Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

May 2005

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 May 10-12, 2005, at the request of Dr. Patricia M. Dehmer, Associate Director for Basic Energy Sciences, SC. The purpose of the LCLS review was to assess the project's progress in all aspects of Title II design and long-lead procurement activities. It was also to determine if SLAC was adequately prepared to start conceptual design of an LCLS instrument Major Item of Equipment (MIE) project. 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 the project has made considerable progress since the August 2004 DOE review. The project has satisfactorily addressed the previous concerns about the aggressiveness of the schedule, but there have been delays in the procurement process supporting construction. These delays have added to the complexity of the construction task, and if allowed to continue, they will increase project risk and threaten the contingency in the cost estimate. Although a very capable LCLS management team is in place, the Committee had some reservations about the project's ability to effectively start construction and the Laboratory's support for the project. SLAC is an organization in transition. The Laboratory is still only beginning to understand that LCLS will be the most important facility there when it is completed in 2009. While many excellent key staff have been added to the project over the last few months, the Laboratory needs to give high priority to identifying and committing the SLAC resources (people, infrastructure, systems) needed for LCLS construction.

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 (ANL) and Lawrence Livermore National Laboratory (LLNL). Relations among the LCLS partner laboratories are excellent and internal communications are generally good. When completed, 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 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 in disciplines ranging from atomic physics to structural biology.

The Total Project Cost (TPC), approved at Critical Decision (CD) 2, Approve Performance Baseline, in April 2005, is $379 million and the Total Estimated Cost (TEC) is $315 million. Project completion (CD-4) is scheduled for March 2009. Cost contingency (33 percent of the TEC work to go, and a ten percent management reserve in Other Project Costs) and schedule contingency (about 26 percent or 216 days) are sufficient in comparison to other BES projects and both are believed to be adequate provided that the procurement for conventional facilities (CF) is awarded expeditiously. The project's cost, schedule, and technical baselines are consistent with those in the FY 2006 LCLS Construction Project Data Sheet and the current DOE-approved LCLS Project Execution Plan, and there appears to be adequate progress to meet the baseline objectives. The information in the DOE Project Assessment Reporting System is consistent with physical progress.

Good design progress has been made since the August 2004 DOE review across all technical areas. The undulator, injector, and linac designs are mature and their long-lead procurements are proceeding on schedule. However, the undulator physics design appears to be overly conservative, and this has imposed costly design requirements for floor vibration and spatial temperature uniformity in the Undulator Hall. There are several proposed design changes (e.g., Far Experiment Hall layout, mirrors in Front End Enclosure, steel for hutches instead of concrete, shorter gas attenuator) that need to be processed as soon as possible in order to avoid schedule impacts. There appears to be good integration of ANL, LLNL, and SLAC design activities.

Title II design of the CF has begun, and the 30 percent review point is scheduled to be reached in late June 2005. SLAC's procurement for the Construction Manager/General Contractor (CM/GC), valued at $60 to 65 million, has fallen about three months behind schedule. The bid package has yet to be reviewed by DOE at Chicago and Headquarters, and the contract award is now expected to occur in September 2005. The CM/GC is needed as soon as possible to take ownership of the CF design and review its constructability. As a fall back, LCLS management is considering options for providing interim constructability reviews of the Title II design at 30 percent and beyond until the CM/GC is on board. Bids for two small CF renovation procurements (Magnetic Measurement Facility, and Sector 20 Injector Facility) have come in substantially over their base estimates and are under evaluation by the project.

With regard to the LCLS instrument MIE, the Committee found that SLAC is sufficiently prepared to start conceptual design of the project. Its scope is well defined, and includes four instruments in three scientific thrust areas. The staffing plan for the MIE project, which requires some key hires over the next six months, appears reasonable.

The necessary ES&H documentation is complete or on schedule. A comprehensive construction safety program is being established that has been proven to work well on other projects.

The Committee provided three action items to LCLS management:

1. Issue the Request for Proposals for the CM/GC procurement by June 13, 2005;

2. The SLAC Director will conduct an assessment and report to BES by June 23, 2005 on the necessary SLAC resource commitments to ensure the project's readiness to proceed with construction as a primary element of SLAC; and

3. Conduct the next DOE Review at SLAC in November 2005 (subsequently scheduled for December 6-8, 2005).

In summary, the Committee found that LCLS has made substantial progress in all areas; however, the Committee had some reservations about the project's ability to effectively start construction and the Laboratory's support for the project. The recommendations and action items set forth in this report are intended to assist in these areas.

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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 beam experiments and for nuclear and high-energy physics experiments on fixed targets. At present, the first two-thirds of the linac is being used to inject electrons and positrons into the Positron Electron Project II (PEP-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 120-meter-long LCLS undulator tunnel, 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 Pulse Source (SPPS) and the next generation of linear colliders, as well as the progress in the production of intense electron beams with radio-frequency 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 (SAC), 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 Linear Collider (SLC) 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 120-meter undulator tunnel and associated equipment. Two new experimental buildings, the Near Experimental Hall (NEH) and the Far Experimental Hall (FEH), connected by an approximately 250-meter-long beam line tunnel, will be constructed. A Central Laboratory and Office (CLO) Building will be constructed to provide laboratory and office space for about 250 LCLS staff and users, and serve as a center of excellence for basic research in X-ray physics and ultrafast science.

Critical Decision (CD) 0 (Approve Mission Need) was approved by the Acquisition Executive, who is the Director of the Office of Science (SC), 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.

Subsequent to the Department of Energy (DOE) Conceptual Design Review in April 2002, the Office of Basic Energy Sciences (BES) provided SLAC with additional funding guidance that resulted in a revised TPC range of $245 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 (Approve Performance Baseline) was split into CD-2a (Approve Long-Lead Procurement Budget) and CD-2b (Approve Performance Baseline).

Based on the above cost and schedule assumptions, the LCLS Acquisition Execution Plan, Preliminary Project Execution Plan (PEP), and CD-1 (Approve Preliminary Baseline Range) were approved on October 16, 2002. This step authorized the project to start Title I design and expend PED funding, which 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. In addition, an LCLS Environmental Assessment was completed (as required by the National Environmental Policy Act (NEPA)), and a Finding of No Significant Impact was issued on February 28, 2003. A DOE review to evaluate the baseline scope, cost, and schedule aspects of those items was conducted in Germantown, Maryland on May 21-23, 2003. The review 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 2, 2003, the Acquisition Executive approved CD-2a, which enabled the long-lead procurement funds ($30.0 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, the Congress appropriated $7.456 million of PED and $2.0 million of Operating Expense funds for R&D. Once again, however, there was a Continuing Resolution that held the available funding to the level of the preceding fiscal year until an appropriation was enacted (in December 2003). The FY 2004 funds enabled the project to acquire architect engineering services for the design of conventional facilities (CF) 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. Then, in preparation for CD-2b, an External Independent Review (EIR) was performed by Burns and Roe Enterprises, Incorporated (BREI). The BREI review team was on site at SLAC during June 7-11, 2004, and provided their final report the following August. In summary, 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 by themselves stood in the way of approving CD-2b.

The next DOE review of the LCLS project was conducted during August 10-12, 2004, and its purpose was to determine the project's readiness for CD-2b and CD-3a. The committee concluded that, in some areas, the cost and schedule contingencies presented did not appear to be adequate given the future risks (e.g., tunneling construction). Also, the planned procurement processing schedule durations for many of the long-lead procurements were unrealistically short. The committee did not recommend approval of CD-2b and CD-3a, and instead recommended that LCLS management re-evaluate the project's TPC and schedule and submit a revision to DOE/SC by October 2004, which it did. Their baseline proposal called for increasing the TPC to $379 million and extending the schedule by six months to March 2009 for CD-4 (Approve Start of Operations). This would serve to increase the cost and schedule contingency amounts to more appropriate levels (35 percent of remaining Total Estimated Cost work and 10.5 months, respectively) in keeping with the review committee's recommendations. It also included the impact of the FY 2005 Continuing Resolution that lasted until December 2004. An SC mini-review of the new proposed baseline cost and schedule, chaired by the LCLS Federal Project Director, was conducted on November 12, 2004. This committee, which contained several members of the August 2004 DOE review committee, concluded that the proposed TPC and schedule were reasonable.

The FY 2005 appropriation for LCLS included $19.914 million of PED funds, $29.76 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 radiofrequency gun system; the X-Band system and bunch compressor magnets for modifying the SLAC linac; the undulator strongback, magnet poles, and magnet blocks; and renovations for Sector 20 and the magnetic measurement facility (MMF) needed for verification of undulator performance. As before, the amounts were somewhat reduced because of a General Reduction and Rescission.

From January through March 2005, the project underwent a limited EIR by BREI at the direction of DOE's Office of Engineering and Construction Management (OECM) to validate the proposed baseline cost and schedule ($379 million TPC and March 2009 completion date). Meanwhile, the Acquisition Executive approved CD-3a on December 10, 2004, so as not to delay placement of the FY 2005 long-lead procurements. The limited EIR ultimately resulted in an OECM validation of the LCLS baseline and the proposed baseline was approved at CD-2b by the Acquisition Executive on April 8, 2005. The LCLS PEP was also approved at that time.

In early FY 2005 and with guidance from BES, SLAC began developing a Mission Need Statement for a suite of four instruments to be installed on LCLS after CD-4. They will be designed to address all but one of the science thrust areas in the *LCLS First Experiments* report. (The high-energy-density physics thrust area falls outside the scope of BES, and funding to acquire instrumentation for that thrust area is being sought from other sources.) The technical concepts for the four instruments have been developed at SLAC in close consultation with the scientific community through a series of workshops, conferences, and focused review committees. They have also been endorsed by the LCLS SAC, which is comprised of senior U.S. and foreign scientists and advises jointly the LCLS Project Director and Director of the Stanford Synchrotron Radiation Laboratory (SSRL) at SLAC. These four instruments are envisioned to be funded entirely by BES as a single Major Item of Equipment.

The President's FY 2006 Budget Request for LCLS includes $2.544 million of PED funds for continuing the design effort, $83.0 million of line item funds to start construction, and $3.5 million for continued R&D. CD-3b (Approve Start of Full Construction) is currently scheduled for February 2006.

1.2 Charge to the DOE Review Committee

In a April 1, 2005, memorandum (see Appendix A), Dr. Patricia M. Dehmer, Associate Director for BES in SC, requested that Daniel R. Lehman, Director of the Office of Project Assessment organize and lead a review of to evaluate the progress of the LCLS project in all aspects: technical, cost, schedule, management, and environment, safety, and health (ES&H).

1.3 Membership of the Committee

The Review Committee (see Appendix B) was chaired by Stephen E. Tkaczyk, Office of Project Assessment. 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 more of the previous three 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 May 10-12, 2005 at SLAC in Menlo Park, California. The agenda (See Appendix C) 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 was devoted to project plenary sessions with presentations given by members of 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. The preliminary results were discussed with LCLS staff at a closeout session on the last day.

2. TECHNICAL SYSTEMS

2.1 Accelerator Physics

2.1.1 Findings and Comments

The Committee thanked the LCLS staff for presenting the accelerator physics issues in a clear and thoughtful manner. The analysis and modeling of the electron beam from its generation in the electron gun through its transport to the end of the undulator has reached a mature state. The emphasis of current work is on optimization of the accelerator configuration for commissioning and early operation. The proposed low-charge operation (0.2 nano-Coulombs or nCs rather than 1 nC) provides a way to ease the requirements on the injector, simplify bunch compression, and reduce wake field effects in the linac and undulator. These benefits are achievable with only a small reduction in the output radiation energy. The electron beam diagnostics have all been designed to have sufficient resolution at this lower charge level. The results presented show that running the accelerator in this configuration will significantly simplify commissioning by easing requirements and eliminating complex phenomena that have the potential of being hard to diagnose. The Committee strongly endorsed this low-charge mode of operation.

The management of the accelerator physics effort has been effective at identifying the most important technical challenges and guiding work toward innovative solutions. The appointment of Paul Emma as Accelerator Team Leader will strengthen the management of the accelerator systems at this critical time.

An important area for work in the near future is the design and implementation of electron and photon diagnostics to properly characterize the electron beam and output radiation. These diagnostics must also provide the basis for feedback or feed-forward systems to provide the required stability in cases where tolerances are too tight for passive solutions to be sufficient.

At the review, it became apparent that there is a need for a comprehensive listing of the hardware and environmental tolerances needed to achieve required system performance. This information is needed to facilitate proper cost-benefit trade-offs.

The development of high-level software to be used during commissioning is of the highest importance. It is necessary to provide intelligent interface to diagnostics, to facilitate comparison of observations to modeling codes, and to implement tuning algorithms to optimize performance. The development of such high-level software is labor intensive and will require additional personnel working in this area.

2.1.2 Recommendations

1. Carry out a comprehensive study of the required hardware and environmental tolerances and document the results in a form easily accessible to all groups working on LCLS. Clearly indicate when feedback and feed-forward can be used to ease tolerances if passive solutions cannot be found by November 2005.

2. Develop the high-level software needed for commissioning. Assign programmers to this task by November 2005.

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

2.2.1 Findings

The Injector/Linac subcommittee heard excellent presentations on the activities since the August 2004 DOE review. The Committee commended the LCLS team on significant progress toward their demanding goals and for continuing to advance the knowledge and technical base required to make the LCLS a success. Overall the Injector/Linac design is mature and sound. With continuing development, the project has a reasonable probability of meeting the performance requirements. The scope and specifications are sufficiently well defined to support long-lead procurement.

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. Despite encouraging modeling, no existing injector/linac system has yet met all of the requirements proposed, so early operation is vital. New ideas such as reduced-charge operation could relieve demands in many subsystems. It is encouraging that procurement of the drive laser is proceeding since the requirements are not met by any existing commercial system, especially the tight tolerances on many of the specifications. Full control of the transverse and temporal profile remains a desirable but challenging goal. It is important to continue development of the required laser technology skill base to ensure in-house support to develop this crucial device.

Other long-lead procurements in the injector, including the gun and linac sections, are also needed to get earliest possible assembly of the injector so that commissioning can begin in earnest. This is proceeding reasonably well and should continue. Again, early performance demonstrations are crucial to giving confidence that the project performance specifications can be met.

Long-lead procurement is also underway for many accelerator components. SLAC experience in this area is extensive and the design is well advanced in most subsystems. The project is also taking advantage of spare components from other programs. Procurement and testing should proceed as planned.

The level of contingency on the Undulator System appeared to be reasonable for this stage of the project. Contingency has not been applied in any major way thus far, and it is being managed properly.

There is some concern that existing magnet power supplies in the linac may not meet the required specifications and would require upgrade leading to cost growth. Attention to this issue and early resolution of real requirements is desirable.

The Committee was encouraged by the recent hires of an expert laser group leader, but hope that this expansion of laser expertise continues as the laboratory recognizes its conversion to a photon oriented facility. Initiatives such as the Ultrafast Center and collaborations with LLNL and others are desirable, but they do not take the place of laboratory staff to be applied to specific design problems that will need resolution as construction, commissioning, and operation of the facility proceeds. Staffing support for the Injector/Linac will need to continue to grow for the next two years.

Support in procurement and human resources is sufficient at this time, but there is need for additional mechanical engineering at this critical design phase. It is necessary to build 3-D models of many existing components because old designs were in 2-D. This takes a great deal of time and expense but is probably unavoidable given the evolution in design software. Some additional support in schedule planning is appropriate.

SLAC and LCLS management need to recognize the importance of achieving the required tunnel waveguide installation in the fall of 2005 if the remainder of the injector schedule is to be maintained. It is important for LCLS management to find a way to accomplish this task on schedule either by multiple shift installation or extension of the downtime.

The Committee found ES&H being addressed at all stages of the planning, which is encouraging. The staff felt very comfortable with the process and "bought in" to all aspects of it. The only issue was that some areas appeared to use different ES&H procedures for the LCLS and other SLAC divisions. This may be confusing to personnel in matrixed organizations and could potentially lead to real implementation problems due to uncertainty as to approach when tasks cross group boundaries.

All Injector/Linac recommendations from the August 2004 DOE review were adopted.

2.2.2 Comments

The Injector/Linac designs are relatively stable and mature. Despite the significant technical challenges of these systems, the staff seems coordinated and well focused on achieving the planned activities. Generally speaking, this area has the right support to get the job done. Over the next year, there should be actual performance data on some of the elements and real progress in establishing the beginnings of a working device. Collaborations with other laboratories have been helpful in resolving issues and identifying problems early and the Committee encouraged the continuation of such efforts.

2.2.3 Recommendations

1. Resolve schedule conflicts by August 2005 in order to achieve waveguide installation by October 2005.

2. Continue to enlarge LCLS laser expertise with additional hires by June 2006.

2.3 Undulator System (WBS 1.4, 2.4)

2.3.1 Findings

The LCLS Undulator System includes undulator magnets and supports, undulator diagnostics, vacuum systems, controls for the undulator equipment, and a MMF. Integration and installation are also included within this area. The project has developed the Work Breakdown Structure (WBS) such that the total cost for the LCLS undulator system planning, project management, design, construction, and installation are summed within this WBS level. There will be a total of 33 undulators installed in the tunnel. Additionally, there will be seven operational undulator spares, including three prepared for installation (mounted to full module assembly) at any given time. One is reserved as a standard.

In the present configuration, an undulator magnet is integrated onto a cradle that also includes an electromagnet quadrupole, a radio frequency (RF) beam position monitor (BPM), a vacuum chamber and support, vacuum pumping, and additional diagnostics. All module components will be aligned with respect to each other on a coordinate measurement machine. The fully integrated cradle will be aligned as a unit in the undulator tunnel on a fixed support structure. The cradle is equipped with precision cam position adjusters. The undulator is also mounted on a transverse translator that allows an undulator magnet to be remotely retracted from the vacuum chamber or, as a result of the canted poles of the undulator magnet, adjust the magnetic field (the undulator K-value).

There have been significant personnel additions to the Undulator System organization in several areas in the last six months. Of particular note is the addition of an overall Undulator System chief engineer with a strong systems perspective, an undulator integration engineer for SLAC activities, a mechanical engineer for undulator fixed support, a survey and alignment liaison, quality assurance, and a dedicated procurement officer.

The following items are changes in the baseline technical configuration or responsibility since the August 2004 DOE review:

- The quadrupole was changed to an electromagnetic design, which also incorporated horizontal and vertical trajectory correctors;

- The responsibility for the undulator fixed support (WBS 1.4.3.8) was transferred to ANL from SLAC;

- The fixed-support configuration has likely changed to an extruded aluminum structure with integrated cooling for thermal management;

- As the result of AC conductivity issues, the vacuum chamber was changed to a stainless steel chamber with an oblong (rounded rectangular) cross section with a highly polished interior surface and pure aluminum ion-sputtered coating; and

- The heat generating equipment has been removed from the undulator tunnel hall and moved to surface equipment halls.

The planned operational configuration anticipates the regular exchange of undulators throughout the length of the device. This is accomplished by changing out the cradle and all of the subsystems it contains in addition to the undulator magnet. This exchange requires breaking the vacuum and exchanging the BPM and quadrupole at the same time, and must not disrupt the 140-meter stretched wire or the hydrostatic leveling systems. In this same context, because of vacuum conductance limitations, the center of the vacuum chamber within an undulator section requires approximately 24 hours of pumping to achieve a vacuum of 10^{-6} Torr.

The RF BPM for the Undulator System is scheduled to be installed on the Final Focus Test Beam (FFTB) facility in October 2005. The FFTB is scheduled to be shut down in March 2006 (June 2006 at the latest). It was reported that installation of a prototype RF BPM at ANL could be accomplished at any time, but that there was a desire to field a complete diagnostic suite and controls at the FFTB.

There are two integrated Undulator System tests planned—a single undulator section test at ANL and a multi-undulator (two or three) test beginning at ANL and then being transferred to SLAC.

The Undulator System organization has placed a number of long-lead procurements. Two procurements have been placed for the titanium strongbacks. These procurements were more costly than originally budgeted as a result of dramatic increases in the price of titanium metal. The availability of adequate titanium stock material remains a risk. A long-lead procurement for the fabrication of the vanadium permendur poles has also been placed at a lower price than originally budgeted as a result of removing titanium wings from the design. The long-lead procurement of the undulator permanent magnet blocks was imminent at the time of this review with the award price being very close to the estimate. The statement of work for the undulator assembly Request for Proposal (RFP) is in final review. These areas for long-lead procurements are sufficiently mature to have the procurements placed and the procurement plans support the project schedule requirements.

A completely integrated error tolerance budget has not been finished. Work in this direction is underway. Many sets of tolerances have been generated independently and not systematically integrated with normal operational assumptions or approaches. This results in tolerance limits that are conservative. The project presented an initial commissioning approach for the Undulator System that includes both pre-beam checkout, electron beam commissioning, and systematic assessment and optimization of free-electron laser gain.

2.3.2 Comments

PED funds will be expended early in FY 2006, yet many of the ancillary parts of the Undulator System are not yet at the equivalent of Title II design development. Among these ancillary parts are the RF BPM, the cradle, the vacuum chamber, and the fixed support. This is not a specific issue, but it is an item for consideration to keep the ancillary systems from either degrading system performance or jeopardizing schedule contingency.

The lack of a completely integrated error tolerance budget analysis is a concern and may adversely impact design choices as the project continues, including the distribution of mechanical misalignments without the compensations that a machine operator would most likely implement. Additionally, the 0.2°C spatial temperature stability criterion does not appear to be well founded. The Committee felt that the Undulator System physics issues have not been shown to clearly justify extraordinary measures for either the undulator hall floor or the spatial temperature uniformity requirement. A complete integrated error tolerance budget analysis must be performed to resolve this issue.

The operational approach of changing out complete cradle assemblies was developed prior to the development of the transverse slides for the undulator magnet, and alignment tolerances may make it difficult. One can imagine a configuration where the undulator magnet is kinematically mounted onto the transverse slides of the cradle so that it could be changed out without impacting the remainder of the systems on the cradle, breaking the vacuum system, or disrupting the stretched wire or hydrostatic level systems.

The dual location of the multi-undulator section integration testing seemed redundant to the Committee. While it is convenient to repeat the integration testing at both SLAC and ANL, it is not necessary. Additionally, the Committee felt that a full integration testing setup using three undulator sections (the super-period of the Undulator System) would have greater benefits than an integration test with only two undulator sections. The project should plan on the existence of learning curve benefits in the development and actual execution of beam-based alignment of the undulator system during commissioning and operation in its assessment and allocation of risk.

The Committee felt that the RF BPM design verification tests should be accelerated and accomplished as soon as possible (i.e., not wait for the scheduled shutdown of the FFTB in October 2005). An additional disadvantage of using the FFTB is that its imminent shutdown in 2006 could force a premature conclusion to these design verification tests.

The Undulator System organization appears to be a well-developed and well-managed team. Integration of activities at both ANL and SLAC is evident. The technical and project progress since the August 2004 DOE review is very good. The Undulator System organization has responded well to the issues associated with AC conductivity that has resulted in the need to completely redesign the vacuum system. ANL, and in particular the Advanced Photon Source (APS), are clearly giving the LCLS activities proper attention and priority. This has been demonstrated by the quality and speed with which personnel are being made available for the Undulator System organization. The Undulator System part of the LCLS project is being adequately managed as needed to proceed with construction. This has been further demonstrated by moving responsibility for the undulator fixed supports (WBS 1.4.8.3) to ANL and the response to the change in the vacuum chamber requirements.

The undulator magnet effort is very well run and the approach to long-lead procurements (magnets, strongbacks, poles and assembly) shows care and excellent process engineering and quality control. Although a few minor items were identified (such as the definition of a broken magnet for the undulator magnet assembly subcontractor), there is ample evidence that the work done in these areas is both comprehensive and complete.

The Committee was pleased to see commissioning considerations starting as this will likely impact design choices in the ancillary systems as progress continues. Additional work on integration, installation, and commissioning still remains to be accomplished, and the Undulator System organization is cognizant of this need. Specifically, explicit operational tolerance zones should be determined. These tolerance zones will reflect the various optimization approaches that would be undertaken in commissioning or operation. The smallest zone would be at a level that no noticeable performance degradation would be detectable as it would be within the nominal fluctuations of the LCLS. The next tolerance zone would be that which is compensated by standard operating approaches and would not reduce availability. The next largest tolerance zone would be those that are corrected by a variation of beam based alignment (BBA) that does not require intervention in the undulator hall. The next largest tolerance zone would require a full BBA including access to the undulator in the tunnel. Any operational configuration that lies outside of this last tolerance zone would require realignment of the undulator and attendant systems. It is important to think through detailed BBA strategies including decision trees for both commissioning and normal operation.

The ES&H aspects are being aggressively addressed as demonstrated by the care that has been taken in developing handling procedures and requirements for use by the undulator magnet assemblers.

2.3.3 Recommendations

1. Define clear roles and responsibilities for the LCLS Physics Liaison Support group, by June 2005, in order to ensure adequate global integration and consideration of physics requirements and implications. Further, if it is not already the intention of LCLS management, the Accelerator Team Leader should formally be given the authority and responsibility to preside over this group.

2. Examine, by September 2005, the opportunity to kinematically mount the undulator magnet onto the transverse slides of the cradle to allow a greatly simplified exchange during operations.

3. Assess the feasibility and eliminate, if possible, the duplication of the multi-undulator section integration tests by October 2005.

4. Accelerate the development of a design verification test of a prototype RF BPM system for deployment at ANL by mid-August 2005, if feasible.

5. Develop, by October 2005, a complete integrated physics error tolerance budget that factors in civil construction constraints while taking into account the various optimization modes and tolerance zones that will likely be employed during commissioning and operations.

6. Develop, by October 2005, a complete undulator systems engineering plan including decision trees to optimize integration, installation, alignment, commissioning, and operation planning.

2.4 Photon Beam Handling Systems and Endstations (WBS 1.5, 2.5, 1.6, 2.6)

2.4.1 Findings

The Committee was encouraged by the plans for damage testing at the Deutsch Electronen Synchrotron Tesla Test Facility (DESY/TTF) and it is looking forward to learning the results. It is expected that the results will be useful to test and possibly improve computer codes that simulate radiation damage that are extant at LLNL. These codes should then provide a more reliable prediction of the performance of optical materials that may be selected for LCLS mirrors and monochromators.

It was good to see the degree of planning for the 2-D detector to be built at Cornell and an imminent signing of a Memorandum of Understanding (MOU). Detectors of this type are expected to be crucial for many, if not most, LCLS science experiments, and the progress of steps to assure that there will be a tailored, useful, and excellent detector by 2009 appear to be quite adequate.

The Committee was informed concerning changes to the baseline design that are now being seriously considered. A large redesign was proposed for the FEH. Possible additional changes were also presented: 1) diagnostics (and possibly the monochromator) specified in the baseline would be moved into the Front End Enclosure (FEE), 2) two sets of offset mirrors would also be inserted into the downstream portion of the FEE, 3) a possible redesign of the gas attenuator to a shorter unit, 4) a proposed lengthening of the FEE by five meters is also being considered to accommodate the additional items.

The division of effort and procurement between LCLS and LLNL is codified in WBS 1.05 as prepared by the X-ray Transport Optics and Diagnostics (XTOD) group at LLNL.

The Personal Protection System (PPS) falls as a responsibility of the X-ray End Station (XES) group. The apparent plan is to rely at least partially on expertise extant at SSRL for the LCLS PPS. The radiation physics expertise needed for the LCLS project will be drawn from SLAC staff.

There was no concern or comment expressed by the Committee on immediate staffing plans. It was noted that plans to add staff with control expertise, as detailed in August 2004, have been amended as a result of low timing jitter observed in SPPS experiments.

2.4.2 Comments

The proposed lengthening of the FEE by five meters will likely entail a change to the baseline for the conventional facilities, and this is a weighty matter since it may affect the conventional facilities construction schedule.

The introduction of the offset mirrors has the great benefit of reducing background levels for science experiments, and may also reduce shielding requirements. This follows since the spontaneous radiation could, in that case, be blocked from continuing downstream. Since the spectrum of spontaneous radiation extends to 100 keV, the thick concrete walls of the hutches may not be needed, i.e., much thinner steel walls would suffice. However, this change entails risk, since the efficacy and lifetime of both the silicon carbide (SiC) and the beryllium (Be) offset mirrors are not fully predictable. The Committee noted that the above mentioned experiments at DESY/TTF are being undertaken to address this issue, and it is premature to rely fully on the proposed offset mirrors.

Concerning the XTOD work, since WBS 1.05 is based on the baseline design, the costs and schedules for WBS 1.05 will need to be modified if the changes are to be implemented. Since changes are to be approved by change control board(s) within LCLS, close attention should be paid to communicate priorities and work sequences to LLNL/XTOD to assure that the work done within XTOD is useful to the project. Accommodating changes will require flexibility on the part of XTOD staffing. LLNL will have to approach the WBS 1.05 items with a flexible approach, and all divisions of SLAC should support that flexibility.

The engineering designs to be done by XTOD and XES groups are still largely conceptual. In both cases, there are significant radiation safety aspects that need the involvement of radiation physicists. For example, there may be more or less scattering from the gas attenuator depending on the design, and shielding requirements within the FEE, as well as further downstream may be changed. Radiation shielding is an intimate aspect of any PPS system, and radiation physics considerations will be greatly needed for a good and safe design.

2.4.3 Recommendations

1. Process the proposed XTOD and XES change requests with high priority.

2. Prioritize and sequence the work to be done by LLNL to reduce risk. Detail the changes to LLNL so that the work done will eventually be productive and cost effective.

3. Complete the engineering designs with scrutiny by and support from radiation physicists at SLAC. Study and scrutinize the PPS at hard X-ray light sources (e.g., the Advanced Photon Source).

2.5 Control Systems

2.5.1 Findings and Comments

In addition to the plenary overview, the Committee was presented a series of well-prepared technical presentations on a broad range of controls topics and issues by a skilled, enthusiastic, committed, and very helpful Controls Systems team.

The Controls Systems cost and schedule are consistent with the LCLS Construction Project Data Sheet and the approved PEP. Very good progress has been made toward meeting the early baseline objectives. The controls group is responsible for a far larger scope than is traditional for accelerator control systems—in addition to accelerator, undulator, and beam-line controls, it includes diagnostics, low-level radio frequency (LLRF), and power supplies (even some lead shielding). This extended scope means that common rules-of-thumb for cost estimates can be expected to be low, and that the controls team needs a broader range of skills than usual, or at least priority access to these skills. Predictably, the cost basis improves as the design proceeds, and the Committee was pleased to note that the controls group intends to update their cost estimate after prototyping is complete. Meanwhile there appears to be adequate contingency for the Controls Systems tasks.

The controls effort is being managed well. Although the level of hazard encountered in present control system tasks is low, controls personnel and managers are cognizant of the safety aspects of their work. Hazard levels will increase as equipment installation and prototype testing commences.

There has been excellent success in recruiting software engineers—both full-time LCLS employees and staff members matrixed from other SLAC divisions. The addition of a controls liaison with LLNL for the photon beam lines and of another to the CF team will be of great benefit. An effective controls group has been formed around this talented and experienced staff; but the number of electronic engineers recruited from SLAC will not meet current or near future requirements. The controls group is faced with very challenging engineering design work and tight schedules, particularly in the areas of diagnostics and LLRF. The extremely fast bunch length monitors and cavity BPMs are especially challenging and schedule critical—forces need to be mustered as soon as possible to complete this work in a timely fashion, particularly if advantage is to be taken of the FFTB for testing.

Particularly on the software side, design of the integrated control system is rapidly maturing, and control system design for various LCLS subsystems is presently keeping pace with the development of those subsystems. Several subsystems have been able to apply Experimental Physics and Industrial Control System (EPICS)-based hardware and software approaches developed at other laboratories to LCLS. The result is excellent progress on the critical SLC-aware input-output controller (IOC) and timing interface software—ahead of required schedules. The proposed use of the very flexible commercial power supply control system developed for the Swiss Light Source is particularly endorsed. The Committee strongly supported this design approach, which can significantly (but not totally) mitigate schedule and staff support issues. Care must be taken to assure that these borrowed designs meet all LCLS requirements—technical requirements of course, but also integration and support requirements.

The photo-injector laser will be delivered with a control system that is an exception to LCLS standards since the vendor will supply only LabView controls. Early delivery of this subsystem is critical to the project so the Control Systems group will have to apply extra effort to interface to this non-standard subsystem.

There appears to be no plan at present to integrate CF control into the EPICS-based LCLS control system. This can be done with great benefit at relatively small cost (at least for new CF systems). Accelerator operation can be sensitive to site power and water, and integration with the control system will greatly facilitate correlations when diagnosing problems. The extremely demanding ambient temperature control requirements in the undulator hall demand integration, common archiving, and correlation capability.

The Committee strongly endorsed the proposed PPS design which, like those for most recently implemented accelerator PPS systems, is based upon Programmable Logic Controllers (PLC). The Committee felt this approach would result in a PPS that can provide the necessary level of reliable protection along with the degree of flexibility required to support multiple concurrent photon experiments. A model to test PPS logic and sequences might be useful. (SNS used to great advantage a simple state machine cheaply and easily developed for this purpose in Virtual Basic.) The recommended PLC-based proposal must be approved first by a SLAC "Citizen's Committee." Some work should proceed on a hard-wired, relay-based back-up design to mitigate a possible schedule delay resulting from a Citizen's Committee rejection of the preferred solution. Whatever the final design, care must be taken to integrate the LCLS PPS with the existing SLAC system in such a way as to present a common user interaction throughout the combined facility.

The Committee was shown a controls cost and variance report that gathers together and "rolls up" the disparate WBS elements containing controls work. As promised, the WBS has evolved so that all common control system design is now in a single WBS element. Sign-off by the controls leader is required for any baseline change affecting controls.

With the recent addition of a new level of management, however, controls work has lost some project-wide visibility. Because the common controls work is now explicitly on the linac side of the organization, the important integrating link to the photonic side is less direct. It will take conscious effort on all sides to make this rather arcane reporting structure work. (Because of the cross-project nature of controls, almost any organizational model will involve some compromise—whatever is sacrificed in the compromise requires special attention. LCLS might well benefit from developing an interface model for photon systems similar to the Collaborative Access Team interface developed for APS.)

2.5.2 Recommendations

1. Resolve the issue of electronic design engineering (and associated support infrastructure) for the controls team, using either the matrix model already successful in the software area, or by hiring dedicated electronics engineers (and designers and technicians) directly into the group. Accomplish this without disrupting the areas that are already working well. SLAC must make LCLS positions look appealing to engineers who might be concerned about their long-term future.

2. Develop a plan to expedite establishing a full-time resident controls group leader. If possible, this plan should include retention of the current group leader to direct the EPICS integration activities.

3. CONVENTIONAL FACILITIES (WBS 1.9, 2.9)

3.1 Findings

The LCLS civil construction scope represents a significant fraction (over 31 percent) of the LCLS TEC. The current CF baseline estimate is $76.78 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 requires all of the following: on grade construction, cut and cover construction, and a majority of the tunneling construction is 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 significant CLO Building and some smaller service buildings. Two small detached surface construction elements 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 to be done at SLAC since the 1960s.

LCLS project management has engaged the services of Jacobs Engineering to perform the civil architect/engineering (A/E) work under the direction of the LCLS WBS manager for civil construction. Title I design has been completed, reviewed, and accepted. This work includes Title I drawings, Title I cost estimates, and Title I project scheduling information. The Title I drawing set is extensive, exceeding 100 sheets, and the Title I cost estimate is appropriately detailed for work at this stage of design. The specifications for Title II design were “frozen” on April 8, 2005. This “freeze” was characterized as “slushy” by some members of LCLS management; some significant discussions are ongoing regarding the size and shape of the FEH and the length of one of the tunnel sections. Since the August 2004 DOE review, there was a November 2004 DOE Mini-Review and there have been several meetings of project consultants. An independent project cost and constructability review using a consultant firm was also conducted and the consultant’s estimate was reconciled with the A/E estimate prior to the DOE Mini-Review.

At the August 2004 DOE review, it was recommended that the LCLS project task, specify, and procure the services of a Construction Manager/General Contractor (CM/GC) as rapidly as possible so that the CM/GC could be on board to provide constructability information to the A/E during the Title II design work. The first draft for the RFP was completed by LCLS management in November 2004, but the draft has been iterating (slowly) between SLAC management, the local DOE site office, and the LCLS management since that time. The document must still be submitted to the DOE Chicago Office and DOE Headquarters, and only after this has been done may the RFP be released to potential CM firms. Bid and award are still some months away at best. The A/E is therefore starting Title II without the ability to consult with the CM/GC staff, and much of the Title II work is currently expected to be completed prior to the CM/GC joining the project. LCLS management is considering various “interim” options, including requesting bids for an “interim” CM firm to provide constructability input to the A/E during Title II.

Two bid packages for limited CF work at locations separated from the majority of the LCLS site have been prepared, issued for bid, and bids received. These packages are for the Sector 20 (S20) renovation and the MMF. The S20 requires the construction of a surface building at Linac Sector 20 to house the LCLS Injector Systems. The MMF entails the internal alteration and interior reconstruction of an existing building into the undulator magnet testing facility. Both of these projects were estimated by the A/E, and in both cases multiple bids were received, reasonably clustered, but averaging more than 50 percent over the A/E estimate for the work. Some intense review of this situation has revealed that in the case of S20, some discrepancy existed between the drawing set and the written specifications. The contractors were consulted and some specific clarifications/changes were resubmitted to the contractors for re-bids. In the case of S20, the re-bids have been received but the work remains high with respect to the A/E estimates. In the case of MMF, a re-bid has not yet been requested. It is possible that this situation may reveal a systematic unfavorable differential between the A/E estimates and contractor proposals, with significant unfavorable cost implications for the larger contracts yet to be placed.

In at least one area of the LCLS tunnel construction, two unusually demanding technically driven specifications remain. These are an air thermal stability requirement of better than 0.2°C within the Undulator Hall section of the tunnel, and a general requirement to make the undulator hall foundations “as stable as possible” in the face of expected differential settlements in excess of 1 micro-meter/day. The expected differential settlements are regarded as possibly too large. The air temperature requirement cited is to achieve a thermal stability on all surfaces of better than 1°C. The physics staff has been evaluating the impact of these requirements in conjunction with other parts of the undulator support and magnets. It is still possible that money and effort may be more efficiently expended in other areas of the undulator designs rather that in the CF design. These demanding requirements have been reflected in an unusually extensive heating, ventilation, and air conditioning (HVAC) system for the undulator hall as specified in Title 1, and a new (post-Title I) special design for 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 projected rate of construction, however, which reaches about $3 million per month, is higher than most other recent DOE/SC projects. This rate of work will put heavy demands upon the CM/GC, the A/E Title III effort, LCLS staff, the SLAC laboratory staff, and DOE.

If the physics specifications are now “frozen”, then the CF team has adequate technical, cost, and schedule contingency to accomplish the scope of work defined for the LCLS project. The challenge of accomplishing this work on the project schedule will require a substantially increased level of integration and support from the Laboratory, the project, and DOE.

The delay in the release of the CM/GC RFP is a cause for concern. LCLS management is aware of the potential impacts and disruption that this delay will have (and is already having). The proposed workarounds are both wasteful of LCLS management effort (i.e., additional effort will be expended) and leave large potential gaps in performance. These could have been avoided by a prompt reaction when the delays first were reported.

The value of a CM/GC approach is dependent upon early awareness of the technical approach and design outcomes by the CM/GC contractor. This process is now behind the desired schedule. The introduction of a third-party CM (or an “interim” solution) has a strong potential to introduce loss of accountability and will substantially reduce the “steeping time” that the ultimate CM/GC must have to develop and “own” the designs and work packaging of the LCLS project. The Committee concurred in the project approach to introduce constructability reviews as an integrated element of the design process.

The Committee felt that the facts and data surrounding the A/E cost estimate reflects a current unfavorable variance of no less than 50 percent based on two competitive procurement results. This level of impact has not been addressed in the project’s risk registry at a level necessary for mitigation.

The technical specifications for the undulator tunnel design and environmental control are very conservative. However, the money spent in achieving the environmental specifications of the Undulator Hall may not be addressing the greatest contributors to root mean square (RMS) variation. A global “value engineering approach” (this means technical plus CF designs) is needed to clearly quantify the greatest return in technical performance for the dollars spent in design.

The CF schedule risk is highly influenced by the timely delivery of CM/GC technical services and the integration of this service with design. Risk elements are not adequately addressed in the project mitigation planning

The Committee noted that the previous recommendations regarding increasing schedule contingency, re-evaluation of the estimate for CF contingency, verifying ES&H flow down, planning for technical reviews (now at the 30 and 60 percent levels), and the necessity to define contractor lay-down areas were accepted.

Other recommendations regarding the merger of S20 and MMF contracts, and the construction of an undulator hall mockup were considered, but not implemented with reasons for rejection provided at this review.

3.3 Recommendations

1. Review the management and support staffing at all levels to ensure the level of competence, experience, and availability reflects the integrated schedule requirements.

2. Immediately resolve the process of implementing the procurement for the CM/GC contract. Use the existing A/E to deliver an integrated design at the 30 percent point of Title II design that includes a constructability review.

3. Conduct a thorough review of all design parameters that affect the environmental and physical dimensioning of the tunnel structures and reflect the least conservative physics values that can be addressed through other technical means.

4. Update the risk registry and project planning approach to reflect an adequate mitigation strategy in view of the 50 percent cost overruns for the first two bid packages.

5. Quantify the plan for schedule recovery in the CF activities based on the current understanding of schedule loss created by the delayed CM/GC contract award.

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 LCLS TPC was baselined, in April 2005, at CD-2b (Approve Performance Baseline) at $379 million (as spent). A breakdown of the current cost estimate can be found in Appendix D. It contains $315 million for construction funded activities (TEC), contingency of $73.6 million, which is approximately 33.3 percent of the TEC, and $64 million for Other Project Costs (OPC). There is approximately $5.5 million of management reserve in OPC. Through FY 2004, the project has received $13.39 million in PED funds and $3.5 million of Operating Expense funds (for conceptual design, NEPA support, and R&D). The FY 2005 budget contains $19.92 million in PED funds, $29.76 million for long-lead procurements, and $4.0 million for R&D. The President's FY 2006 Budget Request contains $2.54 million for PED activities, $83.0 million for construction activities, and $3.5 million in Operating Expense funds. The baseline funding profile for the LCLS project is contained in Appendix E.

As a result of the August 2004 DOE review recommendations, the LCLS Program Manager, BES, requested a DOE mini-review to assess the changes between the proposed cost and schedule baseline in August 2004 and the current baseline of $379 million with completion (CD-4) in March 2009. This review was conducted in November 2004. The summary report from this mini-review indicated "that the LCLS has responded adequately to the August 2004 DOE review recommendations." The details of the proposed baseline provided for this review formed the basis for CD-2b. This increase was mainly a result of the project positively responding to the August 2004 DOE review recommendations by increasing the project office staffing, increasing the CF construction management costs and tunneling costs, adding six months to the overall schedule, and increasing contingency and management reserves.

The November 2004 DOE mini-review confirmed that recommendations to re-evaluate the cost estimate, cost contingency, and project schedule were satisfactorily implemented. The Committee also confirmed that the recommendations that addressed the frequency of updating the Risk Registry, the near-term procurement plans to realistic start dates and durations, and construction contract durations to accommodate the potential complexity of work have been adequately incorporated.

Project representatives presented cost estimate information to each of the technical subcommittees (see Sections 2 and 3 for cost estimate comments on specific systems).

At the end of March 2005, the Risk Registry documented 60 risks. As recommended at the August 2004 DOE review, the Risk Registry is a controlled document that involves input from the entire project team and is now updated monthly.

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 12,345 tasks, 7,565 of which have allocated resources. The work is divided into 585 distinct work packages. The proposed date for CD-4 (Approve Start of Operations) is now March 2009. The project critical path appears to be well understood**.** The two most sensitive critical paths for LCLS have 216 and 250 calendar days of schedule contingency respectively, relative to project completion. The first critical path starts from the Undulator Hall beneficial occupancy to installing the undulators to first light to commissioning to CD-4. The second critical path starts from the MMF beneficial occupancy to measuring and testing of the undulators to installing the undulators to first light to commissioning to CD-4. The LCLS summary schedule is included in Appendix F.

The resource-loaded schedule for the LCLS was baselined at CD-2b. The schedule for Level 1 LCLS project milestones is as follows:

CD-0	Approve Mission Need	June 2001 **(A)**
CD-1	Approve Preliminary Baseline Range	October 2002 **(A)**
CD-2a	Approve Long-Lead Procurement Budget	July 2004 **(A)**
CD-2b	Approve Performance Baseline	April 2005 **(A)**
CD-3a	Approve Start of Long-Lead Procurement	December 2004 **(A)**
CD-3b	Approve Start of Construction	February 2006
CD-4	Approve Start of Operations	March 2009

LCLS has 29 Level 2 milestones and about 142 Level 3 milestones. Milestones at all three levels are reviewed and monitored regularly by the LCLS Project Office.

4.2 Comments

The Committee felt that, in general, the cost estimate was adequate. The practice of preparing Estimates-to-Complete on a semi-annual basis should be continued. The Committee commended the project for increasing the contingency by an additional $13.9 million since August 2004 and for identifying scope margins that could be used to generate more contingency.

This represents progress towards enhancing the likelihood of success. In addition, the pre-operations management reserve was increased to reflect the 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. Revising the Risk Registry update periodicity from semi-annually to monthly should prove to 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 and is commended for providing an increased schedule contingency to 216 days (approximately ten and one-half months). 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 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 entire Project Control team is staffed by subcontractors to SLAC. This appears to be consistent with past practices used by previous SLAC projects. The SLAC employee responsible for overall Project Controls is the Chief Engineer, although cost account managers are predominantly SLAC employees. There is no evidence that this arrangement has created issues—the one advantage mentioned is that the contractors bring a vast knowledge of project control systems that may not otherwise reside at SLAC.

The Configuration Control System appears to be working adequately. Baseline Change Requests (BCR) are only processed once a month. As the Title II activities wind down and construction activities commence, only processing BCRs at monthly Change Control Boards (CCB) will likely prove inadequate. Additionally, Level 4 BCRs do not necessarily include impact assessments by other technical areas.

4.3 Recommendations

1. Benchmark, by June 1, 2005, the proposed durations from the CM/CG Statement of Work to award with the experience of the very similar Molecular Foundry CM/CG contract to ensure that the current plan is realistic.

2. Process BCRs as frequently as needed—as Title II activities wind down and project construction activities commence, processing BCRs monthly will create problems.

3. Consolidate Level 4 CCBs to ensure that the impact on all technical areas is included.

5. PROJECT MANAGEMENT

5.1 Findings

The LCLS project cost and schedule baselines were approved in April 2005. The approved project baseline (CD-2b) is consistent with the recommendations provided at the August 2004 DOE review. The project baseline established a TEC of $315 million and a TPC of $379 million. The project schedule calls for project completion (CD-4) in March 2009. The LCLS project baseline includes a total OPC of $64 million that includes a management reserve. Prior to the LCLS project baseline being approved in April 2005, the baseline was satisfactorily reviewed by a DOE EIR.

The LCLS project is about eight percent complete. Overall project status reflects the approval of CD-3a (Start of Long-lead Procurement) in December 2004. CD-3b (Start of Construction) is planned for February 2006, and the project appears to be on track for meeting this schedule. FY 2005 also marks the end of R&D funding for the project. The project funding increased significantly from $9.46 million in FY 2004 to $53.68 million in FY 2005 and project staff will increase from about 56.8 full-time equivalents (FTE) in FY 2004 to 104 FTEs in FY 2005. Much of the increase in funding ($44.22 million) is associated with long-lead procurements. The overall contingency is 33 percent and schedule contingency is about 26 percent. Reported project cost and schedule variances are small (around two percent through March 2005).

The LCLS Management Team has been enhanced and the LCLS organization has evolved since the August 2004 DOE review. A lead physicist, construction safety professional, Electron Beam Systems Manager, and Photon Beam Systems Manager have been added. The overall LCLS project is organized by WBS, with the interfaces managed through the use of Interface Control Documents. Jacobs Engineering (A/E) has been on-board for some time but the GC/CM contract, another key participant in the construction of the LCLS, has not yet been awarded. A procurement cell has been established as part of the LCLS project with $2 million in approval authority. Procurement training for technical managers is being established to ensure that the procurement process and requirements are well understood throughout the project.

The LCLS project includes SLAC, ANL, and LLNL. Memoranda of Understanding are in place between SLAC and the partner organizations (ANL and LLNL). The PEP describes the roles and responsibilities of the three partner organizations. Regular communication channels are open among the partner organizations and a cooperative atmosphere exists. Both ANL and LLNL have been able to meet their staffing projections. Implementation of project controls is in place for all three organizations.

Key project documents and systems are in place and operating, but some improvements are still required (see recommendations). LCLS has an integrated cost and schedule with a critical path. A Project Earned Value System and a Change Control System are in place. Monthly status reports are being generated. A risk analysis is used to support the levels of cost contingency and schedule contingency. A Risk Registry has been prepared and is reviewed monthly. Risks are added, re-evaluated, and if appropriate retired.

The role of SLAC in the Office of Science is evolving; moving from a high energy physics focus to a photon science mission. SLAC management described their commitment to the success of this project and the revised mission of the laboratory to perform photon science. Specific actions include two “All Hands” meetings by the Laboratory Director to explain the change in emphasis at SLAC associated with the “Safety First” culture and the move to “photon science”.

Each of the presenters discussed the importance of ES&H in accomplishing the assigned work. The LCLS project is establishing a comprehensive construction safety program for the project that includes Integrated Safety Management principles. SLAC is still recovering from an electrical arc flash accident in the fall of 2004 that resulted in the Laboratory Director stopping most operations at SLAC until an ES&H review was conducted. A corrective action plan was developed and the corrective actions are underway. These corrective actions will impact the way that SLAC and the LCLS project conduct business.

LCLS presented their preliminary start-up and commissioning plans for the facility. Milestones have been integrated into the LCLS master schedule. Preliminary staffing levels and funding were identified. The project stated that they will continue to develop these plans.

The LCLS Instrument Major Item of Equipment (see Section 7), a separate project but one that needs to demonstrate a close coordination with the LCLS project, was presented and appropriate plans are being developed.

5.1.2 Comments

Notable progress continues to be made on all elements of the LCLS project. The project baseline has been approved and the LCLS project organization and design continue to mature. Project staffing is increasing and arrangements are in place to co-locate the LCLS staff. The positive working relationship among the partner organizations (SLAC, ANL, and LLNL) is notable. Long-lead procurements have begun. SLAC and the LCLS project adequately responded to the recommendations from the August 2004 DOE review. While the LCLS project continues to show progress toward the start of construction, some improvements are still needed prior to the approval to start construction (CD-3b). While the Committee had some reservations concerning the start of construction with the existing systems in place, it is anticipated that the needed changes are understood by SLAC and LCLS management and these changes will occur prior to the next DOE review in November 2005.

The lack of a CM/GC reduces the ability of the LCLS team to perform the necessary planning and preparations for the start of construction. Further, the absence of the CM/GC introduces significant risk to the constructability (quality) of the Title II construction drawing package. LCLS and SLAC management should pursue an aggressive path to expedite the DOE review and approval of the CM/GC contract. Support from the DOE Stanford Site Office and DOE Headquarters will be needed to assist in meeting the procurement approval schedule.

Discussions with the separate LCLS technical WBS elements raised some questions concerning the management of overall project requirements, the associated management of interfaces among the separate elements, and control of those requirements and interfaces. While the partnership among SLAC, ANL, and LLNL is working well, the LCLS should ensure that ANL and LLNL are tightly linked into a single integrated CCB to ensure that all the technical, cost, and schedule issues can be resolved and decisions made on a timely basis. A schedule is needed for "freezing" the specific technical requirements that impact Title II design. The project experience with the early procurements demonstrates that continued attention is needed to ensure that the construction estimates are comprehensive and accurate, and that schedules are being met. The Committee understood that the A/E has made some changes in their development of cost estimates.

The LCLS project has implemented their P3/Cobra project control system. This allows the project to integrate their costs and schedules, including the use of a single database for multiple purposes. A contractor assists the LCLS management team in this area. There is a continuing need to ensure that critical path milestones (or near critical path milestones) are checked each month, even though the project earned value management system does not assign significant values to these particular milestones. While cost and metrics are available, they were not displayed at each of the WBS review presentations. Future DOE reviews should ensure that this information is included in each of the WBS presentations.

LCLS management needs to be diligent in maintaining adequate levels of contingency for the project. This effort should include continued value engineering studies, ensuring that additional scope is not inadvertently added, and that the design and procurements do not exceed the actual requirements that directly contribute to technical completion of the project.

The project management staff continues to expand through additions of senior level expertise, although, in many cases these senior level individuals are new and their contributions are still evolving.

The LCLS Control Systems are spread among separate WBS elements, which do not provide distinct visibility for Controls (see Section 2.5). This introduces additional responsibility for LCLS management to ensure that this work is appropriately coordinated and managed.

There is a need to define and commit SLAC resources (people/infrastructure/systems) for initiation of construction. For example, the Committee identified project needs for electrical engineers, laser optics technical support, and construction management. Each of the SLAC organizations needs to understand how they support the construction of the LCLS. This includes the management resources needed to manage the interface between the A/E and CM/GC contractors.

5.1.3 Recommendations

1. Award the GC/CM contract as soon as possible. By June 13, 2005, the LCLS project needs to work through the reviews and comments on the GC/CM contract and issue the request for proposals for this contract—Site Office and DOE Headquarters support will be provided.

2. Identify, by July 15, 2005, the specific needs for the LCLS project to ensure that adequate SLAC resources are provided to fully support the LCLS construction as a primary element of SLAC. This includes the management needs of the CM/GC contract such as the interface between the A/E and the CM/GC contracts.

3. Clear roles and responsibilities need to be identified and communicated for the SLAC organization units by July 15, 2005. Ensure the SLAC organizations understand how they support the accomplishment of the LCLS project.

4. Integrate, by July 1, 2005, the CCBs into a single board that evaluates technical, cost, and schedule risks and changes. The LCLS project should ensure that both ANL and LLNL input are adequately linked to the change control process.

5. Ensure that interface and requirements management is effective. Specific major project decisions on technical changes need to be scheduled to ensure that decisions are timely. The project parameters list (PRD 1.9-001 rev 1) needs to be updated, reviewed, approved, and maintained by the integrated CCB by July 15, 2005.

6. ENVIRONMENT, SAFETY and HEALTH

6.1 Findings and Comments

The project has developed an Integrated Safety Management (ISM) plan that has been promulgated to project personnel. ISM principles are being applied in the development of LCLS project construction safety program.

LCLS management recognizes the importance of safety in the conduct of contracted work. The LCLS has taken steps since the August 2004 DOE review to establish a comprehensive construction safety program for the project that includes ISM principles. The LCLS Project Director retained a safety consultant to structure this safety program and has also hired a full-time safety coordinator who is very familiar with the workings of SLAC. The construction safety program (CSP) being developed contains the same ISM principles that were applied to the Spallation Neutron Source, National Ignition Facility, Advanced Photon Source, and Molecular Foundry projects.

The model used to develop the LCLS CSP has been proven to work at other sites, and it meets industry standards and ISM principles. The project plans to be ready to implement key elements of this new program in time for the S20 and MMF contracts in June 2005. The Committee fully supported and encouraged rapid and thorough application of the CSP.

In the aftermath of the arc blast incident (Type A Investigation) in October 2004, and several contractor related incidents subsequent to that, SLAC has recognized that they also need to develop a more effective contractor safety management processes. In recognition of this, SLAC has assembled a working group that includes LCLS staff to rectify this situation. The contract safety specifications in the statement of work for the LCLS CM/GC have been reviewed by the LCLS safety consultant to assure that appropriate safety requirements have been included.

SLAC has charged its Citizens Committees with participating in the LCLS design review process. The Committee found that the authority of these committees and their involvement in this process is unclear, as some committees have “approval” authority while others limit their involvement to offering observations.

LCLS is in the initial steps of Title II CF design and beginning design of technical systems. LCLS has yet to define safety criteria for the technical systems. The LCLS Project Director has charged his safety staff to develop such criteria. This will serve two functions: 1) it will assure LCLS project management that standards are being applied on its associated work being performed by collaborating laboratories; and 2) it will set the stage for a smooth transition and uniformity of safe work practices at SLAC when the equipment and personnel from partner laboratories come to LCLS.

In developing its technical system designs, the LCLS project should consider including equipment configurations that address current safety standards (such as the recently promulgated NFPA 70E arc blast exclusion zones, e.g., remotely actuated rack-out of breakers), as well as anticipate changes in future standards.

Various safety procedures are in use across SLAC divisions. Installation, activation, and operation of LCLS shared equipment with different procedures and staff could compromise the safe work environment.

The project has already begun considering how it will demonstrate to DOE that the appropriate prerequisites of personnel, procedures, and safety of hardware have been met prior to technical system startup (Operational Readiness Review).

The Preliminary Hazards Analysis Report, the Environmental Assessment and the Preliminary Safety Assessment Document are complete. The Fire Hazards Analysis is in process and is on schedule to support the construction schedule.

The ES&H recommendations made by previous DOE reviews have been satisfactorily addressed.

ES&H activities will rapidly transition to implementation and the focus will shift to ensure effective field implementation. This includes field monitoring and audit of contractor safety implementation and LCLS management safety walk-throughs.

6.3 Recommendations

1. Clarify the role and responsibilities of the SLAC Citizens Committees for ES&H by June 30, 2005.

2. Develop an ES&H plan by July 31, 2005. Include delivery dates for completion of the LCLS ES&H elements, ES&H staffing, and SLAC ES&H support for the LCLS project.

3. Compile technical specifications and safety criteria for equipment that is being developed by LCLS and its partner laboratories and adopt the “best practices” to be uniformly used by August, 31 2005.

4. Review LCLS systems that are used by other SLAC organizations and develop a common safety program for shared use before the next DOE review.

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7. INSTRUMENT MAJOR ITEM of EQUIPMENT

7.1 Findings

SLAC is preparing to initiate a conceptual design study for a suite of four instruments that would apply the extraordinarily bright LCLS X-ray source to experiments in a broad range of scientific disciplines. DOE and SLAC have agreed that these instruments should be grouped together as a single Major Item of Equipment (MIE) project. Review of the MIE project focused on whether SLAC has adequately prepared (e.g., organized and staffed) to start conceptual design of the instrument MIE project.

A formal process, including letters of intent, workshops, advisory committee meetings, and proposals was established to engage representatives from a broad range of areas within the scientific community in defining science thrust areas for LCLS. This process led to the selection of three science thrust areas that are covered by four proposed instruments. A fifth instrument covering atomic, molecular, and optical (AMO) science will be built as part of the LCLS project. The formulation of science thrust areas and subsequent selection of instrument concepts has already led to significant involvement by scientists and future users of the LCLS facility.

The Committee found that the organization needed to execute the MIE project is defined well enough for the CD-0 stage. Key positions have been identified although many still remain to be filled, and technical interfaces are defined at an appropriate level. The staffing ramp-up plan is reasonable and necessary to support an aggressive Phase 1 schedule, which envisions two of the four instruments operating in a limited manner by mid-FY 2008. Accomplishing this aggressive schedule relies on filling some key positions over the next six months (e.g., lead engineer, three instrument scientists), which would require FY 2006 funding of about $1.5 million that is not currently budgeted.

7.2 Comments

Plans for integrating the MIE science and technical teams with LCLS (especially with the AMO instrument) in a practical way, regardless of organization, are encouraged. Measures should be taken to ensure that the MIE project and LCLS teams work together to integrate the two projects with the goal of maximizing scientific impact.

Integration of administrative and support efforts (e.g., ES&H, project controls, finance) with LCLS should also be done to ensure efficient use of resources. Establishing an implementation plan, signed off by both project management teams, would help to initiate this integration process.

The roles and responsibilities of the science thrust area leaders/teams relative to the interface with the MIE project for all phases of project execution and into operation of the experiments should be clearly defined. This will be required soon for the project execution phase (e.g., Preliminary PEP for CD-1), but addressing this early will avoid confusion.

7.3 Recommendations

1. Include a member of the MIE management team on the LCLS CCB.

2. Create an "Implementation Plan" that formalizes a mutual agreement to coordinate the division of resources between the instrument MIE and LCLS projects.

APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government Department of Energy

memorandum

DATE: April 1, 2005

REPLY TO ATTN OF: SC-12

SUBJECT: INDEPENDENT PROJECT REVIEW FOR THE LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

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

I would like to request that you organize and lead an Office of Science (SC) semi-annual status review of the Linac Coherent Light Source (LCLS) project at the Stanford Linear Accelerator Center (SLAC) during May 10-12, 2005. The purpose of this review is to evaluate progress in all aspects of the project: technical, conventional facilities, cost, schedule, management, and environment, safety and health (ES&H).

The LCLS project is in the process of starting Tktle II design activities and placing long-lead procurements. These long-lead items include the 135 MeV injector linac, undulator modules and their associated magnetic measurement system, and main linac magnets and RF systems. Actual construction start is scheduled for March 2006.

In addition to the LCLS construction project, SLAC is preparing to initiate a Major Item of Equipment (MIE) project called the Photon Instrumentation for X-ray Experiments at LCLS (PIXEL). It will provide the LCLS facility with additional experimental instrumentation once the LCLS is completed. The committee should also evaluate SLAC's preparations to start conceptual design of this MIE project later in FY 2005.

In carrying out its charge, the review committee should respond to the following questions:

1. Are the project's cost, schedule, and technical baselines consistent with those in the FY 2006 LCLS Construction Project Data Sheet and the current DOE-approved LCLS Project Execution Plan (e.g., Total Project Cost of $379 million and CD-4 in march 2009), and is there adequate progress to meet the baseline objectives? Is the information in the DOE Project Assessment Reporting System consistent with physical progress?

2. Are the designs of the technical systems sufficiently mature to support the long-lead procurements planned in FY2005? Will the procurement plans support the project schedule requirements?

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

4. Is the project being managed (i.e., properly organized, adequately staffed) as needed to proceed with construction? Is there adequate support from SLAC in all necessary areas (e.g., procurement, human resources, etc.)?

5. Is SLAC adequately prepared (e.g., organized and staffed) to start conceptual design of the PIXEL MIE project?

6. Are ES&H aspects being aggressively addressed and are future plans sufficient given the project's current stage of development?

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

Jeff Hoy, the LCLS Program Manager, will work closely with you as necessary to plan and carry out this review. I would appreciate receiving your Committee's report within 60 days of the review's conclusion.

[signed]

Patricia M. Dehmer
Associate Director of Science
for the Office of Basic Energy Sciences

cc:
H. Lee, SSO
N. Sanchez, SSO
K. Hodgson, SLAC
J. Galayda, SLAC
M. Reichanadter, SLAC
J. Hastings, SLAC
P. Montano, SC-12
J. Hoy, SC-12
L. Cerrone, SC-12
M. Martin, SC-10
E. Rohlfing, SC-13
P. Debenham, SC-22
S. Tkaczyk, SC-81
K. Hodgson, SLAC

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the Linac Coherent Light Source (LCLS) Project
May 10-12, 2005

Stephen E. Tkaczyk, DOE/SC, Chairperson

SC1	SC2	SC3	SC4	SC5
Accelerator Physics	**Injector/Linac**	**Undulator**	**Photon Beam Handling Systems**	**Control Systems**
Sam Krinsky, BNL	* George Neil, TJNAF	* Kem Robinson, LBNL	* Al Macrander, ANL	* Dave Gurd, ORNL
	Zenghu Chang, KSU	Erik Johnson, BNL	Robert Schoenlein, LBNL	Michael Thuot, Consultant
		David Robin, LBNL		

SC6	SC7	SC8	SC9	SC10
Conventional Facilities	**Cost and Schedule**	**Project Management Procurement/Pre-Ops**	**ES&H**	**Endstations**
Dixon Bogert, Fermilab	* Bob Simmons, PPPL	* Robert Wunderlich, DOE/CH	* Arnold Clobes, LLNL	* John Haines, ORNL
Jerry Hands, SNL		Jeff Atherton, LLNL/NIF		
Dale Knutson, ANL		Bruce Warner, LLNL/NIF		
		Les Price, ORO/SNS		

Observers

Pat Dehmer, DOE/SC	Michael Casassa, DOE/SC
Jeff Hoy, DOE/SC	Hanley Lee, DOE/SSO
Pedro Montano, DOE/SC	Nancy Sanchez, DOE/SSO
Kristin Bennett, DOE/SC	Jim Krupnick, LBNL

LEGEND

SC Subcommittee
* Chairperson

Count: 21
(excluding observers)

APPENDIX C

REVIEW AGENDA

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

AGENDA

Tuesday, May 10, 2005—Bldg. 41, Redwood Room

8:00 am	DOE Executive Summary	D. Lehman
9:00 am	Welcome	J. Dorfan/P. Dehmer
9:15 am	Welcome/Photon Science at SLAC	K. Hodgson
9:30 am	Project Overview	J. Galayda
10:00 am	LCLS Integrated Safety Management System	M. Scharfenstein
10:30 am	LCLS Project Management	M. Reichanadter
11:00 am	Break	
11:15 am	Injector-Linac System Overview	E. Bong
11:45 am	Undulator System Overview	S. Milton
12:15 pm	Lunch	
1:00 pm	X-ray Transport/Optics/Diagnostics System Overview	R. Bionta
1:30 pm	Endstation System Overview	S. Moeller
2:00 pm	Conventional Facilities Overview	D. Saenz
2:30 pm	LCLS Global Controls Overview	L. R. Dalesio
3:00 pm	Break	
3:30 pm	Pixel Status	J. Arthur
4:00 pm	Breakout Groups Meet with LCLS Breakout Teams	
5:00 pm	DOE Executive Session	D. Lehman
6:30 pm	Adjourn	

Wednesday, May 11, 2005

8:00 am	Breakout Sessions (see page 2 agenda)
12:00 pm	Lunch
1:00 pm	Tour (Linac/Research Yard/Future Construction Site)
2:00 pm	Additional Breakout Sessions
3:00 pm	DOE Executive Session

Thursday, May 12, 2005

8:00 am	DOE Closeout Dry Run	Lehman
10:30 am	Closeout Presentation to LCLS Management	
11:30 am	Adjourn	

APPENDIX D

COST
TABLE

LCLS Cost Baseline

WBS	System	Budget ($M)
1.0	LCLS Project TEC	
1.1	**Project Management**	**29.30**
1.2	**Injector System**	**18.46**
1.3	**Linac System**	**26.75**
1.4	**Undulator System**	**48.59**
1.5	**X-ray Transport and Diagnostics**	**26.60**
1.6	**X-ray Endstations**	**14.88**
1.9	**Conventional Facilities**	**76.78**
	TEC Base Budget	241.36
	Contingency	73.64
	TEC	315.00
2.0	LCLS Project OPC	
2.1	**Project Management**	**33.15**
2.2	**Injector System**	**6.15**
2.3	**Linac System**	**2.54**
2.4	**Undulator System**	**7.10**
2.5	**X-ray Transport and Diagnostics**	**4.39**
2.6	**X-ray Endstations**	**5.21**
	OPC Base Budget	58.54
	Management Reserve	5.46
	OPC	64.00
	Total Project Cost (TEC + OPC)	379.00

APPENDIX E

FUNDING TABLE

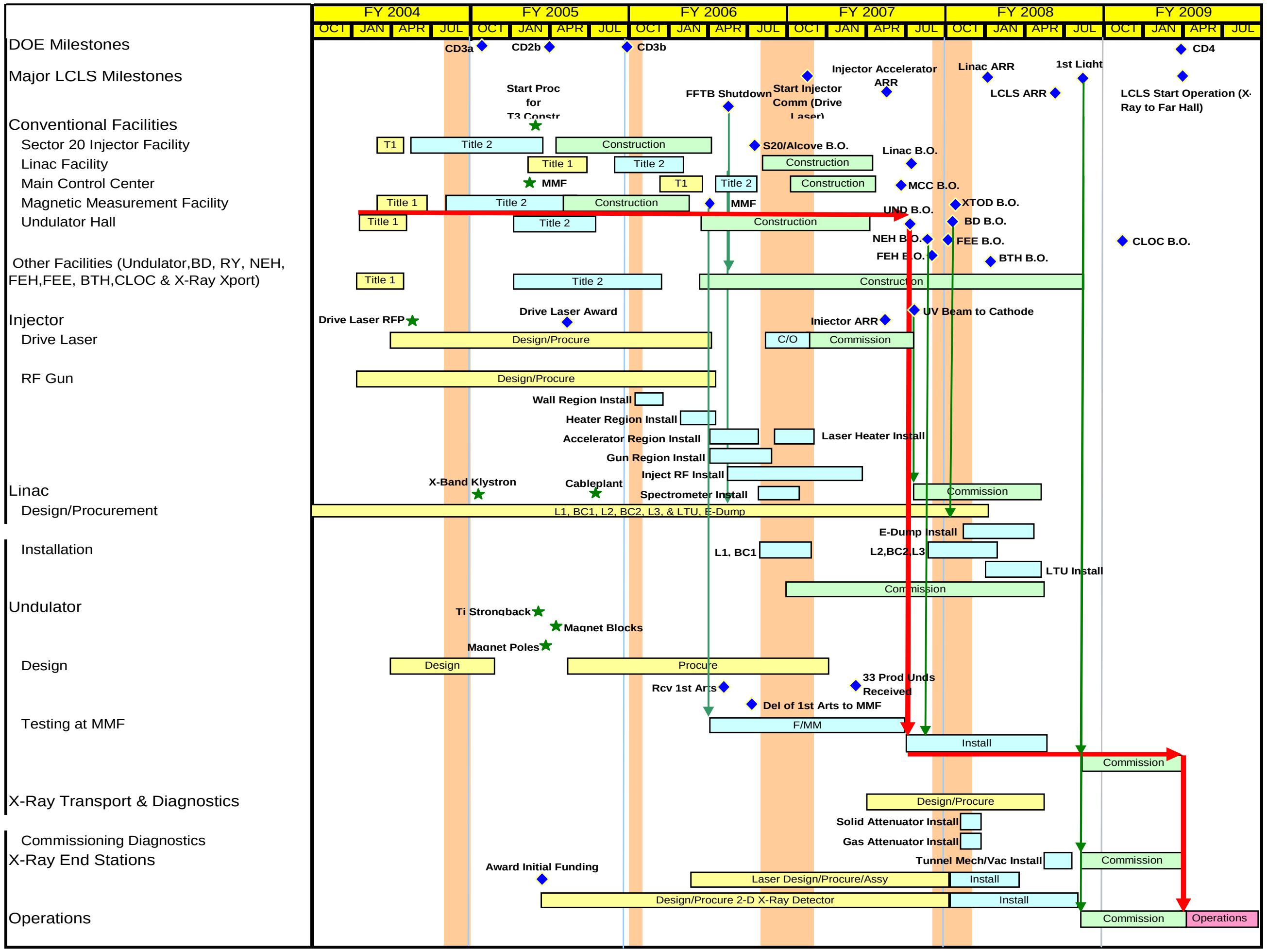
LCLS Funding Table

Linac Coherent Light Source Funding Profile (AYM$)									
	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	Total
TEC Funding	**0.00**	**5.93**	**7.46**	**49.68**	**85.54**	**105.90**	**50.50**	**10.00**	**315.00**
PED		5.93	7.46	19.92	2.54	0.16			36.00
LLP				29.76					29.76
Constr					83.00	105.74	51.00	9.50	249.24
OPC Funding	**1.50**	**0.00**	**2.00**	**4.00**	**3.50**	**16.00**	**15.50**	**21.50**	**64.00**
R&D	1.50		2.00	4.00					7.50
Spares						6.00	2.00		8.00
Pre-Ops					3.50	10.00	13.50	21.50	48.50
Total Funding	**1.50**	**5.93**	**9.46**	**53.68**	**89.04**	**121.90**	**66.00**	**31.50**	**379.00**

APPENDIX F

SCHEDULE CHART

LCLS Schedule Chart



APPENDIX G

ACTION ITEMS

Action Items
DOE Review of LCLS
May 10-12, 2005

ITEM DESCRIPTION	DUE DATE	RESPONSIBILITY
1. Resolve all comments and issue the Request for Proposal for Construction Manager/General Contractor activities.	June 13, 2005	LCLS / SC / SSO
2. The Laboratory Director will conduct an assessment and report to the Director, Office of Basic Energy Sciences, the necessary resource commitments from SLAC to ensure the readiness of the project to proceed with construction as a primary element of SLAC.	June ~~13~~ 23, 2005	SLAC Director
3. Conduct the next DOE Review	November 2005	LCLS / SC

12 MAY 2005
John N. Galayda
LCLS Project Director
SLAC

5/12/05
Steve E. Tkaczyk
Review Chair
Office of Project Assessment
DOE Office of Science

Jonathan M. Dorfan
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