LCLS Response to Recommendations from February 2006 DOE Review of the LCLS

2. TECHNICAL SYSTEMS

2.1 Accelerator Physics

2.1.1 Findings

The LCLS accelerator design is mature and well planned. The interface between the physicists and engineers is effective and the planning and scheduling activities are proceeding well. Project status tools are implemented and continually used to identify problem areas. Integrated safety management is effective and considered as a fundamental part of all designs and activities.

There is a good concept for the high-level controls (XAL/MATLAB). However, the control system may not be ready for commissioning in December 2006. Work on control system hardware and the high-level accelerator physics applications is lagging behind the required schedule.

Interfacing the LCLS hardware with the existing SLC presents a schedule risk. Development of the utilities (water, electrical, heating, ventilation, and air conditioning [HVAC]) needs enhanced attention. Having two control systems (one for LCLS and one for SLC) is a significant complexity that can be expected to cause problems. The possible changeover between LCLS and 30 GeV SLAC operations may introduce delays.

The bunch length monitor after Beam Compressor 1 (BC1) is critical for injector commissioning in December 2006, but is still in an early stage of design.

2.1.2 Comments

It is important to transport the electron beam to the Beam Switchyard in order to verify the bunch length monitor using the transverse deflecting cavity. To accomplish this, the project must resolve Beam Containment System and SLAC linac Beam Position Monitor (BPM) timing issues.

LCLS Controls and the Accelerator Operations department continue to investigate how to best accomplish running LCLS beams to the end of the linac. Solutions have been proposed and are being studied further.

The plan in place for BCS and BPMs for commissioning will allow transporting the beam to the switchyard.

A very tight vibration tolerance (50 nanometers) is required on certain quadrupoles. Work should be carried out to model quadrupole vibrations in their supports.

Most of the new LTU quadrupole magnet vibration tolerances are set at 50 nm rms for the LCLS. These magnets will have new supports, which will meet these tolerances. The 80 existing linac quadrupole magnets must meet vibration tolerances of 100 nm rms for LCLS operations. Quadrupole vibration in the linac has recently been measured. Special attention was focused on sector-25, which is directly beneath the Interstate 280 pass-over. Certain of the quadrupole vibration amplitudes are 2-3 times larger than the tolerance, due mostly to nearby waveguide water flow (rather than quadrupole water flow). Many magnets, however, already meet the tolerance. Plans are in place to mechanically isolate the water header and pump from the magnet connections and to add expansion dampers to minimize water pressure oscillations.

To ensure meeting the installation schedule for injector commissioning in December 2006, increased priority in the Mechanical Fabrication Department is required.

The TRACE3D model in XAL lacks wakefield and second-order effects and may provide limited value.

2.1.3 Recommendations

1. Identify and resolve issues related to operating LCLS hardware jointly with the SLC hardware by April 2006.

   LCLS is designing utilities for the Injector system. Integration with the existing linac system is being handled with the assistance of experts from the SLAC Conventional Facilities Group. Regarding switchover from LCLS operation to other modes, LCLS Controls and the Accelerator Operations department are preparing for running LCLS beams to the end of the linac.

2. Provide adequate resources and priority to ensure that the control system is ready for injector commissioning by December 2006.

   The Controls group has applied significant resources to commissioning preparedness and is on schedule for the Injector turn-on. A MATLAB-based applications framework will be provided, which will serve as the main utility for this first stage of commissioning.

3. Ensure that the commissioning staff is trained prior to December 2006 to use the MATLAB scripting interface to the control system. Also provide an interface to *Elegant* in XAL to obtain more realistic modeling.

   The MATLAB scripting framework is not at a sufficient level yet to begin training. Training will, however, be completed well before injector commissioning begins. Key applications that are at a mature stage of development include the automated bunch length measurement using the transverse deflectors, the longitudinal feedback system, and the beam-size and emittance packages. An XAL applications environment will not be ready for the 2007 injector commissioning, but should be integrated during the following year for commissioning of the full FEL.

4. Test and calibrate the bunch length monitor prototype at an existing facility (e.g. ANL) prior to December 2006. Consider building two identical devices so that one may be installed, while the other is being tested elsewhere.

   Two bunch length monitors (BLMs) are to be installed for the initial commissioning. The first is a gap monitor which has been prototyped and proven at SLAC End Station A. It will be adequate for the commissioning of Bunch Compressor 1. The second BLM is the CSR detector. A CSR detector will be necessary for commissioning bunch compressor 2 next year. Its design will be refined based on experience with it on BC1 will be invaluable.

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

2.2.1 Findings

The project reported excellent progress in Injector/Linac Systems since the May 2005 DOE review. The team was commended for continuing to advance the knowledge and technical base required to make this ambitious project a success. Overall, the design is mature and sound. With continued development, there is a reasonable probability of meeting the performance requirements. The scope and specifications are sufficiently defined to support long-lead procurement.

The injector is a crucial technology for the performance of the system as a whole. Advancing to a state of operability could promote confidence in meeting the requirements. The drive laser specifications are highly developed and the construction by the vendor has progressed exceptionally well. Full control of the transverse and temporal profile (with high stability) remains a desirable, but challenging goal. Overall performance of the drive laser remains the highest technical risk in this area.

Overall, the project cost, schedule, and technical baselines are consistent with the FY 2007 LCLS Construction Project Data Sheet. There is reasonable progress toward meeting the baseline objectives. The information in the reporting system is consistent with physical progress. The injector costs to date are very close to the plan. The schedule is tight and has some minor slips, but is basically on track.

Specifically, there are some minor technical delays that are not expected to have an impact on the overall schedule. They include: 1) laser bunch control delays due to funding slips to LLNL; 2) the RF gun was two months behind in machining; 3) quad delivery is one month late; and 4) the injector vacuum chamber design was late. Some issues resulted from schedule contingency interpretation, (e.g., a P3 (Primavera Project Planner) plan schedule contingency misinterpretation) led to delays in controls cable installation. This in turn, led to an installation schedule crunch. The present schedule variances are mostly in the controls area, but the new controls manager should help mitigate these over time.

Completing the commissioning plans is the key to remaining on track with the start-up of systems. This, in turn, will allow resolution of any performance shortfalls that may develop. This is good work in progress and is at an appropriate level of completion for this stage of the project. Schedule variances in hardware deliveries will become more critical as downtime activity (linac installation) intensifies. Shutdown activity work planning is critical. The installation team will need to operate on a split or dual shift, but this has not yet been scheduled in detail. This is a work in progress, which requires identification of the required resources. The installation of the linac must be the first priority in order to minimize future interferences; however, resource demand conflicts may result in injector installation delays, which would delay injector commissioning.

The designs in most areas are sufficiently mature to support procurements, although there remain a few element designs in process. Meeting the schedule will be tight, but it is achievable. Most procurements are well underway, including all of the key injector and linac procurements.

Adequate contingency is available to address the risks at this stage of the project. The remaining work is being properly managed. The contingency is generally supported by the risk analysis of this area. In some areas, savings have been achieved, and in others, contingency has been used. The risk mitigation plan is under control. In the case of the gun load lock, the mitigation plan is not reflected in the present budget and contingency estimate. However, it is reasonable to delay requesting contingency until needed in the cathode performance measurements.

The project is properly staffed to proceed with construction. There is adequate support from SLAC in most areas, although this should receive additional attention for installation support to meet the schedule needs. The controls area needs attention for proper coordination and management of support on a schedule to meet commissioning needs of the injector.

The Committee observed an encouraging incorporation of integrated safety management and ES&H at all stages of the planning and performance.

The project responded appropriately to all recommendations from the May 2005 DOE review.

2.2.2 Comments

The injector and linac designs are relatively stable and mature. Despite the significant technical challenges of these systems, the staff seems coordinated and focused on achieving the planned activities. Generally speaking, this area has high-quality support to achieve its goals. Over the next year, the first performance data will be available on key elements to establish the beginnings of a working device. The primary technical risk in the injector is the drive laser performance. Therefore, operational status and performance delivery is key to alleviating concerns. Collaborations with other laboratories have been helpful in resolving issues and managing risks by parallel development.

A significant risk area is the interface between controls and hardware. Technical requirements are now published, but not everything may work as hoped. Control power supplies are on order, but there is a concern that some of the other control hardware orders have not been placed. Receiving the supplies is critical, as is the development of the high-level control programs, especially those that support the start of injector commissioning.

A functioning bunch length monitor is necessary for successful operation of LCLS. At the present time, the plans for this and for its integration into the control system are unclear.

There was discussion of a 15-minute changeover time permitted between the SLC and the LCLS operating modes. Both the Committee and the local experts believe that this is unrealistic.

It is very encouraging that the managers believe in the existing project tracking tools, and that they are using them to successfully manage the ongoing work. This does not come easily, but has been well worth the investment in time. The project is using earned value tracking in an appropriate way and has a reasonable budget change control process.

ES&H aspects are being addressed at all stages of the planning, which is encouraging. Some reduction in the variation between similar job procedures between technician groups has been achieved since the May 2005 DOE review, but further laboratory wide coordination is appropriate.

2.2.3 Recommendations

1. Complete installation downtime effort planning to meet both the linac and the injector installation schedules. Resolve mechanical engineering and technician support needs for installation by March 2006.

   A detailed downtime schedule for in-linac LCLS installation has been prepared for the purpose of planning manpower requirements. Reviews of the downtime scheduling occur weekly as a part of normal SLAC Accelerator Department planning. At these meetings interferences and effort leveling issues are identified and resolved.

   In addition, a detailed schedule for the fabrication of all LCLS hardware to be installed during the down has been produced and this schedule is monitored weekly. This fabrication schedule is used to create a detailed parts list of everything needed for the installation. This schedule continues to be a valuable tool as the installation continues.

2. Develop a prioritized list of controls efforts from the commissioning procedures and develop a plan to achieve the required controls on the needed schedule by May 2006.

   A prioritized list of initial Commissioning needs from Controls has been made. Some high level applications have been delayed, and a MATLAB-based applications framework will be provided. Feedback stabilization of electron beam parameters at 120 Hz has been delayed. Early commissioning of the injector will, however, have 10 Hz feedback stabilization of position, phase, and beam energy. Feedback at 10 Hz will provide satisfactory stability for commissioning the injector.

3. Resolve the bunch length monitor approach and operational methodology by May 2006.

   From above:

   Two BLMs are to be installed for the initial commissioning. The first is a gap monitor which has been prototyped and used in the beamline at SLAC End Station A. It will be adequate for the commissioning of bunch compressor 1. The second BLMs is the CSR detector. A CSR detector will be necessary for commissioning bunch compressor 2 next year and experience with it on BC1 will be invaluable.

4. Review and resolve issues with the technical requirements for switching over between the SLC and LCLS modes of operation by July 2006.

   A list of administrative and hardware reconfiguration steps needed to switch between LCLS and Linac modes of operation has been drafted. The steps on this list could be accomplished in a time as short as a few hours. This is considered a reasonable amount of time to safely and reliably switch between the two operations. The hardware reconfiguration could be automated, but the administrative checks of interlock configuration need to be done in any case.

2.3 Undulator System (WBS 1.4, 2.4)

2.3.1 Findings

The LCLS Undulator System includes undulator magnets and supports, undulator diagnostics, vacuum systems, controls for the undulator equipment, and a MMF. Integration and installation are also included within this area. The project has developed the WBS such that the total cost for the LCLS Undulator System planning, project management, design, construction, and installation comprise WBS 1.4 and 2.4. A total of 33 undulators will be installed in the tunnel. Additionally, seven undulator operational substitutes will be installed. Of the seven, three will be prepared for installation (mounted to full module assembly) and one reserved as a standard.

In the present configuration, an undulator magnet is integrated onto a girder, which includes: an electromagnet quadrupole; a RF cavity BPM; a vacuum chamber and support; and 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. In addition, the undulator is 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 addition of an Undulator System Manager occurred approximately a month prior to the review. The Undulator System Manager's principal responsibility will be integration and installation of the Undulator System once it has been delivered to SLAC.

The following items are some of the changes in the baseline technical configuration or responsibility since the May 2005 DOE review:

- The quadrupole was changed to an air-cooled electromagnetic design.
- The undulator fixed support (WBS 1.4.3.8) was changed to two individual insulated sand-filled steel piers holding up each undulator section.
- The undulator girders were changed to a steel (soft magnetic) structure.
- Scanning wire diagnostics and optical transition radiation diagnostics, in the long-break diagnostics area, were dropped from the technical scope.
- Beam finder wires (BFW) at the end of each undulator section were added to the scope.
- The end of undulator x-ray diagnostics used for optimizing tuning and performance throughout the undulator were transferred to Photon Beam Systems.
- Mumetal® magnetic shielding is to be incorporated into the undulator magnetic structure to shield the device from effects of ambient magnetic fields.
- The temperature stability of the Undulator Hall (UH) was relaxed to ±0.5 °C.

The planned operational configuration anticipates the regular exchange of undulators throughout the length of the device. It is desired that this be accomplished by exchanging the magnetic structures in a kinematic manner as recommended in the previous DOE review. Such an approach avoids breaking the vacuum, exchanging the BPM and quadrupole, or disrupting the 140-meter stretched wire or the hydrostatic leveling systems.

The initial prototype RF cavity BPMs for the Undulator System are now scheduled to be installed for testing on the Advanced Photon Source injector linac at ANL (first on the Injector Test Stand Line, and then on either the Bypass or Low Energy Undulator Test Line test area) starting in June 2006. The first production RF cavity BPMs are to be completed in April 2007.

Production of the magnetic structure continues to progress well with two first-article assembled undulator magnet structures (one from each subcontractor) scheduled to be received by ANL at the beginning of April 2006. As a result of the careful planning, value engineering, development, subcontractor selection and management, the Undulator System organization realized a very substantial cost savings in its undulator magnetic structure. Consequently, it has been able to return approximately $8 million of cost savings to the project's contingency account. This is a notable accomplishment and reflects the high quality of the Undulator System staff.

The Undulator System integrated error tolerance budget appeared to be complete and a summary of the work was presented. Tolerances and specifications are now more strongly unified than in the past. LCLS management presented information indicating that none of the technical baseline requirements for the Undulator System were complete. The Undulator System organization presented several approved physics, engineering, facility and interface specification documents, but were unable to identify the missing technical baseline specifications.

Considerable progress is being made on the magnetic measurement testing facilities. The magnetic measurement system is to be transferred to SLAC from the subcontractor by July 1, 2006. The system should be ready for magnetic measurements before August 2006 and the first production measurements are to start before September 2006.

2.3.2 Comments

The Undulator System continues to benefit from its well-developed and managed staff. Integration of activities at both ANL and SLAC is evident. Technical performance since the May 2005 DOE review has progressed well. The addition of a SLAC Undulator System Manager is key to continued timely progress (as integration and logistics are eclipsing procurements in importance) and ensuring that the Undulator System is completely installed on schedule.

The issue of integration and logistics remains a concern. Strong technical presentations on the metrology, alignment, and magnetic measurements, indicate that these areas are receiving significant individual attention. However, there was no evidence to indicate that total logistics, handling, or integration were nearly as well developed.

The Committee observed the development and study of correction zones that detail the various layers and types of correction as a function of time and performance degradation.

The Committee was concerned that several areas of the Undulator System and Undulator System organization were not as well-developed as expected. The greatest concern was the RF cavity BPMs. The delivery of the first production items in April 2007 is behind schedule. In addition, the kinematic interchangeable magnetic structure approach is another area of serious concern. It was stated that the desired operational configuration would be to "swap-out" magnetic structures, which locate kinematically on installed girders to avoid disrupting the vacuum chamber or other components of the Undulator System. However, there has been minimal development progress in this area despite recommendations from the May 2005 DOE review, which set a deadline of September 2005. It is important that this system receive attention immediately, or it will become increasingly difficult to implement effectively. Ideally, it should be part of the Single Undulator Test (SUT) and the approach should be ready for implementation as part of the production magnetic measurements and fiducialization that is to start before September 2006.

The cost estimate and schedule presented were not current with the understood configuration and planning. This greatly complicated assessing the adequacy of both the schedule and cost for the remainder of the project.

Integration, logistics, and installation are likewise of concern. The vacuum chamber, while being carefully developed and well explored, remains a challenging subsystem. The BFW subsystem design is not mature. The lack of conceptual drawings for this subsystem was not perceived by the project as a major concern.

There is an effort to accelerate beneficial occupancy of the entire beamline, in particular the UH. The Committee was unconvinced that the Undulator System could readily or fully exploit earlier access to the UH. The development status of key components, integration, and logistics, as well as the delivery schedule of various components, make it difficult to believe that the complete Undulator System could be installed any earlier than presently planned. The installation of fixed-support piers, to allow additional time for thermal equilibrium to occur, as well as any floor movement, are among the only specific tasks readily identifiable that could be easily moved forward in the schedule to exploit an earlier beneficial occupancy.

In examining the questions specifically to be addressed in the review charge, with respect to the Undulator System, the following points were noted:

- The cost and schedule of the Undulator System appear achievable, but challenging.

- Integration and logistics will be the largest schedule risks.

- The technical development of the Undulator System appears adequate for FY 2006, although there are notable areas of considerable concern with the RF cavity BPMs and the kinematic interchangeable magnetic structures.

- Contingency, upon first examination, appears to be adequate.

- The management of the Undulator System appeared to be well prepared and competent to successfully manage this portion of the project if clear roles and responsibilities are delineated for the SLAC Undulator System Manager.

- ES&H measures appear to be adequate within the Undulator System.

- The Undulator System organization has adequately addressed all of the previous recommendations with the exception of the kinematic interchangeable magnetic structure approach, which was to be developed before September 2005.

All parts of the development, fabrication, and delivery of the RF cavity BPMs need to be accelerated as much as possible. No Undulator System can be effectively installed without the RF cavity BPM in place, and carefully aligned and fiducialized. The performance and stability of the RF cavity BPMs are critical to the ease and effective implementation of beam-based alignment techniques.

The SUT is critical for “fit-up”, functional verification and integration, and logistical aspects of the design for the complete Undulator System. The SUT in its initial configuration consists of a number of ersatz or prototype elements, as opposed to first article production elements. It is essential that the SUT assembly not be viewed as a single milestone. The SUT should evolve as prototype elements (to replace ersatz elements) and first article elements (to replace prototypes) become available. By the time the first article of all Undulator System elements are in hand, the SUT should be, in essence, the first article of a complete Undulator System that will either become the first section installed in the UH or maintained as a viable full-functioning spare. Consequently, a clear and complete set of tests and verifications need to be fully established, not only for the initial configuration of the SUT, but also throughout its evolution to a final complete system. The completion of these milestones and goals should be pursued as aggressively as possible to inject the improvements it reveals into the production of the Undulator System. Special attention should be given to aspects of this test that impact the resources required for assembly, installation, or servicing of the final undulator with a goal to improving schedule, cost, and technical performance.

2.3.3 Recommendations

1. Develop a complete set of tests and verifications for the SUT, throughout its evolution, by March 17, 2006.

The list of tests and verifications may now be found online at:

Main LCLS Undulator Project Page
http://www.lcls.aps.anl.gov/Project_Page/

Main SUT page
http://www.lcls.aps.anl.gov/Project_Page/SUT/indexSUT.html

Main SUT Plan page
http://www.lcls.aps.anl.gov/Project_Page/SUT/SUTTestPlan.html

These are evolving documents and will be updated and expanded regularly as needed.

2. Examine and accelerate the development and design schedule for the RF cavity BPMs as much as possible and provide this accelerated schedule to DOE by June 2006.

   Initial bench tests of a prototype RF-BPM look very promising. The prototype is now under beam tests at APS. Three more prototypes are under fabrication at an outside vendor to install in further beamline tests. A design review for the RFBPMs was held at ANL 10/6/06.

3. Establish clear unambiguous roles and responsibilities within the Electron Beam Systems for the Undulator System by March 17, 2006. Specifically, these roles and responsibilities must address the relationship of the SLAC Undulator System Manager and other parts of SLAC with Undulator System work and the ANL Undulator System organization.

   A memo defining technical responsibilities between the Undulator group and the Linac and Controls groups has been released this week. A memo defining administrative responsibilities was also written, but needs to be revised to address the interface with the SLAC Metrology group. These documents will be updated as the project advances.

4. Develop an assembly methodology for the production undulator sections, which optimizes the sequence of magnetic measurement; fiducialization; installation of ancillary components; and alignment of the consolidated girder assembly, to minimize the time lost to multiple setups by July 1, 2006, which aligns with transferring the magnetic measurements bench to SLAC.

   This is actively being developed by the ANL and SLAC Undulator Groups together. The process requrements are built into the Estimate to Complete.

5. Rectify the physics, facility, system, and engineering specifications and interface documents with the Technical Baseline Requirements, and prepare a completion plan for all remaining documents prior to September 2006.

   Engineering Specification documents that need to be produced have been identified. Some of these have been written, and there is a schedule for the completion of those remaining.

6. Produce a fully engineered and prototyped system that addresses the need for a kinematic support structure that permits the seamless exchange of undulator sections without significant interruptions to beam operations by May 31, 2006. The proposed system must address the uniqueness of each undulator segment, as well as, the accuracy and machine safety of the roll-in/roll-out feature.

   The SUT tests demonstrated the exchange of undulator sections. Undulator sections were removed and exchanged, and located to within the specified tolerance. Further tests are planned on the Long-term Test Setup, which will follow the SUT and will ultimately incorporate production units of all devices.

2.5 Control Systems

2.5.1 Findings

The previous control system manager, Bob Dalesio, will remain associated with the project to work on optical beam line controls. The project owes him a strong vote of thanks for assembling a strong, young software team and for initiating the controls work under less than ideal conditions.

Notwithstanding good cooperation from the Laboratory's engineering support organization, there remain many activities that are resource (manpower) limited, possibly as a result of priority conflicts within SLAC. These priority issues need early and continuing managment attention or the schedule will be adversely affected.

Procurement of cables for the injector (approximately $135K) is three months behind schedule. Delivery estimates extend to four months. Procurement of contract labor for pulling and terminating these cables is due for issuance in two weeks and is not yet ready. Although they are not needed until later, installation of some of these cables is required by April 2006 because of interferences with laser installation. This small cable procurement is placing at risk the installation schedule and possibly compromising the scope of injector commissioning. It requires the approval of no less than three SLAC Citizens' Committees.

As previously noted, Citizens' Committee approval is still required for the use of PLCs in the PPS. Although it is generally believed that this approval will be forthcoming, failure to obtain approval would have a very serious schedule impact. If the result is truly a foregone conclusion, then it is hard to see the value added; if it is not, then the schedule is at risk.

Although plans are well developed for most subsystems, not all plans for integration—vertical and horizontal, internal (between control system elements) and external (between the control system and other subsystems)—are equally so. Many needed subsystem reviews have not been held and several important documents (Requirements, Specifications, ICDs, Test Plans, etc.) are not complete. Fully-working, independent subsystems do not make an accelerator. Integration and interface issues are critical for the success of any control system.

There is considerable complexity added to the control system by the requirements to control two accelerators (SLC and LCLS) and to combine two Control Systems (that for the SLC and the Experimental Physics and Industrial Control System for LCLS). The "SLC-aware input-output controller (IOC)" is an important (and successful) element of the solution, but not the complete answer. This affects many or most subsystems, including PPS, magnet control, BPMs, timing, models, and high-level application software.

It is not clear that these additional complexities, while recognized early, have been fully accounted for in either the schedule or the budget. The requirement to switch between the two LCLS and SLC operational modes in 15 minutes is unrealistic.

The new controls system manager is concerned that the budget is “lean.” Although he has not had time for a thorough review and assessment, a low-cost estimate is possible because of incomplete understanding of the additional complexities (due to two control systems and two accelerators) and untraditional work scope (inclusion of all cables, diagnostic instruments, power supplies, even a shielding wall) that invalidates the usual “rules-of-thumb” used for control system estimates.

In addition, it was unfortunately noted that both the Accelerator Physics Subcommittee and the Injector/Linac Subcommittee expressed concern about control system readiness for the December 2006 injector commissioning run. On a positive note, this suggests that the LCLS managers responsible for these subsystems are paying attention to the controls for their subsystems, which would yield positive results.

2.5.2 Comments

The control system has generally made adequate progress sustaining the LCLS technical cost and schedule goals. Important technical developments, such as: the SLC-aware IOC that ties the SLC and the LCLS control systems together; the cross system timing that integrates timing events between the systems; and the RF control system prototypes (which can meet challenging phase and amplitude control requirements) have been demonstrated this year, thereby reducing the project technical risk. Overall, the control system is somewhat under-spent and behind schedule.

Most of the control system will be assembled from off-the-shelf components and modules. The majority of this equipment is ready for or in procurement, but some procurements are lagging from a shortage of hardware engineering staff. This schedule deficit has been mitigated in most cases through recent additions to the project staff. In a majority of cases, the control system developments listed above are ready to advance to engineering products and to be purchased in quantity. A few exceptions are the cavity type BPMs currently under development at ANL and the beam pulse width monitor, which is still in an early physics design phase. These critical diagnostics will need careful attention to meet the project schedule.

The calculated control system contribution to project contingency should be adequate in both cost and schedule to address the present risks. Most control system technical risks would reduce the project technical capabilities or moderately affect commissioning schedules, but would not prevent meeting major project goals. An estimate of the cost impact should be added to the project risk registry.

The control system electronic engineering staff was augmented to meet project requirements in the last year. However, many of the staff matrixed from the SLAC engineering support organization have part-time commitments to other SLAC projects. Priorities required for LCLS scheduled work must be established and continually monitored to prevent schedule slippage. The resulting larger control system organization may need additional management structure to accomplish the delivery and installation phase of this project. As a minimum, the new control system manager will need direct support in electronic engineering management.

Staff safety training was up-to-date and in compliance with recent changes in electrical safety training for electrical workers.

Both control system recommendations from the May 2005 DOE review have been addressed:

- Electronics engineering staff resources were acquired from inside SLAC and a supportive relationship was established with the engineering support organization.
- A full-time resident control system manager was hired and came on site January 23, 2006. Although a late addition, Hamid Shoaee's extensive project delivery experience should help to bring the control system effort back on schedule.

2.5.3 Recommendations

1. Expedite the injector cable procurements immediately. Consider negotiating faster deliveries for a premium and/or evaluate alternate cable routing approaches where possible.

   The Injection System cable plant installation is now under way. The work was divided into cabling which could be installed in advance and the cabling which needs access to the accelerator tunnel to be done. The first stage is complete and the second is underway and on schedule.

2. Assure availability of matrixed manpower from within SLAC to meet LCLS control system schedules by March 1, 2006.

   Controls teams were established, integrating LCLS personnel with matrixed SLAC personnel, from Controls and other groups. In addition, critical SLAC Controls personnel were transferred to the LCLS division. Most recently, the leader of the LCLS Controls Group has assumed leadership of the SLAC Instrumentation & Controls Department. The LCLS Controls Group will become part of the I&C Department. While this makes makes more urgent the need for a deputy group leader for LCLS Controls, LCLS Management supports the CPE organization changes.

3. Develop a schedule to conduct subsystem design reviews by March 1, 2006. In preparation for these reviews, develop a list of documents required for each review by the same date.

   Six subsystem design reviews have been held since the 7 February Lehman Review. Please see
   https://www-lcls-
   nternal.slac.stanford.edu/projectspace_L2/Tech_Reviews/default2.htm#Controls

4. Review the cost estimates for controls subsystems by March 30, 2006, paying particular attention to the impact of integration activities and allowances for two control systems and two accelerators.

   The Estimate to Complete for LCLS Controls has been prepared and incorporated.

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

2.4.1 Findings

Photon Beam Handling Systems and Endstations deal with both WBS 1.5 (the X-ray transport, Optics and Diagnostics—XTOD), which is the responsibility of LLNL, and WBS 1.6 (the X-ray End Stations—XES), which is the responsibility of SLAC. The Committee was pleased to learn that Peter Stefan, a knowledgeable and well-respected scientist with close ties to the synchrotron radiation community, was appointed as liaison physicist for XTOD. Mr. Stefan can be a valuable asset to the XTOD staff by providing guidance and information from over 20 years of experience (gained in the synchrotron community) in the design and construction of beamlines. One of the responsibilities of XES is the development of the atomic, molecular, and optical physics experiment. The addition of John Bozek to the project is an asset to this activity.

Conceptual designs for many of the XTOD components, such as the attenuators, slits, and diagnostic tools, are well underway and prototyping will soon begin. Therefore, the physics requirements for these components will need to be determined and documented in the near future to avoid wasting the engineering and prototyping effort.

Development of a two-dimensional pixel array detector has commenced and this is a commendable decision, as such a detector will be of value to many of the future users planning experiments on the LCLS. Any detector, to be truly useful, needs to be operable by a non-detector expert. Making the detector user-friendly (through intuitive computer interfaces and good manuals) should be a part of the deliverables.

Recently, a baseline change request was initiated for a pair of off-set mirrors; two mirrors to displace the desired FEL beam from the high-energy (spontaneous radiation and Bremsstrahlung) noise. This is very desirable from the user’s point of view and, if the unwanted radiation is stopped in the front-end enclosure, it can also reduce shielding requirements of the end stations. The risks of such an arrangement are: 1) mirror survivability (from the FEL beam), and assuming the mirror does survive, 2) mirror performance (i.e., can the system preserve the quality of the beam brightness). Concerning the damage issue, the project has performed experiments at the Tesla Test Facility (TTF) at lower photon energies, as a check on the code being used to model optics damage. The project expressed confidence, based on their calculations, that silicon carbide (SiC) mirrors will survive. However, there was little discussion regarding the expected performance of a SiC mirror system. If the mirrors do not perform adequately and must be removed, the beam transport will have to be reconfigured and increased shielding will likely be required on the experiment stations. Therefore, it is crucial that these mirrors are well understood.

2.4.2 Comments

There has been some re-engineering in this area to find cost savings. Flipper mirrors (to direct the beam to different beamlines) and some x-ray diagnostics and detectors have been removed. The XTOD WBS manager expressed confidence that eliminating these items will not affect the project deliverables and the Committee agreed with this assessment.

One of the responsibilities of XES is the design of the personnel protection system (PPS) for the experimental stations. Although progress is not presently delayed, a decision (involving SLAC Citizens' Committees) needs to be made soon on the use of programmable logic controllers (PLCs) for the PPS, so that time and money are not wasted on redesign efforts related to this system.

The performance simulations of SiC mirrors should use present state-of-the-art SiC mirror parameters (roughness and slope errors) to provide realistic results. The results of these simulations should be communicated to the science teams to ensure that the performance of the mirrors is acceptable to them. The Committee recognized the difficulty of obtaining test-beams with parameters expected from the LCLS; however, further experimental testing of mirror damage/performance should be pursued using sources that more closely mimic the beam than does the 39 eV ultraviolet beam from TTF.

2.4.3 Recommendations

1. Develop and finalize the physics requirements for the slits, attenuators, and off-set mirrors (immediately) to avoid wasting engineering effort on redesigns.

   This is being done. Physics Requirements Documents have been written for the slits and attenuators, and a PRD for the mirror system is nearly finished.

2. Finish simulations (via ray-tracings, wavefront propagation, etc.) of the expected performance of the off-set mirror system by the end of FY 2006.
   This is being done on an even faster time scale. Mirror performance calculations should be finished in June 2006.

3. Utilize existing synchrotron radiation facilities for testing of prototype components (diagnostics, optics, detectors, etc.). Not only is this valuable from the testing point of view, it is an opportunity to leverage the expertise and resources of those facilities to further enhance the component's design and utility.

   Testing of prototypes at synchrotron facilities is part of the XTOD schedule for diagnostics and some optical components. Detector testing at synchrotron facilities is being considered.

3. CONVENTIONAL FACILITIES (WBS 1.9, 2.9)

3.1 Findings

The LCLS CF scope represents a significant fraction (over 33 percent) of the LCLS TEC. The current CF baseline estimate is now $106.5 million, up from $76.78 million in May 2005. The vast majority of this work includes all the necessary construction to extend the SLAC linac tunnel by (approximately) one-half mile across a terrain of highly varying elevation. The tunnel requires both on-grade construction, and cut-and-cover construction. A majority of the tunneling construction is to be mined in relatively low-strength sandstone. In addition, two below-grade experimental areas—one cut-and-cover (the NEH), and one tunneled (the FEH)—are required. Surface construction is also specified over the tunnel including the CLO Building and some smaller service buildings. Two small detached surface construction elements are also included. Utilities, outfitting, and other support services are to be provided. The total excavated material, mostly mined, exceeds 50,000 cubic yards in place; and exceeds 75,000 cubic yards as excavated spoil. This work is the most significant tunneling to be done at SLAC since the 1960s.

LCLS project management has engaged the services of Jacobs Facilities, Incorporated to perform the civil AE work under the direction of the LCLS WBS manager for CF. The Title II CF design has been completed, reviewed, and accepted. The accepted work consists of the Title II drawings and specifications. The Title II cost estimates, and Title II project scheduling information is due by February 17, 2006. The Title II drawing set and specifications final comments have been delivered to the AE, and the drawings and specifications will be ready for the CM/GC (Turner Construction) to release for bid at the end of February 2006. During Title II design, significant value engineering and scope changes were accepted in order to partially contain the rapidly increasing cost estimates submitted at the 30 percent and 60 percent Title II reviews. Several directed system designs were incorporated to take advantage of altered tolerance analysis of items such as the UH HVAC and substrate support structure. These have simplified the required designs in a number of areas.

The CM/GC mobilized on site in October 2005 and is rapidly identifying their on-site management forces and relocating to on-site offices. Turner has participated in the cost estimating exercises, has prepared preliminary work schedules for construction, and has organized the work into three solicitation "groups" or phases. The first of the solicitations will be released (containing about 65 percent of the work) at the end of February 2006 with work to commence about three to four months later following Turner's evaluation of responses and award of the Turner subcontracts. Awards for the second and third groups of subcontracts will then be made, with the third group to be awarded by (approximately) September 2006. Turner has reported an increasingly volatile market with rapidly increasing award costs—allegedly as high as one percent per month escalations. Turner has scheduled the work internally, and has produced resource-loaded estimates of the effort and monthly costs. By mid-contract time, their projected costing exceeds $5 million per month, and Turner has estimated an on-site work force in excess of 195 craft and supervisory personnel to support this effort. This plan requires using as many as thirty subcontractors simultaneously. The level of integration complexity and timely responsiveness will require extraordinary and rapid support from LCLS CF staff and the AE to limit delays in response to change submittals, requests for information, and potential claim notices.

Two contracts for limited CF work at locations separated from the majority of the LCLS site were awarded by SLAC to a single contractor (XL Construction) last summer and the work is nearing completion, with delivery expected (approximately) at the end of March 2005. These contracts are for the S20 renovation and the MMF for the undulators. The S20 contract requires the construction of a surface building at Linac Sector 20 to house the LCLS injector support systems. The MMF entails the internal alteration and interior reconstruction of an existing building for use as the undulator magnet testing facility. Both of these contracts were awarded at over 150 percent of the cost estimated by the AE. In both cases multiple bids were received, reasonably clustered, but averaging more than 50 percent over the AE estimate for the work. The S20 work also revealed some need for increased quality assurance in the AE packages, especially for structural work.

3.2 Comments

Substantial work has been accomplished since the May 2005 DOE review of LCLS. Directed solutions to the design of the UH HVAC system and the UH substructure have eliminated technically difficult and expensive design proposals in favor of much more conventional and affordable solutions. Staff reviews of the technical specifications have been professionally accomplished and have resulted in solutions that have reallocated technical performance specifications without overall degradation of LCLS performance. Value engineering options to reduce costs (reduce the CLO Building size, shorten the tunnel between the NEH and FEH) have been pursued in an honest attempt to contain costs as much as possible.

Turner, the CM/GC, is becoming integrated with the LCLS project. The construction contract with Turner is for work with Turner serving as the contract administrator. This requires a strong LCLS/SLAC presence to keep the contract flowing efficiently. There are no fixed-price outcomes that Turner "owns," and to first order their costs are fixed. The Turner team and their tunneling partner (Hatch Mott McDonald) are professional and they are organizing rapidly.

From the review presentations, it was possible to identify a list of action items needed to successfully employ the capabilities of Turner with their subcontractor work starting in a few months. These items were identified by the LCLS CF staff and management, but have not been implemented. There is time to accomplish these items before the start of work under the Turner contract, but they need immediate attention. These items include:

- Improve procurement leadership and outcome accountability. Requests for contractual support need to be supported immediately.

  The Procurement leadership has been improved to include a Senior Level Consultant Manager, and a Senior Level Contract Administrator (SLCA). The SLCA responsibilities are primarily focused to support of the Conventional Facilities construction activities and negotiations with change order and field change orders. Various management processes have been implemented to allow for a more stream-line facilitation of the CF day-to-day issues.

- Support the rapid build up of Title III work. The CF staff needs to be augmented using a contractually fixed unit rate basis.

  A full-time AE (Jacobs) representative has been stationed at SLAC site collocated with the CF staff. This is primarily to rapidly assist in expediting, managing, and resolving design issues and Requests for Information (RFI's) in a timely manner.

- Resolve the Title III negotiations with Jacobs in the immediate future.

  This has been completed and an on-site Jacobs representative is in place.

- Initiate the tunnel emergency response team training, including integrated tabletop exercises with the SLAC Emergency Operations Center. Identify and acquire necessary equipment. The LCLS CM/GC (Turner Construction) has conducted 2 table top emergency drills. The "Call-Out" process has been established and TCCo understands the importance of notifying the Laboratory at the earliest opportunity.

  The CF group has identified and purchased as Government Furnished Equipment, the necessary tunnel support equipment. LCLS ESH, CF, Palo Alto Fire Department, and the CMGC have consulted with a tunnel rescue expert (University of Nevada) for information pertaining to proper identification and implementation of requirements. The required information has been provided as a flow-down requirement to the subcontractor bid packages for implementation of the contractor bids.

The extent of the civil construction required for the LCLS project is significant, but not particularly unusual in comparison with other recent DOE/SC projects. However, Turner Construction's projected rate of construction, which reaches over $5 million per month, is higher than most other recent DOE/SC projects. This rate of work will put heavy demands upon the CM/GC, the AE Title III effort, LCLS staff, the SLAC laboratory staff, and DOE. The Title III effort has yet to be organized to meet the projected increased requirements.

In the May 2005 DOE review report, the facts and data surrounding the AE cost estimate reflected a then unfavorable variance of no less than 50 percent (based on the first two competitive procurement results). This level of impact has since been verified by the evolving Title II estimates, and has resulted in significant value engineering changes. The 100 percent Title II cost estimate was not available at this review and the possibility that some further modifications to the work caused by a potentially high 100 percent Title II cost estimate remains.

The LCLS CF Estimate-at-Completion (EAC) for the work included in the Turner CM/GC contract should reflect $68.5 million (Title II 60 percent estimate) plus the (approximately) $13 million CM/GC cost. This total over $81.5 million (plus contingency). This is not consistent with the (approximately) $75 million CM/GC contract in place.

The LCLS integrated schedule does not yet reflect the work as grouped by Turner for procurement in three "groups" with identified intermediate completion milestones.

The CM/GC, Turner Construction, is ready. The Title II packages have been accepted by the LCLS project. If any additional scope modifications are found to be required after the Title II 100 percent cost estimate is delivered, the LCLS management and AE are ready to implement them. The situation is consistent with the requirements for the approval of CD-3b.

3.3 Recommendations

1. Approve CD-3b, Start of Full Construction.

Improve/augment (immediately) the contracting/purchasing functionality and augment CF field support as necessary via fixed unit rate technical support contracts. As described above, The Procurement leadership has been improved to include a Senior Level Consultant Manager, and a Senior Level Contract Administrator (SLCA). The SLCA responsibilities are primarily focused to support of the

Conventional Facilities construction activities and negotiations with change order and field change orders. Various management processes have been implemented to allow for a more stream-line facilitation of the CF day-to-day issues.

2. Resolve the discrepancy in the $75 million CM/CG contract cost cap prior to subcontractor's bid and award of their first group of subcontracts before this discrepancy becomes an element of contention at a critical time. LCLS/SLAC Procurement, in consultation with the SSO Contracting Officer, have requested approval of revision of this cap, based on bids in hand. Every effort is being made to expedite approval.
3. Integrate the CF work as grouped by the CM/GC for procurement into the LCLS project schedule. Modify the CM/GC contract to enforce the completion of each of the three groups of work on intermediate dates prior to overall contract completion. The identification of additional intermediate milestones to track performance and assist with early issue identification is advisable. CF has developed and incorporated new milestones (Level 4) for the portions of work that are not affected by the fluctuations in CF scope resulting from:

    Awarding of Bid Groups 2, 3 and 4,
    Preparation of the Baseline Schedule,
    Changes due to Value Engineering,
    Early Occupancy of select areas,
    Deletion of the Central Laboratory Office Complex.

   Level 4 milestones are incorporated into the project schedule for Beneficial Occupancy of the major components. For project planning purposes, these level 4 milestones have been revised to coincide with and are therefore over-written by the current equivalent Level 3 milestones. During the forthcoming negotiations of the scope adjustment, CF will integrate additional intermediate milestones.

4. COST, SCHEDULE, and FUNDING

4.1 Findings

The LCLS project CD-2b, Approve Performance Baseline, was approved in April 2005 at a TPC of $379 million (as spent) with project completion scheduled for March 2009. The TPC contains $315 million for line item activities (TEC), contingency of $56.3 million, (approximately 27 percent of the remaining TEC work), and $64 million for Other Project Costs (OPC). There is about $6.2 million of management reserve in OPC (approximately ten percent). A breakdown of the TEC and contingency can be found in Appendix D. A formal change control process exists and is being used for baseline changes. The overall project is 18.5 percent complete as of the end of December 2005.

Through FY 2006, the project has received $158.75 million in funding. The baseline funding profile for the LCLS project is contained in Appendix E. This funding profile and the baseline schedule are consistent with each other. Phase-funded contracting will be employed to optimize Budget Authority (BA) use. In addition, weekly project meetings are held to discuss BA management.

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

At the end of December 2005, the project Risk Registry documented 56 risks. The Risk Registry is a controlled document that involves input from the entire project team on a monthly basis.

Currently the EAC is not reported in the monthly project report; however, it was stated that it is generated monthly by adding the actual costs to date to remaining work scheduled from Primavera Project Planner (P3). The EAC presented included approved Baseline Change Requests in January 2006, although not the potential ones identified for February. The project plans to complete a bottoms-up cost estimate as needed or every six months.

A variety of metrics are available for project management to review.

LCLS uses P3 as the scheduling tool with Cobra as the cost processor. The project has developed a resource-loaded schedule comprised of 11,313 activities, 7,424 of which have allocated resources. The schedule baseline date for CD-4 is March 2009. The project's controlling path, which has not changed since May 2005, starts from the UH beneficial occupancy, to installing the undulators, to first light through commissioning. This path currently has 213 days of schedule contingency.

The LCLS project has 29 Level 2 milestones and 142 Level 3 milestones. Milestones are reviewed and monitored regularly by the LCLS project management team.

4.2 Comments

Two areas in the cost estimate are of concern: CF and control systems.

Based on current plans, FY 2007 activities may be constrained by the FY 2007 BA level. It is essential to continue focusing on BA management, phase fund procurements, and be prepared to re-plan if needed.

Some key project risks were not included in the Risk Registry, e.g., the risk of the award of CF contracts exceeding the baseline budget.

It is extremely important to maintain/review a current EAC, especially when civil construction begins, to evaluate and ensure that sufficient contingency funds remain.

A weak link exists between the project Risk Registry and the bottoms-up contingency analysis process. In addition, a tie does not appear to exist between the Risk Registry and the project EAC.

The LCLS project has a well-developed scheduling system and has produced a detailed resource-loaded schedule. The schedule contingency is presently distributed throughout the schedule, and as a result, schedule interfaces may not be clear. In addition, a natural tendency is to use that schedule contingency, which will drive the project's cost higher. The project should consider removing the schedule contingency scattered throughout the schedule and consolidate it.

The project management control system staff is composed entirely of support contractor staff reporting to the LCLS Chief Engineer. Using support contractor staff in this role has the advantage of flexibility to adjust staff to the needs of the project. However, the absence of a SLAC person to lead the effort places an extra burden on the LCLS Chief Engineer.

4.3 Recommendations

1. Re-evaluate the CF and control systems cost estimates by March 2006.
   Bids for about 70% of CF scope have been received. All LCLS systems have reevaluated their costs-to-go as part of an annual cost and schedule reevaluation and reassessment. For CF, the cost to go have been updated to include awarded bids to data.

2. Develop a process to continually update the EAC and routinely report the EAC in the monthly project report by March 2006.
   Done. LCLS has been reporting EAC since March 2006.

3. Ensure all key project risks are included in the Risk Registry by March 2006. This is an ongoing process
   Monthly Risk Registry meetings are convened to keep the Registry current.

4. Develop a process to integrate the Risk Registry, EAC, and contingency analysis by April 2006.
   Up until July 2006, the EAC incorporated the LCLS BAC, a consistent fraction of cost and schedule variances and a probabilistic determination contingency needed to cover known risks. In July 2006, LCLS revised its Risk Registry to a more tactical “punch” list of risk items which is more consistent with project conditions. Identified risks are also ‘owned’ by the System Managers which have the authority and resources to execute risk handling plans. The Risk Registry, EAC and bottoms-up contingency analysis continued to be reviewed on a monthly basis and compared to actual contingency to ensure adequate contingency is available to complete the project within its TPC.

5. PROJECT MANAGEMENT

5.1 Findings

The LCLS project is 18.5 percent complete as of December 31, 2005. It has a baseline TEC of $315 million and a baseline TPC of $379 million. On December 10, 2004, DOE approved CD-3a, Approve Start of Long-Lead Procurement. The project schedule calls for project completion in March 2009. The overall cost contingency is 27.2 percent of the work remaining and schedule contingency on the critical path is about 10.5 months (213 days). Funding for FY 2006 is $88.19 million and $121.90 million is being requested for FY 2007. This funding profile is consistent with CD-4 in March 2009.

The SLAC Director conducts daily meetings with LCLS management to identify and resolve issues. Where resource needs are identified, they are given a high priority by the SLAC Director. A SLAC Project Management Oversight Group has also been established that advises the SLAC Director on LCLS management issues.

Stanford University has demonstrated support for the successful execution of the LCLS project. The University has a considerable construction budget and has used their influence with senior management at Jacobs (the AE) and with Turner Construction (the CM/GC) to gain support for successfully completing the LCLS project.

The LCLS project team includes SLAC, ANL, and LLNL. The Project Execution Plan reflects the roles and responsibilities of the three partner organizations. Memoranda of Understanding are also in place between SLAC and its partner laboratories. Communication channels are open among the partner organizations and used frequently. ANL and LLNL have thus far been able to meet their project commitments. All three organizations have been active participants in the project's value engineering activities.

Required project management systems and documents are in place, consistent with the requirements for CD-3b. A DOE certification review of the LCLS earned value management system is planned for March 2006. A systems engineering approach was presented and additional refinement is ongoing. A change control system is in place and operating. Value engineering is part of the normal design process. A systematic risk analysis system is being used. A Risk Registry has been prepared and is reviewed monthly. Risks are added, reevaluated, and if appropriate, retired. Contingency is managed at the project level in accordance with the LCLS PEP.

A small procurement cell has been established as part of the LCLS Project Office with $2 million in approval authority. To date, this cell has been able to handle the LCLS procurement workload. Support from the SLAC procurement office is also available. In addition, SLAC management has committed to continue providing the required SLAC resources (people, infrastructure, systems) to support LCLS construction.

Major LCLS subcontractors are onboard including the CF AE (Jacobs) and the newly hired CM/GC (Turner Construction). The hiring of a CM/GC was a significant issue during the May 2005 DOE review. Completed CF Title II designs are available and final cost estimates were to be delivered to SLAC by the week after this review.

A new Director for the Ultra-Fast Science Center has been selected to ensure that the science program is ready to proceed once the LCLS facility was completed. The LCLS User Program is being defined to ensure that user support programs encourage a wide range of users, including those from outside of DOE.

The LCLS project has developed a very positive safety culture with very few reportable occurrences and few lost-time accidents. Subcontractor selection includes a review of the proposing firm’s safety record. Plans are in place to work with the subcontractors to ensure that they understand and comply with the SLAC safety program goals.

Some early construction activities (authorized as long-lead items at CD-3a), such as the MMF and S20 work, are underway. These are support activities for the upcoming main construction work.

5.2 Comments

Since the May 2005 DOE review, considerable progress was evident on all fronts and the LCLS project has satisfactorily resolved the issues from that review. The project is on track to begin construction in June 2006 after the approval of CD-3b.

SLAC management is very supportive and highly engaged in the LCLS project. SLAC has revised their Directorate structure to better support the LCLS project and the enhanced safety culture at the Laboratory. Management actions support the understanding that SLAC is actively evolving from a high-energy physics laboratory to a photon science laboratory. Stanford University has actively demonstrated their support of the LCLS project.

SLAC management has also developed a positive working relationship with the local DOE Stanford Site Office (SSO).

The LCLS project organization continues to mature. The staffing for the LCLS Project Office is nearing completion and several new key managers and staff were introduced during the review. The LCLS management team is sparse and management of the CF (AE and CM/GC) is challenging. The contract management challenges associated with the CM/GC and subcontractor activity will increase significantly with the start of construction.

The role of SLAC Citizens' Committees in reviewing and/or approving LCLS project decisions related to safety, and possibly other areas, was unclear to the Committee. The Laboratory Director should clarify to DOE the role that these committees play with respect to LCLS and assure that their impact, if any, is constructive.

There is considerable evidence that the partnership among SLAC, ANL, and LLNL is working well. Communication and trust among the partner laboratories is excellent and contribute to the effective implementation of this arrangement.

The expeditious hiring of a CM/GC was emphasized at the May 2005 DOE review. Based on the presentations and discussion with the CM/GC (Turner Construction) during this review, they appear to be highly competent, and capable of managing the required construction of facilities (including tunneling).

Overall, cost estimates are considered reasonable. Contingency and schedule contingency, based on past experience, are considered adequate with the largest uncertainties associated with CF. These uncertainties result from the volatile market conditions (price and availability of resources) due to the hurricane disasters last year and the aggressive pace of building construction in California. The overall impact is difficult to predict.

Based on the requirements for CD-3b, the LCLS project must review and update its Project Execution Plan. As part of this update, the definition of CD-4 should be clarified.

The Committee judged that the LCLS project has met the requirements for CD-3b, and recommends DOE approval for this next phase of the LCLS project.

5.3 Recommendations

1. Present to SSO and the Office of Basic Energy Sciences, by March 1, 2006, the plan for strengthening the LCLS management team to ensure that the increased workload that accompanies CD-3b can be effectively managed.
   A plan to strengthen the LCLS management team was presented to the SSO and Office of Basic Energy Sciences as requested. This plan included a strengthening of the LCLS procurement function with the addition of a consultant with significant construction procurement experience (Barry Miller). Additional procurement staff to help support conventional facilities pricing changes and negotiations has also been added (Jim Dee). To strengthen the LCLS Conventional Facilities (CF) staff, an Associate Project Director for Civil Construction has been added with demonstrated experience in directing the LCLS CF team and in coordinating the activities of Turner Construction during the construction phase of the LCLS. Additionally, an A/E (Jacobs) Contract Administrator (Jim Cranston) has been added (on-site) to manage design changes and RFI's on a real-time basis. Finally, an Associate Project Director for Engineering position has been added to strengthen LCLS engineering and system integration. An offer is currently out to the top candidate. It should be noted that all staff added have significant senior management experience on DOE construction projects analogous to the LCLS.

2. Prepare a Systems Engineering Plan to implement the LCLS equipment installation and commissioning approach by September 30, 2006.
   To address the equipment installation, coordination and interfaces between technical and conventional facilities, LCLS has LCLS has created an Integration Management Team (IMT) under the direction of Richard M. Boyce. The IMT consists of individuals which support specific project integration/installation activities. Overall responsibility for each functional area remain under the line management of the respective System Manager who is responsible for assuring that their respective system meets all requirements. For more information, See PMD 1.1-028, 'LCLS Integration Management Plan'.

6. ENVIRONMENT, SAFETY and HEALTH

6.1 Findings and Comments

LCLS management has incorporated DOE Integrated Safety Management System (ISMS) Core Functions and Guiding Principles into their project protocols. Examples of this are found in project staffing, work practices, and supporting documentation.

Current contracted work (Sector 20, Building 81, Sector 24, and the Beam Switchyard) reflects effective implementation of the LCLS ES&H program. Presently, no recordable injuries have been reported in the work performed.

Evidence of ISMS requirements were found in technical system designs and review processes. Safety is included as an element in the design reviews.

LCLS system managers, project managers, and project specialists positions, have been staffed with individuals who recognize the importance and value of safety. There is evidence of their commitment to safety in work planning, project documentation and execution.

Project work planning and execution reflects a systematic integration of safety throughout its processes.

Aggressive ES&H contractor selection criteria have been established for the project. These have been applied to the selection of all contracted work to date, including the CM/GC. The project should endeavor to assure that these criteria do not become eroded or relaxed due to the pressures of construction cost or schedule.

LCLS contractor selection criteria for ES&H include:

- Experience Modification Rate equal or better than 0.81
- Designated OSHA (Occupational Safety and Health Administration) 30-hour trained person
- Written Site Specific Safety Program

The LCLS contractor selection process also includes an assessment of past performance and review of corrective actions taken in response to performance deficiencies (accidents) that occurred in the past three years. Additionally, the project assesses the competencies of the "Key Personnel" assigned to the project, specifically with regard to safety.

The LCLS Project Directorate has established the requirement that provides authorization to proceed on all major work packages. To receive this authorization, WBS managers must outline the process they followed and present evidence of their work planning, engineering and safety reviews, and approval by appropriate Laboratory authorities. The project has developed a checklist that is used to assure completeness of the process.

Contractor implementation of the LCLS ES&H program is being effectively monitored by LCLS management, safety subject matter experts, and line management through multiple levels of inspection. There are, on average, three independent daily inspections conducted and documented at each of the contracted work sites. These include:

- Contractor Self-Inspections
- Project Manager/University Technical Representative (UTR)
- SLAC ES&H Division
- LCLS/SLAC Line Management
- LCLS ES&H Coordinators
- DOE/SSO

Findings (both good practices and areas for improvement) are communicated to the contractors within LCLS and SLAC. Records are kept of all site visits and incidents. Records are reviewed for lessons learned and subsequently communicated to the project and SLAC as appropriate. These lessons learned are also addressed at the weekly management and contractor coordination meetings. As the construction activity increases, the number of findings will also increase and a tracking system should be implemented to ensure tracking and resolution of findings to closure.

Project documentation as required by DOE Order 413.3, Program and Project Management for the Acquisition of Capital Assets, is current and in place. These documents include:

- LCLS Directorate ISMS Plan
- Preliminary Hazards Analysis Report
- Environmental Assessment (the Finding of No Significant Impact is current as of January 2006)
- Preliminary Safety Assessment Document
- Preliminary Fire Hazards Analysis
- Project ES&H Plan

The LCLS ES&H Plan reflects the lessons learned and good practices gained from similar recent large-scale DOE projects. The ES&H Plan document has been incorporated into SLAC's management and operating contract. SLAC's contractors are required to either adopt or incorporate the plan into their site specific ES&H plan, and this was verified to be the case.

Current contracted work activities are reviewed, coordinated, and communicated daily through the pre-work planning and Job Safety Analysis (JSA) process. Daily Job Site Safety checklists are prepared by the UTR. Each day the contractor completes a checklist with copies to the LCLS safety team for review. The contractor(s) conduct weekly coordination meetings where safety performance and improvements are discussed. The UTR prepares a daily status report addressed to the LCLS CF WBS manager. The contractor's superintendent and the LCLS project manager prepare a daily project report. The safety consultant prepares a weekly ES&H Status Report and meets weekly with the LCLS CF WBS manager and the DOE/SSO.

The CM/GC contract requires that the CM/GC (Turner) incorporate the entire LCLS ES&H Plan into their program. Turner's program has been submitted to the project for review. Turner's subcontractors' programs will include the following elements:

- Compliance with the Turner Safety Program
- Area Hazards Analysis for their respective work areas
- Pre-work planning and JSAs for daily and task specific activities

LCLS and Turner are still developing critical project safety elements, including:

- Tunnel Rescue
- Crisis/Emergency Management
- Silica Control and Monitoring Program

Details for each of these program elements are in the process of being implemented and expected to be in place by the time Turner and their subcontractors begin performing "hands-on" construction.

LCLS has defined safety criteria for the procurement and use of electrical cables. These criteria are included in an Engineering Specification Document. This is used for all LCLS procurements and equipment assembly. These criteria have been developed to assure LCLS management that uniform standards are applied to the LCLS and SLAC work, and to the associated work being performed by the partner laboratories. This sets the stage for a smooth transition and uniformity of safe work practices at SLAC when the equipment and personnel from collaborative laboratories come to LCLS.

The LCLS has begun a process of conducting design reviews of all technical system components. Included in this review process is a safety assessment that identifies potential hazards (such as energy sources), and defines hazard mitigation.

Since the May 2005 DOE review, the SLAC Laboratory Director appointed an individual responsible for planning LCLS Accelerator Readiness Reviews (ARR). This individual has developed a schedule for the ARR of the Injector System. The reviews are scheduled to begin in late August 2006 with approval for the start of commissioning of the Injector System in early December 2006. In preparation for this ARR, SLAC is updating its Linear Accelerator Safety Assessment Document, which will include the LCLS.

The SLAC Laboratory Director has charged the Laboratory Citizens' (Safety) Committees with conducting reviews of LCLS work planning (construction, and technical systems). The role and responsibilities of these committees were redefined in the revised SLAC ES&H Manual Chapter 31 "Institutional ES&H Committees", since the May 2005 DOE review. The review by the Citizens' Committees is similar to peer reviews at other Laboratories and other projects. In effect, the Laboratory Director has made available to the project a group of dedicated safety reviewers for the LCLS project. An individual has been appointed by the Laboratory Director to coordinate the LCLS Readiness Review process. This individual is coordinating the schedule of safety reviews with the Chair of the Safety Overview Committee, who defines the required reviews. The relationship between the Citizens' Committees and the LCLS seem to have improved since the May 2005 DOE review. However, their roles and authority have remained somewhat unclear. Further improvements are needed in timeliness of the reviews to be consistent with the LCLS schedule.

ISMS has been integrated into all phases of the project per DOE Order 450.1, Environmental Protection Program Implementation.

6.2 Recommendation

1. Implement an ES&H Tracking System by April 30, 2006.
   LCLS has access to the SLAC Corrective Action Tracking System, and will employ it for tracking Project-related ES&H remediation issues.