

Report of the 20, 21 April 2006 Meeting of the LCLS Facility Advisory Committee

1.0 General

1.1 *Introduction and Charge*

The Linear Coherent Light Source (LCLS) Facility Advisory Committee (FAC) met with the LCLS project team on 20, 21 April 2006. The charge of the Facility Advisory Committee continues to advise SLAC, SSRL, and LCLS management on the continued execution of the LCLS Project and Facility development throughout its several phases and systems:

- Accelerator systems design and construction
- Undulator systems design and construction
- X-ray transport, optics and diagnostics design and construction
- Experiment station systems design and construction
- Conventional facilities design and construction
- Planning and execution of commissioning and early operations

The Committee was divided into five subgroups: the Electron Systems Subgroup that covered the accelerator systems design and construction, the Undulator Subgroup that covered all parts of the undulator and its ancillary systems, the X-Ray Subgroup that covered x-ray transport, optics, diagnostics and experiment station systems design and construction, the Controls Subgroup, and the Conventional Facilities Subgroup. Appendix A is a listing of the members of the Facilities Advisory Committee and their respective subgroup assignments. Appendix B is the Agenda of the 20, 21 April 2006 FAC meeting.

The following sections address the charge through the summary reports of the subgroups. General comments and recommendations precede these summary reports in this section.

1.2 *General Comments and Recommendations*

The FAC found this meeting much more satisfying in its attempt to serve as a tool for the LCLS Project and Facility. The quality and level of interactions between the FAC and the Project were considerably higher and presentations were more tightly focused on raising issues for consideration rather than simply an accounting of progress since the previous meeting. Very convincing evidence was presented that the LCLS project has made strong progress since the previous meeting. The total project as presented was over 21% complete, the injector, 45.3% complete. The Magnet Measurement Facility beneficial occupancy was achieved on 14 April 2006.

Communication within the Project remains an important consideration. As the emphasis of the project begins to shift to one of integration and logistics, communication will become that much more critical across all levels and areas.

An integration engineer is becoming increasingly important to have on the project. The LCLS Project should have had such a person prior to this FAC meeting, as it simply isn't realistic to anticipate that either the LCLS Project Director or LCLS Project Manager can successfully cover these additional responsibilities; including the development the plans and courses of action required for successful integration of the project and in addition to their already considerable duties.

Related to the lack of an integration engineer is the largest potential area of increasing risk – *things falling through the cracks*. Weaknesses and incompleteness in interfaces, specifications, handoffs, responsibilities, etc. will become more and more apparent and difficult to resolve before they impact both productivity and schedule. As the full production phase of the project continues, and more areas of the project are either under direct contract or production delivery, changes to correct oversights may soon exact a nearly prohibitive toll on project costs and schedule. Compounding this is the volatile external environment of several technical areas of the project, in particular conventional facilities. Even very conservative contingency allowances may no longer be sufficient to cover shortcomings in the future.

A specific class of this type of risk has been observed by the FAC – That of trading scope without the full concurrence and conscious agreement of all parties. The most elementary example is that of a cost account (or WBS) manager stating that specific deliverables are no longer part of his/her cost account and belong in another (specified or not) cost account (WBS) area. Without a conscious three-way transfer (between the first manager, the project management, and the second manager) it is likely that progress on these deliverables will snag. This clearly presents an obvious risk that could have a significant impact if not avoided or caught before schedule and fund contingencies are no longer available to address scope issues.

Related to this, the FAC recommends an evolution of the risk registry. In the initial development of the project the risk registry, at the top project level, generally includes only global and sometimes non-specific risks. The LCLS risk registry at the time of this FAC meeting is a good example. It is generally very good, but the quality of the assessment of the risks is highly variable and many of the risks are too generic for active mitigation. It also appears incomplete. The expansion phase of the LCLS project is starting to decelerate and soon the emphasis will, of necessity, switch to integrating activities – *the big crunch*. At this point in time of the project evolution, the risk registry should evolve from an overarching strategic document to a tactical document, almost becoming a *punch list* of *all* issues. Losing a bit of the rigid formalism may not only be acceptable, but necessary in order to keep the risk registry a relevant and tactically important tool for the project. If it isn't consciously transformed into such a tactical instrument, a myriad of less formal lists are likely to respond to the need without the benefit of central project oversight and management. Without proper oversight, oversights will occur and the central project management office will lose a degree of managing the project.

Specific examples some of the items that should now be included in the risk registry are: low conductivity water (LCW) for injector, the undulator vacuum chamber aluminum coating, the transformation of magnetic measurements and undulator system integration into a true mass production efforts, and x-ray optic mirror figures and specifications. These are just a few of the issues that the FAC itself uncovered during the course of this meeting and it is likely that there a great number of issues large and small of which the FAC is not aware.

Individual managers should not rely on the possibility of any *spare* contingency being available for use on less than completely essential and critical aspects of the project needed to meet the DOE Critical Decision 4 (CD-4), Project Completion. The volatility present in the conventional facilities portion of the project makes this apparent to the FAC.

The LCLS project is subjected to significant budget and schedule pressures. The FAC understands and appreciates the difficulties that these pressures exert on the LCLS project. Nonetheless, the FAC encourages the LCLS Project to attempt to finish and reach CD-4 ahead of schedule. While this may

appear counterintuitive to acknowledge schedule and cost pressures by suggesting to accelerate the schedule, it is not. Time and money are not independent variables and schedule slips and delays invariably consume more money by generating additional costs. There is concern that too many members of the LCLS project team view any float time that their particular deliverable may have as being an available buffer. This can generate a situation where the critical path for the project swings wildly between various items. While *just-in-time* delivery may be an appropriate optimization of an ongoing production facility, in large *one-off* projects *just-in-time* frequently becomes *just-too-late*. The FAC suggests that the LCLS Project drive toward an early finish in the hope of not having too late of a finish. In the act of implementing an early finish, contingency – both schedule and cost – may actually be generated.

In a more global context of LCLS within SLAC, the FAC views access to the linac as a limited resource and potential *choke-point* for progress in a number of areas for the LCLS Project. While the FAC understands that there are significant pressures to operate the linac as much as possible, SLAC may wish to consider some more regularly scheduled short accesses to the linac rather than only in the emergency *as needed* basis used at present. Although the FAC cannot identify specific instances where progress has been hampered because of lack of access, having some ability to have additional access has great potential benefit to both the LCLS Project and by extension SLAC. Correspondingly, it is incumbent on the LCLS project that it organizes and has tasks and work packages prepared in advance so that if given relatively short notice of an opportunity to access the linac, LCLS can fully exploit the access. This suggestion goes along with attempting to telescope the schedule as much as possible.

In this same global context, the long range success and evolution of LCLS depends upon continued development and implementation of research and development activities in accelerator technology. This is particularly true with gun and injector development. SLAC may wish to carefully consider how to coordinate and unify both sides of SLAC (that portion of SLAC interested in colliding particles and that portion intent on producing photons) so that talent can be fully leveraged, regardless of the *home* organization within SLAC. This leveraging would allow SLAC to rapidly pursue exciting accelerator technology development opportunities. As has been discussed by the FAC in this and previous meetings, a continuing injector test facility is an immediate area that would benefit from such institutional leveraging.

Finally, in acknowledgement of the evolution and progress of the LCLS Project, the FAC recommends that the next meeting focus on integration, installation, interfaces and other issues as these are likely be the major areas where the FAC can provide value to the project. Likewise, as the FAC has stated previously, the recommendations and suggestions the FAC make are made with the desire to further improve the LCLS and are done within the context of the numerous and substantial accomplishments and high caliber of work apparent in all areas of the project.

2.0 Electron Systems Subgroup Summary

J. Corlett, M. Cornacchia, J. Rossbach, and C. Toth

2.1 Management

The FAC thanks the teams supporting accelerator physics and hardware for the excellent presentations and discussions during the meeting. The teams continue to produce impressive work in accelerator physics, hardware development and installation, and technology development.

The LCLS will become the flagship facility at SLAC within the next two to three years, with an operating budget of \$95M. The continued attention to enabling access to resources during construction is critical to successful completion of the project. The FAC recognizes the priority that SLAC management has assigned to the LCLS construction project, and encourages SLAC management to continue to maintain it as a priority when allocating engineering and other resources within the Laboratory.

The notice of upcoming beneficial occupancy of Sector 20 buildings was good to hear, and continued attention must be paid to installation and testing of the photocathode laser and optics systems to ensure readiness for gun commissioning.

Installation priorities are based on the hardware required for installation within the linac tunnel during the current shutdown. Installation of components outside the linac tunnel may be accomplished after the shutdown, with minimal impact on operations. While the prioritization introduces some delay in readiness of the injector, the overall philosophy followed by LCLS appears to be sound.

Commissioning and staffing plans were presented and are appropriate. The FAC recommends that these plans receive full support of both SLAC and LCLS management. Commissioning plans have been integrated with control systems availability, and are to proceed in an orderly fashion downstream from the gun.

The FAC applauds the accelerator physics group for its level of documentation. Over 85% of physics requirements documents have been completed to date. Engineering specification documents are also being produced.

The FAC encourages the LCLS management to provide sufficient resources to avoid compromising injector readiness for commissioning, e.g. installation of LCW in the injector region is not yet fully planned and there is potential for problems that may be encountered causing delays. Also, the photocathode laser installation schedule is tight and attention should be given to its readiness with at least the minimal required laser systems performance for initial gun tests with beam.

The location of the Laser Group within the Photon Systems Group appears to be working, as the development of the photocathode laser and optics systems is in general proceeding well. Preparations are under way to expand the laser group, and these are welcomed in anticipation of a much expanded role as lasers become operational in diagnostics and user endstations.

2.2 Photoinjector

2.2.1 Laser

Photocathode laser systems procurement from Thales is progressing well, with the Laser Group's oversight. The laser systems installation and commissioning schedule, however, has slipped, and detailed laser commissioning is now planned for early 2007. Commissioning plans are well developed. The schedule is very tight, however, and 1-2 day delays of certain components could avalanche to weeks in the schedule. While there is no immediate concern, there is no insurance against later problems that may arise. Contingency plans should be developed to minimize schedule delays. For example, backup plans should be developed for low-power level, low-rep-rate, or other reduced performance laser operations for commissioning.

This critical laser technology is being implemented by a foreign company, and assurance for uninterrupted operation is needed. The FAC suggests that a service agreement be defined with Thales that minimizes impact of equipment failure, and that critical components should be identified and spares procured.

Communications between groups appears to be satisfactory at high levels; however the FAC recommends that integration of laser systems with the accelerator systems would benefit from regular meetings with all involved in the injector.

Hiring into the Laser Group is critical for future everyday operations – the plan to bring four technician/operators and one engineer/physicist by December 2006 is sound. Rigorous implementation of this plan will be important.

Vacuum systems requirements, impacting the optics to be inserted into the vacuum system, did not appear to be well defined and the FAC recommends that these be understood by all parties involved.

The laser safety culture appears to be well developed, with appropriate preparation and clear understanding of the roles and usage of administrative and engineering laser safety controls.

A second laser system is not planned within the scope of the construction project. The FAC recommends that LCLS management explore means to procure a second laser system for both R&D and hot spares.

2.2.2 RF gun

The fabrication of two RF guns appears to be on track. Hot testing of the first gun will begin in August 2006, and is eagerly awaited.

The FAC recommends that the second gun be constructed as soon as possible, as a spare, and be hot-tested in the ASTA bunker or other suitable location prior to moving to a dedicated gun test facility.

2.3 Laser Heater

Only basic components of laser heater are to be installed in 2006, and details remain to be worked out for this future installation.

2.4 Linac

The Project has responded to solve a difficult situation with progress in the bunch length feedback systems, and now CSR measurement and bunch length feedback systems are on track. Two systems are being pursued: a break in the continuity of the beampipe with antennae detecting radiation emitted by the beam as it passes the gap, and a THz transmission line from a bend magnet. Attention is currently on systems for BC1. BC2 systems will be developed after gaining operational experience with the beam, particularly with regard to the impact of *horns* in the bunch distribution at BC2 that may alter the CSR spectrum and influence interpretation of the measurements.

The FAC suggests that an evacuated THz transport line, with high bandwidth windows, be considered for implementation.

2.5 FEL

The first-article undulator has been measured with good performance, less than 2 μm trajectory error, and phase error less than the 10° specification. Development of the RF BPMs appears to be on track; the first prototype has been fabricated and tested.

The FAC was provided a presentation on alignment of the FEL components, and recognizes this very good work as having necessary redundancy. This is not a detriment to such an exacting state-of-the-art facility.

2.6 Diagnostics

The resolution of the Optical Translation Radiation (OTR) diagnostic, OTR S1, may be insufficient, and the FAC suggests that this remain an option for early upgrade as it may prove necessary.

A significant body of expertise in instrumentation and diagnostics exists at SLAC and is in demand by the LCLS project. The FAC supports the creation of an LCLS beam diagnostics group to pursue diagnostics of both electron and multi-spectral photon beams from THz to x-ray regimes.

2.7 Machine Protection

At the next Facilities Advisory Committee meeting, the committee would like to see a presentation of the machine protection system in terms of philosophy of operation, and hardware implementation.

3.0 Undulator Subgroup Summary

J. Pflueger, K. Robinson

The main production runs are well underway and making good progress at meeting or beating schedule milestones. Because of savings that have been realized in the undulator production development ~\$7.3M has been returned to the main project. The FAC has a good overall impression of the entire production effort and the first article tests at Argonne are underway. This also strengthens confidence in the project work that has been done.

The LCLS project is actively preparing to receive and test the undulators as they are completed and delivered to SLAC. A critical portion of that effort depends upon the Magnetic Measurements Facility (MMF). According to project reports, the MMF is ready for occupation and on schedule. Likewise, all the anticipated problems are being properly addressed. An area that might use additional attention is the transition from “hand-crafted” and “hand-tuned” approaches for single undulators, to automated and streamlined production methods. This is key, as the delivery schedule of magnetic structures to LCLS is quite aggressive being on average two devices delivered per month. Assurance that the project is taking this *industrialization* seriously is provided by the well defined software tools that are

under development at SLAC. These tools and software are to be used by technicians and, if properly developed, help ensure both the quality of the magnetic measurements and the rate that measurements are performed. The FAC strongly endorses these efforts and further efforts to streamline the characterization, tuning, and fiducialization measurements that must be performed on each device.

An area of concern for the FAC is the shortness of time between delivery of the new bench and start of measurements. The FAC recommends that the project ease time pressure and generate more time for the measurements commissioning by examining and possibly rearranging all of the logistics and handling of devices associated with measurements. The Project should also rework the schedule for installation of undulator segments in LCLS by using the time buffers that are present.

A convincing undulator alignment strategy was presented and with the plans that were presented the FAC feels that the required specifications will be comfortably met.

The need for dosimetry in the beam protection system in the undulator section is generally recognized by the Project. This dosimetry is essential for the safety and longevity of the undulator. The commissioning phase is the most critical time for adequate protective dosimetry to be fully operational to limit the dose deposition of ionizing radiation in the undulators. Recent FLASH (formerly VUV-FEL at HASYLAB) experience has demonstrated the critical need for appropriate dosimetry during commissioning. Consequently, activities within the LCLS Project on this important topic need to start soon in order to ensure having a fully operational system available for commissioning.

The FAC is very concerned that status of the undulator vacuum chamber remains very similar to what it was shown at the previous meeting in October 2005 and that only modest progress has been made. According to what was presented to the FAC, the first undulator vacuum prototypes will be available in July 2006, but *first beam* is planned for spring 2008. This makes the time for completion of the vacuum chamber very short. The FAC remains somewhat skeptical and believes the aluminum coating issues have not yet been convincingly resolved. The vacuum chamber design depends critically on a timely and convincing solution to the issues surrounding this aluminum coating. As presented to the FAC the rms roughness of the coated surfaces in the bent vacuum chamber design verification tests are worse than those that were demonstrated with aluminum extrusions. Because of the shortness of time when the completed vacuum chambers must be fielded, the FAC recommends that an exact time schedule highlighting when remaining decisions must be made in order to maintain schedule, be developed. This is a critical task needed to reduce schedule risk that delay of the vacuum chamber would cause. Alternative designs should continue to be considered in parallel until the baseline design has fully demonstrated meeting or exceeding performance requirements.

4.0 X-Ray Subgroup Summary

J. Feldhaus, P. Fuoss, T. Rabedeau

4.1 Presentations and Progress

The attention of the x-ray subgroup is primarily focused on evaluating the development of x-ray systems and conventional infrastructure to support the experimental program of the LCLS, both current and future. The current program consists of six distinct experiments (the acronyms are local to this document for convenience):

- 1) AMO experiments in the soft x-ray region (AMOP)
- 2) soft x-ray pump-probe measurements and coherent imaging (SXP)

- 3) hard x-ray pump-probe measurements (XPP)
- 4) hard x-ray photon correlation spectroscopy (XPCS)
- 5) hard x-ray coherent imaging (XCI)
- 6) high energy density physics (HED)

The first of these experiments is included in the LCLS project, experiments 2-5 are supported by the LCLS Ultrafast Science Instrumentation (LUSI) project and the final item will be separately funded.

The April 2006 presentations to the X-Ray Subgroup can be roughly broken down into three general areas. First, there was a discussion of the overall facility design and the impact of the scope reductions during the last six months. Second, there was a discussion of organization and staffing both for the construction phase and for the future operations. Finally, there were discussions about the design status of the various components necessary for LCLS operation. These discussions were all strongly impacted by the timeline John Arthur presented for the LCLS X-Ray Systems.

- FY2006 will be used to design the X-Ray Systems. Currently the X-Ray Transport, Optics and Diagnostics (XTOD) systems are being reviewed and the X-Ray End Station (XES) designs will be ready for review in a few months.
- During FY2007 the x-ray infrastructure will be built.
- The building will be ready for installation starting August 2007 and components should be installed for first light in spring of 2008.

This timeline is very aggressive and there is concern that some components cannot be designed and procured within the allotted time.

4.1.1 Facility Design

At the last FAC meeting (10/05) a series of scope reductions were presented with the goal of reaching the overall budget. A series of cuts have been implemented to reduce the cost of the Photon Systems including 1) elimination of the flipper mirrors, 2) movement of the Far Experimental Hall (FEH) closer to the source point, 3) removing some XTOD diagnostic instruments that are not needed for commissioning, and 4) removing generic detectors and computers that would be used by the experimental programs. Only one of these (2) is a true cost savings since all other items (or functional equivalent) will have to be provided either through LCLS operating funds or through the experimental programs (e.g. LUSI) if LCLS is to run efficiently. There is some hope that items can be added back into the project if contingency spending is sufficiently small.

4.1.2 Organization and Staffing

The overall organization of the project remains consistent with earlier discussions but the increased staffing has filled out the details. The LUSI project has gained staff, particularly Jerry Hastings as Project Director, Nadine Kurita as Chief Engineer and Bill Foyt as Project Manager. Within the Photon Systems effort, a number of key positions have been filled by Hal Tompkins (installation), Niels van Bakel (detectors) and John Bozek (AMOP experiment). In addition, numerous LCLS-wide hires are helping efforts crucial to the X-Ray Systems (e.g. PPS and Controls). A particularly important addition has been Peter Stefan who is defining the physics requirements for the various systems.

John Arthur described plans for the operational phase of LCLS. An initial operations plan includes:

- 6000 hr/year operation
- one hutch in operation at a time

- a few hour changeover between experiments, and
- access to any hutch not in operation.

The anticipated staffing level is two scientists, an engineer and students for each of the instruments. In addition, there will be an optics and detector group, a laser group to support the various laser systems and their interactions, and an accelerator group. The anticipated staffing level is approximately 150 people, a level that is based in part on the ESRF staffing levels.

4.1.3 Component and System Design Status

As stated, FY 2006 is a crucial year for the design of the XTOD and XES components. As in the past, there was much discussion about the basis for design choices. The management and engineering processes have been improved. Peter Stefan is now in charge of assembling the physics requirements for each of the components and systems, and these requirements are being communicated more effectively to the design engineers. However, there is a significant delay and some uncertainty in the process for approving each level of design and the standards for that approval (e.g. what is an adequate conceptual design). Since there are a large number of components that need to be designed and approved this year, there was a general recognition that those procedures need to be strengthened.

A significant amount of the review focused on the status of individual components and sub-systems.

X-Ray transport

A comprehensive design of the x-ray transport line, components and control system has been completed. The transport line is not significantly different than that for any synchrotron beamline except 1) the average radiation heat load is much smaller and 2) the design must meet SLAC seismic design standards. There are no obvious problems with the design. The final design review is scheduled for May 2006 and components should be available for installation in July 2007.

X-Ray slits

The x-ray slit system has four in-vacuum jaws with separate control of the gap position and the gap width (both adjustments with micron repeatability). The slit jaws are a sandwich of boron carbide (22 mm) to provide radiation damage resistance and heavy met (50 mm of a tungsten alloy) to provide strong attenuation followed by another boron carbide layer. This sandwich design allows for accurate polishing of the slit faces.

The jaws are manipulated in vacuum via bellows by external commercial translation stages. Extensive heat transport and thermal expansion calculations suggest the most cost-effective and robust cooling approach is to use forced air cooling. The dominant diurnal motion is via thermal expansion of the stand and is estimated to be 17 microns.

While the design appears robust, there are still opportunities for value-engineering in its design. There is some uncertainty in the feasibility of bonding of the boron carbide to the heavy met blocks.

X-Ray absorber

The x-ray absorber (attenuator) system consists of both a gas absorber and a solid absorber. A conceptual design and prototype of the gas attenuator has been completed. The prototype has acceptable performance except that the initial 1% attenuation accuracy and repeatability is difficult to achieve at high attenuation. This performance does not appear to have a strong basis in physics requirements and has been relaxed to a 5% attenuation accuracy. Note that this accuracy is still significantly better than the expected shot-to-shot fluctuations in the FEL radiation.

The solid absorber will be constructed using Be blocks of various thicknesses. Seven thicknesses (0.375 to 24 mm thick in factors of two) will be available. These will provide 128 attenuation levels with up to 5×10^{-5} total attenuation. The Be faces will be polished to a mirror finish to minimize coherence degradation. The Be blocks will be inserted and removed from the x-ray beam using standard UHV linear actuators.

There is a conceptual design of an attenuator control system. The schedule for the attenuator system has a preliminary design review in December 2006 and assembly and testing in August 2007. These goals seem reasonable.

Mirrors

There has been progress since the last meeting on the layout of the experiments and the requirements that those layouts place on the x-ray mirrors. However, there has been little progress in translating those requirements into quotable specifications. It continues to appear that mirrors will limit the performance of the LCLS.

Mirror mounts and movers

There is apparently no design effort on the mirror mounts and movers. Since these require exceptional performance compared to normal synchrotron mirror components, attention should be paid to these as soon as possible.

X-Ray hutches

There still appears to be great uncertainty in the requirements and configuration of the x-ray hutches. Some of this uncertainty stems from the interplay between the evolving deflecting mirror layout and the radiation shielding requirements.

Real-time performance monitoring

There seems to be little effort expended on real-time, non-destructive monitoring of the x-ray performance.

4.2 Observations of the FAC

Note that some of these observations (in italics) are repeated from earlier reports for emphasis.

- *Given the revolutionary nature of the LCLS source it is difficult to predict with certainty the requirements that future experiments will place on the optics, detectors, and conventional facilities infrastructure. Thus, flexibility and adaptability are keys to a successful design.*
- *The present optics layout is predicated on the use of reflection optics for x-ray beam separation from Bremstrahlung as well as beam direction into multiple experimental stations. Full preservation of the x-ray beam brightness through the mirror system is a daunting task which appears beyond current mirror fabrication technology. Stated alternatively, realistic, affordable mirrors will have adverse effects on beam properties which must be managed. Consequently, careful consideration of the science driven beam characteristics should be reflected in the mirror specifications.*
- *The design, testing and acquisition of the mirror system is likely to be an extended process since the optic elements are near state of the art, unique alignment techniques will need to be developed for use with low repetition LCLS beams, and the lower operational stability (at least in the short term) may result in drift problems.*
- *Given the potential problems with reflection optic performance, the optics design must*

maintain compatibility with white beam transport for those experiments that cannot tolerate the mirror induced beam degradation. The beam transport system and the NEH/FEH hutch layouts preserve this option. During the detailed design phase of these systems, the potential for future, simple augmentation of the radiation shielding if required for white beam transport should be not be compromised.

- Delaying the design and construction of components to the operational phase and relying on the experimental groups may cause difficulties. In particular, it is important for the experimental programs (mainly LUSI) to define their controls and diagnostic requirements quickly so that they can be incorporated into LCLS planning.
- The definition of the physics requirements for the various components is a crucial process. While much progress is being made on this issue, it is not clear that sufficient staff is available for this important activity to be completed in a timely manner that won't delay design and procurement.
- Communication within the project and with the experimental teams continues to improve. Yet there still seems to be inadequate attention paid to critical path items. In particular, there seems to be no appreciation that the critical path to commissioning may be significantly different than the critical path to successful experiments. Both should be optimized.
- Great progress has been made on the conceptual design of the AMOP experiment.
- The SPPS experience demonstrates that incorporation of shot-by-shot diagnostic and performance information from the RF, the electrons and the photons will be important to the success of the LCLS experimental program. Suitable x-ray diagnostics are apparently not being developed. If this is not entirely accurate, the FAC would like a discussion (and perhaps tour) of x-ray diagnostics and the rationale of their development at the next meeting.
- Real-time x-ray performance information will be important for developing suitable metrics for accelerator performance. The lack of such metrics greatly hindered the SPPS program.
- The basic XTOD systems appear on track for initial LCLS commissioning. However, more sophisticated systems like the x-ray mirrors risk being late.
- The proposed staffing levels for the operational phase appear too low. Basing them on the much different operating environment of a storage-ring based synchrotron source is inappropriate since a much broader skill set will be required to effectively use an FEL.

4.3 Recommendations of the FAC

- The mirrors are now on the critical path and will require extensive design. This should be a focus of the project since it isn't clear that design and procurement can be completed before LCLS commissioning and first experiments.
- Contingency plans need to be developed for slippage in mirror delivery.
 - Determine if high energy beam (Bremsstrahlung and spontaneous) collimation and exclusion zones be used for safe beam transport through the NEH to the FEH such that the FEH periscope optics can be located at the entrance to the FEH where the pointing and figure requirements for these optics are less stringent.
 - Design mirror mounts and alignment systems assuming final mirrors will be delivered later.
 - Start a dialog with mirror vendors now about what is available on the timescale of LCLS commissioning and first experiments.
- Define the critical paths for both commissioning and for the experimental programs.
- Since LCLS uses relatively few (compared to a storage ring) optical and beamline components, reuse technology and engineering where possible.

- A suite of non-destructive x-ray beam characterization tools should be developed and integrated into LCLS controls environment and the experimental computing environment.

5.0 Controls Subgroup Summary

T. Himel, K. White

5.1 *Previous Concerns That Have Been Addressed or Are No Longer Relevant*

There has been a lot of progress made since the last FAC meeting in October 2005. Many of the suggestions we made at the last meeting have been implemented.

Here are a few specific places where good progress was made or where it is no longer timely to worry about the issue.

1. **Database** – For several FAC meetings we had warned that a central DB person was needed promptly if the project were to succeed in having a central relational DB that was used as the source of information for various online files and databases that are used for EPICS and SLC control system and modeling programs. A DB person was finally brought on board, but it was a case of too little too late. LCLS controls will be forced to have similar information entered manually in different files and databases rather than a system where the data is entered once and automated tools write the other files and databases in a way guaranteed to be complete and consistent. This is not a disaster as indicated by the fact that virtually all existing accelerator control systems are done this way. It will be painful though, a pain that could have been avoided if the project had followed the excellent advice of the FAC in a more timely fashion.
2. **SLC Integration and High Level Applications** – At the October 2005 FAC meeting a new evaluation of the requirements for High Level Applications showed that there would be a need to send commands (such as writing set points) from XAL applications and/or EPICS IOCs to hardware controlled on the SLC side. This was not previously planned and hence was a concern for the FAC. This need to control SLC devices from EPICS has now gone away (either forgotten, or a work-around discovered). Unless the need comes back, this is no longer a concern.
3. **PPS** - The PPS system plan calls for a PLC based implementation. Since this implementation choice is new for PPS systems at SLAC, the FAC was concerned about its design passing review committees in a timely fashion. Very good progress has been made on the PPS system. The design is complete and has had multiple reviews that included a subset of the radiation safety committee. The final review is scheduled for June 2006. Assuming this goes well (as we expect), then only a quick status report on the PPS system should be needed at the next FAC meeting.
4. **Management** – At the October 2005 meeting it was clear that the group leader would change from Bob Dalesio to a local more permanent leader. We recommended a period of transition where both were present to ensure a smooth transition and to help keep the project smoothly progressing. While there was a three month overlap it appears that not much benefit came from that overlap. This may be due to the greatly different management styles of the two leaders. No further action is needed here as the transition is complete.

5. **Process** – Documentation and reviews of the work in progress have improved. Continued attention will be needed to keep doing this in a reasonably formal and documented fashion.
6. **Security**- A very good presentation was given on the network security plans. It looks like this is well in hand.

5.2 **Previous Concerns That Have Not Been Fully Addressed**

1. **MPS** – At the October 2005 review we were so concerned about creating a brand new MPS system that Himel made a high stakes bet (5 cents) with Dalesio to encourage the prompt completion of the project. Dalesio would win if the MPS system was operational at the end of the November 2006 shut-down. The controls group made the wise decision to extend the 1553 MPS system for the injector turn-on and will later continue development of the newer MPS system (which is needed to respond in 1 pulse rather than the 3 pulse response time of the 1553 MPS system). Dalesio has graciously conceded the bet and will pay off his debt to Himel next time he is at SLAC. An update on MPS progress should be presented at the next FAC meeting. In addition to implementing the 1553 system, further work should be done on the new system.
2. **BPMs** – They still have a tight schedule. There has been progress since the last review, but no decision has been taken on which digitizer to use yet. This decision should be taken very soon.

5.3 **New Concerns**

1. Management has changed. Hamid expressed great concern about the terrible shape the controls effort was in. This concern was not with the people who were doing the actual work (he is very happy with the people) but rather with the Primavera schedule which had not been updated and the jobs assigned to the people. He has made some changes and does think they can support an on time injector commissioning with some temporary solutions. We agree with the latter statement and believe the schedule will be very tight. Particular attention is needed for the cables in the linac which must be installed in the coming shutdown. We support Hamid's plan to rework the schedule and cost estimates.
2. It seems like now there is less emphasis on using COTS solutions. Increase that emphasis please. For example the plan has been to use a commercial card for the timing system, but now they are thinking of getting rights to the design and modifying it to remove unused functionality and reduce cost. We highly doubt this would be worth the engineering effort.
3. Different groups may be using different embedded IOCs. See if they can be standardized. Don't do this if it is so late in the development cycle that the change would be highly disruptive.
4. Controls would benefit from a full time deputy and designated technical leads for each technical area. The latter would be people who spend 25% of their time on management and do technical work the rest of the time.

5.4 New Progress and Things We Particularly Liked

1. An outstanding group of people have been assembled to execute the controls for LCLS.
2. Plans for the LLRF system were presented. It looks to be in good shape.
3. Manpower has been redistributed to concentrate on near term goals. This is a good strategy.
4. We think it is perfectly alright to use temporary solutions (e.g. Matlab or timing without all the bells and whistles) for the early commissioning. That said, the temporary solutions should be temporary; hence we would like to have a plan presented at the next FAC meeting that gives long term plans for developing the final solutions.
5. More help is being obtained from CPE which is very good.
6. As some activities are being delayed, we endorse Hamid's intention to re-evaluate future manpower needs. In particular, the software manpower probably will not taper off in 2007 as was indicated to us a year ago.

6.0 Conventional Facilities Subgroup Summary

H. Carter, T. Chargin, A. Kugler, K. Schuh

6.1 General

The Conventional Facilities (CF) Subgroup of the LCLS Facility Advisory Committee met with the LCLS CF management personnel in order to review the progress of the CF portion of the project. Significant progress has been made since the October 2005 review of the project. The General Contractor/General Manager (GC/GM) contract has been awarded and preparations have been made to proceed with the procurement phase of the project. The project leader, John Galayda, asked our subgroup to concentrate on three items during this review: (1) Timely direction to the Construction Manager (CM), (2) efficient interface to A/E Title-III lead selection, and (3) the staff-up for the paper workload.

6.2 Findings

Overall, the Subgroup was pleased to see that good progress had been made, but we felt that there is room for improvement in some areas. Those areas are identified later in this report.

The CM/GC contract was placed on 10/17/05, and bid packages worth 60% of the total CF were due on 4/25/06. Both of these items are indicative of the relative maturity of the CF portion of the Project and should serve to alert management that any CF issues that arise require immediate attention in order for the work flow to progress in a timely manner.

The CM/GC incentives to reduce costs were discussed (both explicit and hidden) and are of little value. Substantial increases in incentives would be required to make it attractive to the CM/GC to reduce costs considering the heavy completion penalties in the CM/GC contract. The CM/GC has a strong incentive to advance the schedule for early CF project completion to reduce their penalty risk. Early completion of the project could reduce project indirect costs, but evaluations of the project

integrated schedule and the project fiscal funding plan are required to determine if early completion of the CF scope would benefit the overall project cost.

A dedicated procurement group within LCLS project has been established with CF specialists on-staff. While this action is viewed as a positive development by the Subgroup, it appears that the procurement process is still taking too much of the CF float time, thus the procurement process needs to be streamlined before it becomes the critical project path for conventional facilities. This timing is particularly critical if re-bids are required to obtain reduced costs of construction.

CF Group staff additions are a step in the right direction, and CF management is encouraged to complete their staffing plan, especially in the area of engineering, as soon as possible. In order to handle the anticipated “paper workload” staff specialists will need to be added quickly as well, since the ramp up in project documentation and procurement paperwork is expected to be commensurate with the increasing CF budget/expenditure profile. Re-bids and value engineering studies to reduce costs after bids are in, could also increase the work load on both the project staff and CM/GC.

Little evidence has been presented that the environmental issues have been fully addressed in the LCLS PSAD or the planned SAD. If these issues have been addressed, then documentation should be available to attest to this fact. Additional issues associated with the LCLS PSAD are contained in the comments section.

The LCLS construction safety program is in place and appears to be operating effectively.

The LCLS has developed and is implementing a safety program that will lead to approval for commissioning.

An ES&H database for issue reporting and tracking is in development.

6.3 Comments

The CF Subgroup is concerned about the large increases in industry construction costs in recent months, based upon feedback from various sources including the CF bids received recently (60% of CF construction scope). The impact of these increases will no doubt be felt by the LCLS Project, and CF and LCLS Project management need to formulate a plan to deal with it. There are only a couple options, (1) value engineering approaches (including detailed examination of scope and specifications for over-design as well as construction/contracting methods), and, (2) re-bid if the bids received are too high when measured against unit prices in the market place. Though the construction cost trend (of up to 30% increase over pre-bid estimates) is not unique to the LCLS project, the trend can have large impacts on the LCLS project. In light of this trend, it is critical that CF have the required resources available for value engineering and re-bids. It is also critical that the Project increase the CM/GC incentive for controlling and reducing costs, to balance the schedule incentives (penalties) already in the CM/GC contract for late completion.

A source for evaluating recent trends in construction costs could be DOE, since Dan Lehman should be seeing recent cost trends on the many DOE projects he is reviewing. CF management should also request recommendations from Turner on possible solutions to the high bids received---that's one reason an owner hires a CM, just for this type of situation.

There appears to be a disconnect between CF and technical specifications generated by other organizations that may impact CF work (e.g. CF did not review the general cable specification document). Further, the direct participation of a dedicated scientist on the CF interface has been reduced and there is evidence that configuration management is not sufficiently regimented to preclude specification changes without evaluation of impacts on all project organizations.

It appears that the physics staff is not as involved in monitoring the CF activities (such as changes in design and specifications) as was evident during previous reviews. Channels of communication must be maintained to ensure that field changes do not compromise physics interfaces. CF should have a documented database that can be periodically presented to a broad base of the project technical staff, and changes should not be allowed without all impacts evaluated and all impacted organizations participating.

This subcommittee would like to review the configuration management plan at the next FAC LCLS review in October 2006.

LCLS management should be proactive in assuring that SLACs contribution to the SAD is completed to meet project milestones.

Subcommittee concerns associated with the LCLS PSAD are:

1. No reference made to guidelines used to develop the PSAD, in particular, guidelines for Appendix A, "Hazard Identification and Risk Determination Summary".
2. The text should put more emphasis on the work planning process, very little was mentioned about the importance of ISM and JHAs.
3. The PSAD should identify all the kinetic and potential energy sources that would be present and address each in the summary. Specific items to be included are powered hand tools, welding, and flammable gases and liquids.

Communications need improvement. During discussions of how some of the safety issues and permitting issues would be handled, it was expected that the Lab had methods in place to handle these day-to-day issues. SLAC has not been involved in large construction projects recently and work could easily get delayed if requirements are not communicated or met because someone thinks the other department is taking care of the issue. An example is that in August of 2005, LCLS approved a document titled "General Cable Specifications for LCLS". Section 2 of the document said that low smoke non-halogenated cables should be used. Section 3 and 4 addressed cable marking. This document had a cover sheet that required ten people to sign off on it, yet no one from CF had signed off on it. When asked about this, the CF people said they had heard of the requirement but had never seen the document.

6.4 Recommendations

- Consider adding cost control/reduction incentives to the CM/GC, either by an explicit contract formula or indirect means (incentivizing individuals to project goals has worked on some DOE projects).
- Re-establish top level management meetings between CM and SLAC on a routine schedule before problems develop that require top management meetings.

- In order to address the dramatically increasing construction industry costs, LCLS CF management should contact one or more chief estimators from major CM firms to get independent quantification of what firms are seeing on unit prices in the market place across the industry.
- Obtain system wide construction cost trends from DOE data, such as from the recent Lehman Reviews on multiple projects in the DOE system.
- Request that Turner provide recommendations on possible solutions to the cost trends on CF construction bids.
- Increase attention to configuration management.
- Periodically present field changes above a certain value threshold to representatives of other LCLS systems.
- Continue strengthening the CF organization through new hires and/or personnel transfers in order to complete the staffing plan.
- Ensure that CF is involved in the safety documentation approval process.

Appendix A

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Appendix A

Facility Advisory Committee (FAC) Meeting April 20-21, 2006

AGENDA

Thursday, April 20th – Plenary

Location: Orange Conference Room, Building 040

7:30	Executive Session	
8:00	Welcome	J. Dorfan
8:10	Opening Comments	K. Hodgson
8:20	Project Status Update, and Charge to Committee	J. Galayda
8:50	Safety	M. Scharfenstein
9:00	Project Management	M. Reichanadter
9:20	E-Beam Systems Update	D. Schultz
9:40	Undulator Update	S. Milton
10:00	Break	
10:20	Photon Systems Update	J. Arthur
10:40	Controls Update	H. Shoae
11:00	Conventional Facilities Update	D. Saenz
11:20	Adjourn to Breakout Sessions (see Breakout Session Agenda)	
5:30	Executive Session (Orange Conference Room, B040)	
7:00	Dinner – <i>Amarin Thai Cuisine</i>	Committee/Speakers

174 Castro Street, Mountain View, CA

Breakout Session 1: Design & Construction: Accelerator Systems

Location: Red Slate Conference Room, Building 280-C

11:30pm	Injector/Linac System Overview Integration, Installation, & Schedule	E. Bong
12:00pm	Injector Beamline Design & Fabrication	C. Rago
12:30	Lunch	Orange Room
1:30pm	Laser Installation & Commissioning	B. White
2:00pm	RF Gun Fabrication & Testing	D. Dowell
2:30pm	Bunch Length Monitor Development	S. Smith
3:00pm	SAD & ARR for Commissioning	D. Schultz
3:30pm	Break	
4:00pm	Physics Commissioning	P. Emma
4:30pm	Discussion	All

Breakout Session 2: Design & Construction: Undulator Systems

Location: SSRL 2nd Floor Conference Room, Building 137

11:30pm	1st Article Report & Undulator Production Status	S. Milton
12:00pm	Undulator Vacuum System	D. Walters
12:30	Lunch	Orange Room
1:30pm	Single Undulator Test Status/Plans	G. Pile
2:00pm	Undulator System Assembly Plans	R. Pope
2:30pm	MMF and Magnetic Measurement	Z. Wolf
3:00pm	Alignment Strategy	H. D. Nuhn
3:30pm	Break	
4:00pm	RF BPM Status and Planning	Morrison/Milton
4:30pm	Discussion	All

Breakout Session 3 - Design & Construction: XTOD & Experiment Station Systems

Location: Yellow Conference Room, Building 041

11:30pm	XTOD Planning for 2nd half FY06	D. McMahon
12:00pm	XES Planning for 2nd half FY06	S. Moeller
12:30	Lunch	Orange Room
1:30pm	X-ray Transport System	J. Trent
2:00pm	X-ray Slits	J. Trent
2:30pm	X-ray absorbers	S. Shen
3:00pm	X-ray beamline and experiment layout	J. Arthur
3:30pm	Break	
4:00	Discussion	All

Breakout Session 4 - Controls

Location: Orange Conference Room, Building 040

11:30pm	Controls Organization Overview	H. Shoae
12:00pm	Timing Systems Update	D. Kotturi
12:30	Lunch	Orange Room
1:30pm	LLRF Update	R. Akre
2:00pm	Injector/Linac Controls Installation	Shoae for Fuller
2:30pm	PLC-based Personnel Protection Systems	M. Saleski
3:00pm	High-Level Applications and Feedback	Shoae for Fairley
3:30pm	Break	
4:00pm	Network Security	T. Lahey

Breakout Session 5 - Design and Construction: Conventional Facilities (Saenz)

Location: ES&H Training Room, Building 003

11:30pm	Construction Organization & Processes	D. Saenz
12:00pm	Construction Procurement Management	D. McGiven
12:30	Lunch	Orange Room
1:30pm	Construction Safety	R. Hislop
2:00pm	Tunneling Safety & Logistics	R. McDonald
2:30pm	Discussion	All
3:30pm	Break	
4:00pm	Discussion	All

Friday, April 21st

Location: See Room Location listings below

<u>Time</u>	<u>Topic</u>	<u>Location</u>
7:30am	Executive Session	Orange Room, B040
8:00am	Breakout Sessions, <i>continued if necessary</i>	
	Breakout 1: TBD	
	Breakout 2: TBD	
	Breakout 3: TBD	
	Breakout 4: TBD	
	Breakout 5: TBD	
10:00am	Executive Session	Orange Room, B040
12:00	Lunch	Orange Room, B040
1:30pm	Executive Session	Orange Room, B040
4:00pm	Closeout - Plenary	Orange Room, B040