Closeout Report

on the

Department of Energy
Review Committee

for the

Technical, Cost, Schedule, and
Management Review

of the

LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

May 23, 2003

Department of Energy Review
of the
Linac Coherent Light Source (LCLS) Project

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CONTENTS

2. Long Lead Technical Scope

2.1 Findings

This subcommittee had the primary charge of reviewing the technical scope of long lead procurement items. In doing that there were three main questions that we considered. The first question to respond to is:

> Is the design of the long-lead items sufficiently mature to support their procurement as early as FY 2005?

We commend the team for continuing to advance the knowledge and technical base required to make this ambitious project a success despite delays in funding start due to continuing resolutions. As a whole the team is focused and nothing that we have learned in the last year suggests that the goals of this project cannot be successfully achieved. This team is highly skilled and competent and has made considerable progress within a constrained funding profile. We appreciate their candor in reviewing the technical status of the various subsystems. There are three main areas with scope requiring long lead procurement.

In the first area, the injector, the design is quite mature. The committee finds the team fully prepared for procurement of the entire system as a long lead item. We encourage this action. The injector is a crucial technology for the performance of the system as a whole and the earlier it can be brought into operation the sooner we can gain confidence that the stringent requirements can be met. Despite encouraging modeling no other system has yet met all of the requirements proposed so early operation is vital. One area where long lead procurement may be difficult is the drive laser since the requirements for this laser are near but not met by any existing commercial system as regards the repetition rates required for the amplifier. It may be difficult to find commercial vendors sufficiently interested in this one-of-a- kind system to devote the proper effort required for its development as well as its characterization. In this case an in-house effort may be required or developed within another national laboratory (LLNL or LBNL) Sufficient expertise exists at SLAC and nearby institutions such as LBNL and LLNL which maintain close collaborations so that this is not of particular concern. It is important to start development of the required laser technology skill base as well as the hardware as soon as possible. It is unfortunate that some of the injector long lead procurements are delayed by budgetary constraints and we encourage project management to review the allocation of resources to verify risk in long lead procurements is properly balanced.
In the second area, the wiggler, less progress has been made over the last year. There is concern that attention to the difficulties of manufacturing and procuring 33 highly toleranced components has not been sufficiently addressed. Last year's committee recommended (among other things):

- ***Complete a thorough value engineering and production analysis of the undulator mechanical design. Trade-offs on the choice of strongback materials, thermal***

compensation and phasing control, physical tolerances, and relationship between stringent tolerances and post assembly tuning must be completed. This should be completed prior to submitting any long-lead procurements for bid.

- ***Focus the second undulator prototype on addressing mass production issues. The design and technical approaches have been sufficiently advanced that production issues are the most critical. If a second prototype is pursued, this recommendation must be completed prior to Critical Decision 3, Approve Start of Construction. If industrial production is selected, the second prototype should be produced in industry.***

These recommendations still need to be addressed. In particular the materials choice on the strongback and the method of thermal management have not been adequately addressed to give confidence that minimal changes would be required from the baseline procurements. There are also outstanding issues regarding end sections and interfaces to diagnostics. There is (barely) sufficient time over the next year to resolve these concerns with attention by experienced and knowledgeable engineers. Ongoing QA during the long lead procurements in this area is particularly important.

The third area is the accelerator. SLAC experience in this area is extensive and the design is well advanced in most subsystems. Early procurement and testing of several of these systems is important to ensure performance. X-band linac components need testing to establish phase and amplitude stability. Designs and existing similar hardware for the linac exists and can proceed as funding is available. The superconducting wiggler is required for long lead because of the lack of extensive commercial capability in this technology and the specialized design lead to fears of delivery slips A successful conceptual design review of this system planned for this fall should put this system on track to be ready for approval of long lead procurement next April but production schedules will remain a concern for this one-of-a-kind device..

2. Are the cost estimate and schedule for the long-lead scope credible and realistic? Do they include adequate contingency margins based on a systematic risk analysis?

The cost estimate and schedule are reasonable for the long lead scope. There is concern in a couple of areas primarily because of the lack of extensive commercial support in high repetition rate laser amplifiers and superconducting wigglers. The approach on the wiggler will require review over this year to address manufacturing issues of strongbacks and magnetic components. It will be appropriate to revisit this area before final approval of procurement but the committee believes the budget as it exists is sufficient to cover expected costs. There was no systematic presentation on risk analysis to establish contingency but overall the long lead procurement budget contingency appears appropriate. It is desirable to revisit the allocation of long lead resources during the

coming year so maximize risk reduction while maintaining overall project schedule. This question is addressed in more detail under Project Management.

3. Have the technical and non-technical risks associated with the long-lead scope been realistically assessed, and has the project identified appropriate risk mitigation measures?

The technical risks have been adequately addressed and in many cases little more progress can be expected until real hardware can be obtained making it crucial that long lead procurements proceed as soon as budgets are available. This is also generally true in the non-technical risks (cost and schedule creep due to manufacturing problems for example) although additional attention will be needed in the wiggler area to review procurement strategy, design manufacturability, and quality assurance during performance of the manufacturing contracts. Appropriate risk mitigation measures have been taken; in most cases there are alternate approaches possible although there are a few areas where alternates are not easily or cheaply available: drive laser power amp, superconducting wiggler, X-band linac. These will require particular management attention as the project proceeds to ensure they don't impact the overall project schedule.

2.2 Comments

Although management stated that the allocation of long lead budgets had been optimized with respect to balancing risk while maintaining overall schedule it wasn't clear from the presentations that this criteria had been evenly applied over the various subsystems. We encourage management to continue to look at these allocations during the coming year to balance these needs. Working with DOE to move long lead acquisition funding forward is very desirable.

With funding just becoming available due to continuing resolutions the Argonne team is just beginning its effort. They will need to establish a strong team of individuals experienced in not only the magnet design but also manufacturing technology and control. There has been little work on the wiggler diagnostics and they require prototyping and test to validate the ability to achieve 1 micron resolution at the required charge. It will be crucial for the success for this project to have the strong backing of Argonne management so that these key individuals are made available. The first undulator prototype has performed well but the team now has to learn how to repeat this effort identically 33 times. Working with DOE will be helpful in ensuring the attention of Argonne management.

The injector effort scales up dramatically in the last year. The rate of increase is so large as to suggest there will be difficulties in handling the effort successfully.

2.3 Recommendations

1. Carry out previous recommendations of this committee regarding design trades of the undulator and fabrication of the second prototype. By 4/04, CD2B
2. Develop prototype of undulator beam position monitor and test with beam to demonstrate resolution. 9/04
3. Establish dedicated team of experienced personnel at Argonne for the manufacturing procurement activity and develop a quality assurance plan for the procurement. By 4/04, CD2B
4. Establish a section of laser/optical physics within the org chart. The section will serve both injector drive laser, beam transport, and optical diagnostics but inevitable support for LCLS experimental efforts. By 4/04, CD2B
5. Review approaches with adequate optical modeling for drive laser power amplifier and compressor components with vendors and pursue in-house development if sufficient vendor interest cannot be established. 4/04, CD2B
6. Find space at SLAC or elsewhere (LLNL or LBNL) for early development of the laser capability. Such a crucial development of critical performance cannot wait until the last year for first on-site test efforts. Also develop a plan for long lead procurement at earliest time funds are made available. 4/04, CD2B
7. Perform successful conceptual design review of superconducting wiggler to establish firm specifications for procurement. 1/04
8. Review and update schedule for injector development to optimize resource loading in the last year and to demonstrate required performance of critical components at earliest possible time. 4/04, CD2B
9. Establish engineering change control board. 4/04, CD2B

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Technical, Cost, Schedule, and
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LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

Long-Lead Procurement Budget

May 21-23, 2003

Cost (and funding):

Findings:

1. In summary, and based on the technical review of the design status, the cost estimate data presented supports the $29.9M Long-Lead Procurement Budget for FY05.

2. PED funding profile has been fixed at $6M in FY03, $7.5M in FY04, $20M in FY05, and $2.5M in FY06.

3. R&D funding profile has been fixed at $2M in FY04 and $4M in FY05.

4. Other than the target for the LLP of $29.9M, the TEC funding profile has not been fixed nor has the Project reevaluated it at this point in time.

5. Complete comparisons of current cost estimates and contingency assessments have not been made to previous reviews for either the long-lead procurements or the total project.

6. It was not readily evident that a systematic, or project consistent method was used to assess contingency needs for the long-lead procurements.

7. The reduction in the cost estimate (including contingency) for the undulator long-lead procurements is significant at $3.1M. Further analysis will have to be conducted to determine if this will translate to a project bottom line adjustment.

Comments:

1. Cost and contingency tables comparing estimates from previous review(s) would go a long way to communicate progress made between reviews.

2. Procurements:
   a. The project may need to review who holds the vendor contract paper. This comment is made from a project cost aspect only. *SLAC's M&S Burden is less than ANL's. ANL could still manage the contract even with SLAC holding the paper.*
   b. Further search for vendors/suppliers for the critical materials and equipment could still provide cost and possibly schedule benefits.

Recommendations

1. Provide comparison cost tables (with contingency segregated) to show changes that have been made between reviews. This will be important to have available at CD-2b.

2. Review which participating Lab should make major procurements with consideration of Labs' M&S markup rates.

3. Insure that initial spares ordered with the long-lead procurements portion of the project budget are necessary and do not impact other more critical equipment orders.

Schedule:

Findings

1. Progress on the LCLS Project since April 2002 has been good based on the limited funding received. The first PED funding was only made available in March of this year.

2. PED funding profile has been fixed thus the schedule starts with a significant resource constraint.

3. TEC funding profile has not been fixed nor has the Project reevaluated it in total at this point in time. The schedule may have to change based on updated funding requirements.

4. Approval of this CD-2a is the establishment of the baseline for all the long-lead equipment. Thus, progress reporting and baseline control will be required.

5. The schedule critical path to the long-lead procurements is not clearly demonstrated. As a result, the linkage between the overall project critical path to CD-4 and the long-lead procurements is difficult to communicate.

6. A comprehensive project risk assessment has not been completed. To this point in time, the attention to risk assessments has focused on the technical risks. Current plans are to complete a comprehensive risk assessment prior to CD-2b.

7. The funding profiles are driving a late-start schedule and an end-loaded staffing plan. This form of planning increases risk, both cost and schedule.

Comments

1. Appropriate staffing levels are totally dependant upon a good critical path schedule even when that schedule is limited by funding.

2. Schedule:
    a. The detailed critical path schedule should be able to be completed in less than six months.
    b. The initial critical path schedule does not need to be totally resource loaded. It should however be based on the critical resources.
    c. Subsequent to the initial critical path schedule development the remaining details can be added and resources leveled.

Recommendations

1. Development of a detailed critical path schedule must be complete prior to CD-2b.

2. The schedule associated with the completion of the undulators, magnetic measurement and installation must be examined to increase, or maximize schedule contingency prior to CD-2b.

5. Project Management

Findings

The LCLS project management organization is well underway to being completely solidified. An experienced chief project engineer will be starting 1 June 2003. The Linac Senior Team Leader started approximately one week prior to the review. The Undulator Senior Team Leader at Argonne is on board and actively engaged in managing and organizing the effort. The Injector System Team is one of the most mature within the project and demonstrates a strong cohesiveness. The management model of senior team leaders with scientific system managers appears to operate well, and in effect, provides a type of scientific quality assurance of the project.

The LCLS project will be elevated to the status of a separate division within SLAC in 2004 and will begin co-locating personnel starting in the summer of 2003. The LCLS Undulator System has been elevated to a direct report to the Associate Laboratory Director within the Advanced Photon Source.

Frequent open project communication has been established and fostered. Bi-weekly videoconference meetings are being held. All system teams meet on a weekly basis and interactions between the system manager and the senior team leaders occur on a frequent and regular basis.

PED funding for FY2003 is $6.0M PED. For FY2004 the funding guidance is $7.5M PED and $2.0M R&D. FY2005 funding level is $20.0M PED, $29.9M long-lead procurement, and $4.0M R&D. The abrupt increase in total PED from FY2004 to FY2005 presents a major challenge to all systems and the project as a whole.

The delay in receipt of PED funding in FY2003 subsequently delayed progress both in project management and technical areas. The project team has accomplished a substantial amount of work in view of these funding constraints.

There is a discrepancy between the PED and R&D funding projected for being allocated to the Undulator System for FY2004 ($1.45M) in contrast to the desired staffing level (13 FTEs) for FY2004. A balance between realistic workloads and deliverables and available funding levels is to be established.

In the time since the previous review the project has established the Project Execution Plan for the Project Engineering and Design Phase (approved 20 September 2002), the Acquisition Execution Plan (approved 16 October 2002), the Environmental Assessment for the LCLS Experimental Facility (DOE/EA-1426; approved 28 February 2003), and completed the Preliminary Hazard Analysis.

Comments

The cost estimate and schedule for the long lead scope appears generally credible and realistic. The tuning, measurement, and installation of the undulators remain an area of concern. Generally the project has included adequate contingency margins, though contingency associated with the magnets and poles appears light. The contingency numbers are based on expert judgment. A complete systematic risk analysis has not been completed by the overall systems.

The project is being managed (i.e., properly organized, adequately staffed) as needed to carry out long-lead procurements as early as FY 2005. The delay of PED funding has slowed the maturation of the project organization, but indications of proper control and management practices are in evidence.

Considerable work remains to be accomplished in anticipation of a full project baseline. This includes the full implementation of a project management control system, a configuration management system, change control process, and finalized interface definitions and handoffs.

Staffing plans are not consistent across the systems and the project in general. The ability to accommodate the rapid increases of funding and staffing from year to year will be extremely difficult to accomplish in an efficient manner. The project needs to aggressively address the risks and impacts associated with these rapid increases in staffing levels and funding. Increasing staff levels consumes considerable resources of an already taxed management and reduces productivity for a time before the benefits on the increased staff are realized. This is a major issue in all system areas.

Balancing external expectations in the face of funding profile constraints is always challenging, and the Project and the stakeholders of the project need to fully understand the impact of limited funding profiles.

Technical risks associated with the long-lead scope have been realistically assessed, and the project has identified appropriate risk mitigation measures. Additional attention to non-technical risk assessment, analysis and mitigation should be undertaken.

Recommendations

1. Expand the configuration management system and implement change control processes before CD-2b to minimize the risk of post-procurement changes to long-lead procurements.

2. Examine solidification of matrix agreements between various functional units within SLAC and APS with the LCLS project. Some laboratories employ a formal matrix agreement that clearly establishes levels of support required, responsibilities and obligations of the project and the functional organization. The project may wish examine such agreements as a model.

3. Begin detailed procurement planning of long-lead items by September 2003. This should include the formal trade study of the various procurement options mentioned during the review; the critical planning and scheduling of requirements, specifications, bid, and QA packages; bid preparation by potential suppliers, and bid evaluation and award. Every effort should be made to permit the immediate award of procurements as soon as money is authorized rather than waiting to release requests for bids/proposals until after such authorization is in hand.

4. Conduct an internal project review of the complete undulator system procurement management, support and logistics sufficiently in advance of the release of bid packages to provide assurance of the completeness the approach.

5. The procurement, responsibility and oversight of the long-lead magnetic measurement system should be clarified before CD-2b.

6. Complete a comprehensive risk analysis and management plan of all systems and components before CD-2b. This risk analysis must include all sources of risks and should be controlled and maintained with a central risk registry for the project and each system.

7. Examine and establish a global quality assurance approach for the project prior to CD-2b. This plan must include roles and responsibilities associated with all systems and relationship to the central project office.

8. Resolve the discrepancy between the Undulator System staffing requirements and the funding profile and balance workloads and expectations prior to FY2004.

9. Establish a monthly reporting plan for the long-lead procurements to allow accurate reporting as soon as CD-2a is awarded.

6.0 Environment, Safety and Health

6.1 Findings

The environment, safety and health (ES&H) aspects of the Linac Coherent Light Source (LCLS) Project are being properly addressed given the Project's current stage of development. ES&H and documentation requirements are in place to support Critical Decision-2A.

The Project's overall ES&H progress since the April 2002 DOE review is positive and moving forward in integrating ES&H with the Project. The DOE responsibilities to review the proposed Project under the National Environmental Policy Act (NEPA) prior to CD-2 have been met. The Environmental Assessment (EA) was completed and a Finding of No Significant Impact was approved on February 23, 2003, by the Director of the NNSA Service Center Oakland. The DOE Stanford Site Office (SSO) has verified that the appropriate NEPA documentation is in place for the work being conducted by the partner facilities at Argonne National Laboratory and Lawrence Livermore National Laboratory. The Preliminary Hazard Assessment Report was completed by the Project and was approved by SSO in October, 2002.

6.2 Comments

The Project is utilizing existing SLAC and SSRL processes and resources in ES&H. Several of the SLAC safety committees are participating in review and oversight of the Project and the ongoing design process. The SLAC Radiation Safety Committee (RSC) is actively involved and currently is reviewing the beam loss estimates and the shielding designs of the LCLS Injector.

The April 2002 DOE review report stated that the "FY 2003 ES&H staffing plan cannot support the current schedule". The Project made adjustments and completed the ES&H requirements necessary for CD-2. The Project's ES&H Coordinator is matrixed from SSRL and currently is working approximately at the 0.2 FTE level in support of the Project. This current level of ES&H support has been adequate to support the design initiatives, but will need to be evaluated for its continuing ability to support the Project through the remainder of design and into construction, installation, and operations. This will be important to ensure that work is done on schedule, while maintaining safety, staying compliant and remaining accident free.

The ES&H aspects of the Project work conducted by the Partner Labs at their sites must meet the DOE and local standards in place there for protection of people and the environment. The SLAC safety standards must be met for the components delivered to SLAC by the Partners, such as seismic safety standards. The Project will verify and assure that the components received at SLAC meet the required standards.

The geotechnical study of the site area to be tunneled and for placement and construction of the Near Hall and Far Hall is in progress now and is expected to be completed by the

end of June 2003. The location and footprint of the Near Hall still are being reviewed and reconsidered. It may be moved to a point farther from the LINAC, which may require more excavation than in the current plan. The results of the geotechnical study should be evaluated in light of the potential for redesign of the Near Hall, and against the information and analyses in the EA, to ensure that the EA continues to be valid and adequate to support the entire project.

6.3 Recommendations

1. Review the analyses and conclusions in the EA against the evolving designs of the LCLS, its components and Halls, and the results of the geotechnical study to be sure that the EA remains valid to support the Project through design, construction, installation and into operations.

2. Evaluate the level of ES&H staffing needed to support the continuing design process, as well as construction, installation of components and operations. Determine that point in the future schedule when dedicated full time ES&H support may be needed.

Start clean and stay clean.