Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

August 2004

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science (SC) status review of the Linac Coherent Light Source (LCLS) project located at Stanford Linear Accelerator Center (SLAC) was conducted on August 10-12, 2004, at the request of Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences, Office of Science. The purpose of the review was to assess the project's maturity and readiness for Critical Decision (CD) 2b, Approve Performance Baseline, and CD-3a, Approve Start of Long-Lead Procurements. In carrying out its charge, the Committee evaluated progress in all aspects of the project: technical, cost, schedule, management, and environment, safety and health (ES&H).

The Committee found that although the project has made considerable progress since the May 2003 DOE review, it is not yet fully ready for approval of CD-2b and CD-3a. This is primarily due to an overly aggressive project schedule (especially in FY 2005 for placing the long-lead procurements) and an inadequate amount of contingency in the cost estimate, considering the risks that lie ahead (e.g., tunnel construction). The project critical path schedule has about six months of schedule contingency, which the Committee judged to be inadequate. The project team is extremely competent and committed to making LCLS a success. In order to achieve the rapid expansion of LCLS staff planned for FY 2005-2006, senior SLAC management must ensure that the Laboratory's best personnel are promptly assigned to LCLS and that additional expertise is brought on board wherever necessary.

The LCLS project is a multi-laboratory partnership led by the LCLS Project Office at SLAC in Menlo Park, California. The partners are Argonne National Laboratory and Lawrence Livermore National Laboratory. Relations among the LCLS partner laboratories are excellent and internal communications are generally good. When completed (in 2008-2009), the LCLS will be a world-class scientific user facility to provide laser-like radiation in the X-ray region of the spectrum that is ten billion times greater in peak power and peak brightness than any existing coherent X-ray light source. The LCLS will provide the first demonstration of an X-ray free-electron-laser in the 1.5-15 Angstrom range and will apply these extraordinary, high-brightness X-rays to an initial set of scientific problems in disciplines ranging from atomic physics to structural biology. The top of the Total Project Cost (TPC) range approved at CD-1, Approve Preliminary Baseline Range, is $315 million—the top of the Total Estimated Cost range is $273 million.

Overall, technical progress has been quite good considering the limited funding available in FY 2004. The undulator design is mature and ready for long-lead procurement. There are some uncertainties in the photo-injector drive laser for the 135 million electron volts (MeV) injector that would benefit from a detailed review by a panel of laser experts, and will likely require an enhanced in-house laser capability for SLAC. Conventional construction comprises almost one-third of the TPC and involves a significant amount of tunneling work. However, it carries the lowest contingency percentage (20 percent) of any Level 2 element in the Work Breakdown Structure. A superior quality Title I Conventional Facilities design has been completed and reviewed by the project, and the Committee felt that it would serve as an excellent foundation for Title II design work.

The Committee deemed the base project cost estimate to be adequate, except in two areas: 1) Conventional Facilities, which appears to be low for construction management, and 2) the management reserve for Other Project Cost activities, such as commissioning. The LCLS project has a well developed scheduling system, proven to be effective on other previous SLAC projects. There is a sufficiently detailed resource-loaded schedule in place. The project critical path appears to be well understood and at this time is too aggressive. It was noted that the impact of a FY 2005 Continuing Resolution would have dire impacts given the sharp increase in staffing and procurements planned for FY 2005.

While ES&H is being appropriately addressed for this stage of the project, the Committee recommended a full-time dedicated ES&H professional be brought on board by October 31, 2004.

The Committee recommended that LCLS management develop a comprehensive project staffing plan and work with SLAC senior management to implement this plan in the first quarter of FY 2005. Also, the SLAC Director should communicate the long-term importance of the LCLS project and its scientific program to the SLAC staff as part of the future vision of SLAC. This information will support the LCLS project staffing plan and the need to encourage the necessary talent to participate in the construction and operation of the LCLS facility.

The Committee provided three action items to LCLS management:

1. Re-evaluate the project's proposed baseline cost and schedule, and submit a revision to DOE/SC by October 15, 2004;
2. Initiate weekly project conference calls between LCLS, the DOE Stanford Site Office, and DOE/SC in August 2004; and
3. Conduct the next DOE review in February/March 2005.

In summary, the Committee found that LCLS has made substantial progress in all areas toward CD-2b and CD-3a, however, additional cost and schedule contingencies are warranted before establishing the project's Performance Baseline. The LCLS project team has done a commendable job under difficult funding circumstances.

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1. INTRODUCTION

1.1 Background

The Linac Coherent Light Source (LCLS) project is a collaboration led by the Stanford Linear Accelerator Center (SLAC) and includes the Argonne National Laboratory (ANL) and the Lawrence Livermore National Laboratory (LLNL) to provide laser-like radiation in the X-ray region of the spectrum that is ten billion times greater in peak power and peak brightness than any existing coherent X-ray light source. This advance in brightness is similar to that of a synchrotron over a 1960's laboratory X-ray tube. Synchrotrons revolutionized science across disciplines ranging from atomic physics to structural biology. Advances from the LCLS are expected to be equally dramatic. The LCLS project will provide the first demonstration of an X-ray free-electron-laser (FEL) in the 1.5-15 Angstrom range and will apply these extraordinary, high-brightness X-rays to an initial set of scientific problems. This will be the world's first such facility.

The LCLS is based on the existing SLAC linac. The SLAC linac can accelerate electrons or positrons to 50 billion electron volts (GeV) for colliding beams experiments and for nuclear and high-energy physics experiments on fixed targets. At present, the first two-thirds of the linac are being used to inject electrons and positrons into the Positron Electron Project II, and the entire linac is used for fixed target experiments. When the LCLS is completed, this latter activity will be limited to 25 percent of the available beam time, and the last one-third of the linac will be available for the LCLS a minimum of 75 percent of the available beam time. For the LCLS, the linac will produce high-brightness 5-15 GeV electron bunches at a 120 Hz repetition rate. When traveling through the new 135-meter-long LCLS undulator, these electron bunches will amplify the emitted X-ray radiation to produce an intense, coherent X-ray beam for scientific research.

The LCLS makes use of technologies developed at SLAC for the Stanford Linear Collider, Sub-Picosecond Particle Source and the next generation of linear colliders, as well as the progress in the production of intense electron beams with radio frequency (RF) photocathode guns. These advances in the creation, compression, transport, and monitoring of bright electron beams make it possible to base this next generation of X-ray synchrotron radiation sources on linear accelerators rather than on storage rings.

The LCLS will have properties vastly exceeding those of current X-ray sources (both synchrotron radiation light sources and so-called "table-top" X-ray lasers) in three key areas: peak brightness; coherence (i.e., laser like properties); and ultrashort pulses. The peak brightness of the LCLS is ten billion times greater than current synchrotrons, providing over 10^{11} X-ray photons in a pulse with duration of 230 femtoseconds or less. These characteristics of the LCLS will open new realms of scientific applications in the chemical, material, and biological sciences. The LCLS Scientific Advisory Committee, working in coordination with the broad scientific community, identified high priority initial experiments that are summarized in the document, "*LCLS: The First Experiments.*" These first five areas of experimentation are: fundamental studies of the interaction of intense X-ray pulses with simple atomic systems; use of the LCLS to create warm dense matter and plasmas; structural studies on single nanoscale particles and biomolecules; ultrafast dynamics in chemistry and solid-state physics; and studies of nanoscale structure and dynamics in condensed matter.

The experiments fall into two classes. The first follows the traditional role of X-rays to probe matter without modifying it, while the second utilizes the phenomenal intensity of the LCLS to excite matter in fundamentally new ways and to create new states in extreme conditions. The fundamental studies of the interactions of intense X-rays with simple atomic systems are necessary to lay the foundation for all interactions of the LCLS pulse with atoms embedded in molecules and condensed matter. The structural studies of individual particles or molecules make use of recent advances in imaging techniques for reconstructing molecular structures from diffraction patterns of non-crystalline samples. The enormous photon flux of the LCLS may make it feasible to determine the structure of a single biomolecule or small nanocrystal using only the diffraction pattern from a single moiety. This application has enormous potential in structural biology, particularly for important systems such as membrane proteins, which are virtually uncharacterized by X-ray crystallography because they are nearly impossible to crystallize. The last two sets of experiments make use of the extremely short pulse of the LCLS to follow dynamic processes in chemistry and condensed matter physics in real time. The use of ultrafast X-rays will open up entire new regimes of spatial and temporal resolution to both techniques.

The proposed LCLS project requires a 135 million electron volts (MeV) injector to be built at Sector 20 of the 30-sector SLAC linac to create the electron beam required for the X-ray FEL. The remaining third of the linac will be modified by adding two magnetic bunch compressors. Most of the linac and its infrastructure will remain unchanged. The existing components in the Final Focus Test Beam tunnel will be removed and replaced by a new 135-meter undulator and associated equipment. Two new experimental buildings, the Near Hall and the Far Hall, connected by a beam line tunnel, approximately 250 meters long, will be constructed. A Central Laboratory and Office (CLO) building will be constructed to provide laboratory and office space for about 300 LCLS staff and users, and serve as a center of excellence for basic research in X-ray physics and ultrafast science.

The Acquisition Executive, who is the Director of the Department of Energy's (DOE) Office of Science (SC), signed Critical Decision (CD) 0, Approve Mission Need, on June 13, 2001. The LCLS preliminary Total Project Cost (TPC) range, established during the conceptual design phase, was $180-240 million, with Project Engineering and Design (PED) funds beginning in FY 2003 and construction starting in FY 2005. The LCLS project's Work Breakdown Structure (WBS) is illustrated in Appendix A.

Subsequent to the DOE Conceptual Design Review in April 2002, the Office of Basic Energy Sciences (BES) provided SLAC with additional guidance that resulted in a revised TPC range of $245 million to $295 million and delayed the construction start to FY 2006. Under this scenario, long-lead procurements would be initiated in FY 2005. For this reason, CD-2 was split into CD-2a, Approve Long-Lead Procurement Budget, and CD-2b, Approve Performance Baseline.

Based on these cost and schedule assumptions, the LCLS Acquisition Execution Plan, Preliminary Project Execution Plan, and CD-1, Approve Preliminary Baseline Range, were approved by the Acquisition Executive on October 16, 2002. This step authorized the project to start Title I design and expend PED funding that was included in the President's FY 2003 Budget Request. However, due to a series of Continuing Resolutions, Congress did not appropriate the FY 2003 PED funding for LCLS until February 2003, and it was not available to the project to begin Title I design until mid-March 2003. In addition, the amount provided ($5.925 million) was less than that requested ($6.0 million) because of a General Reduction and Rescission.

During FY 2003, the project completed Title I design of the long-lead items planned for procurement in FY 2005. A May 2003 DOE review was conducted to evaluate the baseline, as well as the scope, cost, and schedule aspects of those items. The committee concluded that the project's long-lead procurement plans were fundamentally sound in all areas (technical, cost, and schedule), and that the project was ready for approval of CD-2a. On July 1, 2003, the Acquisition Executive approved CD-2a, which enabled the long-lead procurement funds ($30 million) to be included in the President's FY 2005 Budget Request. Later in FY 2003, SC re-evaluated the needs of future LCLS users for additional laboratory and office space and directed the project to include a CLO Building in the LCLS scope. This extended the top of the TPC range to $315 million.

For FY 2004, Congress appropriated $7.456 million of PED and $2.0 million of Operating Expense funds for R&D. Once again, there was a Continuing Resolution that held the available funding to the level of the preceding fiscal year until an appropriation was enacted, which occurred in December 2003. The FY 2004 funds enabled the project to acquire architect/engineering services for the design of Conventional Facilities and make further progress on the design and R&D of the technical hardware, particularly the long-lead items. Title I design of the Conventional Facilities was completed in May 2004. In preparation for CD-2b, an External Independent Review (EIR) was performed by Burns and Roe Enterprises, Incorporated (BREI). The EIR team was on site at SLAC during June 7-11, 2004, and provided their final report in August. The EIR team concluded that "the LCLS project can complete the baseline scope within the baseline schedule by September 30, 2008, and Total Project Cost estimate of $315 million actual year dollars." They also found the LCLS baseline scope, cost estimates, and resource-loaded schedule to be complete and reasonable with adequate cost and schedule contingency margins. The EIR report contained a number of recommendations for improvements, but none that precluded the approval of CD-2b.

The President's Budget Request for FY 2005 contains $20.075 million of PED funds, $30.0 million for long-lead procurement, and $4.0 million of Operating Expense funds for R&D. The long-lead items include selected critical path components such as the 135 MeV injector linac magnets, drive laser, and RF gun system; the X-Band system and bunch compressor magnets for modifying the SLAC linac; and the undulator strong-back, magnet poles, and magnet blocks, as well as the measurement system needed for verification of undulator performance. At the time of this review, it appeared that the FY 2005 Appropriation would be delayed by at least several weeks beyond October 1, 2004. Under a typical Continuing Resolution, LCLS project funding would be limited to the total FY 2004 Budget Authority annualized rate of $9.456 million rather than the $54.075 million rate requested for FY 2005.

1.2 Charge to the DOE Review Committee

In a June 23, 2004, memorandum (Appendix B), Dr. Patricia M. Dehmer, Associate Director for SC/BES, requested that Daniel R. Lehman, Director of the Office of Major Systems Assessment organize and lead a review to evaluate the readiness of the LCLS project for CD-2b, Approve Performance Baseline, and CD-3a, Approve Start of Long-Lead Procurement.

1.3 Membership of the Committee

The Review Committee (Appendix C) was chaired by Daniel R. Lehman. Members were chosen on the basis of their independence from the project, as well as for their technical and management expertise, and experience with building large scientific research facilities. Continuity and perspective were provided by the fact that several members served on one or both of the previous two DOE review committees. The Committee was organized into nine subcommittees, each assigned to evaluate a particular aspect of the project corresponding to members' areas of expertise.

1.4 The Review Process

The review was conducted August 10-12, 2004, at SLAC in Menlo Park, California. The agenda (Appendix D) was developed with the cooperation of the LCLS Project Office, DOE/SC, and the DOE Stanford Site Office. Comparison with past experience on similar projects was the primary method for assessing technical designs, cost estimates, schedules, and adequacy of the management structure. Although the project requires some technical extrapolations, similar accelerator projects in the United States and abroad provide a relevant basis for comparison.

The first day of the review was devoted to project plenary sessions with presentations given by the LCLS Project Office staff. On the second day, there were presentations and discussions in subcommittee breakout sessions to answer detailed questions from the Committee. The third day was spent on Committee deliberations, report writing, and drafting a closeout report and the preliminary results were discussed with LCLS staff at a closeout session.

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2. TECHNICAL SYSTEMS

2.1 Injector/Linac Systems (WBS 1.2, 2.2, 1.3, 2.3)

2.1.1 Findings

The Committee commended the LCLS project for continuing to advance the knowledge and technical base required to make this ambitious project a success. The group at SLAC has extensive experience and world-class capability in injectors and linacs, which gives confidence that the technical goals can be achieved. The scope and specifications are sufficiently well defined to be baselined. The staff is highly skilled and competent, and has made considerable progress since the May 2003 DOE review, considering the funding constraints. The Committee appreciated the project's candor in reviewing the technical status of the various subsystems. There are several areas with scope requiring long-lead procurement (LLP). Overall the accelerator design is sound and with continued development, has a reasonable probability of meeting the performance requirements. Nonetheless, significant progress in demonstrating the electron beam quality necessary to meet LCLS performance specifications is still needed—this represents some lingering risk for the completion of the project.

The injector design is quite mature. LCLS prepared for procurement of most of the system as a long-lead item and the Committee encouraged that 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 confidence can be established that the stringent requirements can be met. The photo-injector package appears to be the most challenging aspect of the injector/linac portion of the project. Successful demonstration of the required emittance for Self-Amplified Spontaneous Emission (SASE) lasing should be given a very high priority by project management. Despite encouraging modeling, no existing injector linac system has met all of the requirements proposed, so early operation is vital.

While most of the injector design is sound and virtually certain to meet technical performance requirements, one lingering difficulty remains: the design and procurement of the photo gun drive laser, a LLP scheduled for early FY 2005. The laser required for this system is extremely challenging and represents a system unlike any previously developed, either in industry or at a National Laboratory. Given the critical nature of this system's performance in meeting technical performance requirements, the Committee felt that further technical work would be required before proceeding with procurement of this laser. The project has done a commendable job of stewarding interactions with potential vendors, however, the limited SLAC in-house laser expertise has made it difficult to complete an acceptable design with acceptable technical risk. It is important to start developing the required laser technology skill base and hardware as soon as possible.

Despite this lingering hurdle on the injector, other technical aspects of the project appear to be capable of meeting the required technical performance requirements. The design for the 135 MeV injector, the laser heater, the X-band RF system, and the main linac modifications appear to be sound and in a good position to proceed with construction in FY 2005-2006.

The LLPs items include the injector laser, the gun, injector linac sections, a X-band RF system, and numerous magnets and vacuum systems. Most of these items are based on existing designs or are to be built to specifications that are well defined. An exception is the injector laser, which as previously mentioned, is a system requiring performance beyond that commercially available. It depends on sub-element performance, which in some cases has not been demonstrated. This subsystem needs further element testing and evaluation before the package is procured from vendors.

The procurement plans do support the proposed construction schedule, but the concern about the drive laser may impact the ability of the project to deliver a usable system in time to permit extensive injector testing on the schedule envisioned.

Other LLPs in the injector including the gun and linac sections are also needed to get the earliest possible assembly of the injector so that commissioning can begin in earnest. Given the impact of this system's performance on the project as a whole, early performance demonstrations are crucial to giving confidence that the project performance specifications can be met. Another LLP area is the magnets for the main linac's bunch compressors. 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. The X-band RF components need testing to establish phase and amplitude stability. Designs and existing similar hardware for the linac exists and other procurements can proceed as funding is available.

The current schedule to procure long-lead components of the bunch compressor and injector linac components is appropriate and the project is in a position to proceed with these procurements. Some significant technical issues still surround the finalization of the drive laser design and this item will likely not be ready for procurement on the current schedule.

The cost estimates and schedule are credible and reasonable for the long-lead scope. There is concern, however, with the lack of extensive commercial support in high repetition rate laser amplifiers with the temporal and amplitude stability requirements desired. There was no systematic presentation on risk analysis to establish contingency, but overall the LLP budget for contingency appears to be appropriate. On the other hand, the photo-gun drive laser requires additional contingency to deal with potential difficulties. The project should revisit the allocation of long-lead resources during the coming year to manage risk while maintaining the overall LCLS schedule.

The chief schedule concern is manpower allocations to permit system design, procurements, and ultimately installation. Although reasonable manpower estimates have been generated (and in some cases the relevant individuals to perform the activities identified), specific commitments of the required personnel have not been made by SLAC management. Particular shortfalls exist in several skill areas including procurement, controls, and designers. Lack of available manpower for this effort could seriously impact the project schedule and also the resulting project cost. Resolution of this concern is required in the near-term in view of the LLPs.

With the exception noted above, LCLS staff has worked together well to place themselves in a good position to launch into the procurement and construction phase of the project. This aspect of the project appears to be managed exceptionally well. Staffing levels will be a challenge to LCLS in the coming two fiscal years. The Committee was concerned that adequate support from upper management at SLAC to retask individuals from other divisions is lacking. In particular, the strong expertise in RF technology in other parts of the laboratory should be strongly encouraged by SLAC management to support the injector linac activities of the LCLS project.

The project has pursued the injector development and linac modifications plans with a good recognition of ES&H issues. Given the increased reliance on high-power laser operation in this portion of the project, the Committee felt that SLAC should elevate the priority of laser safety work to ensure that the injector WBS element has adequate support in this area.

2.1.2 Comments

The injector drive laser is a complicated device that will continue to evolve and require hands-on maintenance. Technical success of the injector drive laser is absolutely crucial to the technical success of the entire LCLS and its achievement of saturated SASE at 8 keV. Given that some of the critical emittance specifications have yet to be demonstrated in the laboratory, there is still some technical risk in this aspect of the project. Fortunately, the LCLS personnel fielding the photo-injector are outstanding and continue to make progress. They also have good ideas and a plan to demonstrate the required emittance, giving the Committee confidence that this project will ultimately be successful. Nonetheless, it is important that the LCLS and SLAC management acknowledge the importance of success on the injector and that adequate attention and resources are allocated to insure that the project will be successful.

While the current staff is excellent, they are too few in number. The level of SLAC staff with experience in this area is not large, considering how complicated this system is and how crucial it will be to the system performance. Despite the desire to have vendors deliver a turn-key system with a long mean time between failure, it is likely that this will be a system requiring continuing effort. This suggests that a vigorous effort to build-up expertise in this area is necessary for the long-term health of the project.

The injector and linac manpower effort is planned to scale up dramatically in FY 2005. The rate of increase is so large as to suggest there will be difficulties in handling the effort successfully. To date, it has often been difficult to get the proper manpower assigned to an area so that technical issues can be resolved early. This suggests that getting the proper priority from SLAC management communicated to laboratory personnel is a near-term priority. It is essential that other SLAC activities and programs do not continue to monopolize key technical skills.

2.1.3 Recommendations

1. Proceed with the LLPs as per the baseline plan on linac and injector acceleration hardware. Assign a specific procurement person to carry out these key LLPs by November 2004.

2. Identify specific individuals to perform the planned activities for FY 2005 in the RF and controls areas. Obtain management commitments for the time of these specific individuals. Hire personnel with such skills in areas where appropriate personnel cannot be identified or made available by December 2004.

3. Conduct a detailed review of the photo-gun drive laser design with a panel of laser experts. Perform a complete set of risk reduction experiments on pulse frequency conversion with shaped pulses using the capabilities at Brookhaven National Laboratory. Both actions should be performed prior to awarding the contract for the drive laser by June 2005.

4. Aggressively seek to hire a laser technology team to oversee all laser activities, both in the injector but also in the endstation area lasers. Seek greater involvement by laser scientists from LLNL to further augment any in-house expertise developed at SLAC (June 2005).

2.2 Undulator System (WBS 1.4, 2.4)

2.2.1 Findings

The Undulator System includes undulators, a vacuum system, quadrupoles, and electron beam diagnostics that are deployed within the undulator length. There will be a total of 33 undulators installed in the tunnel. Additionally, there will be seven undulator spares, including three prepared for installation (mounted to full module assembly) at any given time. One is reserved as a standard.

An undulator module includes undulator, quadrupoles, RF beam position monitors (BPM), and a vacuum chamber mounted to a cradle. All module components will be aligned with respect to each other on a coordinate measurement machine. The cradle will be aligned as a unit in the undulator tunnel. The cradle is equipped with movers.

A production plan, including procurement and development of a magnet measurement facility (MMF), has been developed.

Recent modifications in the undulator design include: simplification of the pole; canting of poles; and decoupling the undulator from the vacuum chamber to allow extraction without breaking vacuum.

The undulator design is mature and has been thoroughly reviewed. It is at the stage appropriate for proceeding with long-term procurements. The cost was extensively reviewed recently in an EIR. The shimming method has been well demonstrated in previous prototypes.

The current baseline includes permanent magnet quadrupoles without field adjustment. The option of using electro-magnets is currently under study. The electro-magnet design is being developed at SLAC. The undulator, vacuum system, quadrupoles, and RF BPMs are mounted to a cradle that will move as a unit.

The vacuum system is still at the conceptual design stage. The current plan is to use a copper tube welded to a copper strong-back. The strong-back is held to a carriage by five supports. The first prototypes are currently being planned. Many issues still need to be fully developed and tested, including:

- RF BPMs have not been addressed;
- Bellows and transition details still need to be considered;
- Welding of tube to strong-back;
- Brazing of copper to stainless steel flanges; and
- Internal polishing is at the conceptual stage.

A detailed schedule of the vacuum system was not presented. However, milestones indicate that design is to be completed by the end of December 2004, with prototyping running through FY 2005, and production running through FY 2006.

LCLS management believes that increased staffing needs can be accommodated mostly within the current pool at ANL. LCLS is incorporated into ANL project planning for establishing priorities and assignments.

A MMF is being developed at SLAC for conducting magnetic measurement and trajectory tuning, fiducialization, alignment, and assembly of cradles. Magnetic measurements and tuning of the first two articles are to be done at ANL, and cross-checked at SLAC. The remaining articles are to be completed at SLAC. SLAC has responsibility for the static supports in the undulator tunnel.

Intra-undulator X-ray diagnostics have been removed from scope, due to high heat load. Reliance is now primarily on far-field diagnostics.

The LLP plan for undulator components calls for the magnets, poles, and strong-backs to be procured separately from single vendors. Assembly will be done by additional vendors. The plan is to qualify two assembly vendors.

ES&H personnel from the Advanced Photon Source (APS) at ANL have been incorporated into the project. Communication between ANL and SLAC ES&H has been established.

Plans to augment Undulator System management include: 1) ANL hiring an Undulator System deputy with responsibility for system/engineering integration, and 2) SLAC hiring a undulator integration engineer as primary point of contact for undulator activities at SLAC.

2.2.2 Comments

Introduction of pole canting represents a significant improvement in design. This offers many advantages, including allowance for on-line tuning and easy tapering of the field to optimize output power.

The choice of quadrupole type (permanent magnet or electro-magnet) affects the scheme for beam-based alignment, as well as for utility layouts (water, power). Inclusion of power supplies in the undulator tunnel must be considered in evaluating the tunnel temperature stability scheme.

The plan is to orient magnets under test in the measurement facility parallel to the beam axis to best replicate environmental fields in the tunnel. However, some variation between the measurement facility and tunnel is to be expected.

The staffing for the MMF (three senior physicists, two senior engineers, and three technicians) seems adequate. There is a plan to add another technician.

The steady-state vacuum load has been evaluated. The start-up, beam-induced vacuum load, and the impact on commissioning need to be carefully evaluated.

The system integration plan currently assumes that the undulator design is essentially frozen. Other components must fit around it. The vacuum chamber is the most significant component affecting system integration. A complete module should be assembled before procurement of the vacuum system is initiated. This needs to occur within FY 2005 to accommodate the planned FY 2006 production.

Expediting the first article procurement offers several advantages, including: establishment of early interaction/evaluation of vendors; opportunity to modify assembly process; and commission the MMF.

The cost basis for the Undulator System is reasonable. An estimate of approximately $500,000 is consistent with previous experience at synchrotron laboratories. Approximately 30 percent contingency seems reasonable.

The design and procurement plan is mature. This formed the basis for the recent EIR, which did not identify any issues.

Vacuum system design is at an early stage. The technical approach seems to be sound. However, considerable work remains to fully develop the design. The remaining uncertainty corresponds primarily to technical performance risk rather than cost. However, schedule could be affected if difficulties develop during prototyping. The vacuum system is not currently on the project critical path; it represents approximately ten percent of the overall cost.

Communication and division of responsibility between ANL and SLAC seems to be working well. Good communication/coordination with a single point-of-contact at SLAC (undulator integration engineer) is essential for this portion of the project to continue to operate smoothly through installation and commissioning.

Recommendations from the May 2003 DOE review for augmentation of project management have been addressed. The plan for hiring an Undulator System deputy is consistent with previous review recommendations. This needs to be expedited to incorporate this person in early planning for system integration.

The current undulator design is based on a temperature specification in the tunnel of +/- 0.2° C. The design requirements will need to be re-evaluated if the tunnel temperature specification is altered.

2.2.3 Recommendations

1. Expedite acquisition of the first undulator article early in FY 2005 to allow for delivery by the end of FY 2005.

2. Expedite system integration design/plan of a full undulator module over the next year.

3. Finalize choice of quadrupole type by the end of FY 2004, or very early in FY 2005, in order to accommodate required facilities changes.

4. Incorporate stretched wire based field integral measurements for each article in the magnet measurement plan.

5. Make sure that experience in magnet measurements of first articles is incorporated into necessary modifications of assembly procedures.

2.3 Photon Beam Handling Systems (WBS 1.5, 2.5, 1.6, 2.6)

2.3.1 Findings

Cost, schedule, and contingency appear adequate.

The most important hardware items are the 1) 2-D detector; 2) imaging detector(s); and 3) the gas attenuator. There is more than a year of lead time before design work is planned to start and the priority of these items has been correctly set.

Management of the LLNL staff and work must be dealt with differently than for their SLAC counterparts because only the latter will have the potential opportunity of staying on at LCLS through its operation. The LLNL staffing will be done in a more matrixed way and that should be recognized at a senior management level, especially for the mechanical engineering work.

Computer simulation codes for the assessment of material damage exist at LLNL, but their suitability remains an open question. There may be opportunities for experiments at the Deutsches Elektronen Synchrotron (DESY) FEL, the Z-pinch Source, and the National Short Pulse Laser Facility for the purpose of testing the simulation codes. Tests of the codes at wavelengths longer than 1.5 nm should still be useful since it appears likely that the physical processes that should be simulated will still be important. These experiments should be done before the procurement of major optics such as the flipper mirror.

2.3.2 Comments

The 2-D detector, an important component for eventual LCLS experiments, is currently planned as a collaborative effort between SLAC/LCLS and Cornell University.

Procurements made by LLNL will fall under the purview of ES&H at LLNL. As a result, there is the possibility that different procurement procedures and ES&H standards will be applied.

2.3.3 Recommendations

1. Undertake a set of experiments to test the simulation codes for material damage of optics against experimental data by making the plans in calendar year 2004 and conducting experiments in 2005.

2. Schedule regular meetings between senior LCLS management and corresponding levels of LLNL management (i.e., at a higher management level than the WBS managers).

3. Formalize and document the relationship between SLAC/LCLS and Cornell, and set milestones with them for the 2-D detector.

2.4 Control Systems

2.4.1 Findings and Comments

The Controls Systems have made considerable progress in the last several months. With the help of an assigned accelerator physicist, Control Systems requirements are being better understood and documented. Good relationships have been forged with the subsystem team leaders. A detailed item-by-item cost and contingency estimate has been prepared at WBS Level 5 and 6 for approximately 2,000 identified items—material and labor. A small, talented, and enthusiastic team has been enlisted, and they have made considerable progress in some important areas, notably on the critical "Stanford Linear Collider (SLC)-aware Input/Output Controllers (IOC)". The staff was extremely helpful in supplying all requested information and answering all questions. With this level of effort and enthusiasm the outlook for LCLS Controls Systems is excellent.

Work Breakdown Structure

Several earlier reviews (April 2002 DOE Review; April 2004 Control System Review; June 2004 EIR) have recommended some consolidation of the Controls Systems effort in the WBS. LCLS has responded to these suggestions by separating the effort into two categories.

The first category includes all of the "global" subsystems common to all subsystems throughout the facility (timing, Machine Protection System, network, application API, etc.), as well as all the non-recurring design work on hardware and software components that will be used in two or more subsystems (the SLC-aware IOC, power supply interface, Programmable Logic Controllers (PLC) driver, etc.). This work will be done in WBS 1.1.3.1 and WBS 1.1.3.5 (new) under the direct control of the Control Systems Manager.

The second category includes all of the recurring costs (cabling, installation and testing, as well as specific instances of IOCs, power supplies, PLCs, controllers, etc.), in addition to all hardware and software specific to particular subsystems. This work will be done under each subsystem Level 2 WBS as WBS 1.X.2, with the Control Systems Manager having cosigning authority (with the Level 2 WBS Manager) for these costs.

It is not clear that this model has been fully internalized at all levels of the LCLS organization. The Linac WBS Manager reported no controls personnel in WBS 1.3.2 because "all resources are under the controls group outside my organization;" whereas the End Station WBS Manager plans for nine controls people in WBS 1.6.2 for activities including PPS and MPS. Nonetheless, work is in progress to modify both the WBS dictionary and the detailed cost estimate spreadsheets to conform to the approach, which largely meets the spirit of earlier recommendations of this and other committees.

Design

Considerable progress has been made in the LCLS Control Systems design during the last six months. The most important advance is the decision to develop an SLC-aware IOC to allow new systems (developed in Experimental Physics and Industrial Control Systems or EPICS) to have access to the rich suite of application programs already available in the SLC system. This development is critical, as was recognized by the April 2004 Control System Review and again by the EIR, which stated (Finding PD-01): "failure of the integration of the existing SLC Controls System and the LCLS EPICS controls could prevent the operation of LCLS from the MCC and rendering (sic) useless many essential SLC control functions in the LCLS. Lack of the integration… could require developing extensive new software products that would have a significant schedule and cost impact to the project." The controls staff has recognized the importance of this effort. A design is in place and several software components have been developed and tested. As much as 4.5 FTEs of effort (approximately $1 million) remains, however, and this task should continue to have high priority and strong managerial support. A complete prototype should be tested by October 2005.

There are also significant challenges in the areas of timing and beam instrumentation. These challenges are apparently understood, and solutions appear to be within reach. In this area especially, the controls staff has benefited from the excellent project-wide approach of associating an accelerator physicist with each Level 2 WBS element.

It was particularly gratifying to hear all of the WBS managers endorse the use of EPICS and, in particular, the need for standardization and close collaboration with the controls staff.

Cost, Contingency, and Schedule

A great deal of excellent work has gone into preparing a detailed cost estimate for controls to WBS Levels 5 and 6.

The estimates related to global activities (WBS 1.1.3.1 and 1.1.3.5) and to the Injector (WBS 1.2.2), Linac (WBS 1.3.2), and Undulator Systems (WBS 1.4.2) have been considered in detail and are well supported and credible. A sensible approach of buying (or borrowing) whenever possible has been assumed. The Control Systems Manager has not yet had the time to carefully review and understand the estimates for the X-ray Transport Systems (WBS 1.5.2) or the End-Station Systems (WBS 1.6.2). This can proceed most efficiently after the appointment of controls liaison persons to lead these activities—these positions are “to be determined” in the organization charts presented. These two WBS elements represent about $6 million (or 20 percent) of the total Control Systems cost, and so it is important that they be refined as soon as possible. The project needs to reach the point where the Control Systems Manager is comfortable with and can defend all aspects of the Control Systems design, and cost and schedule estimates.

The costs of Conventional Facilities controls do not appear to have been broken-out. The possible benefits of integrating these controls with the rest of the Control Systems by creation of a WBS 1.9.2 should be considered.

Because the Control Systems activities are spread over a large number of WBS elements it is difficult to arrive at totals or to apply “rules-of-thumb.” This difficulty is compounded by the fact that the Control Systems budget is responsible for several activities and/or components not traditionally included under controls—the most important being power supplies. The high cost of power supplies also distorts the traditional controls ratio of manpower to materials and services (M&S), which for LCLS appears to be about fifty-fifty.

Contingency has been estimated line-by-line, and the estimates appear to be reasonable. The overall Control Systems contingency is 35 percent, which is what should be expected for a controls program at this very early stage.

One advantage of distributing a Control Systems WBS in each Level 2 WBS element is the more natural way in which the controls schedule for those systems can be integrated with other schedule activities. Each WBS Manager will include controls in his schedule. The Control Systems Manager needs to make sure that the common and global elements are developed in a time frame consistent with other schedule requirements. Control Systems requirements for each major system milestone need to be met. In general, most global subsystems will be required, possibly with reduced performance specifications, for the first of the major systems, the Injector. A schedule of global and common controls activities needs to be developed that meshes with the rest of the project schedule.

Staffing

The Control Systems staff has already gained a small number of talented engineers and programmers who have made significant progress. The extremely aggressive project schedule, however, requires a very rapid staffing up as soon as funding is available. The present plan calls for a staff increase of 20 controls people in October 2004. A slower ramp-up implies a need for even more people at year's end than the 26 in the plan, but that greater number is not supported in later years. This plan is unrealistic. The only way to come close to the plan is to minimize external hiring—this approach would require strong support from SLAC management. The schedule impact of a more realistic staffing ramp-up should be assessed as soon as possible.

At this time, the Control Systems staff has only a part-time, acting leader. His presence, even part-time, has had a very large impact and his contribution has been and continues to be extremely important. Nonetheless, it well understood by the project that that a full-time permanent leader will be required as soon as possible.

2.4.2 Recommendations

1. Complete the transfer of Global Controls activities to WBS 1.1.3.1 and WBS 1.1.3.5 in both the WBS Dictionary and the detailed cost estimate spreadsheet.

2. Identify and hire the controls liaison people for WBS 1.5.2 and WBS 1.6.2, and work with them to complete the scrutiny of those WBS elements, assuring standardized approaches where appropriate.

3. Establish an approach to the integration (or not) of Conventional Facilities controls, and identify a controls liaison person for WBS 1.9 if integration is to be pursued.

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3. CONVENTIONAL FACILITIES (WBS 1.9, 2.9)

3.1 Findings

The civil construction of the LCLS project represents a significant fraction (over 29 percent) of the total work included in the LCLS TEC. As estimated by project management, this currently exceeded $62.68 million. The vast majority of this work includes all the necessary construction to extend the SLAC linac tunnel by approximately one-half mile across a terrain of highly varying elevation. The tunnel will require: on grade construction; cut and cover construction, and a majority of the tunneling construction to be mined in relatively low-strength sandstone. In addition, two below-grade experimental areas (one cut and cover, and one tunneled) are required. Surface construction is also specified over the tunnel including a 68,300 gross square foot CLO Building. Two small detached surface construction projects are also included. Utilities, outfitting, and other support services are to be provided. The total excavated material, mostly mined, exceeds 50,000 cubic yards in place; and exceeds 75,000 cubic yards as excavated spoil. This work is the most significant tunneling at SLAC in several decades.

At this time, LCLS project management has engaged the services of Jacobs Engineering to perform the civil architect/engineering work under the direction of the WBS Manager for Conventional Facilities. Title 1 design has been completed, reviewed, and accepted. This work includes Title 1 drawings, Title 1 cost estimates, and Title 1 project scheduling information. The Title 1 drawing set is extensive (exceeding 100 sheets) and the Title 1 cost estimate is appropriately detailed for work at this stage of design. Some conversations with two tunneling contractors have been conducted on tunneling issues, and a tunneling review board is being constituted. The recent EIR reviewed the work and the draft EIR report was made available for this review. In general, the EIR team was satisfied with the work at this stage.

The LCLS Conventional Facilities staff reported that the vast majority of the work (all the tunneling, the experimental areas, and the major surface facilities over the tunnel area) are proposed to be executed in a single, large contract of perhaps a 26-month duration. LCLS management expects that this contract will exceed SLAC's capability to administer, and the services of a construction management contractor (i.e., "Construction Manager") will be solicited. LCLS management has not yet defined the scope of work expected for the Construction Manager. Such fundamental decisions as to whether the Construction Manager, or SLAC, will hold the contract have not yet been made. LCLS management intends to make these decisions and to draft the task orders on which the solicitation of the Construction Manager will be based within the next month or so. The existing work schedule did not include the Construction Manager procurement duration and work start dates. In discussions during the review, LCLS management did emphasize the urgency of this procurement. The existing schedule for the work did provide for the bid and award of the principle construction contract. The duration for this major bid and award activity was approximately six and one-half calendar months.

Some significant attention has been expended during Title 1 design to address at least two unusually demanding technically driven specifications: 1) an air thermal stability requirement of +/-0.2° C within the undulator hall section of the tunnel, and 2) a general requirement to make the undulator hall foundations “as stable as possible” in the face of differential settlements in excess of 1 micro-meter/day. The air temperature requirement, to achieve a stability on all surfaces, is better than 1° Celsius. These demanding requirements have been reflected in an unusually extensive heating, ventilation, and air conditioning (HVAC) for the undulator hall system as specified in Title 1, and in an unusual interior floating foundation under the undulator hall tunnel floor.

3.2 Comments

The extent of the civil construction required for the LCLS project is significant, but not particularly unusual in comparison with other recent DOE/SC projects.

The Title 1 design report (drawings, cost estimate, schedule) is complete and the drawings are extensive. The Title 1 material presented was of an overall superior quality. It is an excellent foundation upon which to base the Title 2 design and the project is ready to proceed with this next phase.

The decision to execute all of the tunneling work, experimental hall excavation, surface support buildings, utilities and outfitting in a single large contract is both sensible and likely to be very cost effective.

The services of a qualified Construction Manager to supervise this large, single contract are urgently needed. The Construction Manager should hold the contracts for the execution of the major civil construction that includes the underground tunnel extension, the underground experimental areas, and the above grade tunnels and buildings. This approach will simplify the responsibility of the Conventional Facilities WBS Manager and also reduce confusion in communications and directions to the general contractor. The services of the Construction Manager are required at the earliest possible date during the development of the Title 2 design. LCLS management must define the tasking of the Construction Manager and proceed to procure the Construction Manager in the immediate future.

The procurement and award of the large contract to the general contractor is very likely to exceed (by months) the time allocated in the existing Title 1 schedule. The overall LCLS project schedule contingency is inadequate to support the time likely to be expended in this effort. The schedule contingency must be increased.

A full-scale mock-up of the undulator hall floating floor foundation could provide very useful information concerning both constructability and performance.

Consideration should be given to assuring that ES&H flow-down to the Construction Manager and on to the general contractor and subcontractors is provided in the contracts signed at all levels consistent with DOE/SC expectations as accomplished in recent comparable work at other sites.

The Conventional Facilities contingency presented is the lowest (by percentage) of all Level 2 WBS areas. At 20 percent, the Committee found the contingency unrealistically low for the Title 1 stage of design development. This assessment is not a criticism of the quality of the Title 1 work, which is assessed as superior, but is rather an assessment of the complexities of the work proposed. The contingency at this point should be significantly higher.

Technical staff planning to use civil facilities of this type at other institutions have frequently been tardy with significant comments on the details of the work. All too frequently these comments are expressed only as the construction is underway and the site visited. While this syndrome is unlikely to be completely defeated, frequent detailed reviews of the Title 2 work while underway have proven advantageous. Such reviews, at the 40 and 65 percent completion points of the Title 2 design, should be scheduled with a wide interaction with the technical staff required and demanded. Any delay beyond the 65 percent point will be impractical to affect the final Title 2 design.

The EIR report suggested obtaining a budgetary quote from at least one competent tunneling contractor. The Committee felt that further technical discussions with competent tunneling contractors could indeed be of service during Title 2 design, but the utility of a budgetary quote is questionable.

The LCLS Conventional Facilities are ready to complete Title 2 and to proceed to construction. The schedule for project completion, however, should be adjusted for realistic expectations for major contract bid and award durations, which could be substantially longer than presently estimated. It is possible that design iterations and re-bids may be required. The present estimate presents a significant risk to the total overall project schedule.

3.3 Recommendations

1. Task, specify, and procure a construction management contractor (Construction Manager) for the LCLS project as soon as possible. Increase the Title 3 cost estimate for the Construction Manager.

2. Increase the amount of contingency in the overall project schedule.

3. Re-evaluate the estimate for the cost contingency on Conventional Facilities.

4. Consider merging the proposed two small contracts named "S20" and "MMF" into a single construction task.

5. Check that the ES&H flow-down clauses, to be inserted in the construction management, general contractor, and subcontractor contracts, are consistent with the expectations of DOE as found at other recent major DOE/SC construction projects.

6. Continue Title 2 design work as rapidly as possible after funding and approvals are obtained.

7. Conduct technical reviews by the project technical staff of the Title 2 design work at both the 40 and 65 percent complete points.

8. Define the contractor lay down areas required and their locations and amend the Title 1 drawings accordingly. Also note the receiving and warehouse locations.

9. Consider construction of a full-scale test mock-up of the undulator hall to test the constructability and performance of the undulator hall floor stability design. The length (approximately 30 feet) should be chosen to be sufficient to check constructability issues and evaluate the design performance.

4. COST, SCHEDULE, and FUNDING

4.1 Findings

A summary of the evolution of project scope, cost estimate, and contingency was provided by the project. The top of the LCLS TPC range is now $315 million (as spent), compared to $233 million estimated at CD-1 (April 2002), is mainly a result of increasing the length of the tunnel, adding a CLO Building, adding instrumentation for initial experiments, and increasing contingency. A breakdown of the current cost estimate can be found in Appendix E. It contains $213.2 million for construction funded activities (Total Estimated Cost or TEC), contingency of $59.8 million, which is approximately 29.5 percent of the TEC, and $42 million for Other Project Costs (OPC). There is approximately $500,000 of management reserve in OPC. Through FY 2004, the project has received $13.38 million in PED funds and $3.5 million of Operating Expense funds (for conceptual design, NEPA support, and R&D). The President's FY 2005 Budget Request contains $20.075 million for PED, $4.0 million for R&D, and $30.0 million for LLP.

The cost estimates and bases of them for several WBS elements were reviewed during the EIR in June 2004. The EIR report concluded that they "….have a level of detail consistent with what is expected to support a CD-2 baseline. The bases are clearly specified and, for most of the equipment, the estimates are based on vendor quotes or experience with comparable equipment that was used for other projects."

Project representatives presented cost estimate information to each of the technical subcommittees (see Sections 2 and 3 for cost estimate comments on specific systems). The Committee evaluated the cost estimate basis and contingency data, and in some cases provided recommendations that were entered into the spreadsheet that appears in Appendix F.

The project has identified possible scope reductions that could be used to increase contingency if necessary.

A Risk Management Plan was developed and a Risk Registry prepared documenting 30 risks. The Risk Registry is a controlled document that involves input from the entire project team and will be updated semi-annually.

LCLS is using Primavera Project Planner (P3) as its scheduling tool with Cobra as the cost processor. This system has successfully been used before at SLAC for the Positron-Electron Project II (PEP-II), the Gamma-Ray Large Area Space Telescope (GLAST), and the Stanford

Positron Electron Asymmetric Ring-III (SPEAR 3) projects. The LCLS project has developed a resource-loaded schedule comprised of approximately 14,000 tasks, 8,700 of which have allocated resources. The work is divided into 864 distinct work packages. The critical path for LCLS is essentially a parallel path through the linac and the undulator, with 140 and 170 days of schedule contingency respectively, relative to project completion. The LCLS summary schedule is included in Appendix G.

The resource-loaded schedule for the LCLS was presented at the EIR in June 2004. The EIR report contained several recommendations for improving the project schedule, some of which were incorporated into the current schedule, while others are still being considered. LCLS is trying to achieve a goal of adding two to three months of schedule contingency. The actual and proposed Level 1 LCLS project milestones are as follows:

CD-0	Approve Mission Need	June 2001 (actual)
CD-1	Approve Preliminary Baseline Range	October 2002 (actual)
CD-2a	Approve Long-Lead Procurement Budget	July 2003 (actual)
CD-2b	Approve Performance Baseline	September 2004
CD-3a	Approve Start of Long-Lead Procurement	September 2004
CD-3b	Approve Start of Construction	September 2005
CD-4	Approve Start of Operations	October 2008

LCLS has 34 Level 2 milestones and about 130 Level 3 milestones. Milestones at all three levels are reviewed and monitored regularly by the LCLS Project Office.

The LCLS project presented a list of critical procurements, including LLPs, with milestones to take the process from Advance Procurement Plan to award date. There are six award dates within the first two months of FY 2005.

4.2 Comments

The Committee felt that, in general, the cost estimate was adequate, except in Conventional Facilities, which appears too low for construction management. The Committee commended the project for increasing the contingency by $14.4 million since April 2002 and for identifying scope reductions that could be used to increase contingency. This represents progress towards enhancing the likelihood of success; however, the Committee felt that the project risk is still understated in the cost contingency, and that the contingency should be increased. In addition, the pre-operations management reserve should be re-evaluated to consider uncertainties in commissioning activities.

The risk assessment and management process that has been developed has and will continue to help LCLS management in identifying technical, cost, and schedule risks. When risks are evaluated/updated frequently, the Risk Registry can be a good and timely forecast of potential contingency usage.

The LCLS project has a well-developed scheduling system that has been proven effective at SLAC in the past. The project team has produced a sufficiently detailed schedule (although aggressive). The schedule is resource-loaded, which allows the LCLS Project Office to develop plans, work schedules, and perform studies, which they are doing currently.

The proposed date for CD-4, Approve Start of Operations, is October 2008. The project critical path appears to be well understood, although some schedule durations are aggressive. The Project Office is actively pursuing possible scenarios to increase the amount of contingency in the schedule.

The quantity and intervals of control milestones appear to be reasonable for providing regular checkpoints for project progress reporting. Level 2 milestones occur on average at intervals of one and two-thirds months. Level 3 milestones are at average intervals of two weeks.

The near-term critical procurement plans are a concern since there are only a few months left until the award of the first few contracts. This is potentially complicated by the likelihood of a Continuing Resolution on October 1, 2004. The duration of the conventional construction efforts for the in-ground/tunneling work is also a concern.

4.3 Recommendations

1. Re-evaluate the cost estimate and cost contingency, especially those areas where the Committee advised adjustments be made and provide an updated estimate to DOE by October 15, 2004.

2. Continue to enhance the risk assessment process and use the risk assessments when evaluating available contingency. Consider reviewing/updating the Risk Registry monthly, instead of semi-annually.

3. Re-evaluate the project schedule and provide an updated schedule to DOE by October 15, 2004.

4. Re-evaluate near-term critical procurement plans to reflect realistic start dates and durations.

5. Analyze conventional construction contract durations to accommodate potential complexity of the work.

5. PROJECT MANAGEMENT and PROCUREMENT

5.1 Project Management

5.1.1 Findings

The LCLS project has made considerable progress since the May 2003 DOE review. These FY 2003 and FY 2004 efforts were directed at R&D and design to support the development of a project baseline, as well as identifying and planning for LLPs. SLAC management is highly committed to the success of this project and recently elevated the LCLS Project Director to an Associate Laboratory Director position.

The LCLS project team includes SLAC, ANL, and LLNL. Memoranda of Understanding have been signed between SLAC and the other partner organizations (ANL, LLNL). Regular communication channels, as well as a cooperative atmosphere exist among the partner organizations.

SLAC has a history of successful projects including PEP-II and SPEAR3 that involved equipment installation but with limited conventional construction. The SPEAR3 project recently received the DOE Secretary's Award for Project Management.

Key project documentation has been approved. This includes a Preliminary Project Execution Plan, an Acquisition Execution Plan (approved October 16, 2002), an Environmental Assessment for the LCLS Experimental Facility (DOE/EA-1426; approved February 28, 2003), and a Preliminary Hazard Analysis. The Project Execution Plan accurately reflects how the project will be implemented, the roles and responsibilities of the three major participants (SLAC, ANL, LLNL), and risk management.

Key project systems are in place and operating. LCLS has established an integrated cost and schedule with a critical path. A LCLS Earned Value Management System (EVMS) is in place and operating, although some refinements are still needed. A Project Change Control System is also in place and operating.

Project funding will increase significantly from $9.5 million in FY 2004 to $54 million in FY 2005 and project staff are planned to increase from about 58 in FY 2004 to 125 in FY 2005. Much of the increase in funding ($30 million) will be for LLPs. Since the May 2003 DOE review, the project has prepared a more systematic risk analysis to support the levels of cost and schedule contingency. The overall cost contingency is 29.5 percent of the remaining Line Item work and schedule contingency is assessed as 14 percent.

The June 2004 EIR was generally satisfied with the completeness of the LCLS baseline, while providing a number of comments and recommendations. The EIR report was reviewed and the results were used by the Committee during this review.

5.1.2 Comments

The project organization and design continue to mature. A proposed project baseline scope, cost, and schedule has been prepared. A project organization chart is directly linked to the Project WBS and many key positions are filled (see Appendix H). The project team is highly skilled and competent, and has made considerable progress in FY 2004 using limited PED funding.

The SLAC organization has a positive reputation for operating with limited overhead. Overall, the SLAC organization has several important ongoing commitments including the operation of the PEP-II machine, the GLAST project, and the LCLS project. The LCLS project is reliant on SLAC matrix support, funded out of laboratory overhead, in a number of areas. There is some concern that if issues arise with any of the ongoing commitments, the "lean" SLAC organization may not have the flexibility to adequately respond without impacting other commitments.

The SLAC procurement organization reported that it is automating their procurement system using the latest PeopleSoft programs. This will aid the operation of the procurement system, as well as the project when the automated system is fully functioning in FY 2006.

The staffing of the LCLS Project Office has been limited due to project funding. While this has not prevented the project from making considerable progress to date, it has created some important constraints in preparing the project for the very aggressive FY 2005 work plan, with its dramatic increase in funding and effort. Early FY 2005 scope/milestones are very aggressive and the Committee did not believe that these start-up activities would be achievable. The initial FY 2005 project staffing levels will be strained to meet the needs of the project and the result is that the project staff will have a slower build-up than is planned. LCLS management should re-assess the project schedule and the costs associated with any additional time to achieve the project scope in an orderly fashion.

There is a continuing need to consistently identify milestones and use the project EVMS to track the progress of the entire project including the partner laboratories. This will ensure that work performed remotely from the Project Office stays tightly connected to the needs of the project.

The LCLS project is to be commended for the implementation of their P3/Cobra project control system. This has allowed the project to integrate their costs and schedules, including the use of a single database for multiple purposes. The contractor hired to assist the project (AIM) appears to be helpful and competent.

LCLS should continue to identify those activities that do not directly contribute to the technical completion criteria for the project. The reported project schedule contingency is 14 percent, but additional efforts are needed to determine the actual amount, as it appears that schedule contingency may be imbedded in individual project activities. This schedule contingency should be identified and managed at the overall project level.

The project should begin planning for a Continuing Resolution at the beginning of FY 2005. As a new start, no construction LLP funding will be allocated to the project until the FY 2005 Appropriations Bill has been enacted.

The project management staff currently consists of three full-time staff plus some supporting staff. The Committee assessed that this is not sufficient and the project needs additional senior level expertise in the following disciplines to ensure the effective start-up of this project: construction management, procurement management, ES&H, quality assurance/ quality control, Systems Integration/Chief Scientist, and commissioning. While plans are in place to obtain project staff, specific project management needs should be included in a comprehensive staffing plan (including dates) for implementation in early FY 2005.

The existing OPC activities are comprised of R&D, commissioning, and commissioning expenses (e.g., electricity). The OPC costs do not include a management reserve. The Committee observed that the anticipated costs carry risks that warrant consideration of a management reserve. In addition, any reassessment of the project cost and schedule should examine the impact on the OPC costs.

The Committee felt that additional refinements are needed in the project planning and estimating prior to approval of the LCLS project baseline and start of LLPs. It is anticipated that these refinements will require one to two months of work. The Committee anticipated that CD-2b/3a could be approved by late October 2004 and funds permitting, LLPs could begin at that time.

The Committee had some questions regarding the role of the LCLS at SLAC and the Laboratory's transition to operate the LCLS, but there was insufficient time to address these questions. As there will be a significant change in the overall focus of the SLAC to operate the LCLS, these changes will impact the skill set at SLAC and may affect the overall operation of existing facilities. These changes should be a topic at the next DOE review.

5.1.3 Recommendations

1. Re-evaluate the overall project cost estimate and schedule by October 15, 2004, based on concerns associated with the limited project staff on-board now and early in FY 2005, and due to the aggressive schedule for the project.

2. Develop a comprehensive project management staffing plan and work with the SLAC management to implement this plan within the first quarter of FY 2005.

3. Reconsider the risks associated with implementing the OPC activities and the need for an OPC management reserve by October 15, 2004.

4. Implement a uniform level of project controls for SLAC and the partner laboratories by the next DOE review.

5. The SLAC Director should, by October 15, 2004, communicate the long-term importance of the LCLS project and its scientific program to the SLAC staff as part of the future vision of SLAC. This information will support the LCLS project staffing plan and the need to encourage the necessary talent to participate in the construction and operation of the LCLS.

6. Add an agenda item for the next DOE review on the role of the LCLS at SLAC and the operation of the LCLS in 2010 and beyond.

5.2 Procurement

5.2.1 Findings

The project has developed an Advance Procurement Management Plan that establishes the requirement for Advance Procurement Plans (APP) for all critical project procurements. These plans are also required for partner laboratory activities. The requirements are adequate, but put the full responsibility for the procurement tracking system on the Project Chief Engineer. At the time of the review only one APP had been approved and several more were in process or due. The APPs will require more specific details as to the schedule and milestone tracking data.

The LLP plans will support the construction schedule, but the design status of each procurement package has yet to be finalized. The procurement process lead times are very aggressive and require that all activities occur without delays or disruption. The project schedule is predicated on these aggressive time lines and thus could be impacted by delays or changes in design criteria or vendor identification.

Plans for a construction management contract are still being developed and the resulting contract will be critical to the success of the project. The time line to accomplish this task is very aggressive and poses significant hurdles for the project.

Risk analysis has been carried out and appears to be adequate.

Project staffing is limited, but it is in the process of ramping up to meet the schedule. Procurement staff support is being provided with plans to increase the numbers and types of personnel in the future. The project needs more dedicated procurement staff to support planning and executing the critical LLPs and initial critical construction activities.

5.2.2 Comments

LCLS project procurement planning is ongoing, and if there is adequate staffing, it should meet the needs of the project.

SLAC management is committed to providing the necessary procurement staff to support the project in the future, and is prepared to assign procurement staff to the project now and in the future as the laboratory plan indicates. The laboratory procurement group recognizes the need for LCLS staffing and is fully supportive of the project needs and re-assignment of the needed staff to the project for direct support.

The Conventional Facilities effort has a very ambitious schedule that does not allow for delays. The Statement of Work for the Construction Manager is still being developed and needs to be expedited to meet the current project goal of spring 2005. This contract is the biggest and most significant of the Conventional Facilities endeavors, and there is potential for adverse schedule impact.

The LLPs are also very aggressive and present a real management challenge to the project since any delay can, and most probably will, affect the overall project schedule.

5.2.3 Recommendations

1. Review and revise the procurement process lead times for the LLPs and Conventional Facilities procurements, and reflect any changes in the project schedule by October 15, 2004.

2. Review, revise, and approve all required APPs for FY 2005 LLPs by October 15, 2004.

3. Coordinate the re-assignment of SLAC procurement staff members directly to the project by October 15, 2004.

4. Expedite the design completion of LLP items and issue the associated procurement bid packages.

5. Complete the development, review, and approval of the project Construction Manager Statement of Work and procurement bid package by November 1, 2004.

6. Revise the Advance Procurement Management Plan by October 15, 2004, to make the Project Procurement Lead responsible for the maintenance of the Project Procurement Tracking System.

6. ENVIRONMENT, SAFETY and HEALTH

6.1 Findings

The ES&H aspects of the LCLS project continue to be properly addressed given the project's current stage of development. ES&H and the Preliminary Safety Assessment Document requirements to support CD-3a are in draft, awaiting DOE comment. The project's overall ES&H progress since the May 2003 DOE review continues to be positive. The project is moving forward in integrating ES&H.

6.2 Comments

LCLS management is continuing to evaluate the analyses and conclusions in the Environmental Assessment against the evolving designs of the LCLS, its components and facilities, and the results of the geotechnical study, thereby assuring that it remains valid to support the project through design, construction, installation, and into operations.

An evaluation of the ES&H staffing needs was conducted and determined. A full-time, dedicated ES&H professional is required to support the continuing design process, as well as the construction, installation of components, and operations.

The project continues to use existing SLAC/Stanford Synchrotron Radiation Laboratory processes and resources for ES&H support. Several of the SLAC safety committees are participating in review and oversight of the project and the ongoing design process.

The ES&H aspects of the project work conducted by the partner laboratories at their sites must meet the DOE and LCLS standards. The LCLS safety standards must be met for the components, as well as the installation activates delivered or conducted at SLAC by the partners.

The first guiding principle of Integrated Safety Management (ISM) states, "line management is responsible for safety." LCLS management did not indicate through their review presentations, their involvement in the safety process at this stage in the project.

6.3 Recommendations

1. Hire a full-time dedicated ES&H professional with a construction background by October 31, 2004.

2. Execute a plan allowing LCLS management to take a more active role in developing the safety plan and execution of the safety program after construction begins.

3. Develop a LCLS Construction Safety Plan (CSP) with ISM as its core, incorporating SLAC ES&H work smart standards, OSHA standards, DOE standards, as well as specific construction best practices. A document should be in place prior to awarding the first contract bid package.

4. Review SLAC's contract/procurement packages to assure that all LCLS ES&H requirements are included in the bid documents.

5. Develop a contractor pre-bid and pre-construction LCLS ES&H orientation by December 2004.

6. Develop an ES&H procedure to be included in the CSP, as well as a quality assurance/quality control process for the partner laboratories' equipment and their employees (coming to SLAC) to assure compliance with LCLS' requirements.

7. Review the need for dedicated Laser Safety Officer.

8. Review the project's future requirements in the area of safety: industrial hygiene, environment, and the expected level of support from SLAC's ES&H staff.

9. Explore using an Owner Controlled Insurance Program instead of contractors supplying Workers Compensation insurance by December 2004.