Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

LINAC COHERENT LIGHT SOURCE (LCLS) PROJECT

July 2007

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science (SC) review of the Linac Coherent Light Source (LCLS) project located at Stanford Linear Accelerator Center (SLAC) was conducted on July 10-12, 2007, at the request of Dr. Patricia M. Dehmer, 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). In addition, the Committee was charged to evaluate the revised project baseline as a result of the delay and shortfall in FY 2007 funding.

The Committee found that the project made good progress since the October 2006 DOE review, in particular, commissioning of the injector and progress in conventional facilities. The Committee believed the project provided sufficient justification and documentation on the impacts of the FY 2007 Continuing Resolution. However, the project had not yet adequately developed the revised baseline to ensure sufficient confidence in completing the project to the new cost and schedule.

The LCLS project is a multi-laboratory partnership led by the LCLS Project Office at SLAC. The partners are Argonne National Laboratory and Lawrence Livermore National Laboratory. 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 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.

Approximately 46 percent of the project was completed as of April 30, 2007. The baseline Total Project Cost (TPC) at $379 million and project completion scheduled for March 2009 were proposed to be revised to $409.0 million and May 2010, respectively. This proposed baseline change will be further reviewed by the project as recommended by the Committee. The current project's cost, schedule, and technical baselines are consistent with those in the FY 2008 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.

Progress in injector commissioning was impressive since starting in April. The electron beam was accelerated to the end of the linac. Installation of the second bunch compressor will begin in September during the annual shutdown of the SLAC linac. Forty undulator units were delivered to SLAC and are undergoing magnetic measurements. The undulator vacuum chamber is still a key technical concern. The stainless steel chamber was abandoned because of unacceptable permeability and impact on the undulator field. The project is leaning towards an aluminum extrusion chamber. The project needs to commit to a solution soon to minimize schedule impact.

Conventional facilities construction made substantial progress since the October 2006 DOE review. The Undulator Hall tunnel heading is complete and the lower bench is being removed. The access tunnel has reached the Far Hall. The Near Hall lower level is poured and the upper level is in place except for the roof. About 80 percent of the Beam Transfer Hall is constructed. Overall, beam path construction is approximately 35 percent complete. The construction schedule is about two to four weeks behind; however, if construction can perform as scheduled, early occupancy of some areas could be achieved by the end of 2007. However, this requires at least three months of effort that exceeds $8 million per month ($2 million in labor and $6 million in materials installation). This is aggressive and the project should investigate the impact of not achieving early occupancy as planned.

Approximately $8 million of conventional construction activities remain at the conceptual design stage. This includes the renovation of two existing buildings for office space and the build out of experimental hutches in the Far Hall.

The project prepared a revised baseline as a result of the delay and shortfall in FY 2007 funding due to the continuing resolution. The revised cost baseline includes only the impacts of the continuing resolution. The project should re-evaluate the proposed baseline to ensure that all known scope is included, and conduct a risk-based contingency analysis consistent with the proposed baseline.

The revised schedule proposed a project completion date of May 2010, which is 14 months delayed from the original date of March 2009. The constrained budget in FY 2008 needs to be managed carefully to ensure completion of conventional construction and procurement of technical equipment to allow start of the LCLS science program in 2009.

To successfully navigate through the FY 2007 continuing resolution issues, the LCLS project leadership established priorities and kept conventional facilities construction on track.. Both SLAC and LCLS management have satisfactorily addressed the actions and recommendations from the previous DOE reviews.

The Committee recommended two actions items. The first Action Item is to have the project re-evaluate the new baseline to address the review recommendations, and the second is to conduct a mini-review in late August 2007.

In summary, the Committee found that LCLS made satisfactory progress in all areas; however, challenges remain as the project continues construction.

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1. INTRODUCTION

1.1 Background

Now under construction at the Stanford Linear Accelerator Center (SLAC), the Linear Coherent Light Source (LCLS) is designed to be the world's first X-ray Free Electron Laser. 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 an undulator magnet 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 will be a scientific user facility to 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. Key components include the following:

- an "injector" (laser light pulses impinging upon a photocathode to produce electrons in a radiofrequency (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;

- an Undulator Hall (UH, built under a hill to aid in temperature stability), containing an undulator magnet assembly 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;
- construction of a Front End Enclosure (FEE), Near Experiment Hall (NEH), X-ray transport tunnel, and Far Experiment Hall (FEH), all below grade; and
- X-ray beam optics, diagnostics, and controls systems.

Current plans call for the X-ray beam to be delivered 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.

Attainment of 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 the October 2006 DOE review report and other project documentation.

This project's formal history began with Critical Decision (CD) 0, Approve Mission Need, approved by the Acquisition Executive (AE), 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 and the Lawrence Livermore National Laboratory) 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 AE 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 contractor Burns and Roe Enterprises, Incorporated (BREI) performed an External Independent Review (EIR) with 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.

A DOE review of the LCLS project was conducted 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 Total Project Cost (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. A SC mini-review of the new proposed baseline cost and schedule, chaired by the LCLS Federal Project Director, was conducted in November 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 funds for long-lead items that were critical path components, 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. Dr. Decker approved CD-3a on December 10, 2004, 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's Office of Engineering and Construction Management (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, Dr. Decker, then Principal Deputy Director for the Office of Science, approved CD-3b, Approve Start of Construction.

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 is 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 prior to about February 2007, and appropriated funds were approximately $8 million less than

the full request. As a consequence, not all of the originally scheduled FY 2007 project activities could be undertaken, within available resources. Mid-FY project indicators (e.g., the schedule performance index, cost performance index, and available contingency) show significant cost and schedule overruns to the baseline plan for progress to date. Planning exercises in value engineering have led to some concepts for rebaselining the project. The purpose of rebaselining 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 offers.

1.2 Charge to the DOE Review Committee

In a May 17, 2007 memorandum (see Appendix A), Dr. Patricia M. Dehmer, Associate Director of Science, Office of Basic Energy Sciences, requested that Daniel R. Lehman, Director of the Office of Project Assessment, organize and lead a review to assess all aspects of the LCLS project, including technical, cost, schedule, management, and environment, safety, and health (ES&H) issues. The purpose of this review is to inform a formal decision about rebaselining the project.

1.3 Membership of the Committee

The Office of Project Assessment 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 of the Office of Project Assessment chaired the Committee.

1.4 The Review Process

Prior to the review meeting, the LCLS project team provided project documents such as the Project Execution Plan, Risk Management Plan, risk registry, project schedules, the most recent Monthly Report, and other project information to the Committee as downloadable read-aheads. A review meeting was held at SLAC in Menlo Park, CA, during July 10-12, 2007. Representatives from SLAC, the DOE Stanford Site Office (SSO), DOE/SC, and the DOE Office of Project Assessment 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. A site tour was held to view the BTH (in the "research yard"), the UH tunnel entrance and exit, the construction site of the NEH, and the injector at Section 20 of the Linac.

Breakout sessions were held in the afternoon of the first day and most of the second day for additional follow-up on questions and issues of interest to the Committee. The Executive sessions at the end of the first and second days, and the morning of the third day, were devoted to Committee deliberations, report writing, and drafting a closeout report. Preliminary results were discussed with LCLS staff at a closeout session on the last day.

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.

2. TECHNICAL SYSTEMS

2.1 Accelerator Physics

2.1.1 Findings

Progress in injector commissioning has been very impressive. Injector beam quality meets requirements for commissioning of downstream elements.

Safety is integrated into all planning for the accelerator systems.

The availability of diagnostics and controls is critical for BC2 commissioning. Because the installation schedule for the fall 2007 shutdown is very tight, it will be challenging to have diagnostics and controls ready in time.

Undulator commissioning plans, including details of diagnostics provided by ANL and LLNL, are not well advanced. Good interfaces between SLAC, ANL, and LLNL will be essential for successful commissioning of the undulator systems. Electron beam and X-ray diagnostics being built at ANL and LLNL must be well-integrated into the commissioning plans. X-ray diagnostics must be available continuously as an operational tool.

There was progress in comparing simulations of the output of the photo-injector to experimental results. These simulations are impeded by limited access to high-speed computing resources.

2.1.2 Comments

It would be beneficial if SLAC could provide enhanced access to on-site computing resources to facilitate computation-intensive simulations of LCLS beam dynamics.

Commissioning of the X-ray free electron laser (FEL) will require a real start-to-end, on-line simulation, including the FEL physics in it. This will involve utilizing Parmela/Astra/Impact + Elegant + Ginger/Genesis, with the codes not only linked together and further developed, but also linked to the on-line control system so that operating machine configurations are readily available as input. In addition, the outputs must be aligned with real diagnostics of both the

electrons and photons, so that simulation-to-measurement comparisons can be easily made. The Committee was pleased that work is underway to make start-to-end simulations available on-line for commissioning, and looks forward to hearing more about this in the future.

2.1.3 Recommendation

1. Improve the interface between all groups (SLAC, ANL, and LLNL) responsible for construction, installation, and commissioning of the undulator systems (September 2007).

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

2.2.1 Findings

The Injector/Linac subcommittee was very impressed with the rate and amount of progress since October 2006 DOE review. The progress to date confirmed that the photoinjector design is mature and sound. The photoinjector is a crucial technology for the successful performance of the FEL system as a whole. The initial results from the photoinjector indicate that the stringent beam quality parameters for successful FEL operation can be met. These results indicate that the linac beam will be able to be focused and transported in the undulator and meet the CD-4 requirement for producing spontaneous emission at X-ray wavelengths.

Although there is good progress in meeting the baseline objectives, the Committee was concerned with the schedule and cost to complete. In particular, the linac-to-undulator transport line and beam dump installations will be on the critical path for light from undulator milestone.

Integrated Safety Management is addressed at all planning stages. Safety is taken seriously by staff, who are constantly attentive to the work environment. The team was encouraged to keep track of required documentation, approvals, and readiness reviews.

The project responded appropriately to recommendations resulting from the October 2006 DOE review.

2.2.2 Comments

Although there is good progress in meeting the baseline objectives, the Committee was concerned with the schedule and cost to complete. The injector has experienced overruns in many systems of the combined Injector/Linac cost and has consumed an unexpected amount of

contingency. On the positive side, controls software development at the injector will help with commissioning BC2 and beyond. Also, the injector linac and BC1 installation lessons-learned significantly lower the risk for the rest of linac installations.

The committee, however, estimated that the remaining contingency of 22 percent (approximately $4.5 million on $20.5 million remaining work) may not be sufficient to cover the uncertainties associated with the bunchers and the linac-to-undulator (LTU). The Committee found the 2007 operations schedule to be tight, and the plan to use weekends and a PEP-II delayed restart will put stress on the accelerator commissioning team. The project has not, however, exceeded the allocated schedule contingency at this point, and the work is on track to meet the next milestone.

The beam diagnostics (the BC2 wire scanners and the linac low-charge BPMs) removed from scope may not significantly affect meeting the generation of measuring light from the undulator (spontaneous emission) milestone but could have a significant negative impact on the FEL commissioning schedule. Integrating new diagnostics later will cost substantially more then implementing during a construction phase.

The injector will require many changes for successful FEL operation, but injector funds are expended so these modifications are on hold—this will delay FEL commissioning.

Meeting the schedule will be tight for the LTU, and how co-occupancy will be successfully managed is still to be determined. The Committee would have liked more detail about how this phase will be accomplished. Once again, the gun load lock is not in the present budget or contingency allocation; therefore it will not be pursued (as such a system would reduce schedule risk for operation of the whole system).

The drive laser is operating at the level necessary for future operations. The drive laser is to be handed over to operations by January 2008, but no formal schedule or transition plans were presented. As part of the Laser handoff to operations, requirements such as spares counts, maintenance manpower, and implementing automation need definition. Also, this assumes no new issues with the replacement oscillator. A significant positive development is that the temporal profile appears to be stable and further improvement will yield some FEL improvement but not substantial performance increases. The uniformity of the transverse emission from the cathode surface still remains as a critical issue, pushing the drive laser and other optical train components to their respective limits.

Since beam commissioning has begun, engineering and physics issues are rising to the forefront. Some of the technical issues that have arisen are: anomalous emittance growth with high compression; field quality of BC1 dipole magnets out of specification; X-band structure delivers a transverse kick; oil/dust in optical transport tube with limited options for remediation; and 120 Hz operation limited by radio frequency (RF) probes presently installed in gun #1.

At this point, the Committee saw no reason seen to switch to gun #2 for commissioning.

The long bellows associated with the bunch compressor 2 may have lifetime issues, this can impact commissioning and/or operations.

2.2.3 Recommendations

1. Re-evaluate the schedule contingency for LTU activity.

2. Determine cost/schedule/risk impact of removal of beam diagnostics with respect to the FEL commissioning.

3. Re-evaluate cost to completion.

2.3 Undulator System (WBS 1.4, 2.4)

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 (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 girder that also includes an electromagnet quadrupole, a 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 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 LCLS Undulator System continues to make very strong and notable progress since the October 2006 DOE review. As of the July 2007 review, all 40 of the main magnetic structures have all been assembled and delivered. Thirty-nine production undulators were delivered to SLAC and one to ANL for long-term testing and development. The Magnetic Measurement Facility (MMF) has now moved past its commissioning difficulties and is now a fully operational facility capable of production measurements. The undulator alignment diagnostics development is continuing apace, and the ASK (Assemblies, Sub-Assemblies, Kit) tracking system is now fully deployed and in use. Deployment of the ASK system is a noteworthy development since it provides a potentially powerful tool for scope and Work In Process (WIP) management, which will be increasingly important as the undulator systems move into installation and integration into the LCLS facility.

The quadrupole magnets have seen encouraging progress since the October 2006 DOE review as the first two articles have been received from the vendor, Everson-Tesla, at the end of June. Initial testing indicates that the magnetic center stability is well within specifications. However, the magnetic length is somewhat below specification. This will likely be addressed at the vendor by increasing the number of laminations within the designated length. The magnet is designed with field clamps due to proximity to the undulator and the BPMs. However, initial measurements have shown that the performance is better without the shields. The Undulator Systems team will evaluate the fringe fields from the quadrupoles. Discussion during the review indicated that the shields may not be necessary since the components in close proximity, the undulator and the RF BPMs, are not likely to be affected by the quadrupole fringe field. The undulator has its own shield, and the DC magnetic field should not have an adverse impact on the operation of the BPMs. However, before discarding the quadrupole shields, consideration should be given to the impact of the undulator shield on the quadrupole (i.e., the fringe field may be modified, thus changing its magnetic length). This would result in a different behavior on the test bench vs. the installation in the FEL.

The Undulator Support and Motion System production contract was awarded in May. Production is proceeding on schedule. The Committee noted that timely production was facilitated by advanced planning on the part of the ANL team. Even though the Continuing

Resolution delayed the award of these contracts, long-lead items, such as bearings, were purchased ahead of time and provided to the contractor as government furnished equipment.

The Committee found that the LCLS Undulator Systems Team was responsive in spirit to the recommendations of the October 2006 DOE review, adapting to the constraints imposed by the Continuing Resolution and the difficulties ultimately encountered in pursuing the (previously) selected stainless steel vacuum chamber option. With respect to the specific recommendations, the team was to capture the cost of the backup vacuum chamber design and development work in the LCLS project plan. As yet, this has not been accomplished, since the chamber selected through the back-up evaluation process has proved to have unacceptable performance. As noted by the team in their response, action on this previous recommendation awaits completion of the current round of prototyping, anticipated to be complete by the end of August 2007. Similarly, the team developed a backup chamber design based on an aluminum clamshell and ran a review to make a down selection in February 2007. That review resulted in the selection of the baseline stainless steel chamber as the project selection, since it was deemed most likely to meet the interior surface finish requirements of the project. Because of the funding constraints from the continuing resolution, work on back-up options was essentially halted after the down selection. The activities related to the chamber to some extent overshadowed the Committees' recommendation to establish a Long-term Test Setup (LTS) at SLAC , although the Undulator Systems Team is presently planning to build a stand at SLAC using the first articles from the component production runs.

The LCLS Undulator Systems Team has successfully worked through the evolution of leadership at ANL resulting from the departure of Steve Milton to pursue other research interests. Geoff Pile stepped in to fill this void at a challenging time for the project and quickly adapted to his expanded role. The Committee felt that he made very positive contributions to the management of the ANL contributions to the undulator systems and to their integration into the LCLS facility. Although the Committee felt that overall communications and coordination between ANL and LCLS continue to improve, there is still room for growth in this area.

Examples include continued refinement and clarification of technical requirements such as using a common description for the surface finish of the vacuum chambers (slope error vs. rms roughness), and communication of technical developments and issues as they arise. While good coordination is clearly happening in many areas across the project, evidence of gaps continues to surface. In one instance, concerns over the selection of material for the vacuum chamber support (steel) were raised during a breakout session, which may indeed merit consideration, but it would seem to the Committee that they are coming up long after the selection was made and thought to be communicated widely across the project. Other instances

of pockets of isolationist approaches to issues were evident during the course of the review, which are counter to the needs of the project. The LCLS management is encouraged to continue to cultivate a team approach among its collaborating partners.

The vacuum chamber remains a critical concern for the project. As previously noted, the project team was responsive to the Committee's recommendations from the October 2006 DOE review and had been working to refine the selected chamber option, the four weld stainless steel chamber, to production readiness. While the full-length prototypes appeared to be a promising and feasible option in most respects, the processed stainless steel exhibited variable and unacceptable permeability, which would result in unacceptable performance of the undulators in the FEL. This "show stopper" became evident only in the last month, and an effort to develop and select an alternative back-up chamber fabricated from non-magnetic material is already well under way.

It must be noted that the selection of the stainless chamber for further development was made by LCLS management based on an informed assessment of the characteristics of each alternative considered in the February 2007 down selection process. None would fully meet all of the specifications or desired properties for the LCLS project, but at that time, the balance tipped in favor of the stainless steel based chamber because it was deemed to have the best prospect of meeting the extremely stringent surface finish tolerances.

At the time of this review the Undulator System (WBS 1.4 and 2.4) cost, schedule, and technical baselines are being reported against the current DOE approved LCLS Baseline and Project Execution Plan. As presented at the review, the Undulator Systems Total Estimated Cost (TEC0 budgeted cost of work performed (BCWP) was $24.7 million, with actual costs of work performed (ACWP) at $26.9 million within a budget at completion of $37.4 million. The cost performance index (CPI) was 0.91 and the schedule performance index (SPI) was 0.92. A Baseline Change Request is pending that is intended to factor in the impacts of the continuing resolution. The Committee felt this represented a more realistic estimate to complete (ETC) at $18.5 million with an anticipated contingency of $3.8 million.

When the Committee examines the Undulator System portion of the project with respect to the questions posed in the charge it arrives at the following conclusions:

The Undulator System's cost, schedule, and technical baselines are consistent with those in the FY 2008 LCLS Construction Project Data Sheet. There was demonstrated adequate progress to meet the baseline objectives that information was reported from the Undulator System to the DOE Project Assessment Reporting System and is consistent with physical progress.

With the exception of the undulator vacuum chamber, the Undulator System technical systems are sufficiently mature to support the hardware procurements planned in FY 2008. The procurement plans and equipment installation plans for the Undulator System do support the overall project schedule, but much work remains to be completed in addressing integration tasks and deliverables. The Undulator System Team and the LCLS project, as a whole, appear to be well aware of this and the Committee believes that satisfactory progress in this area will continue.

The estimated contingency (cost and schedule) within the Undulator System area of the LCLS project appears to be adequate to address the risks inherent in the remaining work. However, recent experience with cost and schedule overruns of key integrating activities lead the Committee to believe that the Undulator System will consume the contingency estimated as being necessary ($3.8 million) as the vacuum chambers and RF-BPMs move into production, and the integrating and installation activities begin to dominate the schedule. With these caveats in mind, the Committee believes the LCLS project should be able to meet the baseline objectives within the Undulator System, but careful, active vigilance is required.

2.3.2 Comments

The undulator vacuum chamber remains an area of considerable concern for the Committee. The chamber option selected as part of the schedule recovery plan arising from the October 2006 DOE review (Four weld Stainless Steel) has arrived at a technical impasse. The LCLS project management judged that the permeability effects noted in the full-length prototypes were unlikely to be resolved in adequate time to meet the schedule needs of the project. As a result, the project (with its FY 2007 budget now known) restarted parallel efforts for development of alternative chamber designs from inherently non-magnetic materials. In essence this is a strategic recognition of the need to potentially relax some surface finish requirements to meet the schedule and technical needs associated with project completion.

The teams are largely parallel and require minimal overlap of technical resources to pursue their assigned development projects. At ANL, one team is working on a chamber design based on using copper tubing that would be executed with minimal modification of the original baseline design. The best surface finish of drawn copper seen thus far is 60 mrad, a factor of six above specification, but certainly adequate for the CD-4 milestone and probably to support lasing at longer wavelengths. Simulations have shown that the resistive wakefield component for the copper chamber will adversely affect the performance of the FEL at the shortest wavelengths of its intended operational range. Even if improvements in surface finish are achieved for the copper option, this chamber will likely not be satisfactory for short wavelength FEL operation.

Two parallel efforts are underway to develop aluminum chambers, one at ANL, and one at SLAC. The resistive wakefield component is lower for aluminum than it is for copper. Recent simulations show that if a surface finish of 25 mrad or better is achieved, all planned FEL operations should be possible with an aluminum chamber. The ANL effort is directed at developing an extruded aluminum chamber. In this approach the vacuum chamber is made from a one-piece extrusion with the beam channel running its length. After extrusion, the chamber stock will be machined to the proper outside dimension to fit in the undulator gap. Previous measurements of surface roughness of aluminum extrusions have shown them to be inferior to those obtained in copper. Recently work has begun in collaboration with a vendor to polish extrusions internally using "mud polishing" where a slurry of alumina abrasive is forced at high pressure through the blank before external machining. Initial results have shown significant improvement over the untreated extruded surface finish. Work continues on refinement of the process to obtain the best finish possible in the limited time available for prototype development.

The effort at SLAC is to develop the aluminum clam shell design abandoned in the February 2007 down selection. Based on two half extrusions that would be welded together after polishing of the internal surfaces, this approach would seem to have the greatest likelihood of meeting the surface finish requirements. However, it is the most complex of the designs, and would require the most process development to move into production. This development time would certainly be a threat to the overall project schedule. Because of the higher surface conductivity for aluminum, if surface finishes comparable to or better than those found in the copper tubing are achieved, efforts for the copper should be curtailed.

The development efforts are all aimed at providing prototypes adequate for reaching a decision on preferred technical approach by the end of August 2007. Once this selection is made, the project needs to consider the impact of any projected sub-specification performance from the vacuum chambers on the project. These risks and any potential methods for their mitigation should be captured in both the risk registry and in project planning.

The Committee also has concerns with respect to the diagnostics. In the case of the RF-BPMs progress was both steady and encouraging. The recent three BPM tests at the APS Low Energy Undulator Test Line (LEUTL) have shown preliminary results demonstrating 8 micron sensitivity. Refinements of the measurements are planned to address some problems in the testing to achieve the project goal of 1 micron sensitivity. The RF-BPM cavities are at or near the critical path for the project, since they are a vacuum component that is installed in the beam path along the undulator. The cavity design is deemed to be ready for production, but procurements are not yet awarded to vendors. Meeting the project schedule requirements with

respect to the RF-BPM's should be possible, but it will require careful attention of management to expediting every aspect of actually moving them into production. Other electronic components for the RF-BPM's, such as the receivers, are not on the critical path and can be procured in a less vigorous (yet timely) manner.

It was also noted during the review that the Beam Loss Monitor (BLM) diagnostic is "on hold". In discussion with the LCLS team and other review committees, it was felt the BLM system was an important tool for monitoring (and limiting) exposure of the undulators to excessive radiation through electron beam mis-steering. Mitigation of this risk to the facility in its commissioning and operational phases may have a significant impact on the ability of the LCLS to achieve its best physics performance.

It is the understanding of the Committee that two factors contribute to the BLM system moving into stasis; the continuing resolution and consequent lack of funds for further development, and the belief that the originally specified system was too expensive to pursue. This latter point is somewhat difficult to address as it required an assessment of what losses are important to measure and how the operation should respond to the losses when observed. Knowledge of the mechanisms leading from beam loss to degradation of undulator performance are still not precisely known. Given this fact, the approaches to measurement and mitigation are often quite broad and multifaceted, involving multiple detectors and collimators in an effort to restrict the possible trajectories of errant beam and to measure losses of any sort and utilize the information to inhibit operations or reduce beam intensity. These approaches may not be effective for a project at the energy scales of the LCLS, and would certainly be costly at the scale of the LCLS. Never the less, the risks must be identified and efforts made to address their potential consequences.

The project noted that refinement of the BLM system is on the short list of areas needing immediate attention, including a re-examination of the system and production of a new Physics Requirements Document (PRD) to guide the technical development of the eventual BLM system. The Committee encourages the project to ramp-up this effort quickly so a BLM system can still be a component of the toolkit for the LCLS physics program during machine commissioning.

2.3.3 Recommendations

In the area of the undulator vacuum chambers:

1. Fabricate prototypes of each back-up option Vacuum Chamber by end August 2007.

2. Select the “best” option from the completed prototypes to move into production by mid-September 2007.

3. Evaluate the potential impact of any anticipated sub-specification performance from the selected chamber option. Include these impacts in the risk registry with any mitigation strategies and potential costs as soon as feasible; in no case later than the next DOE review.

In the area of diagnostics:

4. Provide adequate support to ensure placement of procurement contracts for RF-BPM cavities on or before end September 2007.

5. Develop the Physics Requirements Document for Beam loss monitors to meet project needs by end August 2007.

6. Develop a revised estimate for the BLM system as soon as feasible, no later than the next DOE review.

In eager anticipation of the imminent Installation and Integration of the Undulator systems into the LCLS complex, the Committee requests that:

7. The project present plans for the Installation and Commissioning of the Undulator Systems plans at the next DOE review.

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

2.4.1 Findings

Photons Systems

The reviewers were pleased at the considerable progress that was made in the Photon Systems area since the October 2006 DOE review. As in other areas of the LCLS project, the Continuing Resolution of FY 2007 took its toll on Photons Systems. (The re-calculated baseline showed a budget increase due to an extension of length of the project brought on by the CR but otherwise the budget remains unchanged.) FY 2008 does not look much better as the project looks to delay whatever procurements it can to FY 2009. The choices and compromises that the

Photon Systems Managers have made to accommodate this situation are sound as they still allow for the start of the AMO science program in FY 2009, which the reviewers feel is important.

The area of controls continues to be a concern due the considerable amount of work that needs to be completed. The recently named cost account manager (CAM) for controls/data acquisition for Photon Systems is a positive step towards completing the task.

The current plan pushes some work into FY 2009, however the Photon Science Manager believes that by the summer of 2009 all instrumentation will be installed in the front end enclosure (including the mirrors), a subset of the full AMO instrumentation will be installed along with the laser in the near experiment hall (NEH), and the hard X-ray beamline would be completed to the third experimental end station in the NEH.

X-ray Transport, Optics, and Diagnostics (XTOD)

Significant progress made in most XTOD components that required prototyping, including gas detector and total energy thermal sensor. Effective use of existing facilities, SSRL and FLASH, for materials and prototype testing was made. The soft X-ray mirrors, including testing the damage threshold of the coating material, certifying vendors, developing in-house metrology and an award to vendor was made. Preservation of the mirror figure in the coating process is well within the experience of the LLNL team. Most other components have been designed to the level of a preliminary design report (PDR), and in some cases to the level of a final design report (FDR). To date, approximately 50 percent of work was completed in XTOD and they have a 21 percent contingency on remaining work. This is probably an adequate, although somewhat tight, level of contingency. FDRs for the remaining components in XTOR are scheduled to be completed this calendar year.

X-ray End Stations (XES)

As would be expected XES is not as far along as XTOD, with less than 20 percent work complete. The 26 percent contingency reflects this larger amount of work to completion. The particle imaging capabilities and laser amplifier associated were with the AMO experiment were removed so that the LCLS laser timing system could be added.

2.4.2 Comments

Photons Systems

There are a significant number of FTEs scheduled to support the controls effort in October, November, and December 2007 in Photon Systems. Although this number is certainly justified given the amount of controls work that needs to be done, there was a question in the minds of the reviewers as to whether this level of manpower was available at SLAC.

It was not clear to the reviewers that spares were properly accounted for in the OPC costs and these area should be revisited by the Photon Science Managers.

Planning for commissioning activities has started, but more work is needed. For instance, how will the "handoff" of components developed by LLNL to the LCLS staff occur? The Committee was told that LCLS staff will participate in the commissioning of the XTOD components designed by LLNL. However, it was not clear whether the manpower schedule reflected that shared commissioning responsibility.

Interfaces/Integration of Photon Systems and LUSI

The reviewers urge the continuation of the very important interactions between the Photon Systems and LUSI staff. Having the LUSI manager under the LCLS Director is a good start as is the sharing of the controls/data acquisition CAM between Photon Sciences and LUSI.

X-ray Transport, Optics, and Diagnostics (XTOD)

Although good progress was made in many areas, a notable exception is the hard X-ray mirrors and associated mechanical/vacuum system. The physics requirements document is scheduled to be signed this week and so a considerable amount of work must go on between now and the end of the calendar year to get this to the FDR level. These hard X-ray mirror-related components are CRITICAL to the success of hard X-ray science programs. Since the design of the mechanical/vacuum system for the mirrors is in the early stages, this is an excellent time to bring in experts from other light sources (national and international) to critique the proposed design to see if it will meet the very stringent pointing stability requirements. The Committee judged the K-spectrometer construction schedule to be rather tight.

X-ray End Stations (XES)

The prototype pixel array detector (PAD) seems to be progressing well, but continued vigilance is required to ensure that the schedule for the deliverables are met.

Procurement of the refocusing optics, an X-ray emission spectrometer, and an ion imaging spectrometer for AMO experiment were delayed due to the Continuing Resolution and will not be available until CD-4b. In all likelihood this will be acceptable, as not that much time will be available for science experiments between CD-4a, the start date for the AMO experiment, and CD-4b and so there will probably not be enough time to utilize the full suite of instrumentation. Given the stretched schedule for fully outfitting the AMO instrumentation, this additional time could be used to evaluate a KB mirror system with fixed-figure mirrors for AMO endstation as an alternative to the bendable mirror system, as it might be more cost-effective.

Work related to radiation safety (PSS hardware, software, shielding, etc.) tends to take longer than expected due to the many groups that are involved and the stringent reviews that are required and therefore a close watch on the schedule and progress of these systems should be maintained by the managers.

2.4.3 Recommendations

1. The commissioning plans should be reviewed to ensure proper staffing and schedule is allocated for both LLNL and LCLS staff.

2. Bring in and/or visit with experts in mirror vacuum tank design from other light sources (national and international) to critique the proposed design of the mirror motions and drive scheme, specifically to determine if the design will meet the very stringent pointing/stability requirements, before finalizing mechanical/vacuum hardware for the hard X-ray mirrors. Also explore the capability for in-situ optimization of hard X-ray mirror figure before the design is frozen.

2.5 Control Systems

2.5.1 Findings

The Controls subcommittee met with Hamid Shoaee and many members of the LCLS Controls Project Team for a series of presentations and discussions.

The controls group has made excellent progress on its technical deliverables since the October 2006 DOE review, notwithstanding an extremely tight schedule, many first-of-a-kind deliverables and the reduction of its pre-commissioning testing time almost to zero. The team produced an outstanding effort to meet the injector commissioning schedule. This, coupled with smart management decisions to use a few interim technical solutions and some redirected effort, made possible the successful delivery of all required injector equipment, wiring, software, and data analysis tools and led to a productive commissioning of the LCLS injector.

The Committee was particularly gratified to note the successful deployment of a PLC-based Personnel Protection System (PPS)—a first for SLAC. The system was completed for $20K under budget, and its certification took six people five hours. The PPS design for the next sections is complete and there is no apparent technical risk. Schedule risk is being mitigated with the addition of two staff members.

The report of the commissioning team in plenary session featured many impressive images produced by the control system and its beam instrumentation. The promised availability of certain SLAC applications through use of the "SLC-aware" IOC was demonstrated to be effective, and greatly facilitated commissioning, as did the availability of Matlab and the ability of accelerator physicists to develop programs and scripts on their own. In plenary session, the commissioning team thanked the controls team for their contributions and their cooperation. The list of required applications recommended at the previous review was delivered, and was updated for the next commissioning run.

The reorganization of the Controls effort that was announced at the October 2006 DOE review has taken effect. In that reorganization, Hamid Shoaee became leader of the SLAC Controls Department, out of which the LCLS controls effort is now matrixed. The downsides to this change (noted in the last report) are the disappearance of an identifiable and focused LCLS controls group and group leader, and the increased (and from the LCLS point-of view, diversionary) responsibilities of Dr. Shoaee. The important upside is the fact that Dr. Shoaee now controls all the necessary resources to accomplish his LCLS mandate. The Committee felt

that there was a net advantage to LCLS from the reorganization; however, change is always difficult and such a large personnel action will inevitably take time to "settle in." Care must be taken to insure that everyone fully understands their changing roles in the new organization.

Most staffing concerns were addressed and the controls team is at full strength. An experienced EPICS team leader is an important addition. Support for undulator controls has been added at ANL. A new CAM was appointed for WBS 1.6.2—Controls and Data Acquisition for the X-ray Experimental areas—and this will greatly relieve the work load on the group leader, as well as making available new resources experienced particularly in data acquisition. Increased confidence in the scheduled delivery of these systems was apparent. The plan is to follow the standards and approaches already set by the controls group. The position of deputy group leader, however, remains both important and unfilled.

The success of injector commissioning indicates that the design of the injector/linac control and diagnostic systems is mature. The photon systems control design has matured significantly over the past year and is presently adequate to support procurements planned in 2008. A few items await definition, including the X-ray mirror supports, pointing and perhaps active figure controls. These could have a significant impact on cost at the subsystem level.

The Controls Group participated fully in the recent cost rebaseline motivated by the 2007 continuing resolution. A cost increase of $4.8 million (from $32.4 million to $37.2 million) was reported, attributable almost entirely to "standing army" costs due to a delayed CD-4b finish date. The revised budget for the control system is very tight but seems to be adequate for the project-defined scope. Some scope was removed to achieve the present baseline (see below), however, there is no obvious possibility of further scope contingency.

Although almost all of the scope of the control system appears to be covered in the current estimate, the Committee identified at least one item—network equipment costs for the LTU, undulator, and XTOD areas—that was not included in the budget. This discovery, following a necessarily cursory review, leads to a concern that other omissions may exist. Some required items, including, for example, significant costs for cable plant installation, are awaiting baseline change approval and will have a significant impact on the available 2008 contingency.

Contingency for the entire project is extremely tight in FY 2008, and because the contingency estimate for controls is distributed throughout the WBS, its amount (and hence its adequacy) is difficult to evaluate. The Committee did not attempt to do so. Controls contingency needs to cover the likelihood, famously difficult to avoid in control systems, of

"scope creep." Subsystems discover they need to implement more data channels here and there and these add control system requirements. With controls scope for LCLS embedded in the subsystems, there are few effective controls on these changes.

The schedule for the next commissioning run is as aggressive as was that for the injector. Sufficient time was allowed in the schedule for control system testing, but the risk remains that much of this time will again be "eaten up" by precursor activities (as it was for the injector). The significant CPI and SPI variances reported for controls are largely attributable to purchases delayed because of the Continuing Resolution of FY 2007. The Project Controls System appears to be working for the Controls Group; and the resource-loaded schedule is used as the basis for earned-value reporting.

Controls scope was reduced in some areas since the October 2006 DOE review, and some of these reductions increase technical risk. An example is the elimination of the upgraded linac BPMs. This upgrade would have allowed the linac BPMs to respond adequately to the LCLS lower charge-per-bunch beam. The elimination of this upgrade will make it more difficult to identify and locate errors in the linac that could impact the quality of the LCLS beam. As a minimum, the entries in the risk registry for this item should be updated to reflect this project decision and identified increased risk.

Performance of the BPMs in the injector (delivered just-in-time!) exceeded resolution specifications although long-term stability has not yet been measured. R&D is nearly complete on the X-Band cavity BPMs now under test at ANL. The results are promising but schedule is a concern.

SLAC legacy applications were available to LCLS injector commissioners through the use of the SLC-aware IOC. This approach will continue to be used through BC2 commissioning. A plan and applications list for that run was presented. A proposal to create an integrated suite of applications in an Eclipse environment (SEAL) was also presented. This is very similar to a parallel initiative (known as CSS) at SNS and DESY. There is a lot of application development still required for LCLS commissioning. Beware of too many good ideas! Although the use of Matlab for application programming during injector commissioning was both wise and effective, the Committee cautioned (as it had done before) that Matlab is unlikely to prove an appropriate integrating tool for the entire facility and encourages the Controls group to continue to pursue the planned deployment of XAL.

An interim MPS system was used for the initial injector commissioning. This was expedient; however, the planned new 120Hz-capable system will be required for commissioning of the undulator and beyond. The team and design is in place and the project presents only a modest schedule risk. As yet not-fully-developed toroids are required for this system. Remember to develop and implement a strategy to handle "chatter faults" in the MPS auto-reset system.

The low-level RF (LLRF) system appears to be working adequately. Stability varies from cavity to cavity—not all meet the requirements. The short-term jitter specification is also elusive to date, but should still be attainable. Configuration management requires care. Magnet power supplies continue to use a mixture of the old (SLAC) and new (LCLS) designs. Some noise issues were observed; these are being addressed with filtering. The noise was not observed in the beam. The timing system is also still a "blended" system. It worked well for injector commissioning but work remains in extending it. Sixty Event Receivers still need to be ordered for BC2—this is a critical path item.

Progress on undulator controls at ANL is substantial and encouraging. One girder (out of 33, with 7 actuators on each) was successfully run. A detailed software deliverable for the undulator control module has not yet been agreed between ANL and SLAC; however, a final choice of processor 2as not made, and this is critical.

2.5.2 Recommendation

1. Insure that all costs-to-complete—including any newly identified costs not related to the Continuing Resolution of 2007—are covered in the proposed cost re-baseline.

3. CONVENTIONAL FACILITIES (WBS 1.9, 2.9)

3.1 Findings

The LCLS Conventional Facilities (CF) scope represents a significant fraction (over 41 percent) of the LCLS TEC. The current CF baseline estimate is now $128.8 million, up from $116.6 million in October 2006. The total work accomplished through April is reported as $48.0 million, which is 37.2 percent of the total estimated CF work. The majority of the work is contained in a contract with the Construction Manager/General Contractor (CM/GC), Turner Construction valued currently at $89.5 million, including management fees of $11.3 million.

Substantial progress was made in the last nine months with CF construction. The undulator hall tunnel heading was "holed through." The lower bench is being removed. The access tunnel has reached the Far Hall. The Near Hall lower level is poured and the upper level is in place except for the roof. About 80 percent of the beam transfer hall from the linac to the undulator hall is constructed.

Personnel were added to the LCLS team, including some needed positions such as estimating support. The CM/GC, Turner Construction, has realigned their team and the results were positive. There is good cooperation between the LCLS and Turner teams and they have conducted partnering sessions in order to improve working relationships. This has led to improvements for implementing and negotiating field changes.

The current value of the work construction awarded by Turner Construction is $76.9 million, which includes $2.8 million of Change Orders and Field Change Orders work. The work that Turner has under contract was seven to eight weeks behind schedule through April. The construction workforce is averaging 120 construction workers working a normal five days/eight hours schedule; although the tunneling subcontracted to Affolder was working multi-shifts five days/20hours weeks. At end of April, Turner reported that construction was approximately 22 percent complete. The 35 percent completion status is an LCLS Project estimate of the progress to the date of this review. Since the start of construction, $722K of Field Change Orders were negotiated and approved, which is approximately 4.5 percent of the construction progress to date. Although this is a low percentage, it may not be indicative of the work yet to be performed. Potential claims at this stage of construction are approximately $4.5 million.

After a slow start, and a change of project management personnel, Turner Construction put in place a recovery schedule and states that they should be able to maintain the LCLS project baseline schedule. The "recovery schedule" is at present reported two to four weeks behind, but if Turner and subcontractors can perform as scheduled then shared occupancy of some areas by the end of CY 2007 may be possible. The Turner schedule requires at least three months of effort during the next four months that exceeds $8 million each month. Each month is reported to consist of about 150 FTEs (approximately $2 million of the $8 million) and about $6 million of materials.

It is planned to grant early occupancy to the technical groups and allow joint usage with Turner in December into the Beam Transfer Hall, Beam Dump, Undulator Hall, Near Experiment Hall and Front End Enclosure. Early occupancy for the X-ray Hall would occur in January 2008, and the Far Experiment Hall in March 2008. The Turner recovery schedule reflects that there is considerable construction work to be performed after these dates. Adding additional workers into already congested areas will present coordination issues.

CF has additional work to perform which is not included in the scope being performed by Turner. The cost that is being carried for this work is without a bottom-up estimate. The contingency that was assigned is five percent, which reflects their history to date. Only conceptual design costs estimates are available for the work. These areas of work consist of design and construction of: 1) building 28 renovations for 45 offices, 2) building 751 renovations for 63 offices, and 3) additional experimental hutch construction and are shown as totaling about $8 million.

The Turner contract, although "fixed price," already generated some substantial claims, and the elimination of the "CLOC" work has generated further disagreement on the size of credits due the LCLS Project. At 35 percent completion, it is by no means certain that additional substantial claims will not be generated. Turner has filed a claim of $4.5 million, which is associated with removing the "CLOC" from their scope of work. CF in turn is withholding $110K a month from Turner's invoices up to a maximum of $1.4 million pending a "proper proposal" from Turner. The EAC makes no provision for this claim or any other potential claims. Although some claims may seem without merit, the potential always exists of having to pay some portion.

Several serious safety incidents have occurred during the Turner contract. Turner has experienced sixteen construction occurrences with six of those resulting in some sort of personnel injury. This has resulted in increased oversight by many parties. Turner has increased

their safety oversight and is applying management attention to safety. With the impending MEP work that will involve closer coordination of trades in restricted spaces, the team must continue to proactively examine the upcoming work and take measures to assure that processes are in place to safely deal with that work.

The FY 2008 funding is very constraining for the LCLS project as a whole.

3.2 Comments

At the end of April, the latest LCLS Monthly Report presented, the civil construction was running seven to eight weeks behind schedule. LCLS management requested a recovery plan. In response, Turner Construction provided a plan re-sequencing construction activities to minimize the schedule impact in the Beam Transfer Hall (BTH) and Undulator Hall. The re-sequencing plan provides for LCLS occupancy of the BTH through the Near Experimental Hall (NEH) in December 2007. This is roughly on the baseline schedule. The re-sequencing of activities by Turner indicates a positive approach taken by the new Project Superintendent. Coordination between the CF and equipment installation will be critical to maintaining progress.

The recovery plan is showing a joint occupancy by early December 2007. To meet this date the revised schedule indicates that direct work by subcontractors will peak at approximately $8.0 million for three months with manpower peaking at 150 workers. The Committee judged that while possible to achieve the completion date contained in the Turner recovery schedule, this is an ambitious goal, and various events could prevent reaching this level of accomplishment. The joint occupancy dates may not be met. Possible workarounds could be considered now, including investigating the transfer to Turner of some or all of the work intended for the joint occupancy period. Maintaining the joint occupancy dates with significant work to be accomplished by Turner's contractors could complicate all work in the area.

As part of the re-baseline of the project, it would be advisable to have as accurate an estimate as possible of the remaining uncontracted work elements. Until the designs are completed and contracts awarded for this remaining work, it will not be known whether the estimating was better than all previous contracts for the LCLS CF, which have run about 50 percent over estimates as contracted.

Although a good personal working relationship exists between Turner staff and LCLS staff, it is by no means clear that disagreements over claims may not proceed to arbitration and thence to awards unfavorable to the LCLS project. Contingency consideration at this time should include these possibilities.

The Committee is concerned about the current level of contingency at 13.8 percent of work remaining ($80,763K). This should be re-evaluated based upon the potential for modifications, currently estimated at $3.0 million, which the Committee believes is low, current claims at $4.5 million, potential future claims, and needed contingency on work that has yet to be designed (valued at approximately $8.0 million). The Committee believes the level of contingency should be approximately 20 percent of the work remaining.

Sufficient safety incidents have occurred under the Turner contract to suggest consideration of whether the commitment of Turner to safety is permeating all aspects of the work. Turner continues to foster Integrated Safety Management and generally has high marks for planning and housekeeping. However, three lost time and two recordable injuries require proactive planning on the part of Turner Construction. Some consideration should be given to whether cross communication of all aspects of the work and ownership of the entire safety program is fully understood and accepted by all Turner subcontractors and the entire workforce, and whether the entire workforce is consistently examining all aspects of their efforts. This commitment by the workforce is as critical as all the safety inspections in place.

Consideration should be given to the possibility the FY 2008 funding might have to include contingency associated with the Turner contract that exceeds present expectations.

Insituform Technologies announced plans to seek buyers for its tunneling business and assets. Insituform is the parent company of Affolder, Inc., tunneling subcontractor for the LCLS tunnels and Far Experimental Hall.

Turner Construction, who holds the contract with Affolder, and LCLS management were in contact with Affolder senior management to understand and assess the impact to the LCLS project. Affolder management stated that it intends to honor contractual agreements for the LCLS project and has offered retention bonuses for key staff. Turner and LCLS management plan continued discussions with Affolder as the details of the liquidation unfold. This situation needs to be closely watched should a default situation develop.

3.3 Recommendations

1. Continue to monitor Turner's schedule recovery plan.

2. Investigate the impact to the project of a failure to achieve the first joint occupancy date of December 2007. Consider the impact of an up to three-month delay of joint occupancy.

3. Re-evaluate the cost estimate for the remaining work not under contract.

4. Retain a contingency allowance of between 30 and 50 percent for all CF work for which a final design and an accompanying cost estimate are not in hand, at the time of this review. Retain that level of contingency until contract award.

5. Prepare a pessimistic worst-case scenario for funding unsettled and future claims arising from the Turner contract. Include these considerations in contingency planning for the project re-baseline. It is essential to avoid forced de-scoping of any remaining project work.

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

7. Use care and maintain some financial flexibility in the latter part of FY 2008.

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4. COST, SCHEDULE, and FUNDING

4.1 Findings

Table 4.1 shows the changes in the funding profile required to support rebaseline. The total change to the overall funding profile for the project is a $29.8 million increase in total project cost over fiscal years 2009 and 2010.

Table 4-1. LCLS Funding Profile

	PY	FY2007	FY2008	FY2009	FY2010	Total
Existing Funding						
TEC	147.7	105.9	51.4	10.0		315.0
OPC	11.0	16.0	15.5	21.5		64.0
TPC	158.7	121.9	66.9	31.5		379.0
Proposed Funding						
TEC	147.7	100.8	51.4	31.5	7.4	338.8
OPC	11.0	13.0	15.5	17.0	13.5	70.0
TPC	158.7	113.8	66.9	48.5	20.9	408.8
Delta						
TEC		(5.1)		21.5	7.4	23.8
OPC		(3.0)		(4.5)	13.5	6.0
TPC		(8.1)		17.0	20.9	29.8

The FY 2005 project baseline defined a single CD-4 event schedule for July 2009. This single event was subsequently split into two CD-4 events in the proposed post-CR rebaseline. The first CD-4 event, CD-4a is defined as the “Start of FEL/Near Hall Operations” scheduled for July 2009 and CD-4b “Project Completion”, scheduled for May 2010.

The project schedule is logically linked and a critical path schedule is developed and apparent. The project schedule is resourced appropriately, and the resulting time-phased budget is consistent with the available funding profile. The revised baseline schedule allows for approximately three-and-one-half months of schedule contingency before the completion of CD-4b.

The effects of the FY 2007 Continuing Resolution were incorporated into the revised baseline for the LCLS project. The revised baseline includes the actual schedule adjustments and cost escalations that occurred as a result of the continuing resolution. The project did not include any scope additions or updated cost estimates except for those directly affected by the Continuing Resolution.

The LCLS project completed its last detailed estimate in August 2006. This detailed estimate was used as the basis of estimate to recalculate the project's revised baseline to assess the Continuing Resolution impacts. The proposed rebaseline includes only the costs associated with the Continuing Resolution in the baseline cost.

4.2 Comments

The project management team actively uses the resource-loaded schedule to assess project performance, actively manage authorized work and analyze the impact of proposed changes to the baseline.

Several known risks were identified and are pending in the project change control process. These same risks were inconsistently included in the project's risk registry. Project risks found in the risk registry were sometimes represented in the project's contingency pool. This inconsistency between these two risk management tools could have an adverse effect on the integrated project risk management process.

4.3 Recommendations

1. The proposed baseline should be re-evaluated to incorporate updates to the underlying detailed cost estimate and sequencing of the activity schedule required to manage the revised approach to project completion and transition to operations. This will incorporate knowledge about the detailed work to complete that have resulted from design maturation and review, emerging market conditions, and additional experience and interaction with the vendor base.

2. Early integration with the user community is a requirement of the project. An interface milestone with the scientific program should be clearly defined and placed into the baseline schedule to clarify what capability will be available to begin the process of integrating experimental activities into the schedule prior to full facility capability.

3. The method of execution should be reviewed to ensure that the schedule is sequenced appropriately. The FY 2008 funding level is a significant constraint to providing an initial R&D capability in FY 2009. The project should be carefully organized to ensure that all work required deliver the initial capability defined above can be completed free of undue risk to completion of the project as a whole.

4. The contingency estimate to accompany the revised baseline should be derived using a graded risk approach that incorporates both endogenous risk in the baseline estimate and exogenous risk from outside the project. This will provide a risk management pool that is both reliable in derivation and robust in scale to deliver the project with a reasonable level of risk at an acceptable cost. This estimate should include an analysis of the impact of schedule delays at key points in the project that could have an impact on the overall completion date or interim deliverables to the user community.

5. The level of procurement authority ($100K) held by the SLAC site requires that over 80 procurement packages for the project be reviewed and approved by the SSO prior to release and award. This process should be closely managed to ensure that potential impacts to the schedule are appropriately managed until the level of authority is restored by the SSO.

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5. PROJECT MANAGEMENT

5.1 Findings

The LCLS project team made excellent technical progress since the October 2006 DOE review. The recent commissioning results are very encouraging. The project is over 50 percent complete and construction activities are progressing in accordance with the current funding plan.

The project organization was strengthened to include: the position of a Chief Instrument Scientist to promote tighter integration of LCLS instrumentation plans; an Associate Project Director for Engineering to manage the engineering effort and the transition of engineering staff from accelerator to experimental activities; and a Controls Manager filled by the Control Department Head from the Laboratory's Operations Directorate.

Responsibility for the LUSI project to create three diagnostics systems to be housed in the experimental hutches is incorporated into the existing LCLS management organization. SLAC accelerator operations will begin to transition into the LCLS organization in FY 2008. Hence, the LCLS management team is now responsible for the LCLS project, the LUSI project, and the transition to operations with the associated support of science program.

The project team was generally very responsive to the recommendations from the previous comprehensive review.

An LCLS project dedicated procurement cell was established early on to support project procurement activity. This cell reports directly to the SLAC Business Manager separately from the SLAC-wide procurement office. A recent Procurement Evaluation Review Team (PERT) audit of SLAC found problems with procurements in both the SLAC-wide procurement office and LCLS dedicated procurement cell. Subsequent to the PERT review, the DOE SLAC Site Office imposed a drastic reduction in the SLAC procurement authority threshold from $7 million to $100K. There are numerous LCLS procurements that exceed the $100K threshold and require DOE review and approval.

There were three "safety incidents" in the CF arena of the LCLS project. Two of these involved minor injuries.

Beginning in FY 2008 the Linac Operating budget is supported directly by the Office of Basic Energy Sciences. The FY 2009 Linac Operating budget is expected to be $96.7 million. It is expected that some number of LCLS project staff will move to commissioning and operating activities as they complete their project tasks.

LCLS meetings with the Director are held twice per week. Nine months ago these meetings were held daily.

The LCLS Project Management Oversight Group (PMOG) chaired by Lowell Klaisner that reports to the Director continues to be active with a recent important task having been to carefully scrutinize the coming shutdown installation plans for LCLS and advising on the readiness and likelihood of completion on schedule.

SLAC management and Stanford University have retained management consults from McCallum-Turner to conduct a Management Systems Analysis for the laboratory.

The project developed a new LCLS project baseline based on the impacts of the FY 2007 Continuing Resolution. Extensive documentation on these impacts were provided and discussed with the Committee.

The revised baseline proposal includes a budget of $339 million (TEC) that includes $27.1 million of contingency and a budget of $70.0 million (OPC), and includes $7.8 million of management reserve. The proposed LCLS Total Project Cost (TPC) is estimated at $409 million.

The Estimate to Complete (ETC) is $157.2 million of the TEC. Contingency of $27.1 million represents 17.2 percent of the ETC. The go-forward OPC budget is $46.9 million of OPC and includes a management reserve of $7.8 million, roughly 16.6 percent.

The FY 2008 TEC budgeted cost and contingency figures are $68.2 million and $8.2 million respectively (12.0 percent contingency). Civil construction costs are estimated at $38.9 million.

The CD-4 milestone for project completion is delayed by 14 months from March 2009 to May 2010. This delay was a result of the FY 2007Continuing Resolution and the resultant budget reduction of $7 million in that fiscal year. The reduction resulted in a shift of procurements from FY 2007 to FY 2009 needed to complete the construction project. The critical path includes just over three months of schedule contingency. In addition, the LCLS organization plans to start a science program in late FY 2009.

SLAC personnel working on LCLS are beginning to transition off the project as elements of the project are completed. This transition is a challenge to manage for both the LCLS project team and the Laboratory. Delays implementing planned staff transitions can result in additional costs to the project.

As noted above, the DOE Site Office reduced the procurement authority at SLAC, including the LCLS, from $7,000K to $100K. The Site Office Manager committed to rapid review of these procurement packages, from three to five days depending on the complexity of the package. The LCLS Deputy Project Manager estimates that there are 20 procurement actions in excess of $100K over the next six months.

5.2 Comments

The Project Director and Deputy Project Director continue to provide capable leadership during a very challenging phase of the project. The LCLS project management team has also successfully managed the additional challenges of the prolonged FY 2007 Continuing Resolution. With DOE concurrence, the leadership focused on maintaining the civil construction work as the highest priority.

LCLS management has an increasing workload with responsibility for LUSI, the merging of the SLAC Accelerator Operations Division into the LCLS organization, LCLS Operations, and User Community Outreach.

The designs of the technical systems were sufficiently mature to support the planned hardware procurements. Procurement plans and equipment installation and commissioning plans are consistent with the current working schedule.

There is very close attention paid to the contingency budget to ensure that only essential contingency allocations are approved. The combination of science goals in FY 2009, less than optimum annual construction funding in FY 2008, and a tight overall contingency budget leaves the management team with limited flexibility.

Members of the committee spoke with SLAC Site Office (SSO) staff about the SLAC procurement situation. The SSO Manager is supportive of the LCLS dedicated procurement cell, and is working with the Laboratory to achieve improved quality procurement packages. It is stated that as the quality of the procurement packages improves over time increasing or even restoring the original approval thresholds will be considered.

A new Business Manager was recently hired at SLAC—the Director noted that improving SLAC Procurement is a high priority for this new position.

The recent "safety incidents" are a concern to all. The project places a high emphasis on safety including a strong safety program and capable safety staff personnel. LCLS and SLAC worked with Turner to apprise them of the strong LCLS and SLAC commitment to safety and safety awareness. With urging from SLAC, Turner replaced their on-site safety person in April. There were positive results from this action in several areas. A Laboratory-wide initiative is planned where each Division will focus at the supervisor level for two to three hours on safety and interactions between supervisors and staff on safety awareness.

A Transition Plan needs to be prepared by SLAC and the LCLS project that shows the schedule by individual employee for completion of work and movement off the project. This plan needs to be agreed upon with the Directorate and adhered to closely and rigorously. The rudimentary version of such a plan exists which identifies functional job titles and numbers of staff in each category. Persis Drell, SLAC Directorate, heads a Transition Working Group (TWG) that was charged by the Director with creating a Laboratory-wide plan.

Twice per week LCLS meetings with the Directorate may be adequate, but a more careful focus on questions critical to project success may be required.

SLAC management worked with LCLS to develop a reasonable plan for renovating office space and laboratories that should meet the requirements for LCLS facility operations.

The project prepared extensive documentation on the impact of the Continuing Resolution in FY 2007. The Continuing Resolution resulted in a project slow down during the beginning of the fiscal year and reduced funding in FY 2007. The funding delays and reductions were encountered at the worst possible time for the LCLS project, when the project had already ramped up labor and monthly spending rates were peaking. Management elected to slow down accelerator activities in deference to funding existing CF contracts and related critical path activities. The Continuing Resolution impacts as described by the project appear to be reasonable.

The revised baseline proposal is almost entirely focused on the impacts of the FY 2007 Continuing Resolution. The Committee was not confident that the project can be completed in accordance with the cost and schedule baseline as currently proposed and some adjustments to the CD-4 schedule, contingency budget, and early science program are appropriate. Specific concerns are the schedule for CD-4 (CD-4a and CD-4b as currently proposed), which does not

provide adequate time for the DOE approval process, and the contingency funding available in FY 2008, which is less than the Committee concluded would be needed in that year. There is also a more general concern that the management team has limited flexibility to address cost and schedule issues that are likely to be encountered as the project transitions from construction and commissioning into operations. The schedule for CD-4 can be strengthened by the addition of a couple of months to address the time required for DOE approval following the completion of the LCLS construction and commissioning. The contingency situation in FY 2008 can be improved by pushing some additional work currently planned for FY 2008 into FY 2009, primarily activities associated with the near experimental hall. If cost experience is good in FY 2008 some of these activities could be advanced earlier than the revised plan.

As noted above, the available contingency funding in FY 2008 does not appear to be adequate to address the cost risks associated with the work planned. The Deputy Project Manager identified approximately $2.4 million of "swing" procurements that can move from FY 2008 to FY 2009, and suggested that there may be other opportunities. A careful evaluation of the critical path to project completion and the associated scope in FY 2008 should be completed as rapidly as possible.

Scope needed in FY 2008 to support the science mission in FY 2009 but not on the critical path to project completion in FY 2010 should be clearly identified.

The project baseline should be revised to not only address the impacts of the FY 2007 Continuing Resolution but also a second category of items derived from a current bottoms-up estimate of the project costs, schedules, and risks.

Past project reviews highlighted issues with staff planning across SLAC to support the LCLS project. FY 2007 represents the year of the highest head count of individuals that will work on the project. FY 2008 will see completion of several major elements of the project. The ability to move staff onto the LCLS project and off the project in a rapid way is the only way SLAC can succeed with the execution of multiple projects and maintain continued operation of the existing program. The laboratory must develop a staffing transition plan that integrates LCLS project staffing requirements with the rest of the laboratory. The project needs to be in a position to move people off the project as the project work comes to an end. A complete transition plan for staff to move on and off projects needs to be developed before the beginning of FY 2008.

A dedicated procurement "cell" for large construction projects provides the opportunity to ensure timely bid and award of contracts. A procurement authority of $100K is unusually low for a project of this magnitude, and introduces the possibility of significant delays in additional, serial reviews. The key issue is that high quality procurement packages are awarded, and the resulting contracts are well managed.

The LCLS management team, including the procurement manager, need to ensure that this goal of timely, quality awards are achieved. The team should work closely with the DOE Site Office to review the status of the procurement packages over the next few months, and implement whatever means are necessary to produce contracts of the required quality. Through a combination of staffing and training the goal should be to restore the LCLS procurement authority as rapidly as possible. An interim goal should be to increase the procurement authority, to perhaps $1 million within the next two months.

5.3 Recommendations

1. Revise the baseline to address the review recommendations within 30 days.

2. Determine the science program that can be accomplished prior to CD-4 (FY 2009-FY 2010) and submit a description of this program to DOE for concurrence with the final baseline.

3. Develop an initial staffing transition plan to support the final revised baseline within the next 30 days, proceed to the final plan as soon as possible, secure directorate approval, and adhere rigorously to the plan.

4. Establish procedures and agreements within SLAC that enable LCLS management to transition staff off the project when it meets the needs of the project.

5. Establish a Senior Scientific Leadership position within the organization of the Associate Laboratory Director for LCLS that can address the increasing demand for coordination of the science program and interactions with the growing user community.

6. Work closely with the DOE SLAC Site Office to improve procurement packages and increase LCLS procurement authority as soon as possible.

7. Continue ongoing efforts to emphasize safety performance improvement.

6. ENVIRONMENT, SAFETY and HEALTH

6.1 Findings and Comments

Construction activities during the time of the review consisted of excavation, tunneling, and concrete forming. This work will transition shortly to Mechanical Electrical and Plumbing installation.

The Committee's principle safety concern during previous reviews was the tunneling operation and its associated risks. This aspect of the project was effectively addressed. The Palo Alto Fire Department emergency rescue team was trained in tunnel emergency response and extraction. Tunneling operations are being conducted by Affholder with effective line management safety oversight. Industrial Hygiene assessments are being conducted per Cal OSHA requirements. Interviews with tunneling personnel reflect they were given a baseline medical prior to starting work on this project. They further indicated that it is Affholder's practice to conduct annual follow-up medicals. The Committee considered this aspect of the project is being handled effectively.

Concrete preparation and forming activities have been underway for ten months. Conco is effectively managing this operation. Of particular note was the cleanliness of their site, the depth of experience of their field supervision and the effectiveness with which they coordinate their work crews. The Committee observed a tool box talk that was conducted in both English and Spanish. It included active involvement by all work team members and concluded with a stretch and flex session. The stretch and flex program was included in the Conco safety program by their corporate safety manager. All the perimeters of elevated work locations were delineated by flagging in compliance with Cal OSHA and all workers at heights were protected by engineered fall protection systems. Conco had clearly given this aspect of work safety planning a great deal of consideration. All forms have built-in anchor points and are assembled with fall protection mechanisms in place.

Turner's new safety manager has implemented several positive safety initiatives: Safety Coaches and Safety Newsletter, and has introduced elements of a safety observation process. The new TCCo safety manager is a Certified Safety Professional with good relevant safety experience. The TCCo safety staff currently includes two individuals during the day shift and one covering after hour activities. The professional safety presence on-site is average. Turner requires that each subcontractor have a designated safety person. Where subcontractors' on-site work crews exceed 50 people, a dedicated safety person must be on-site.

The Committee heard conflicting statements during Turner management interviews regarding their understanding of the basis of the project safety program. The conflict lay in the lack of clarity of whether oversight of subcontractor safety performance compliance would be based on the Turner Site Specific Safety Program or each subcontractor's respective Site Specific Safety program. This lack of common understanding of the safety program within TCCo management indicates that there is a weakness in Turner management's understanding of their roles and responsibilities. If they do not understand their own safety program requirements, they cannot be expected to effectively steward safety compliance. A review of the Turner Site Specific Safety program revealed several program elements that are not being implemented. For example, the Fall Protection section (p. 60) defines specific requirements for anchor points. Documentation of compliance with this requirement was not readily available for a specific anchor point identified as an example. The Turner Site Safety program Material Handling section (pg. 69) requires that a Stretch and Flex program be in place. This is a good practice, but was being implemented by only one subcontractor. This is another indicator that TCCo management is not familiar with their safety program requirements. If they were, these elements would be expected to be in place.

Another inconsistency in the Turner safety program was a sign at the site entrance that states "All Injuries Are Preventable" and repeated comments made by Turner management that some accidents and injuries just happen and cannot be avoided. Turner has the safety program elements in place that can make the statement "All Injuries Are Preventable" a fact, if applied. The assessment team suggests that the project (both LCLS and Turner) review their respective project field personnel's familiarity with the Site Safety Program elements and its program implementation throughout the project. It is the Committee's position that a single site specific safety program is preferable to that of that of each subcontractor having their own site specific safety programs which meets minimal Turner Corporate Safety Program requirements. The Turner requirement that each subcontractor submit an individuals site specific safety program entails that Turner management review each plan and that the superintendents monitoring work compliance be familiar with each of their subcontractors' site specific safety programs. This results in an inordinate amount the project management team's time being spent maintaining familiarity with each subcontractor's safety program and will result in conflicting interpretation and levels of enforcement. Turner's management effort would be better spent becoming familiar with and enforcing a single site specific program.

Numerous safety inspections are being conducted throughout the project by the various organizations with responsibility for project oversight. The results of these inspections are being recorded and the deficiencies tracked. Not withstanding the number of inspections being

conducted the assessment team identified several safety compliance deficiencies in a relatively short time at the job site. The assessment team suggests that the project evaluate the quality of the inspections being conducted by both LCLS and TCCo field personnel. The project should also re-evaluate its analysis techniques of this information to identify trends of observations and assess leading indicators of future exposures.

Turner safety has introduced elements of a safety observation process to its line management. The assessment team believes this is a positive initiative that will effectively support project safety. The Committee supported the project's implementation of a safety observation process by both LCLS and TCCo management and field personnel. Best-In-Class organizations have management safety observation processes incorporated into their programs.

The assessment team also recommends that given the imminent escalation in field activities as the project transitions into Mechanical, Electrical, and Plumbing that the frequency of All-Hands Meetings should be increased from its current schedule of being held monthly.

The project installation and commissioning work planning and execution reflects a systematic integration of safety throughout its processes. Safety requirements were included in the work scope defined for each of the project major components and the Integrated Installation and Commissioning Plan. Safety is also readily apparent in the Installation Readiness Review process and Work Authorization approvals obtained before work begins.

Oversight of work execution is provided by a University Technical Representatives (UTR). UTR training was recently upgraded by SLAC and is a requirement to be completed by all UTRs. Job Safety Analysis (JSA) are completed for each task and daily coordination meetings are held between the UTR and subcontractors or SLAC workers.

While still early in the overall LCLS installation/commissioning schedule, the process and procedures were proven to effectively provide for the safety of installation and commissioning work. Safety performance of each task is reviewed on completion and Lessons Learned integrated into the next cycle for continuous improvement.

6.2 Recommendations

1. Analyze inspection data to look for leading indicators to predict and prevent future injuries by July 31, 2007.

2. Provide visible Senior Management (LCLS and Turner) leadership in safety program implementation to demonstrate management commitment to project safety goals by July 31, 2007.

3. Increase the frequency of Turner “All-Hands Meeting” by July 31, 2007.

APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government
Department of Energy

memorandum

DATE: May 17, 2007

REPLY TO
ATTN OF: SC-22

SUBJECT: DOE REVIEW OF THE Linac COHERENT LIGHT SOURCE (LCLS) PROJECT

TO: Daniel R. Lehman, Director, Office of Project Assessment, SC-1.3

I request that you organize and lead an Office of Science (SC) status review of the Linac Coherent Light Source (LCLS) project at the Stanford Linear Accelerator Center (SLAC) during July 10-12, 2007. The purpose of this review is two fold: 1) evaluate progress in all aspects of the project—technical, conventional facilities, cost, schedule, management, and environment, safety and health (ES&H), and 2) coordinate with OECM who will conduct a limited External Independent Review (EIR) to validate the revised performance baseline.

During the past several months, progress has been made in fabricating/assembling the LCLS technical hardware and construction activities. The project was forty-five percent complete as of the en dof March 2007. The project team started implementing the plan to reutilize existing facilities to provide office space for LCLS operations in lieu of constructing a Central Laboratory Office Complex (CLOC). The FY07 continuing resolution (CR) has impacted the project cost and schedule due to the delay and shortfall in funding. The project team has evaluated the impacts and prepared a revised performance baseline as a result of the CR. A Baseline Change request (BCR) has been prepared for the effects of the CR. At the same time, the CLOC construction will be removed form the baseline. The BCR will be processed after the completion of the review.

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

1. Is the proposed baseline sound, considering the reduced funding scenario imposed by the FY07 Continuing Resolution and the FY08 President's Budget? Are the project's cost, schedule, and technical baselines consistent with these limitations and the FY08 LCLS Construction Project Data Sheet? Is the information in the DOE PARS consistent with physical progress?

2. Are the construction field activities progressing in a manner consistent with the predicted costs and schedule? Has the CLOC replacement laboratories and office space been integrated into the appropriate project planning and execution documents?

3. Are the designs of the technical systems sufficiently mature to support the planned hardware procurements? Will the procurement plans and equipment installations and commissioning plans support the project schedule?

4. 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?

5. Are ES&H aspects being properly addressed given the project's current stage of development?

6. Is the project being managed (e.g., properly organized, adequately staffed) as needed to continue with construction? Is there adequate support from SLAC in all necessary areas (e.g., contracts, procurement, human resources)? Has the project responded appropriately to recommendations from prior DOE/SC reviews?

Thomas Brown, the LCLS Program Manager, will serve as the Basic Energy Sciences point of contacts for 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:
A. Richards, SSO
H. Lee, SSO
H. Joma, SSO
J. Dorfan, SLAC
K. Hodgson, SLAC
J. Galayda, SLAC
M. Reichanadter, SLAC
S. Tkaczyk, SC-1.3
P. Montano, SC-22.3
T. Brown, SC-22.3
L. Cerrone, SC-22.3
M. Martin, SC-22
E. Rohlfing, SC-22.1
M. Procario, SC-25.1
P. Bosco, MA-50
S. Kapur, MA-50

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the Linac Coherent Light Source (LCLS) Project
April 10-12, 2007

Daniel R. Lehman, Chairperson, DOE/SC

SC1

Accelerator Physics

* Sam Krinsky, BNL
Glenn Decker, ANL

SC2

Injector/Linac

* Richard Sheffield, LANL
John Lewellen, ANL

SC3

Undulator

* Erik Johnson, BNL
Steve Marks, LBNL

SC4

Photon Beam Handling Systems

* Dennis Mills, ANL
Chi-Chang Kao, BNL

SC5

Control Systems

***** Dave Gurd, ORNL
Michael Thout, Consultant

SC6

Conventional Facilities

* Dixon Bogert, Fermilab
James Lawson, ORNL
Mike Schaeffer, BNL

SC7

Cost and Schedule

* John Post, LLNL
Bob Swale, ANL
Steve Tkaczyk, DOE/SC

SC8

Project Management Procurement/Pre-Ops

* Jim Yeck, BNL
Jeff Atherton, LLNL/NIF
Pepin Carolan, DOE/FSO
Scott Gibbs, LANL
Ed Temple, Fermilab

SC9

ES&H

* Arnold Clobes, LLNL
Joel Becks, DPR Construc.
John Kyle, Jacobs

Observers

Jeff Salmon, DOE/SC
Pat Dehmer, DOE/SC
Tom Brown, DOE/SC
Thomas Kiess, DOE/SC
Pedro Montano, DOE/SC
Hanley Lee, DOE/SSO
Hannibal Joma, DOE/SSO

LEGEND

SC Subcommittee
* Chairperson
[ ] Part-time Subcom. Member

Count: 25 (excluding observers)

APPENDIX C

REVIEW AGENDA

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

AGENDA

Tuesday, July 10, 2007—B048/Redwood Room

8:00 am	DOE Executive Session	D. Lehman
9:00 am	Welcome	J. Dorfan
9:15 am	LCLS Project Overview and Assessment	J. Galayda
10:00 am	Break	
10:15 am	LCLS ES&H and Integrated Safety Management System	M. Scharfenstein
10:30 am	LCLS Project Management and CR Impacts/Baseline Updates	M. Reichanadter
11:15 am	LCLS Commissioning	P. Emma
11:45 pm	E-Beam Systems/Undulator Status	D. Schultz/G. Pile
12:30 pm	Lunch	
1:30 pm	Site Tour (Research Yard/NEH/Injector/Laser)	CF PMs
2:30 pm	Photon Beam Systems	J. Arthur
3:00 pm	Conventional Facilities	J. Albino
3:30 pm	LCLS Global Controls	H. Shoaee
4:00 pm	Break	
4:30 pm	Breakout Sessions (see detailed agenda)	
5:00 pm	DOE Executive Session	D. Lehman
6:30 pm	Adjourn	

Wednesday, July 11, 2007

8:00 am	Breakout Sessions	
12:00 pm	Lunch	
1:00 pm	Breakout Sessions	
3:00 pm	DOE/IPR Executive Session	Executive Committee
5:30 pm	Adjourn	

Thursday, July 12, 2007

8:00 am	DOE/IPR Closeout Dry Run	Lehman
10:30 am	IPR Closeout Presentation	
11:30 am	Adjourn	

APPENDIX D

COST TABLE

Continuing Resolution

Linac Coherent Light Source BCWS Profile (AYM$)										
WBS	System BCWS	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	Total
1.1	Project Mgmt., Admin. & Integration	0.00	1.45	2.39	5.75	8.77	4.91	1.72	0.41	25.39
1.2	Injector System	0.00	0.65	1.91	4.57	11.14	2.17	0.03	0.00	20.46
1.3	Linac System	0.00	0.19	1.15	1.92	6.84	13.78	3.07	0.00	26.96
1.4	Undulator System	0.00	0.59	1.58	5.86	11.71	18.18	2.67	0.00	40.60
1.5	X-Ray Transport & Diagnostics	0.00	0.71	0.82	3.28	5.30	11.60	2.90	0.00	24.60
1.6	X-Ray Endstations	0.00	0.00	0.20	0.54	0.77	6.11	7.09	0.65	15.36
1.9	Conventional Facilities	0.00	0.12	1.60	4.45	17.95	75.11	25.62	0.00	124.86
Estimated Base Cost		**0.00**	**3.71**	**9.65**	**26.36**	**62.48**	**131.87**	**43.10**	**1.06**	**278.24**
Total	**Construction Budget Authority**	**0.00**	**3.71**	**9.67**	**49.68**	**85.54**	**105.90**	**50.50**	**10.00**	**315.00**
2.1	Project Mgmt., Admin. & Integration	1.50	0.00	1.15	1.84	2.18	5.86	7.20	10.70	30.43
2.2	Injector System	0.00	0.00	0.13	0.57	0.27	3.09	1.26	0.01	5.33
2.3	Linac System	0.00	0.00	0.00	0.00	0.03	0.81	1.93	0.56	3.33
2.4	Undulator System	0.00	0.00	0.45	0.30	0.46	3.21	1.58	0.78	6.77
2.5	X-Ray Transport & Diagnostics	0.00	0.00	0.27	0.22	0.00	0.72	2.21	1.13	4.54
2.6	X-Ray Endstations	0.00	0.00	0.00	0.13	0.56	1.34	2.46	1.10	5.60
2.9	Conventional Facilities	0.00	0.00	0.00	0.00	0.00	0.38	0.30	0.00	0.68
Other Project Costs Budget Authority		**1.50**	**0.00**	**2.00**	**3.07**	**3.50**	**15.40**	**16.95**	**14.27**	**56.68**
Total Other Project Cost (Base + MR)		**1.50**	**0.00**	**2.00**	**4.00**	**3.50**	**16.00**	**15.50**	**21.50**	**64.00**
Total Budget Authority, TEC + OPC		**1.50**	**3.71**	**11.67**	**53.68**	**89.04**	**121.90**	**66.00**	**31.50**	**379.00**

APPENDIX E

SCHEDULE CHART

Recent L3 Milestone Performance

Milestone	Plan	Actual	Var
CF – Research Yard Mods BO	9/21/06	8/30/06	-16d
UN - MMF Ready to Measure	10/27/06	8/28/06	-44d
LN – X-Band Klystron RFI	11/27/06	8/31/06	-62d
IN – Start Laser Commission	12/14/06	1/16/07	14d
IN – Inj Controls Install Complete	1/2/07	3/16/07	52d
LN - Start BC1 Commissioning	2/28/07	3/30/07	22d
IN - Start Injector Commission	3/6/07	4/5/07	22d
CF – Linac Power/Water Available	6/11/07	3/29/07	-52d
UN – 33 Undulators @ SLAC	7/6/07	4/30/07	-49d

Despite the CR effects, LCLS team has been able to deliver on its near-term milestones.

Key Upcoming L3 Milestones

Milestone	Plan	Comments
XT – AWARD: LE Mirror Substrate	Jul-07	Awarded
XE – COMP: AMO PDR Meeting	Aug-07	On schedule
PM – FY07 Shutdown: HW RFI	Nov-07	On schedule
XE – 2-D Detector Mid-Project Review	Nov-07	On schedule
XT – AWARD: HE Mirror Substrate	Nov-07	On schedule
XT – Fixed Mask RTS to SLAC	Dec-07	On schedule
LN – BC-2 Installation Complete	Jan-08	On schedule, tight
UH – 1st Prod Vac Chamber @ SLAC	Jan-08	Near CP, issues
CF – BTH, FEE, UH, EBD Co-Occ	Dec-07	CP, On schedule, tight
LN – Start Linac Commissioning	Feb-08	On schedule, tight

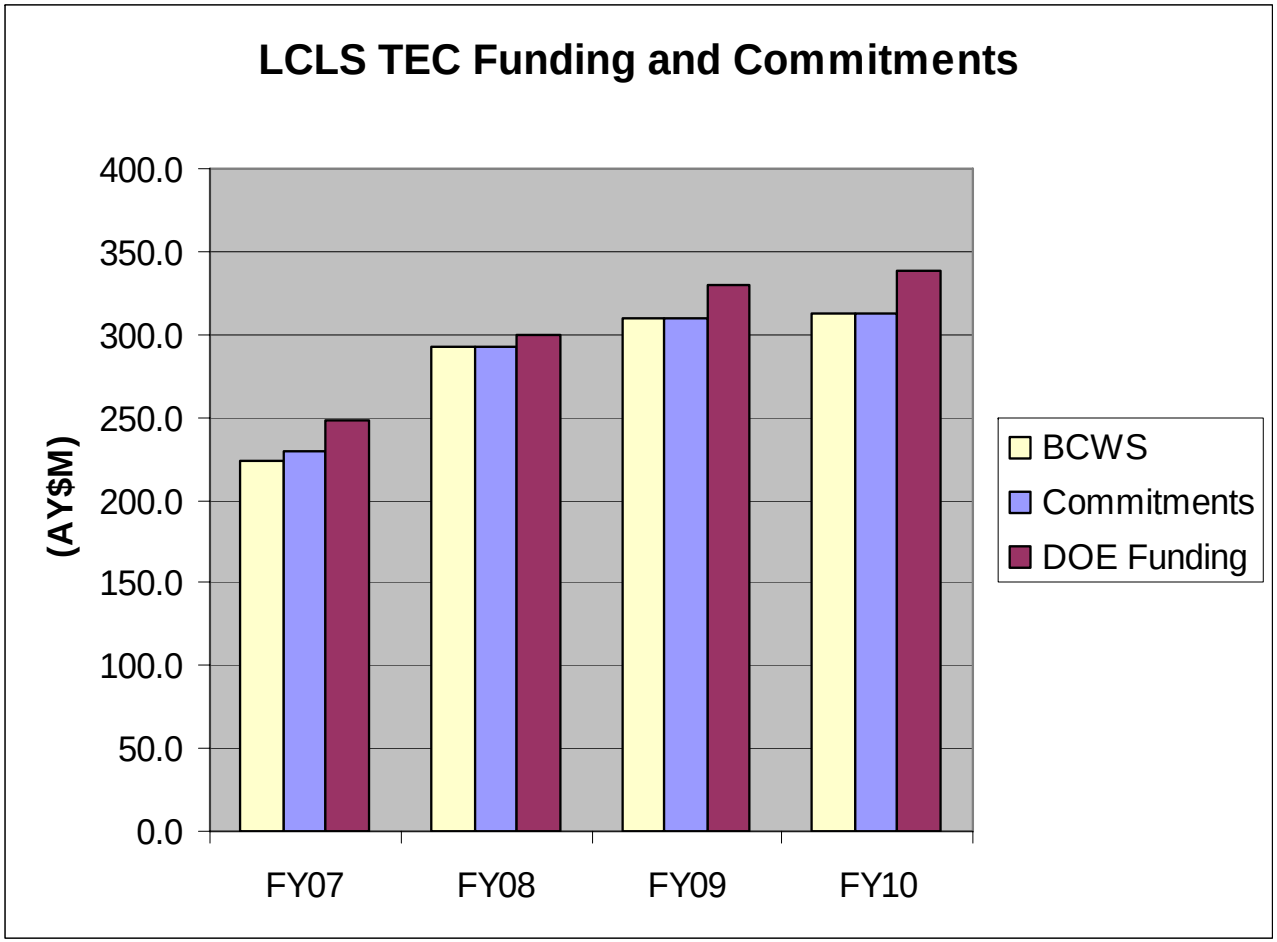
Mitigate vacuum chamber risk with focused and experienced task force

Co-Occupancy interface to installation effort. Critical interface.

APPENDIX F

FUNDING CHART

Revised TPC Funding Profile



FY08 contingency is tight

- FY07 TEC down $5M
- FY08 no restoration
- CR degraded performance

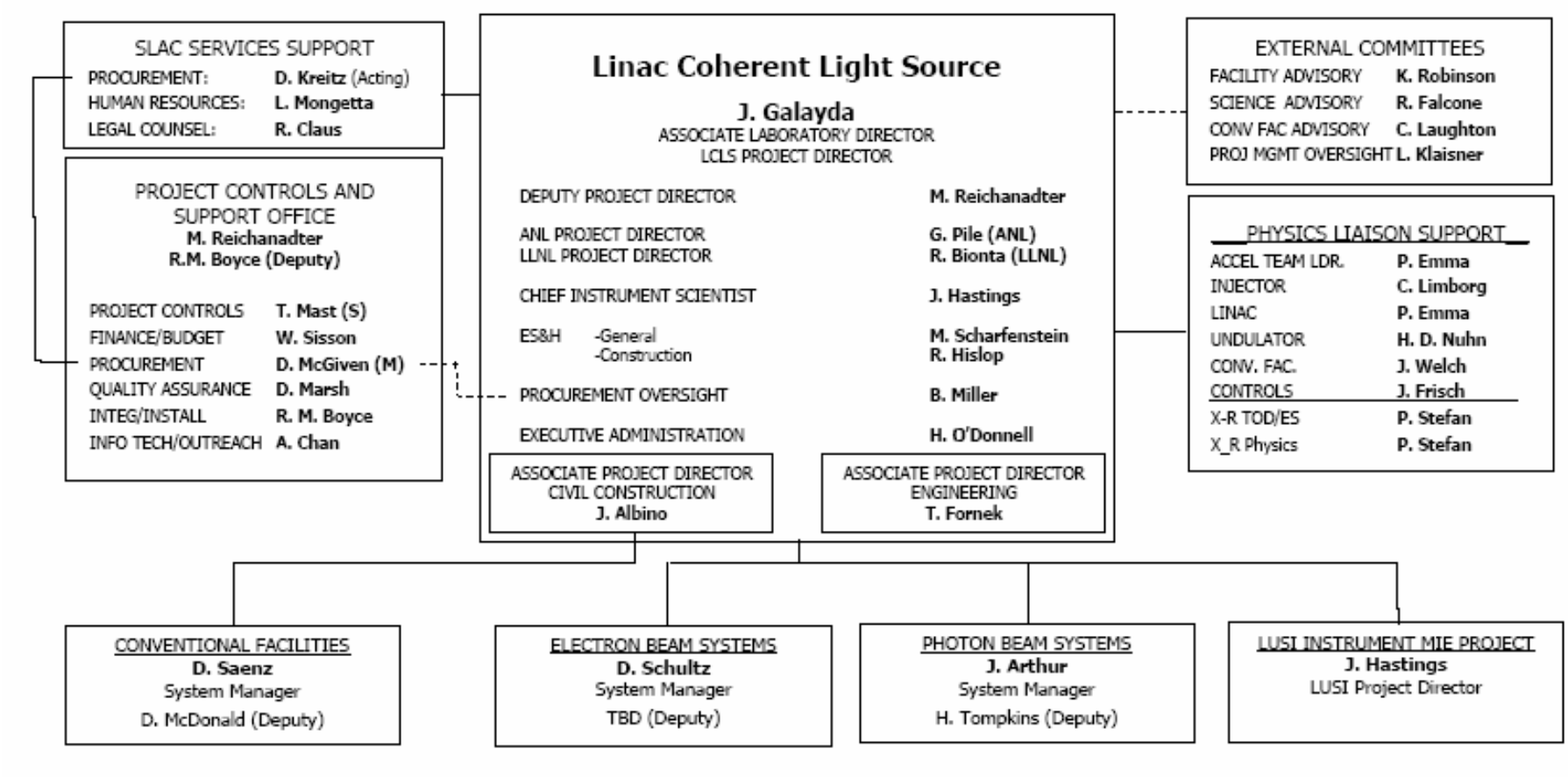
Mitigation

- Pushed work into FY09.
- Identified swing procurements
- Track on risk list.

APPENDIX G

MANAGEMENT TABLE

LCLS Organization



APPENDIX G

ACTION ITEMS

Linac Coherent Light Source (LCLS)
SC Project Review, July 10-12, 2007

Action Items

Action	Responsible Party	Due Date
1. Re-evaluate the project baseline change request.	SLAC	August 15, 2007
2. Conduct a Mini-Review to evaluate the projects readiness to proceed with Baseline Change Request.	DOE BES, DOE SSO, and SLAC	Late August 2007

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