Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

May 2009

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science (SC) review of the Linac Coherent Light Source (LCLS) project, at the SLAC National Accelerator Laboratory (SLAC), was conducted on May 13-14, 2009, at the request of Dr. Harriet Kung, Associate Director for Basic Energy Sciences, SC. The purpose of this review was to evaluate progress in all aspects of the project: technical; conventional facilities; cost; schedule; management; and environment, safety and health (ES&H). A specific objective was to ensure the project has an adequate 'end game' plan that assures successful completion of the project.

The Committee found that the project has made excellent progress since the May 2008 DOE/SC review, in particular fabricating hardware, completing the major portion of construction, commissioning, and beginning a controlled and gradual transition to operations. The viability of constructing a full-scale version of a fourth generation free electron laser (FEL) X-ray light source is proven, and the light beam exceeds performance objectives for commissioning. The project is actively working to begin early science operations and optimize final work scope decisions. The Committee concluded that the project is on-track to successfully achieve the scientific, technical, cost, and schedule goals of Critical Decision (CD) 4, Approve Start of Operations.

The LCLS project is a multi-laboratory partnership (with partners are Argonne National Laboratory and Lawrence Livermore National Laboratory) led by the LCLS Project Office at SLAC. When completed, the LCLS will be a world-class scientific user facility to provide laser-like radiation in the hard X-ray region of the spectrum that is ten billion times greater in peak power and peak brightness than any existing coherent hard X-ray light source. The LCLS project will provide the first demonstration of an X-ray 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.

Fabrication and construction work is more than 91 percent complete as of March 2009. Construction of underground and surface facilities necessary to produce X-ray light is complete. The injector, linac, bunch compressors, and undulators are installed and operating. The accelerator is operating at the design point and is consistent with the particle beam simulations. FEL performance is consistent with measured electron beam properties. Beam wavelength and flux performance meets the CD-4 requirements for commissioning.

The Total Project Cost remains at $420 million and project completion is scheduled for July 2010. Designs, procurement, and commissioning plans are sufficiently mature to support the project schedule. Final work scope planning is underway. Cost estimates and expenditures are being reviewed to update the remaining cost contingency. The cost information will be used to optimize final (‘end-game’) decisions for office space and scope enhancements. The remaining cost, schedule, and technical baselines are consistent with those in the FY 2009 LCLS Construction Project Data Sheet and the current DOE-approved LCLS Project Execution Plan. The information in the DOE Project Assessment Reporting System (PARS) is consistent with physical progress.

The LCLS project has addressed sufficient instrument scope issues to enable the X-ray beam to meet or exceed CD-4 objectives for operations. Higher resolution Beam Position Monitors are ordered and planned to enter service in August 2009. A new Machine Protection System was successfully deployed. Successful beam performance enabled the project to lower the urgency for early implementation of wire scanners in sector 24.

Civil construction is nearing completion. The Turner subcontract work is complete but the contract is not closed. Negotiations over claims and retention continue. Most of the remaining work consists of constructing and commissioning the three hutches in the Far Experimental Hall (FEH); and providing office space for LCLS staff.

Scope enhancements were added to the Front End Enclosure (FEE) to boost operability and performance, including: FEE diagnostics; Soft X-Ray (SXR) integration and installation; H6 design and construction; and CDR for the Near Experimental Hall Annex. The FEE is scheduled to be commissioned by August 2009.

AMO designs are complete and fabrications are on schedule. Hutch designs are complete and construction bids are being evaluated. Structural steel is procured and in fabrication. Commissioning is scheduled to support beginning early science operations in September 2009**.**

Approximately $8 million of office space remains to be established to house LCLS staff. The project is deliberating whether to renovate Buildings 28 and 751 or proceed with a more expensive new construction alternative under a guaranteed maximum cost design/build contract. The location of the new building alternative would be significantly closer to LCLS work areas than renovated space. Five design/build proposals were received and are being evaluated. Designs and cost estimates for renovating Buildings 28 and 751 will be complete by June 1, and the project is prepared to solicit bids in the same month. The decision on which alternative to choose depends on the project having sufficient cost contingency to pay for the remaining work, and preserving a minimum of three months of schedule contingency to CD-4.

The project is properly managing work to complete commissioning. A LCLS directorate organization is established to manage operations and administration. Staffing of the new organizational structure is in progress. A controlled and gradual transition to LCLS science is underway. The injector, linac, undulator, magnetic measurement facility, and most LCLS conventional facilities are transferred to LCLS operations. A User Access Policy is in development.

The project is properly managing ES&H. Recommendations from the May 2008 DOE/SC review were adequately addressed. LCLS and the DOE/Stanford Site Office elevated safety oversight by increasing site presence, daily team walkthroughs, reinforce positive safety practices by engaging workers, and formation of a Safety Stewardship Committee. As a result, safety performance has significantly improved to desired ranges.

There were no action items resulting from this review.

In summary, the Committee found that LCLS has made satisfactory progress in all areas, and is on track for successful achievement of technical, cost, and schedule goals.

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1. INTRODUCTION

1.1 Background

The Linear Coherent Light Source (LCLS) is designed to be the world's first hard X-ray Free Electron Laser (FEL). LCLS will operate, as a scientific user facility at SLAC National Accelerator Laboratory (SLAC). The goal of the LCLS is to produce intense, ultrashort, coherent laser pulses of X-rays with wavelengths between 15 and 1.5 Angstroms. The technical approach is to inject the energetic electron beam from the SLAC LINear ACcelerator (linac) into undulator magnets in order to generate synchrotron radiation of two types—spontaneous emission, as well as Self Amplified Spontaneous Emission (SASE) X-rays. When fully operational, the LCLS scientific user facility will enable researchers in the U.S. and abroad to apply this new X-ray tool to the study of ultrafast chemical reaction dynamics, precision imaging of macromolecules, novel physical effects (of atoms, molecules, and condensed matter), and behaviors of other material systems.

The LCLS beam's peak brightness, coherence, and ultrashort (sub-picosecond) pulses will vastly exceed those of current X-ray sources (e.g., other synchrotron radiation sources and 'table-top' X-ray lasers). Producing this beam will be an important engineering feat, and using a beam with these characteristics will be the goal of early scientific experiments. These experiments plan to probe material system effects that can only be detected with the LCLS beam; that is, they depend upon one or more of the LCLS X-ray beam properties (unique characteristics not available elsewhere) for their detection. The LCLS Scientific Advisory Committee (SAC), working in coordination with the broad scientific community, identified several such high-priority initial experiments in the document, *LCLS: The First Experiments* (SLAC-R-611, September 2000).

The scope of LCLS project is to build the facilities and equipment needed in order to produce the X-ray beam and direct it to locations of experimental stations, including

- An injector (laser light pulses impinging upon a photocathode to produce electrons in a radio frequency (RF) gun that are accelerated and steered into Section 20 of the linac);
- Modifications to the last kilometer of the linac system, including installation of magnetic bunch compressors and beam diagnostics for the electron beam;
- A Beam Transfer Hall (BTH) to direct the energetic electron beam to the undulator;
- Construction of a Front End Enclosure (FEE), Near Experiment Hall (NEH), X-ray transport tunnel, and Far Experiment Hall (FEH), all below grade;

- X-ray beam optics, diagnostics, and controls systems; and
- An Undulator Hall (UH, built under a hill to aid in temperature stability), containing undulator magnet assemblies composed of sections of rare earth magnets that when aligned produce a magnetic field to oscillate and bunch the electron beam (producing X-rays), and a vacuum system whose chamber vessel is compatible with the electron and X-ray beams.

Current plans call for LCLS to deliver the X-ray beam to several endstation locations (or ‘hutches’) in the NEH and FEH that will contain instrumentation to enable experiments of different types to be performed. As part of the LCLS construction project, one instrument—designed for atomic, molecular, and optical physics studies—will also be built (in the NEH) to support early science experiments.

Major Milestones for the LCLS Project

Below is a brief history of the LCLS project’s progress to date to achieve major milestones. More complete descriptions are included in other project documentation.

This project’s formal history began with Critical Decision (CD) 0, Approve Mission Need, approved by the Acquisition Executive, Dr. Raymond Orbach, Director of the Department of Energy (DOE) Office of Science (SC), on June 13, 2001. The mission need summarizes the technical specifications and scientific value of the LCLS. Next, SLAC and its two partner laboratories (Argonne National Laboratory (ANL) and the Lawrence Livermore National Laboratory (LLNL)) developed a conceptual design and a supporting cost estimate and schedule, which a DOE/SC committee reviewed in April 2002. Dr. Orbach then approved CD-1, Approve Preliminary Baseline Range, on October 16, 2002, a decision that authorized the project to start preliminary (Title I) design using Project Engineering Design (PED) funding in FY 2003.

During FY 2003, the project completed Title I design of the long-lead items planned for procurement in FY 2005, and presented these results to a DOE review committee. This 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 CD-2a, Approve Long-Lead Procurement Budget, which was approved on July 2, 2003, by the Acting Acquisition Executive for Science, Dr. James F. Decker. This approval enabled long-lead procurement funds 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 Central Laboratory and Office (CLO) Building in the LCLS scope.

The FY 2004 funds enabled the project to acquire architect engineering (A/E) services from Jacobs Facilities, Incorporated, 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 CF was completed in May 2004. In preparation for CD-2b, Approval of the Performance Baseline, the Office of Engineering and Construction Management (OECM) chartered the contractor Burns and Roe Enterprises, Incorporated (BREI) to perform an External Independent Review (EIR). BREI performed an on-site visit at SLAC in June 2004, and a final report in August 2004. The EIR team concluded, "the LCLS project can complete the baseline scope within the baseline schedule by September 30, 2008, and Total Project Cost (TPC) 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 stood in the way of approving CD-2b.

DOE/SC conducted a review of the LCLS project in August 2004 in order to determine the project's readiness for CD-2b and CD-3a, Approve Start of Long-Lead Procurement. This review 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 proposed baseline TPC and schedule and submit a revision to DOE/SC by October 2004, which the project did. This revised project 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 (TEC) work and 10.5 months, respectively) in keeping with the committee's recommendations. It also included the impact of the FY 2005 Continuing Resolution (CR) that lasted until December 2004. DOE/SC conducted a mini-review of the proposed baseline cost and schedule, chaired by the LCLS Federal Project Director, in November 2004. This Committee, which contained several members of the August 2004 DOE/SC review committee, concluded that the proposed TPC and schedule were reasonable.

The FY 2005 Appropriation for LCLS included funds for long-lead items that were critical path components. These components included items such as the 135 MeV injector linac magnets, drive laser, RF gun system, the X-Band microwave system, bunch compressor magnets, the undulator strong back, undulator magnets, magnet blocks, renovations for Section 20 of the linac, and the magnetic measurement facility (MMF) needed for verification of undulator performance. On December 10, 2004, CD-3a was approved, so as not to delay placement of the FY 2005 long-lead procurements. From January through March 2005, the project underwent a limited EIR by BREI at the direction of DOE OECM to validate the proposed baseline cost and schedule ($379 million TPC and March 2009 completion date). The limited EIR ultimately resulted in an OECM validation of the LCLS baseline, and Dr. Orbach approved the proposed baseline (CD-2b) on April 11, 2005.

In May 2005, a DOE/SC committee conducted a status review of LCLS. The committee's primary concerns were the schedule delay in getting the construction manager/general contractor (CM/GC) solicitation out for bid, and the Laboratory's inadequate level of support for the project as an institutional priority. Both areas received action items. During the remainder of FY 2005, good progress was made in fabricating long-lead procurement items (undulator strong backs, magnet poles and blocks, and facility modifications for Linac Section 20 and the MMF), and the A/E worked towards completion of Title II design of the CF.

The CM/GC procurement was finally awarded in October 2005 to Turner Construction and its partner for tunneling work, Hatch Mott McDonald. The CM/GC reviewed and provided input to the Title II CF design, and the A/E delivered the 100 percent Title II drawings to SLAC in early February 2006, with a corresponding cost estimate to arrive later that month. On March 21, 2006, CD-3b, Approve Start of Construction was obtained.

Since then, the project received bids for Turner subcontracts in civil construction that grossly exceeded estimates (due in part to the escalated costs in the San Francisco Bay Area for construction materials and labor). To proceed within available resources, project management sought to replace the new CLO building construction with less expensive renovated space elsewhere at SLAC, and used available contingency to make awards for the other construction activities.

FY 2007 was the project's peak year of spending, with a Presidential budget request of approximately $122 million. However, a lengthy CR prevented the project from receiving funds until February 2007, and appropriated funds were approximately $8 million less than the full request. Therefore, not all of the originally scheduled FY 2007 project activities could be undertaken, within available resources. The DOE Directed Change caused the project to delay activities which resulted in project indicators (e.g., the schedule performance index, cost performance index, and available contingency) showing significant cost and schedule overruns to the baseline plan for progress to date. Planning exercises in value engineering led to some concepts for re-baselining the project. The purpose of re-baselining would be to facilitate completion of the LCLS project, thereby meeting its mission need, in a better management approach (e.g., with more realistic cost and schedule parameters) than the current baseline plan offered due to the Directed Change. This re-baseline was then pursed, using an EIR site visit in October 2007 and its follow-on report, and was formally accomplished by a memorandum from the DOE Deputy Secretary dated January 24, 2008, and a memorandum from the Office of Science dated February 7, 2008. The revised baseline set the project's TPC at $420 million, with a Level 2 milestone for LCLS' readiness to support early science by September 2009, and a project completion date of July 2010.

1.2 Charges to the DOE/SC Review Committee

Dr. Harriet Kung, Associate Director of Science for the Office of Basic Energy Sciences, requested in a March 24, 2009 memorandum (see Appendix A), that Daniel R. Lehman, Director of the Office of Project Assessment (OPA), organize and lead a review to evaluate progress of all aspects of the LCLS project. The review elements included technical, cost, schedule, management, and ES&H issues. The purpose of this review was to assess the project's status.

1.3 Membership of the Committee

The OPA formed a Committee composed of members (see Appendix B) selected based on their independence from the project, as well as for their technical and management expertise, and experience with building large and complex scientific research facilities. The Committee was organized into nine subcommittees, each assigned to evaluate a particular aspect of the project corresponding to members' areas of expertise. Daniel Lehman, OPA, chaired the Committee.

Experience on projects with similar features was the primary method used by Committee members for assessing technical designs, cost estimates, schedules, and adequacy of the management structure. Although the LCLS project requires some technical extrapolations to address its technical challenges, similarities exist with other scientific facility construction projects and related technical systems in the United States and abroad, and these similarities provide a relevant basis for comparison.

1.4 The Review Process

Prior to the review meeting, the LCLS project team provided downloadable project documents and other project information to the Committee for early study. The Committee conducted an on-site review at SLAC in Menlo Park, California, during May 13-14, 2009.

Representatives from SLAC, the DOE Stanford Site Office (SSO), DOE/SC, and the DOE/OPA jointly developed the meeting agenda (see Appendix C).

The first day of the review consisted of presentations given by SLAC staff and discussions to answer detailed questions from the Committee. The LCLS project managers and other principals overviewed project activities, civil construction status, and developments to date on major technical systems and components. The Committee toured the site to view progress to date. The first day ended with breakout sessions and an Executive session so the Committee could assess the review progress.

Breakout sessions continued the second day for additional follow-up questions and issues of interest to the Committee. The Executive Sessions at the end of the first and at the middle of the second day were devoted to Committee deliberations, report writing, and drafting a closeout report. The Committee determined the third day was unnecessary and scheduled the closeout briefing at the end of the second day.

2. TECHNICAL SYSTEMS

2.1 Accelerator Physics

2.1.1 Findings

Progress in commissioning the injector, linac, and bunch compressors has been outstanding. The commissioning team demonstrated great physical insight and technical skill in achieving such excellent results. Beam quality at the end of the linac meets the requirements for CD-4 Lasing milestones and operations.

Safety is integrated into all planning for the accelerator systems.

The MatLab-based control applications have greatly facilitated commissioning. The sophistication of these applications, written very quickly by the physics group, is impressive. There will be a natural transition of these systems to more overview level programs as operations crews take over, but already many of the programs are being used by operations staff in addition to physicists. In general, transitioning to operator control is a work in progress and is at the appropriate stage of development.

Expected availability for this linac-based system is projected to be less than storage ring users are used to normally. Discussions with users are essential to ensure this is properly factored into experiment planning.

This area has met the CD-4 requirements for wavelength and flux early and on budget.

2.1.2 Comments

Plans to replace beam position monitors (BPM) with more modern high resolution ones should proceed as quickly as possible. The present system performance is an impediment to commissioning and operations.

Integration of the control of the old linac hardware with the new LCLS control system is of great importance. Replacement of legacy controls is important to meet availability and control for users. For example, the ability to perform trajectory feedback is limited in some sections of the accelerator.

The output SASE depends on a great many beam and system parameters. Developing a start-to-end simulation model and placing it in correspondence with the experimental observations will be of great value in understanding and optimizing the FEL system behavior. At present, the work toward implementing start-to-end simulations available on-line for commissioning is not proceeding.

It is incumbent on the team to understand the details of the lasing and linac performance so that others in DOE and the international community can apply the lessons. Beam studies with experimental comparisons to models need to be completed for reduction of design contingency in future LCLS upgrades and for benefit of other machines. Ideally this would include end-to-end modeling.

The linac and FEL team deserves much praise for meeting their milestone early and obtaining superior performance of the laser. This was thanks to the exceptional electron beam and wiggler performance. The achievement required insight into new physics and subtle effects and required delivering to very demanding engineering specifications. The Committee commended the scientists and management of the LCLS for this outstanding achievement.

2.1.3 Recommendations

None.

2.2 Injector/Linac

2.2.1 Findings

The accelerator is operating at the design point and the measured beam quality is consistent with the particle beam simulations. Although not all of the electron beam properties are measured in detail due to diagnostic limitations, the FEL gain and saturation length are consistent with the measured and simulated electron beam properties. Based on present results, all beam-dependent, CD-4 milestones are well managed, and in fact will be well exceeded.

Attaining this performance is an exceptional accomplishment, and these results demonstrate the practicality of fourth generation FEL X-ray light sources!

2.2.2 Comments

Two recommendations were made at the May 2008 DOE/SC review. The first recommendation was to establish a schedule for early implementation of wire scanners in sector 24. This recommendation has been superseded by the successful operation of the FEL, and so the priority for implementing wire scanners is lower, relative to other required systems.

The second recommendation was to implement a plan for installing higher resolution BPMs in the remaining linac. The LCLS team has followed up on this recommendation. The components have been ordered, planned to be installed in July, and operated in August. The installation of the higher resolution BPMs should enable more repeatable and faster energy change for X-ray wavelength variations.

The following two comments are not part of project construction scope. One significant hardware concern that still needs to be addressed is the upgrade of the RF legacy computer components and power supplies to modern systems. The use of legacy Vibration Monitoring Systems (VMS) causes a difficulty in synchronizing the older systems with the modern control system and therefore makes operations more difficult. This could impact future flexibility and might result in some unscheduled down-time.

The other comment that is not part of project construction scope has to do with operations at 120Hz. Initially, the Committee was told that high-power 120 Hz operations were last performed in 1997. During the out brief, Project Director John Galayda said that the last high-power operation was in 2003. Still, operating at this duty factor again for prolonged operation periods could produce component failures and result in unanticipated down-time. Determining which components might be susceptible to failure due to the higher duty factor and developing a strategy for replacements could increase later availability.

The LCLS team has made an accomplishment that is truly extraordinary, and several world-class results have been attained.

The demonstration of the production, bunch compression, and propagation to an undulator at 14 GeV of sub-micron emittance electron beams at a substantial fraction of a nanocoulomb is remarkable. The possibility that an electron beam of this brightness could be generated and propagated to the undulator entrance was met with heavy skepticism in some scientific quarters. This question has been laid to rest. The second significant demonstration is that the electron beam slice emittance from a photoinjector is not longitudinally mixed, maintained to the undulator entrance, and in agreement with simulations. This demonstration will have significant financial impact through a reduction in contingency in beam performance parameters for future machines, as well as for future upgrades of the LCLS.

The next technical accomplishment was reaching the design point of 10 GW of 1.5 Å laser light. The gains and saturation levels attained are consistent with the electron beam slice properties. In reference to the preceding comment on contingency reduction, the undulator was designed with a factor of two longer than simulations indicated, was required in case the electron beam properties were not met, a $20 million cost increase. This undulator investment will not be lost since a longer undulator can be tapered for increased efficiency (demonstrating this now) or be used for a second beamline. This paves the way for the next generation of light sources world-wide.

Perhaps most impressive is that the FEL was brought to full power in a couple of weeks from the undulator being installed and first beam transport through the undulator. The expected commissioning time to reach a machine operating point is typically planned to be a year. To attain this level of performance in so short a time has to do not only with the excellent planning and careful attention to detail, but with the experience the team garnered from operating a high-energy collider beams in the past—an excellent training ground. Still to reach this level of performance so quickly implies a very robust system and bodes well for users and for future fourth generation machines world-wide.

2.2.3 Recommendations

None.

2.3 Undulator

2.3.1 Findings

The scope of the LCLS Undulator System includes undulator magnets and supports, undulator diagnostics, vacuum systems, controls for the undulator equipment, and the magnet measurement facility. Integration and installation are also included within this area. The project has developed the 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 at any given time. One is reserved as a standard.

In the present configuration, an undulator magnet is integrated onto a girder that also includes an electromagnet quadrupole, a RF 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 girder will be aligned as a unit in the undulator tunnel on a fixed support structure. The girder is mounted on 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).

The Committee took opportunity to reflect on the spectacular progress of the project with regard to the undulator development and commended them for their high level of accomplishment.

Thinking back to the inception of the project, the length of undulator required rivaled the installed worldwide inventory of insertion devices at that time. The tolerances and specifications for these devices were beyond the existing state of the art for FEL undulates and diagnostics. During the construction, the team met the challenges of developing value engineered designs and construction methods, as well as developing and refining technologies for component manufacture including the RF BPMs and fabrication techniques to control chamber roughness. The project also built a MMF that was optimized for production throughput while meeting the stringent precision requirements of the project. The capabilities of the undulator system have been utilized to great advantage in facilitating the commissioning of the FEL including moving the insertion devices in and out of the beam remotely (turning them on and off segment by segment), exploiting the canted poles to adjust undulator K ‘on the fly’, and employing the precision alignment capabilities to facilitate rapid tune up of the FEL.

With respect to cost, schedule and contingency, the undulator reported 99.33 percent complete against a TEC of $45.720K as of March 2009. Baseline objectives for this part of the project have all been met or exceeded. Design, procurement, and commissioning plans are *defacto* mature in as much as 28 of the 33 undulator modules have been installed. All 33 are planned to be installed by June of 2009. And of course FEL Saturation achieved at 1.5 Å with 18 undulators installed (less were actually needed to saturate).

Functionality of the undulator systems has been clearly established. The project has a remaining risk registry entry for mechanical failure of the undulator system. During commissioning the undulators are being monitored for radiation induced performance degradation. The project has in place a rotation plan for periodically taking undulator modules out of service, measuring them, and if necessary retuning or repairing them before returning them to service.

The Committee found that the LCLS Undulator Systems Team has been responsive to the recommendations May 2008 DOE/SC review. The specific recommendations included:

1. Complete the re-fiducialization of undulators as necessary and assure that 33 are ready for installation to meet project schedule.

   Project response: Undulator tuning and fiducialization is nearing completion on schedule. Undulator system beam commissioning began without the undulator magnets installed. This allowed commissioning to proceed at a faster pace without the concern of damage to the magnets. At this time, 25 magnets are installed. The installation of the remainder of the magnets is scheduled for June 2009.

2. Do not proceed with enhancements of the ‘good field’ region requiring magnetic measurement until recommendation 1 is achieved.

   Project response: Upon further analysis, including tolerance stack-up, it was found the ± 2.5 mm spec on motion in the good field region could not be guaranteed, the x-trajectory shims interfere with the vacuum chamber, and therefore had to be replaced, allowing the ± 6mm good field region to be used. In addition, the x-translation stops on the girders had to be set prior to the girders' installation. Resetting the x-stops in the field was not considered a viable option. Therefore the x-trajectory shims are being replaced (as they must be), and the x-stops are being placed to take advantage of the larger good field region.

3. Consider developing response plans for undulators should they experience temperature excursions outside of specification (during storage, transit, or after installation).

   Project response: Tests were done moving girders and undulators from the MMF to the Undulator Hall and back. There is a better understanding of the limits in temperature and handling that the undulators and girders can safely see. The Undulator hall HVAC is now operational and is being closely monitored through the Undulator Control system.

2.3.2 Comments

A number of valuable lessons learned have emerged, regarding the production, measurement, and tuning of undulators over the duration of the LCLS project. These lessons could prove to be valuable for future upgrades of the LCLS, as well as other projects throughout the DOE complex. In addition to lessons learned as a result of project difficulties, examples of positive lessons include the new and cost effective model for industrial production of undulators, and the development of an effective mass production scale facility for undulator measurement and tuning. These lessons learned should be captured in a project wide database and shared throughout the DOE complex.

Also of note, the project recognized the importance of accurate magnetic measurements in an accelerator project at an early stage, and invested adequate budget for the MMF. Tthis is a contributing factor to the exceptionally successful commissioning result. Finally, the Committee noted that more accurate monitoring of the neutron dose to the undulators may be beneficial. It is possible that in addition to moderated thermal luminescence detectors, other types of neutron monitors such as uranium fission detectors could be usefully employed.

2.3.3 Recommendations

1. Incorporate the valuable knowledge gained by the team during the development and construction of the undulator systems into the project lessons learned. Include sufficient detail that this knowledge can be utilized by SLAC/LCLS staff to guide future work, as well as being shared in a meaningful way across the complex (Complete by CD-4)

2. Maintain measurement facility and develop repair capabilities as continuing risk mitigation strategy against possible radiation damage of undulators (continue to CD-4 and beyond).

2.4 Photon Beam Handling Systems

2.4.1 Findings

The reviewers were pleased at the considerable progress made in the Photon Systems area since the May 2008 DOE/SC review. During the past 12 months, there has been several changes in manpower and scope in the X-ray Transport and Diagnostic (XTOD)/X-ray End Stations (XES) area:

- Geoff Pile is now responsible for Photon Beam Systems Installation and Engineering (effective March 2009).
- X-ray beam transport scope from the near experiment hall to the far experiment hall has been removed from LLNL and is now the responsibility of SLAC.
- Far Experiment Hall now includes three hutches and equip mezzanine.
- LCLS has agreed to cover the installation of the beamline and integration (into the LCLS facility) controls, laser interface, etc. for a Soft X-Ray (SXR) instrument.

Geoff Pile, who managed the now completed insertion device portion of the LCLS project, has been assigned to manage the installation and commissioning of the XTOD and XES. To better coordinate the SLAC and LLNL effort, he has initiated weekly meetings, attendance at which is required by members of both teams. The estimated cost of the X-ray beam transport was reduced when that responsibility was given to SLAC.

The new SXR instrument has been added to the LCLS program, the soft X-ray (SXR) instrument. The end-station for the SXR beamline will be funded by a consortium formed between Stanford University, the University of Hamburg, CFEL (at DESY), and Lawrence Berkeley National Laboratory (LBNL). The LCLS will provide the beamline and optics. This required LCLS to use $1,500K from project contingency; however, it will leverage an additional $2927K from consortium members for the end station and so the Committee judged that it was a good decision.

Installation and commissioning of XTOD and XES components is progressing. There has been concern by the reviewers during previous reviews regarding on-time delivery and installation of both the soft and hard X-ray mirrors that allows the X-ray beam to enter the near experiment hall.

All mirrors have been were received at LLNL, most are coated. A few had to be sent sent back to the vendor for further polishing (at vendor expense), and LCLS awaiting the return of the last mirror. The project has enough mirrors delivered, and could do without the final if necessary (i.e., there are two spares). However, the project is waiting to see the final mirror, in order to pick the best two mirrors for installation.

Vacuum chambers for the collimators have yet to arrive and some components are yet to be designed. All this leads to a very tight installation schedule for the mirrors. Nonetheless, there seem to be no showstoppers to reach the CD-4 milestones. However, the success of the early science experiments could be at risk should the installation slip and/or the commissioning schedule be reduced.

2.4.2 Comments

Many of the FEE components are novel/unique components. This, combined with the very tight installation and commissioning schedule will likely be a challenging exercise. Similarly, the Atomics Molecular Optics (AMO) installation and commissioning schedule is also ambitious, but seems to be achievable. The current schedule calls for complete mechanical instrument installations by June 30, the start of AMO commissioning in July (without Refocus

System and Magnetic Bottle), installation of the Refocus Optics by the end of July, and Users in September. The SXR schedule is even more ambitious, particularly considering the SXR instrument had a slow start due to funding issues. However, the Committee judged that this is achievable as well. The Committee expected that the FEE and AMO commissioning will be greatly aided by the good performance of the FEL. LCLS staff expected that lasing may require many weeks this summer; however, good FEL performance should help to make commissioning proceed very smoothly and quickly.

Finally, the Committee judged that a very close collaboration will be required between the controls group and experimenters to minimize the user's frustrations and assure productive and successful early science.

2.4.3 Recommendation

1. Members of the LCLC and LLNL teams need to continue the close coordination efforts during the push over these next, last several months to insure that the delivery, installation, and commissioning of the remaining FEE components meets the proposed schedule.

2.5 Control Systems

2.5.1 Findings

The electron-beam controls efforts are essentially complete, including the newly deployed machine-protection-system. Some of the credit for the successful production of 'first light' is due to these controls, bolstered by an impressive suite of MatLab-based physics applications. Clearly, the electron-beam controls meet CD-4 requirements. However, there is room for improvement that would enhance the LCLS program—including support for more rapid energy changes, and 120Hz feedback systems. 'Off project' efforts are underway to address both these issues.

The remaining controls activities involve photon beamlines and end-stations, including 'slow' controls, data acquisition (DAQ), and integration with the machine protection system (MPS) and personal protection system (PPS).

In January, a $1.14 million cost variance was reported. This was related to excess labor charges associated with XTOD installation. This seems to be a one-time issue, unlikely to recur.

2.5.2 Comments

Cost and schedule seem adequate for remaining work. No significant technical issues remain.

Much of the electron-beam control system continues to depend on legacy SLAC systems. This could hamper achieving future LCLS availability/uptime goals. Upgrades are occurring ‘off project’ via Accelerator Improvement Projects (AIP) and operations funds.

There is still a separation between the MatLab applications developed by the physics group, and XAL-based and other applications developed by the controls group; however, this is now an officially recognized approach—supported by an external review. The controls group supports infrastructure for developing applications—including online models, MatLab-EPICS connectivity tools, and other controls infrastructure. The controls group also supports the XAL-based LINAC-energy-management system (required for rapid energy changes), and feedback systems. The physics group develops the high-level applications. This approach is used at several light sources and has been effective. Observing control room operations, staff appears to be able to effectively use the hybrid system.

Recently, the reality of user-provided detector equipment became apparent—beginning this year with the CAMP module use at AMO. This results in controls integration issues, and may result in increased need for a “staging area” to perform system integration prior to first use. The project should continue the practice of establishing clear and documented interfaces/processes so that users and Photon Controls and Data Systems (PCDS) group adequately review integration issues for user furnished detector equipment. This dialogue should occur early in the process of designing the endstation. The project should also provide adequate infrastructure and time in a staging area prior to installation into the hutch in order to optimize of beam-time usage when bringing in external endstations.

2.5.3 Recommendations

None.

3. CONVENTIONAL FACILITIES

3.1 Findings

The LCLS Conventional Facilities (CF) scope represents a significant (over 40 percent) fraction of the LCLS TEC ($352 million). The current CF baseline estimate at completion (EAC) is now $143.6 million. The work under the Turner contract is completed. Notice of Substantial Completion was issued on November 17, 2008. All work was completed on April 24, 2009.

The Turner contract is complete but not closed. Negotiations over claims and retention continue. Additional recent and remaining activities with respect to the Turner contract include:

- Redline mark-ups sent to Jacobs (engineer of record) for Record Drawings
- 23 of 26 trade subcontracts require closeout binders
- Turner has returned to San Jose Offices
- No final retention amounts have been released
- Townsend Audit – Phase II (audit of Western Maintenance T&M subcontract)

Other CF work remaining is approximately $11.0 million, which includes Office Space, $6.4 million; Far Experimental Hall Hutch Construction, $4.2 million; and the Far Experimental Hall Electrical Substation Installation, $415K.

The Title II design for the office space renovations planned in the project baseline for Buildings 028 and 751 is nearing completion. An RFP is anticipated in June and Notice to Proceed in July. Construction completion is planned for March 2010. The preliminary cost estimate for this work is $6.4 million, which includes $3.8 million for Building 028, $1.4 million for Building 751, and $1.2 million for Engineering Design and Indirect Costs.

An alternative approach was presented that in not in the baseline. This approach called for a new building close to the NEH with a guaranteed maximum-price, design-build contract at approximately $8.9 million. Construction would be completed at the end of April 2010. The scheduled completion would be one quarter prior to CD-4.

Safety had been an issue on the civil construction site. Since the May 2008 DOE/SC review the safety record has improved tremendously: all work accomplished without injury (Total Recordable Rate (TRR) and Days Away and Restricted Time (DART)).

The project has responded appropriately to the recommendations from the May 2008 DOE/SC review—with exception of the Turner claim, which has taken longer than expected to closeout.

3.2 Comments

The underground and surface facilities necessary to produce X-ray light have been completed, equipment installed, and X-rays produced. A very impressive facility was shown to the reviewers on tour.

The remaining CF work in the baseline consists of two activities: 1) construction of three hutches in the FEH; and 2) creation of some office space by refurbishment/rehabilitation.

The design work for the hutches is complete; bids for construction are due May 19, 2009. The structural steel required has already been procured and is being fabricated. The design for rehabbing/refurbishment of two existing SLAC locations (parts of Buildings 28 and 751) is almost complete, and the project is prepared to bid this work in June 2009.

The project has prepared an alternate option in lieu of the refurbishment of Buildings 28 and 751. The alternate is to construct a new 'LCLS Office Building' under a 'guaranteed maximum' design-build contract. In order to have a firm basis of choice, a conceptual design report and specifications were prepared, proposals have been solicited, received, and are being evaluated. The execution of this 'guaranteed maximum' contract will exceed the current cost baseline for this portion of the project work. The project must evaluate carefully the available contingency for the entire project before committing to proceed. The work can be completed within the schedule contingency to CD-4.

The project has the information and methodology to make an informed decision on whether it is possible to proceed with the more expensive 'guaranteed maximum' contract for construction of new office space.

Safety performance during the final work of the Turner contract improved. The safety record on work outside the Turner contract continues to be good.

The closeout of retention and settlement of the Turner contract claims has been slow. This does not appear to be due to the LCLS project management. The project could consider a counterclaim to Turner to offset LCLS management expenses associated with the time connected with closing the contract, as well as for the increased safety oversight during the contract work.

The project should be congratulated on the facilities construction accomplishments to date.

3.3 Recommendations

1. Carefully review the contingency available across the project before any commitment is made to proceed with the "guaranteed maximum" procurement of the proposed LCLS Office Building option in lieu of the baselined building renovation projects.

2. Continue to examine and implement proactively all possible factors necessary to achieve an exemplary safety record during the remaining work.

3. Closeout the Turner contract.

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4. ENVIRONMENT, SAFETY and HEALTH

4.1 Findings and Comments

The project responded appropriately to recommendations from the May 2008 DOE/SC review.

Technical Systems Safety

The LCLS Technical Systems installation and commissioning activities reflect a systematic integration of safety throughout their respective processes. Safety is the highest priority. The activities are well managed with an exceptional safety record. In over 120,000 work hours no worker has been injured beyond minor first aid. The Total Recordable Rate (TRR) and Days Away and Restricted Time (DART) is zero. This is particularly noteworthy considering the high level of activity and complexity associated with the work.

The project managers, Installation and Commissioning Managers, and University Technical Representatives (UTRs) overseeing the work execution, supported by the project and SLAC ES&H Team, effectively communicate ES&H expectations. They proactively manage the work, provide safety guidance, provide feedback and through work planning and control, aggressively manage to Integrated Safety Management (ISM) core functions and guiding principles.

Daily “Tool Box” meetings are held before beginning work. Work Supervisors, coordinators, subcontractors, and SLAC workers attend. Only work for that day is authorized. The processes and procedures used have been proven to effectively provide for the safety of installation and commissioning work. On completion, Lessons Learned are integrated into the next cycle for continuous improvement.

Readiness Reviews are conducted consistent with the project status. Accelerator Readiness Reviews (ARR) and Instrument Readiness Reviews are in place to review phased turnover from commissioning to operations. The Safety Assessment Document (SAD) and Accelerator Safety Envelope (ASE) are expanded in stages consistent with phased commissioning. The SAD and ASE have been reviewed and approved by the DOE/SSO. The interactions between LCLS and DOE/SSO are collaborative and effective.

The Committee considered the LCLS Technical Systems installation and commissioning activities to be exceptionally well managed, consistent with ISM.

Transition to Operations and User Facility

ES&H personnel are in place and dedicated to developing Operations and User Facility safety programs. These are modeled after the SLAC experience and bench marked against similar programs at other national laboratories.

A comprehensive set of work planning and control processes and procedures based on ISM are in development. Included are: Standard Operating Procedures (SOPs); Safety Assessment of User Experiments; training requirements; and work authorization and control processes. LCLS has put in place and is fully engaged in the transition from a construction project to Operations as a User Facility.

Construction Safety

Since the May 2008 DOE/SC review the CM/GC and subcontractors have completed the conventional facilities work and demobilized from the site.

At time of the May 2008 DOE/SC review, the LCLS safety experience associated with the CM/GC was failing to meet DOE goals or the construction incident rate within the complex. A number of proactive measures had been put in place and the committee assessment at that time was these efforts were starting to show results.

An effective and collaborative effort between the LCLS management, SLAC, DOE/SSO and the CM/GC significantly improved the contractor safety performance. Emphasis was placed on positive safety reinforcement of workers, in addition to the review of work performance for safety compliance. The result was training and acceptance of the LCLS/SLAC ISM safety culture by the workers. The DART rate was zero from May 2008 to demobilization December 2008. This is noteworthy considering end of construction typically results in accentuated or new safety issues (e.g., loss of focus by CM/GC workers and field personnel as they think about the next job).

The efforts were guided by an LCLS End-of-Construction Safety Plan developed and implemented to address safety issues unique to job completion.

The CM/GC experience has been effectively captured and documented in two Lessons Learned documents for the benefit of future BES projects. One specifically addresses the CM/GC safety experience and the other is ES&H combined with project management experience. Lessons Learned applicable to the procurement process have been included in the solicitation and evaluation phases for future CM/GC type contracts.

LCLS ES&H Program

The LCLS ES&H staff is capable and has an effective working relationship with line management. The Committee found the number of staff may not be consistent with the challenging workload associated with the many concurrent LCLS activities.

There were no environmental incidents.

Project safety documentation (e.g. Fire Hazard Analysis, Hazard Analysis Report, SAD) is reviewed periodically throughout the project life cycle and is current.

ES&H processes developed by LCLS early in the project have been adopted and improved by SLAC, and are now being used in LCLS as institution wide processes. Included are: Work Planning and Control (WP&C), Safety Observations, and Construction Safety. This demonstrates an effective Continuous Improvement process.

Lessons Learned are prepared, reviewed and entered into an LCLS data base. The Committee judged that SLAC and the DOE complex could benefit from wider dissemination of these reports.

The LCLS Risk Registry states regular safety audits will be conducted at the completion of major activities as steps for handling ES&H risk. Safety audits have been done but dropped off in the past year. It would benefit LCLS to resume safety audits as a ES&H risk management tool.

4.2 Recommendation

1. Evaluate the ES&H staffing level required for Operations prior to start of User Program and adjust as necessary, by September 2009.

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5. COST and SCHEDULE

5.1 Findings

Project cost and schedule baseline information are realistic, reasonable, and consistent with the current version of the Project Execution Plan (PEP). The project performance is consistent with the cost and schedule objectives documented in the PEP and the project is highly likely to complete all specified technical objectives on time and within budget constraints. Selected LCLS project performance statistics through March 2009 are shown in Table 5-1.

Table 5-1. LCLS Project Performance Statistics

March 2009	$M			
	TEC	OPC	TPC	Source
Actual Cost of Work Performed	$315.6	$45.3	$360.9	March 2009 Monthly Report
Estimate to Complete	$29.4	$16.7	$46.1	J. Galayda Presentation
Estimate at Completion	$345.0	$62.0	$407.0	
Budget at Completion	$352.0	$68.0	$420.0	Project Execution Plan (Rev.3)
Total Available Contingency	$7.0	$6.0		
Percent Complete	91%	70%	89%	March CPR
Cost Performance Index	.99	1.06	1.00	March CPR
Schedule Performance Index	.98	.97	.97	March CPR

The project cost/schedule baseline assumes the project will receive full funding in first quarter of FY 2009. This assumption was used in developing the project baseline to plan for early science in July 2009. The project received a large portion of their FY 2009 planned funding in October 2009. This was a positive event because it allowed the project to plan and award early procurements which helped advance the planned work in FY 2009, early and full funding for FY 2009 allows the opportunity for early science another milestone planned in July 2009.

There are three scope enhancements totaling $4.5 million added to the baseline since the May 2008 DOE/SC review: 1) the addition of the SXR Instrument Installation and Integration totaling $1.5 million; 2) the addition of the Far Hall Hutch 6 and Mezzanine for a total cost of $800K; and 3) the addition of Building 28 office space area for a total cost of $2.15 million. A new construction alternative is under consideration for office space. The new office construction alternative would reduce the uncertainties of the renovation options by guaranteeing the maximum contract price, and is significantly closer to LCLS operations areas.

A bottoms-up contingency analysis including risk assessment provided by individual Control Account Managers (CAM) estimated that $6.8 million of contingency was sufficient to address perceived project risks remaining on the project (TEC work-scope). The project's Total Available Contingency (see Table 5-1) supported by a bottoms-up Estimates to Complete (ETCs) is in-line with the CAM's risk based contingency analysis.

Information in the DOE Project Assessment Reporting System (PARS) is consistent with the physical progress.

The project responded appropriately to cost and schedule recommendations from the May 2008 DOE/SC review.

5.2 Comments

Bottoms-up estimate to complete (ETC) have been developed and appear reasonable. The ETCs are developed by the CAMs as a part of the monthly performance reporting cycle. The ETCs include values that recognize impacts of cost and schedule variances and pending Baseline Change Requests.

Significant (reportable) cumulative cost and schedule variances exist in X-ray Transport (WBS 1.5), XES (WBS 1.6), and CF (WBS 1.9). Within X-ray Transport and XES, reasonable recovery plans have been developed and are reflected in the EAC. For X-ray Transport the schedule variance is projected to be recovered by late summer 2009. To better control performance and manage the completion of the work, weekly schedule coordination meetings are conducted between SLAC and LLNL.

Variances within CF result, partly, from the delayed release of contract retention balances and the delayed start of work associated with the FEH. The issue of contract claims raised during the May 2008 DOE/SC review remains unresolved. However, an assessment of the issue was conducted by independent professionals with previous relevant experience. They have provided valuable insight into the reasonableness of the outstanding claims and likely mediation/settlement outcomes. This input was used as the basis for adjusting the accrual amount management has included in the LCLS project budget baseline. The project is employing due-diligence on the contract claims. A reasonable path forward for resolution has been developed.

The EAC appears reasonable. A risk assessment (March 2009) validated $7.0 million of remaining contingency based on the EAC. Sub-project EAC and burn rates are reviewed monthly to update contingency.

5.3 Recommendations

1. The project should consider the new office construction option as an alternative to the renovation option currently in the baseline. The new construction alternative should be considered after reviewing bids for the Hutches, and available April/May performance data, to maintain the baseline. The project should also carefully review the project schedule recovery plans for X-Ray Transport and Diagnostics and XES.

2. The PEP was last updated in November 2007. The PEP should be updated if significant changes occur on the project such as the Tilt-up Building.

3. The Lessons Learned document is an excellent tool to document Lessons Learned for the benefit of other projects both within SLAC and within the DOE complex as a whole. The project should add a section for reporting cost/schedule lessons learned in this document to assist others in developing baseline plans for cost and schedule and to assist others in the development and preparation of an Earned Value Management System (EVMS) and preparation for an EVMS certification review.

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6. PROJECT MANAGEMENT

6.1 Findings

The LCLS project has continued impressive progress since the May 2008 DOE/SC review. Technical systems and civil construction are nearing completion. The main emphasis of the project is shifting to commissioning and operations. The project team responded well to the recommendations from the May 2008 review.

The project has developed an end-game plan supported by DOE and SLAC.

The LCLS project has constructive relationships with DOE, both at headquarters (DOE/BES) and the local DOE/SSO. All parties are fully committed to project success.

An LCLS directorate has been put in place and is engaged in the transition from a construction project to a user facility. Staffing of the new organizational structure of the LCLS directorate is in progress with a number of key positions still to be filled.

DOE recently raised the procurement authority for SLAC to $1 million that will streamline procurement actions.

The project has prepared a draft 'lessons-learned' document that captures information useful for future SC projects.

The LCLS project has a letter indicating that the AMO design meets the requirements of the AMO Design Team. The LCLS directorate has developed a process for requesting and reviewing proposals to use the facility. For the first round, 28 proposals were received from 219 scientists from 16 countries.

6.2 Comments

The Committee concluded that LCLS is on track for successful achievement of project technical, cost, and schedule goals.

DOE should continue to closely monitor progress of the project to CD-4 through the channels already in place. It is unlikely that another on-site progress review will be needed.

As pieces of the project are finished, they should be incorporated into a draft close-out report.

Plans for contingency usage and use of American Recovery and Reinvestment Act (ARRA) funds will continue to place high demands on the procurement office for the duration of the project.

As the laboratory continues the transition from single program to multi-program, overhead structure and rates may change.

Spending and staffing plans show a reasonable run-down to the end of the project.

Adequate time for the DOE review and approval of CD-4 should be incorporated into the project schedule.

6.3 Recommendations

1. Continue close and frequent communication between the project and DOE on progress towards completing the CD-4 deliverables in July 2010.

2. Start preparation of the Closeout report now so that a nearly complete draft is available at CD-4.

3. Monitor work load and staffing of the LCLS procurement office through project completion.

APPENDIX A

CHARGE MEMORANDUM

memorandum

DATE:

REPLY TO
ATTN OF: Office of Basic Energy Sciences, SC-22

SUBJECT: DEPARTMENT OF ENERGY REVIEW OF THE LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

TO: Daniel R. Lehman, Director, Office of Project Assessment, SC-28

I request that you organize and lead an Office of Science status review of the LCLS Project at the SLAC National Accelerator Laboratory during May 13-15, 2009. The general 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). A specific objective is to ensure the project has an adequate 'end game' plan which assures successful completion of the project.

During the past several months, the project has continued its civil construction and technical hardware procurement and installation activities, in preparation to meet the Level 2 Milestone, Approve Start of Near Hall Operations (scheduled for September 2009), and the Critical Decision-4 Project Completion Milestone (scheduled for July 2010). The project was 87 percent complete as of the end of January 2009.

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

1. Are the project's remaining cost, schedule, and technical baselines realistic, reasonable, and consistent with the current approved Project Execution Plan? Is the information in the DOE Project Assessment Reporting System consistent with physical progress?

2. Are the designs, procurement, and commissioning plans of the scientific and technical systems sufficiently mature to support the project schedule? Has LCLS properly addressed instrument scope issues identified by the Instrument Development Teams?

3. Has the renovation of office space (Buildings 28 and 751) been integrated into the appropriate project planning and execution documents, and is progress appropriate to complete this renovation as scheduled?

4. Are risks properly managed and is there adequate contingency (cost and schedule) to address the risks inherent in the remaining work?

5. Is the project properly managed (organization, adequate staffing) to complete construction and technical equipment installation and commissioning? Does the project have the 'end game' properly planned and are they capable of completing the project as defined in the Project Execution Plan? Is transition-to-operations planning adequate?

6. Are ES&H aspects being properly addressed?

7. Has the project responded approapiratley to recommendations from prior DOE and other reviews?

The BES program will further address the current status of the project and any corresponding questions the reviewers should consider at the opening executive session of the review.

Thomas Borwn, the LCLS Program Manager, will serve as the Office of Basic Energy Sciences point of contact for this review. I would appreciate receiving your committee's report within 60 days of the review conclusion.

/signed/

Harriet Kung
Associate Director for Science
for the Office of Basic Energy Sciences

cc:
P. Golan, SSO
H. Lee, SSO
H. Joma, SSO
P. Drell, SLAC
D. Knutson, SLAC
J. Galayda, SLAC
M. Reichanadter, SLAC
S. Tkaczyk, SC-28
P. Montano, SC-22.3
T. Brown, SC-22.3
L. Cerrone, SC-22.3

APPENDIX B

REVIEW PARTICIPANTS

Linac Coherent Light Source (LCLS) Project
May 13-15, 2009
Daniel R. Lehman, DOE/SC, Chairperson

SC1 Accelerator Physics	SC2 Injector/Linac	SC3 Undulator	SC4 Photon Beam Handing Systems
* George Neil, TJNAF	* Richard Sheffield, LANL	* Erik Johnson, BNL	* Dennis Mills, ANL
Michael Borland, ANL		Steve Marks, LBNL	Mark Beno, ANL
		Toshiya Tanabe, BNL	Zahid Hussain, LBNL

SC5 Control Systems	SC6 Conventional Facilities	SC7 Cost and Schedule	SC8 Project Management
* Larry Hoff, BNL	* Dixon Bogert, Retired FNAL	* Cathy Lavelle, BNL	* Brenna Flaugher, Fermi
Elder Mathias, CLS	Mike Schaeffer, BNL	Angus Bampton, PNNL	Chad Henderson, DOE/PNSO
		Ray Won, DOE/SC	

SC9 ES&H	Observers		LEGEND
* Arnold Clobes, LLNL	Pedro Montano, DOE/SC	Brian Huizenga, DOE/OECM	* Chairperson
	Tom Brown, DOE/SC	Bob Raines, DOE/OECM	
	Hanley Lee, DOE/SSO		
	Hannibal Joma, DOE/SSO		

Count: 20 (excluding observers)

APPENDIX C

REVIEW AGENDA

Department of Energy Review of the
Linac Coherent Light Source (LCLS) Project
May 13-15, 2009

REVIEW AGENDA

<u>Wednesday, May 13, 2009—B048/ Redwood Room, Building 48</u>

8:00 am	DOE Executive Session	Executive Committee
8:30 am	Welcome	P. Drell
8:45 am	LCLS Directorate Overview	D. Knutson
9:00 am	Project Overview & Assessment	J. Galayda
9:45 am	Project Management	M. Reichanadter
10:15 am	Break	
10:30 am	Safety	M. Scharfenstein
11:00 am	LCLS Commissioning	P. Emma
11:30 am	Photon Beam Systems Project Activities	G. Pile
12:00 pm	Lunch	
1:00 pm	Readiness and Start of Experiments	J. Schneider, J. Arthur
1:30 pm	Conventional Facilities	J. Albino
2:00 pm	Electron Beam Systems Wrap-up	D. Schultz
2:30 pm	Break	
2:45 pm	Tour of LCLS	
4:15 pm	DOE Executive Session	
6:30 pm	Adjourn	

<u>Thursday, May 14, 2009</u>

8:00 am	DOE Breakout Sessions (See detailed agendas)	Subcommittees
12:00 pm	Lunch	
1:00 pm	Breakout Sessions Continue	Subcommittees
3:00 pm	DOE Executive Session	Executive Committee
6:00 pm	Adjourn	

<u>Friday, May 15, 2009</u>

8:00 am	DOE Executive Session	Executive Committee
9:00 am	Closeout Dry Run	Executive Committee
10:30 am	Closeout Presentation	All
11:30 am	Adjourn	

APPENDIX D

COST
TABLE

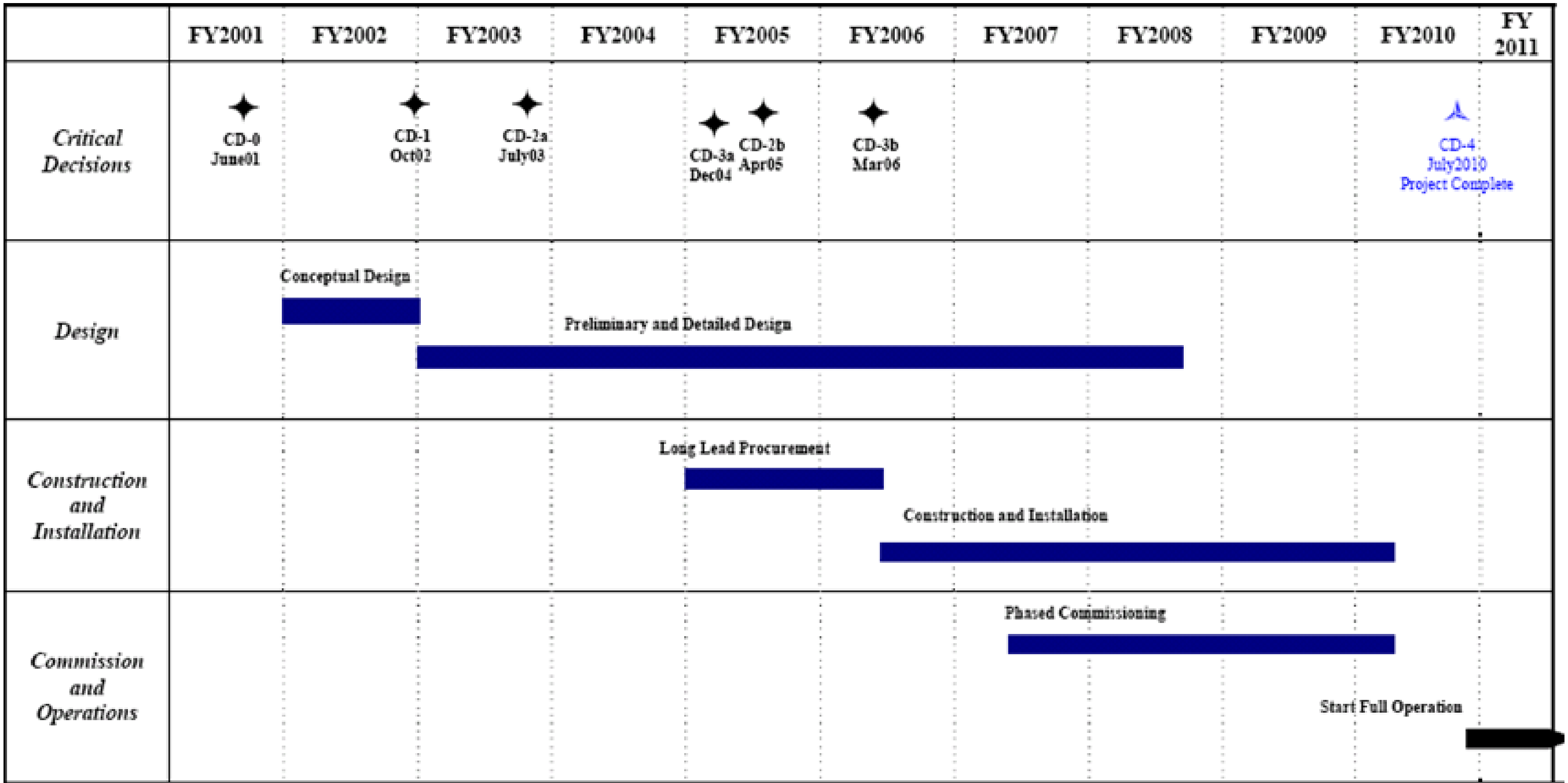
LCLS Cost Table

LCLS Baseline Performance - March 2009 (AYK$)			
WBS	Work Accomplished	% Complete	Total Budget at Complete
1.1 Project Management	$ 21,185	93.75%	$ 22,599
1.2 Injector	$ 20,239	100.00%	$ 20,239
1.3 Linac	$ 27,948	100.00%	$ 27,948
1.4 Undulator	$ 45,720	99.33%	$ 46,030
1.5 X-ray Transport	$ 24,885	86.23%	$ 28,858
1.6 X-ray Endstations	$ 6,629	62.13%	$ 10,669
1.9 Conventional Facilities	$ 127,797	89.50%	$ 142,794
1.X LCLS Controls	$ 37,508	89.44%	$ 41,937
1.0 LCLS Total Base Cost	$ 311,911	91.45%	$ 341,074
		LCLS Total Estimated Cost (TEC)	$ 352,000
		Available Contingency	$ 10,926
		% Contingency on ETC	37.5%
2.0 LCLS Total Other Project Cost (OPC)	$ 47,981	75.38%	$ 63,656
		LCLS Total Other Project Cost (OPC)	$ 68,000
		Available Mgmt Reserve	$ 4,344
		% Mgmt Reserve on ETC	27.7%
LCLS Total Project Cost (TPC)	$ 359,892	88.92%	$ 420,000

APPENDIX E

SCHEDULE CHART

LCLS Schedule



CD-0 Mission Need
CD-1 Preliminary Baseline
CD-2a Long Lead Procurement Budget
CD-2b Performance Baseline
CD-3a Start Long Lead Procurement
CD-3b Start of Construction (Full scale)
CD-4 Project Complete/Full Operations

	FY02	FY03	FY04	FY05[1]	FY06	FY07[2]	FY08	FY09	FY10	Total
TEC	0	5.93	7.46	49.67	84.69	101.16	51.35	36.50	15.24	352.00
OPC	1.50	0	2.00	4.00	3.50	13.00	15.50	17.00	11.50	68.00
TPC	1.50	5.93	9.46	53.67	88.19	114.16	66.85	53.50	26.74	420.00

[1] *FY2005 TEC funding includes $29,760,000 for long lead procurements.*
[2] *FY07 TPC funding reflects the ~$8M reduction as a result of the FY2007 CR and directed change.*

APPENDIX F

MANAGEMENT TABLE

LCLS Organization

LCLS Directorate

Dale E. Knutson
Associate Laboratory Director (Acting)

Mark Reichanadter – Deputy Director
TBD – LCLS Chief Scientist (Acting)
TBD – Chief Technical Advisor
Helen O’Donnell – Executive Administration

ESH
Michael Scharfenstein – ES&H
Richard Hislop – Work Planning/Control

Special Projects
Richard M. Boyce
Uli Weinands

LCLS Administration
Helen O’Donnell

Advisory Committees

Facility Advisory – Kem Robinson
Scienctific Advisory – Roger Falcone
PM Oversight – Lowell Klaisner

Business Office

Cindy Lowe

Accelerator Systems Division

John Seeman

Engineering and Physics Div.

David Schultz

Strategic Projects Division

John Galayda