issues been identified, addressed and resolved, or are plans in place to accomplish resolution?
c) Are the possible effects on other projects/facilities, imposed by this project, being fully accounted for and documented?

Site Documents/Requirements

a) Have all applicable permits, licenses, and regulatory approvals been obtained, and milestone dates for pending and new applications reviewed and revised as appropriate?
b) Have all permits, licenses and approvals necessary to construct and operate a facility or to initiate and perform project activities been identified? Will they be obtained when needed/in time to continue project execution on schedule?
c) Is the schedule for receipt of authorization from regulators realistic, based on experience?

Stakeholder Integration

a) Have all the stakeholders been identified, and their relationship to the project evaluated? Has the project's impact on stakeholder interests and potential stakeholder groups within community been identified and resolved?
b) Have all required interfaces with external organizations or authorities been identified and addressed?
c) Is an appropriate Public Participation Plan is in place, based on available stakeholder information and size and scope of the project?
d) Have all of the specific stakeholder group issues been addressed, relative to project goals and objectives, technical issues, project risk, and environmental strategies?

EXTERNAL INDEPENDENT PROJECT REVIEW OF THE
CENTER FOR NANOPHASE MATERIALS SCIENCES PROJECT
AT
Oak Ridge National Laboratory

APPENDIX F – CORRECTIVE ACTION PLAN

ID No.	Section Ref	Pg Ref	Recommendation	Required Action (Discussion)	Action Office	Start/Compl.	Current Status	Site Use	Review Team Perspective
1	3.1.1 - Cost Estimate/ Project Funding	9	Use the latest DOE escalation rates. Use Primavera to apply escalation to a spending pattern based on a resource loaded and costed schedule, taking care not to apply escalation where it has already been included in the base numbers. Illustrate how escalation was applied to the Construction Manager Furnished Equipment and Materials (CMFE) items in the estimate.						
2		10	Prepare an LCC estimate to cover all acquisition costs, operating and maintenance costs, assumed future rehab or expansion costs (if any), and decommissioning costs. Update the LCC as necessary to reflect significant changes, e.g., addition/deletion of major technical equipment, building size changes, and significant changes in recurring operating costs such as utilities, security, etc.						
3		10	Further refine the current construction WBS (currently one element) to at least two additional levels. Include those levels in the WBS dictionary.						

ID No.	Section Ref	Pg Ref	Recommendation	Required Action (Discussion)	Action Office	Start/Compl.	Current Status	Site Use	Review Team Perspective
4	3.1.2 - Cost Risk Analysis	11	Include language to the PEP and/or the Risk Mitigation Assessment and Plan documents to provide regular, periodic review of risk elements including their relationship to remaining contingency and the status of the risks and management activities.						
5	3.2.1 – Project Schedule	12	Develop a fully integrated resource and cost loaded Critical Path Method Schedule from design through commissioning including technical equipment, construction, design, design support, project management, Title III, OPC activities, demobilization, etc. The revised schedule should be independently reviewed.						

ID No.	Section Ref	Pg Ref	Recommendation	Required Action (Discussion)	Action Office	Start/Compl.	Current Status	Site Use	Review Team Perspective
6	3.2.1 Project Schedule	12	Add all appropriate project activities to the summary level project schedule. – Display the technical equipment schedule by activities that comprise the Level II WBS 2.1, i.e., Equipment, Procurement, Installation, Test and Checkout, Technical Design Support and Project Management. – Display the conventional facilities schedule by activities that comprise the Level II WBS 2.2, i.e., Design, Construction, Project Management, Design Support, Construction Management Construction Support, and Title III services. – Add OPC elements such as CDR/VE Study, Scientific Scope Development, ES&H Documentation and Engineering Support. – Add key events and milestones as appropriate to a summary level project schedule. Add key events and milestones, such as dry-in, foundations, clean room, mechanical, steel, foundations, and integrate equipment delivery/installation to the existing construction schedule. Add key events for individual equipment items, such as procurement, inspection, installation, test and acceptance to the preliminary technical equipment schedule.						

ID No.	Section Ref	Pg Ref	Recommendation	Required Action (Discussion)	Action Office	Start/Compl.	Current Status	Site Use	Review Team Perspective
7	3.3.2 – Solution Requirements	13	The SNS AE/CM's ES&H Plan should be formally adopted as the ES&H plan for the CNMS Project by UT-Battelle.						
8	3.3.3 – Solution Design	14	Review project technical decisions and provide supporting documentation for all major issues used in the design decision-making process. At a minimum, this should include all analyses performed by external consultants. These analyses must detail all primary methods, assumptions, data sources, lessons learned, and key experience based knowledge and show how the parameters impact the equipment and building requirements, as well as major sources of risk and error.						
9	3.3.4 – Solutions Preparation for Next Phase	15	Implement a commissioning plan for the CNMS and establish a Commissioning Authority. Include the cost of commissioning in the cost estimate.						
11	3.4.2 – Team / Management Issues	16	A RAM for the CNMS Project should be developed and included in the PEP.						
12		16	It would be good practice to start planning for that event now by growing one or more candidates for the Technical Equipment Project Managers position.						
13	3.4.3 – Documents / Requirements	16	Secure approval of the PEP prior to CD-2, but after incorporating EIR Team suggestions discussed in the following observation.						
14		16	Increase the level of detail included in the PEP.						

ID No.	Section Ref	Pg Ref	Recommendation	Required Action (Discussion)	Action Office	Start/Compl.	Current Status	Site Use	Review Team Perspective
15	3.4.4 – Project Risk Analysis / Mitigation	17	An overarching QA Plan at the UT-Battelle level, that encompasses the SNS AE/CM's QA Plan and the technical equipment QA plan should be formalized for the CNMS Project by UT-Battelle. Within this plan, the independence of the QA organizations should be clearly delineated.						
16		17	Revise the Risk Assessment/Plan to incorporate more detail and specificity on the aforementioned risks and on any other risks that the project team may identify.						
17		18	Implement a Constructibility Review Process starting at this preliminary stage of the project and continuing throughout project development.						

Red = Essential Finding
Yellow = Finding
Green = Observation