Report of the June 16th through 18th, 2008 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 and the LCLS Ultrafast Science Instruments (LUSI) project team on the 16th through the 18th of June 2008. 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

As the project has evolved the emphasis of the charge to the LCLS-FAC has evolved as well, and in meeting the FAC was specifically charged to

- Assess installation planning;
- Identify technical risks remaining in the photon beam systems and LUSI;
- Assess the controls applications strategy with specific comments on risks and priorities being sought;
- Assess commissioning plans; and
- Advise on how to best integrate LUSI into the FAC mission.

The FAC 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 and the LUSI project 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 June 16–18, 2008, FAC meeting.

The following sections address the aspects of the charge through individual reports of the subgroups. General comments and recommendations precede these individual reports and follow in the next subsection.

1.2 *General Comments and Recommendations*

Progress on the LCLS Project continues to accelerate and continues strong. Since the previous FAC meeting (October 2007) the LCLS project baseline was revised to a total estimated cost (TEC) of $352M and a total project cost (TPC) of $420M. As part of this revised baseline the Department of Energy (DOE) Critical Decision 4 (CD-4), the official project completion milestone, has been set to July 2010. An additional global project milestone has been added as well *Early Finish* in July 2009. This *Early Finish – Start Near Hall Operations* includes characterizing x-ray flux at 0.15 nm in the front-end enclosure and detecting x-rays in the Near Experimental Hall. Overall project construction was listed as being 82% complete. The injection is 100% complete. The Linac was reported at 86%, the Undulator System at >89% complete (ANL workscope at 95%). The Conventional Facilities was reported as being more than 84% complete and Turner Construction activities at more than 89% complete. The emphasis of the project has moved towards the installation and integration, X-Ray Transport/Optics/Diagnostics at more then 76% complete, the XR End Stations at ~30% (the most significantly delayed as a result of the continuing resolution) and LUSI has been scheduled for a CD-2 review in August 2008 which will baseline three major instrumentation efforts.

To date, commissioning and injector results are impressive. The Project team is functioning well, working very closely together in a unified effort with no obvious difficulties. Implementation of the integration and installation processes is progressing very well. The switch to the operating organization is well underway in the areas of Accelerator Systems Division, LCLS Experimental Facilities and LCLS System Engineering. There has been a strong emphasis on accomplishing tasks correctly which demonstrates the cohesiveness of a unified, mature team. This team is appropriately focused paying attention on the deliverables and end goals.

During the transition phase to a facility, the Project must focus on the deliverables and SLAC must focus on the facility. SLAC should pursue the facility aspects that are not *on-project* (e.g. monitoring of floor motions throughout new construction). Complete understanding of the interplay of all aspects of SLAC, the Facility and the Project is imperative. As the LCLS Project is heading toward completion, the LCLS Facility is striving to become established and the SLAC is evolving to single entity with a multipurpose mission. A healthy tension naturally exists and it is important that to understand.

Installation in several areas has proceeded as far as possible due to the challenges presented by co-occupancy. This may cause further schedule delays in the technical systems installation. A suitable environment and controls are necessary before many systems can be attempted. The emphasis at this time is to <u>not</u> unwittingly assume a greater risk while attempting to mitigate or transfer other risk.

The commissioning plan has gone well but great care must be exercised not to allow the desire for the early science milestone to compromise aspects of the facility. Free-electron lasers have demonstrated over more than thirty years that they can be quite challenging in commissioning. The LCLS Project is encouraged not to promise a usable x-ray beam by a given date. More advisable is stating that an x-ray beam of a given quality will be available no earlier than a given date. This will make it incumbent upon the LCLS *Facility* to inform and select *first users* that have sufficient flexibility to start experiments with relatively short notice once x-ray beam characteristics and stability have advanced sufficiently experiments to be conducted without undue frustration.

- RESPONSE: Relatively conservative "early operations" specifications have been communicated to LCLS users for the summer of 2009. Nonetheless, the LCLS has "stuck out" its institutional neck by announcing that first use of the AMO experiment by LCLS users will take place in August 2009. We may pay a price for promising too much. For now, the Project is enjoying the "payback" for ambitious promises, in the form of a high degree of motivation to install, check out and commission the LCLS in support of the August 2009 goal. Prospective users have informed us that they may need over 6 months to prepare for assigned beam time. LCLS will schedule first experiments around March 2009. By this time LCLS will have had 3 months' experience commissioning the undulator transport, and will be starting SASE studies – admittedly a "success-oriented" schedule. Many of the first LCLS users are likely to have done experiments at the DESY FLASH facility. FLASH alumni are familiar with (and hopefully prepared for) the realities of early facility operation.

As the emphasis of the project changes, the FAC should evolve to meet the needs of the LCLS. The Electron and Undulator subcommittees should be merged into a Commissioning subcommittee. Conventional Facilities should remain intact through one additional review process. It is likely advisable to expand and subdivide the x-ray subcommittee so that the instrumentation efforts of LUSI project can be adequately supported. There should be comprehensive coordination with the SAC to ensure complementary roles.

- RESPONSE: The advice of the FAC will be implemented in this meeting. An x-ray optics expert has been added to the committee. Going forward, the Conventional Facilities review function of the FAC will be revised after discussion with the FAC Chair during the upcoming review.

The LCLS project continues to be an exciting project. SLAC and LCLS should not lose any opportunity to preserve and provide valuable lessons learned throughout the entire evolution of the project. This is extremely important for the benefit of this project and for future projects that follow at SLAC and elsewhere.

- RESPONSE: A comprehensive and painful-to-prepare "Lessons Learned" study will be presented at the next Lehman Review in February 2009. LCLS will share results of this study with the FAC.

As always, the FAC is very appreciative and would like to extend their sincere thanks to Helen O'Donnell, Siony Matni and the LCLS staff for all of their hard work and efforts in organizing these meetings.

2.0 Electron Systems Subgroup Summary

John Corlett, Max Cornacchia

2.1 *Commissioning*

Commissioning of the accelerator systems has progressed very well. The injector commissioning was completed in the fall of 2007, and those systems have been handed over to operations. The injector produces excellent beam quality, with measured projected emittance less than 1 μm at 0.25 nC, at 135 MeV and before bunch compression. Beam commissioning to design energy of 13.6 GeV was completed in March 2008. Projected emittances are 1.36 mm-mrad horizontal and 0.90 mm-mrad vertical, measured at 9.2 GeV with 0.25 nC, 75 fs bunches. With these parameters the FEL is expected to saturate in 100 m and produce 10^{12} photons per pulse at 8 keV, achieving the design goals for the LCLS. The horizontal emittance is observed to be sensitive to charge, probably due to CSR effects, whereas vertical emittance remains approximately 1 mm-mrad at 0.50 nC.

The committee applauds the excellent progress in beam commissioning, which reflects excellent planning and execution, and strong contributions from the LCLS team involved in the many areas needed to bring a concept to practical realization.

The committee recommends beam test at higher repetition rate, ideally up to 120 Hz where possible, to allow early identification of potential problems in hardware, diagnostics, and in software needs.

- RESPONSE: During the 2008 commissioning 120 Hz testing was done. These test showed that time slot dependant feedback will be needed for high rate beam operations. Beam synchronous data acquisition routines were also made to work during the tests. The results will be discussed in Paul Emma's talk in the upcoming review. Full implementation of 120 Hz capability is anticipated prior to approval of Critical Decision 4.

2.1.1 BC1

The central dipole magnets in the first bunch compressor were removed and field flatness improved by mounting caps onto the pole pieces. Magnetic measurements were performed before re-installation, and the magnets are now of sufficient field quality.

2.1.2 Main Linac

BC2 was installed to a very tight schedule, and the committee applauds the careful planning and continued attention that resulted in this success.

The tight RF tolerances are being met, using RF feedback for short-period control, and beam-based feedback for longer timescales, resulting in very good energy stability measured to be 0.03% RMS at 14 GeV, transverse phase-space jitter typically less than 12% of beam size, and bunch arrival time jitter of ~46 fs (with respect to the transverse deflecting cavity RF). Bunch charge jitter is measured to be ~1.5%. A 10 μm bunch length is measured after BC2, limited by the resolution of the bunch length monitor screen.

2.1.3 Controls

Powerful high-level application tools have been generated in Matlab by physicists, and have proven essential in the success of commissioning and operations. Feedback systems implemented in Matlab are essential in meeting specifications for peak current, charge, bunch length, etc. Not all feedback systems will be able to function at 120 Hz, and the necessity for such bandwidth is not yet determined and would be investigated at higher repletion rate operations (see earlier recommendation to pursue this).

- RESPONSE: As stated above, 120 Hz testing was done during the 2008 commissioning. The results will be discussed in Paul Emma's talk in the upcoming review.

New BPM electronics, read directly by EPICS, have high readout speed and have proven very useful in commissioning, for example the shot-to-shot transverse phase-space measurements. Old SLC BPMs readout rate is low in EPICS, ~1 Hz

The software group will migrate code from Matlab and implement features for improved reliability and maintainability (see comments in Controls section). Have EPICS BPMs in critical areas (high dispersion, etc.).

- RESPONSE: This has been done. Data on vertical and horizontal beam position, as well as beam profile at the end of the linac, were taken using a number of improved BPM readouts near the scanning wires.

2.2 *Photoinjector*

Performance of the photoinjector has been very good. The gun, laser systems, and diagnostics are now fully functional and highly reliable.

The committee reiterates its recommendation that the LCLS project pursue means to build a gun test facility, for the testing and development of components for LCLS applications without disruption of operations.

- RESPONSE: The Project gratefully acknowledges the FAC endorsement of the Injector Test Facility.

2.2.1 Laser

The photoinjector laser systems have proven to be highly reliable, and 99.9% availability was reported. The systems are typically operating at 10-30 Hz, although they have been tested at 120 Hz. A Dazzler is used to generate the laser beam temporal profile, and the spatial profile provided by an iris imaged onto the cathode plane. Fused silica windows have been replaced, the laser room to injector enclosure transport tube cleaned, and pointing stability and energy adjustment systems improved. Stability of the systems, and safety, has been enhanced by enclosing all laser tables with opaque screens.

The daily operation of the photoinjector laser is now controlled by operators in the main control room. Operators log laser system parameters daily, allowing engineers to analyze data for predictive maintenance. Operators do not go into laser room.

2.2.2 RF gun

A change in staff responsible for the gun appears to have been smoothly implemented.

RF field probes have been replaced with ones that are less tightly coupled to the cavity, and can be operated at 120 Hz with design gradient at the cathode.

The second gun has been built and RF conditioned at 125 MV/m, 120 Hz, 2 μs pulses.

Cathode quantum efficiency has been improved by laser cleaning, although with some resulting non-uniformity in emission, and with reduced quantum efficiency following venting to install the new field probes. A less aggressive laser cleaning technique is under development. The committee recommends that the cathode not be replaced at this time, since the performance has been demonstrated to meet the needs of the FEL, and a new cathode may bring fresh challenges as yet unanticipated.

- RESPONSE: The cathode was replaced in April after a degradation in quantum efficiency that could not be remedied with "laser cleaning". New 120Hz-capable field probes were installed at the same time. The changeout was a success and satisfactory QE has been maintained through the summer 2008 run. The summer's experience suggests that some (as yet unidentified) vacuum event caused a degradation of QE which could be corrected only temporarily by laser cleaning.

2.2.3 GTL Diagnostics

GTL diagnostics have been repaired and re-aligned where necessary, with the Faraday cup and YAG screen, IM01 toroid, in-vacuum laser mirror and window, and laser alignment window now fully functional.

2.3 *Coherent optical transition radiation*

Strong signal from coherent optical transition radiation (COTR) saturates the OTR monitors designed as beam diagnostics, and makes them unusable downstream of the first bunch compressor. As a result, the emittance cannot be measured until downstream at a beam energy of 9.2 GeV, where scanning wires are installed for this purpose.

Studies of the COTR have improved understanding, although the detailed structure of the beam giving rise to coherent radiation in the optical region is not yet fully understood. The solution to the COTR problem is believed to be the laser heater, which is designed to introduce an incoherent spread in the beam energy, smearing out micro-structure in a bunch that gives rise to COTR.

2.3.1 Laser Heater

The laser heater design packages are being completed, and the system is planned to be installed September 2008, with beam commissioning no later than January 2009.

Since COTR significantly impacts the usefulness of OTR diagnostics, and the micro-structure in charge distribution that gives rise to COTR may affect lasing in the FEL, the committee strongly supports continued attention to installation and commissioning of the laser heater.

- RESPONSE: Acquisition of the laser heater was delayed until mid-summer to avoid risk of exceeding Project budget authority. Acquisition has been expedited. All systems will be in-house by the end of October. This means, however, that commissioning activities will be interrupted for final installation, probably sometime before the end of the calendar year.

Plans for FEL Commissioning

The committee thanks the LCLS team for their responsiveness to our request for a detailed description of FEL commissioning plans.

Beam commissioning in the from the LTU to the beam dump will begin without the undulators installed, in order to minimize potential damage to the magnetic material while the beam is steered through the transport line. RF cavity BPMS and beam finder wires, with mechanical girder movement systems, will be used to steer the beam through the quadrupoles in a straight line. Undulator sections will then be installed at a rate of approximately 3 segments per day, taking about 2 weeks to install all sections. An alignment diagnostic system (ADS), consisting of a stretched wire and hydrostatic level measurement systems allows for compensation of long-term ground motion, providing feedback signals for the girder mechanical movement. The undulator hall temperature is to be maintained at a constant temperature ±2.5°C, and installation of undulator sections will not begin until the HVAC system is fully functional.

Spontaneous emission will be characterized initially at 1.5Å. Setup will then switch to a 4.5 GeV beam energy and SASE optimized at 15Å, with a reduced number of undulators, and shorter gain length than with a 14 GeV beam and 1.5Å radiation. The undulator beamline lattice is fixed regardless of beam energy (quadrupole settings are unchanged). The SASE radiation will be detected by direct imaging, If not readily observed, then a lock-in detection scheme may be used, using a modulation in energy spread introduced by the laser heater (@ 7 Hz) to effectively switch lasing on and off. Tools and diagnostics will be available for both 15Å and 1.5Å, allowing flexibility to work at different wavelengths to make best progress.

Initial operations are expected at 60 Hz pulse rate, in October 2009, and at 120 Hz by June 2010.

The committee commends the LCLS team on developing a plan that is thoroughly considered and detailed. Integration between installation, accelerator, undulator, and the x-ray teams is good.

The early science goal, with beam to users in mid-August 2009, drives the commissioning schedule with little room for slippage. The committee notes that additional pressure may be added to this schedule if beneficial occupancy proves to be later than expected.

3.0 Undulator Subgroup Summary

Joachim Pflüger, Kem Robinson

3.1 *General*

The undulator setup is in full progress and was found an impressive effort. All components of the undulator systems are making good progress. Former items of big concerns now run very smoothly, in time and budget. A noticeable change in climate from confrontation towards collaboration partners was observed, which is very beneficial for the project. All items are being addressed, under way, in production or already finished.

There were some changes on the undulator, which came in very late and which need re-measurements.

3.2 *Vacuum chamber*

This item, which was subject to many concerns and comments in the past, now is in a very good shape. All Al-extruded vacuum chambers have been produced and are delivered. They fulfill surface roughness/slope requirements. At the excursion the test setup was presented in Hall 750.

3.3 *Magnetic Measurements*

There were late changes:

- Slight K changes were observed after storage in winter, where the magnet temperature was low. They are not fully understood where they come from.
- New horizontal shims were developed, which allow a higher good field region of ± 6 mm to be used.

As a result at least partial re-measurement of the already measured undulator segments is needed. This increased the pressure on undulator time schedule. Time float for undulator measurements consequently has shrunk closed to zero. Therefore no more delays can be tolerated without affecting the project. Some of the already measured segments are on specification limits but can still be used. For mitigation, Zack has made the plan to install those segments, which are within specs and measured, but only good to ± 2.5 mm and to modify them one after the other as part of the undulator re-measurement plan during operation at a rate of three segments per month.

> ➢ RESPONSE: Undulator tuning and fiducialization is proceeding on schedule. For mechanical fabrication reasons the decision was made to re-shim and tune all undulators for the larger good field region. There will be 12 Undulators RFI by the end of the calendar year. 12-15 more will be ready by the by the start of March when Undulator installation on the girders will begin. 33 total Undulators will be RFI by May.

3.4 *System Installation*

The benefit of co-occupation is almost exhausted. There are no more items of the undulator system, which can be installed under the present situation. Installation of the sensitive items can be made only after beneficial occupancy. Depending on the BO there is an additional schedule risk, which requires appropriate planning.

3.5 *Beam Loss Monitors*

The BLM system has appropriate importance. However, for budget reasons only five BLM systems will be available for commissioning and the rest later. These are considered sufficient for the beginning. Although some workarounds and other protection means such as an orbit control system are foreseen, it was questioned throughout the committee enough protection can be provided by the proposed 5 systems in the delicate commissioning phase. This is considered an additional risk.

- RESPONSE: 27 Beam Loss Monitors (BLMs) from PEP2 have been installed on girders in the Undulator Tunnel. The other 5 girders will have ANL BLMs installed when these unit arrive in November. An optical fiber beam loss monitor has also been installed along the girders. Details of this plan, including beam loss simulations, will be presented by Heinz-Dieter Nuhn in the upcoming review. Joe Frisch will present the PEP and fiber BLM systems.

4.0 X-ray Subgroup Summary

Lahsen Assoufid, Paul Fuoss, Tom Rabedeau, Peter Takacs, *Thomas Tschentscher (not present at the review)*

4.1 *Overview*

The x-ray efforts of the LCLS project are progressing rapidly but are being severely squeezed by the current spending profile. As was discussed in our last report, procurement of the AMO scientific instrument is being delayed until the beginning of FY09. This delay results in a significant risk that no functioning scientific instrument will be ready when x-rays are first available at the LCLS. The project is actively working to mitigate this risk and we believe that these efforts will be successful.

There has been significant restructuring of the LUSI MEI effort since the FAC last met in October, 2007. Tom Fornek has taken over responsibility for the LUSI project from Jerry Hastings and the project has been more tightly integrated into the overall LCLS project. LUSI faces severe constraints due to the reduced budget authority, particularly in the near future. The FY08 budget is only 60% of the planned amount, a budget reduction that causes great difficulty to long-range procurements. These constraints are being addressed by rearranging priorities and descoping the project. Significant early scientific opportunities are likely to be lost because of these budget constraints.

An area of significant concern for the committee was the addition of a Soft X-ray Materials beamline to the planning. At a time when the baseline experimental program is under severe stress, the encouragement by senior SLAC management of this new effort aimed at early operation can create uncertainty regarding priorities within the project. For example, much effort is going into restructuring the AMO experiment to move it from Endstation #2 to Endstation #1. While the scientific and technical case for this move may be strong, the potential diversion of staff from a sharp focus on completing the AMO experiment and balancing these competing interests is a significant risk.

- RESPONSE: The restructuring of the Hutch 1/Hutch2 layout was accomplished in only a few days. The payoff was deemed to be worth this cost. Extra manpower has also been added to the XES group to help assure that the AMO readiness milestone will be met.

LCLS has started a process to evolve from a construction project to an operational x-ray light source and this has led to a much sharper focus on the x-ray scientific infrastructure. A series of proposal workshops are being held. The workshops have already identified areas where the proposed instruments could be refined to support a broader range of scientific programs and a broader user community. This is a very positive development.

4.2 *Summary of Highlighted Areas*

The x-ray subgroup heard detailed presentations on a key selection of important areas to the LCLS x-ray community. These are summarized below.

4.2.1 XTOD Status

The X-ray Transport, Optics and Diagnostics (XTOD) effort has made significant progress in the last six months but there are still significant areas of concern. Many of the key components for the Front End Enclosure (that are critical of commissioning the FEL) are currently being assembled at LLNL including the Fixed Mask/slit, the Gas Attenuator, Gas Detectors and FEE controls racks. In addition, the components for the thermal sensor and the direct imager are either on order or in house at LLNL. The pop-in monitors are still in the design stage. Of most concern is the K monochromator that is still in the final design stages. This instrument is key to doing the initial calibration and tuning of the FEL undulators during initial commissioning of the FEL. There is not a readily identifiable person with responsibility for the completion of this instrument.

- RESPONSE: The design of the k-monochromator is complete and drawings for the mechanical components are being finalized. A SLAC scientist will be given responsibility for the commissioning of this instrument.

The design and procurement of the x-ray transport system to deliver x-rays to the experimental stations is going well. Preliminary design and prototyping of the x-ray mirror support and movers has been done and a final design review is scheduled for August. The mirror movers meet the stability and pointing requirements for the soft x-ray offset mirrors (SOMS) and, with additional temperature stabilization, meet the hard x-ray offset mirrors (HOMS) requirements. Three of the five mirror blanks for SOMS have been delivered.

The first two were just out of spec while the third was comfortably within specification. The first two will be repolished if the final two come in with specification as is anticipated. The HOMS blanks are currently being fabricated but have more stringent specifications than the SOMS. The panel urges a close interaction with the vendor to emphasize these very demanding specifications.

- RESPONSE: The SOMS and HOMS mirrors have now all been received. All meet the critical figure specifications (the measured HOMS figures are actually much better than spec). Some of the SOMS mirrors slightly missed the roughness spec, but this was determined to be acceptable. Interactions with the mirror vendors were in fact very close and very productive.

The committee was given a tour of the near experimental hall (NEH) and the far experimental hall (FEH) and shown the endstation rooms in the NEH. These are progressing well although there was concern about the configuration of the air handling system and temperature stability across the room since ventilation air is only being introduced on one side of the very large rooms. A preliminary design review for the laser and transport system for the NEH has been completed although it cannot be ordered until FY09.

There appears to be excellent progress on the 2D Pixel project lead by Cornell University.

4.2.2 AMO Instrument

The AMO instrument is on schedule for completion by the time x-rays are available from the LCLS but there is no float in the schedule and timely procurement is essential. Thus, the recent proposal to relocate the instrument from Endstation #2 to Endstation #1 is worrisome since staff effort and resources could easily get diverted into dealing with unforeseen problems and not expediting the crucial procurements.

The AMO project also faces some stress from the outcome of the recent Proposal Workshop that revealed that most outside investigators wish to bring specialized chambers to attach to the basic AMO instrument. This requires straightforward but potentially time consuming redesign of portions of the AMO instrument. Nevertheless, the design of the AMO instrument is excellent and the team should be commended for their work to this point.

- RESPONSE: The relocation of the AMO experiment to Hutch 1 solved most of the issues related to attaching specialized user chambers. Extra chambers can be attached behind the AMO chambers. Very little effort has been put into accommodating extra chambers at this point, and will not happen until after the instrument is running. Most of the experimental proposals received in the first round do not require extra chambers.

4.2.3 XPP Instrument

Excellent progress continues on the design of the x-ray pump-probe (XPP) instrument. There was an extensive discussion of the merits of using industrial robot technology to move the x-ray detector and how to specify tolerances and reproducibility of motions. The committee believes that the robot approach is very promising and recommends the design team determine whether there are standards (e.g. ANSI) for robot design that will make specification easier.

The design of the sample orientation system (goniometer) is still at an early stage. The committee is concerned that the design is being done without clearly defined reference loads and moments.

- RESPONSE: The current engineering specifications call for a design load of 225 pounds with a moment arm of 2 inches for the sample tilt platform.

It would be beneficial to have several conceptual sample chambers (e.g. a cryostat) that could be used to get realistic performance numbers from standard commercial instruments. The mechanical stability of the instrument could be improved by limiting the vertical range of motion, a distance that is currently quite large.

- RESPONSE: The reduction of vertical motion range has been proposed by one potential vendor to increase the mechanical stability of the system. The current engineering specifications require a minimum of 35 mm of vertical motion.

The design team has adopted the philosophy that the incident slits and beam conditioning hardware should be absolutely defined in space. This has led to the use of an extremely large, monolithic block of granite as the support for the incident optics. This appears to be an unnecessarily difficult approach since both the incident beam and the goniometer will have significantly larger motions than the granite block on the relevant time scales. If a large, monolithic block is necessary, it may be possible to find synthetic products that can be poured in place that will approach the performance of the monolithic granite table. The current plan also has the optics being repositioned on top of the monolithic block to reach the direct and offset positions. It may be much more efficient and stable to have a much narrower table top to which the optics are referenced and to move the entire table between the two operating positions.

- RESPONSE: The XPP team agrees that the diffractometer and incident beam will likely drift with respect the monolithic granite support. However, it is the x-ray optics that define the beam for the experiment. With the use of a stable support structure, the drift of beam on the sample is reduced to a one dimensional problem (movement of the sample). The team further emphasizes that the design, manufacturing and installation of a monolithic block is neither difficult nor expensive.

- RESPONSE: The preliminary design of the support table was completed since this FAC meeting (review held on Aug. 27). Details of the considered design options were presented, including the narrow table option described above. However, it was confirmed by the review committee that the current design best met the physics requirements and safety needs.

4.2.4 CXI Instrument

The presentation and discussion of the coherent x-ray imaging (CXI) instrument mainly concerned the design of the KB mirror focusing systems. Two separate mirror systems are being designed for the project, one to create a 1 micron focus and one to create a 100 nm focus. The project is investigating the use of a bilayer mirror with a 40 nm Rh layer capped with a 30 nm B_4C layer. The goal would be to get high performance from the B_4C layer at low photon energy and high performance from the Rh layer at higher photon energy. The committee was not enthusiastic about this approach. The mirrors are required to perform at an extremely high level to meet the design criteria. Whether the required interfacial roughness can be preserved when creating multiple interfaces between materials that have uncertain wetting characteristics and residual stresses is a significant risk. Even if almost ideal interfaces can be created, there will be subtle thickness variations across the mirror that could lead to complicated interlayer interference and coherence degradation.

- RESPONSE: On the advice of the FAC, the idea of using a bilayer coating was abandoned until radiation damage and stability measurements can be made at LCLS. This comes at the cost of a reduced energy range for the mirrors. This loss of functionality was somewhat offset by reducing the incidence angle of the mirrors which allows a single layer of SiC to reflect the beam up to 10.5 keV. The SiC coating is the same as for the HOMS mirrors of LCLS. The reduced incidence angle implies a reduced clear aperture which in turn implies that the mirrors are not large enough to accept the full beam at lower energies. The focal spot will therefore be larger below 4 keV but will still produce a usable beam. The decision was also made to widen the clear aperture of the mirrors so that a second coating strip, which would consist of a bilayer that can reflect the beam up to 18 keV, could be added in the future after the stability of the bilayer has been characterized with the LCLS beam.

Finally, the stability of this structure under high instantaneous photon fluxes is uncertain. There appears to be no strong scientific driver that requires rapid switching between low and high energy x-ray operation. The committee felt that a better approach was to concentrate on mirrors optimized for a particular, narrower energy range.

- RESPONSE: There are valid reasons to desire the ability to use the LCLS beam between 2 and 6 keV. Imaging at LCLS is fundamentally different than at a synchrotron because there is no possibility to increase the signal by accumulating over many shots. Under some circumstances, with unique samples such as cells, the highest achievable resolution may be with lower energy photons since the scattering cross-section increases roughly as λ^3. It is therefore important to be able to utilize the lower energy photons (2-6 keV) from LCLS. The switching between the low and high energy (8.3 keV) does not need to be rapid but a single layer of SiC coating allows both energies to be used without realigning the mirrors. The CXI team has revised the mirror specifications as described above to allow for 2 coating strips, with the first one optimized for 8.3 keV but functional over the 2-10.5 keV range. The second strip, which will only be deposited after some research has shown that it is a valid option, will be allow the energy range to be extended to 18 keV for the use of the 3rd harmonic of LCLS.

The design of a temporary experimental chamber that supports 1 micron operation but that may not be compatible with 100 nm operation was discussed. The committee felt that this was a good approach to dealing with the experimental uncertainties.

4.2.5 XCS Instrument

The discussion of the XCS instrument centered on the design of the diffractometer and detector stages. The design effort of this instrument is progressing very smoothly and the committee endorses the decisions that have been made to date. The largest risk appears to be the split and delay line. The committee supports and encourages the team's efforts to construct a prototype instrument and test it at both third generation synchrotrons and the LCLS as soon as possible. The large offset monochromator also requires design attention and carries risk. This has been recognized by the project and appropriate efforts are being made to create a solid design.

4.2.6 X-Ray Diagnostics and Common Optics

The presentation focused on three areas that the FAC was asked to comment on: 1) an intensity-position monitor, 2) the wavefront monitor and 3) the design of slits. There is a common theme running through the discussions that it is extremely difficult to have solutions that work for both soft x-rays (<4 keV) and hard x-rays. However, it is unclear why the LUSI team is expending large amounts of effort on soft x-ray problems since there is no scientific program in the LUSI scope using soft x-rays.

- RESPONSE: As stated in the CXI section, there are valid reasons to desire the ability to use the LCLS beam between 2 and 6 keV. Imaging at LCLS is fundamentally different than at a synchrotron because there is no possibility to increase the signal by accumulating over many shots. Under some circumstances, with unique samples such as cells, the highest achievable resolution may be with lower energy photons since the scattering cross-section increases roughly as λ^3. It is therefore important to be able to utilize the lower energy photons (2-6 keV) from LCLS. The switching between the low and high energy (8.3 keV) does not need to be rapid but a single layer of SiC coating allows both energies to be used without realigning the mirrors.

- RESPONSE: The possibility of going to 2 keV was purposely kept, which then led to the decision to design and implement diagnostics and optics components that would work in the X-ray energy range of 2 - 25 keV. In addition, it is a common understanding that LCLS would most likely to lase at softer energies when it first starts up, and it would be extremely important that experiments are to be conducted at these energies.

Thus, we would encourage the program to find robust, reliable solutions that function in the hard x-ray regime above 4 keV. If that decision is made, it appears that suitable solutions are available for most of the diagnostic and beam definition instruments.

- RESPONSE: It was found that the energy dependence of all diagnostic devices is rather weak such is the case in intensity monitors. For the X-ray optics components such as attenuators, harmonic rejection mirrors, slits, solutions are available to cover the entire hard X-ray range. In the case of the offset monochromator, the energy will indeed be limited to above 4 keV.

The design of the wavefront sensor is promising. This is a device that can easily be tested on an existing source and we would encourage a prototype to be quickly constructed and tested. Demonstration of a robust reconstruction with a computation time consistent with dynamic feedback to the experiment would eliminate substantial uncertainty in experimental and data acquisition design.

The lack of any completed designs for these key components causes concern.

- RESPONSE: It was perhaps a miscommunication on LUSI's part in not providing updates on the designs for the common diagnostics and optics, which may have led the committee's concerns over the design maturities. On the contrary, the design efforts are proceeding on schedule, except for certain diagnostic devices where personnel changes have caused come delays. LUSI has been actively addressing these problems by bringing on board very experienced engineering staff from the LCLS accelerator division which would ultimately speed up the design process and bring the schedule back to the baseline.

4.2.7 X-Ray Commissioning

Hal Tompkins presented detailed planning for the x-ray commissioning of LCLS. The overall plans appear reasonable. There is a need to retain a great deal of flexibility in the scheduling since it is likely that some operations will take considerably less time than allocated and some considerably more than anticipated. Also, contingency plans for the failure of components to reach design performance are not included.

- RESPONSE: LUSI is considering the failure of components to reach design performance in its risk registry. We are developing contingency plans, when possible. We are also accelerating the design and procurement process, when possible, in order to determine whether components will meet specifications.

A plan for "on call" technical support to respond rapidly to surprises in the performance of the instruments, should be developed.

- RESPONSE: LCLS is in the process of staffing up to support user operations. It is intended to provide on-call technical support to the experiments. The steady state staffing goal includes several scientists, engineers, and technicians for each instrument, along with additional support for detectors, diagnostics, controls, data acquisition, and data analysis.

4.3 *Summary*

The x-ray instrumentation program is under severe stress due to budget constraints and late starts on many key design issues. The staff should be commended for their very positive response to this difficult environment. The project is encouraged to develop plans that identify the minimum capabilities needed for scientific programs to take advantage of the unique x-ray beams the LCLS is expected to produce, and to focus on making sure that those capabilities are provided as soon as practicable. There appears to be an implicit assumption in planning for LCLS beamlines that the LCLS will not reliably produce hard x-rays for a significant period of time (i.e. over a year) in the planning for infrastructure development. This assumption does not appear consistent with the other presentations to the FAC and the project is encouraged to have contingency plans to exploit early success with pioneering hard x-ray experiments. The current proposal workshops appear to be a good mechanism to facilitate the development of such plans.

- RESPONSE: It is planned to include hard-x-ray experiments in the next call for LCLS proposals, which will take place in Winter 2009-10.

5.0 Controls Subgroup Summary

T. Himel, K

There has been a lot of great progress made since the last FAC meeting in October 2007. The installation and commissioning of BC2 went very smoothly with the tight schedules being met. The MPS system which has been a schedule concern for two years has its first modules working in the field with a test database. There is still considerable work to do on this system but this is a significant milestone and reduces the level of concern. Finally (at last), Hamid has the deputy that both he and the FAC have wanted for several years. Welcome aboard Enzo Carrone! It looks like you have rapidly come up to speed.

The hardware and low level software for the electron beamline are either satisfactorily done or ballistic, so there are no major remaining concerns. Some minor comments:

- There is not yet an adequate plan for setting the thresholds of the Beam Loss Monitors (BLMs). Setting them to the lowest setting where they don't trip and having no idea of the calibration is likely to lead to problems. We suggest combining data on the radiation damage rate of the undulators with EGS modeling of beam losses with source or beam calibrations of the loss monitors to arrive at an initial threshold setting. This can later be adjusted by comparing undulator deterioration with TLDs with the BLM readings.

    - RESPONSE: The schedule has the BLM system installed during the initial electron beam commissioning of the Undulator beamline, without the undulator magnets installed. This will allow for some calibration of beam loss, radiation levels and BLM response before the magnets are placed at risk. As stated above, details of this plan, including beam loss simulations, will be presented by Heinz-Dieter Nuhn in the upcoming review. Heinz-Dieter will also discuss plans for magnet damage studies with the SLAC-Spring8-DESY collaboration.
- We are concerned that the reduction from 33 BLMs to only 5 for budgetary reasons may compromise the safety of the undulators.
    - RESPONSE: As stated above, 27 Beam Loss Monitors from PEP2 will augment the 5 from ANL, and an optical fiber beam loss monitor has been added. These will be discussed at the review.
- Presently feedbacks are implemented in Matlab and due to this architecture are limited to running at 5 Hz. They are working quite well and are providing adequate stabilization at present. It is a fairly big job to implement the architecture that allows high rate (120 Hz) running and since the project is not sure it is needed, its implementation is low priority. There are 3 feedbacks in the linac using the legacy control system that do run at full rate. With the planned modernization of that control system, these loops will no longer run at full rate. The experience at SLC was that some of the loops needed to run at 120 Hz. Considerable effort was put into increasing the rates of some loops from 20 Hz to 120 Hz. We strongly suspect that since the FEL is supposed to be as fussy about its beam as the SLC was that full rate feedback will be needed to obtain stable operation. Consideration should be given to accelerating (from zero speed) the development of higher rate feedbacks At minimum, some early 120 Hz testing should be done to see what problems occur not only for feedback, but for other systems.
- Without doubt, when the linac is run at 120 Hz, there will be timeslot separation where every other pulse has a different energy and trajectory. To solve this does not require 120 Hz feedback. It only requires controls and actuators that can switch at 120 Hz (such as a PAU and a solid state phase shifter). The plan for how to compensate for timeslot separation should be developed soon so it can be implemented and tested before production 120 Hz running starts
    - RESPONSE: We have setup a dedicated team of hardware and software engineers to focus on the development of a fast feedback system capable of

operating at 120 Hz. We are nearing the decision on the choice of the hardware layer, and have already developed a high level architecture for the software system. The project schedule indicates availability of the first 120 Hz feedback loop in January of 2010.

In the push to get a new control system operational, emphasis is properly given to getting needed new hardware and features implemented and hence the fixing of minor operational problems are given low priority and essentially ignored. If not fixed, these minor problems increase in number and operation of the accelerator becomes difficult and frustrating. Things are going well enough (rumor has it that some controls people are even being allowed to sleep at night) that it is time to devote more attention to finding and fixing these problems. Finding them may only involve encouraging the operators to complain or sitting in on shift for a few hours. An example of such a problem (which is minor enough we're embarrassed to mention it here, but nevertheless if there are several others like it they add up to a significant problem) is that the drag and drop of a PV from one place to another (e.g. data archive viewer) does not always work.

- ➢ RESPONSE: Starting with the November machine commissioning, we have also set up a team to support the control room to identify and address operational issues. These problems are collected daily and assigned to responsible engineers and their progress is tracked on a daily basis. There is a dedicated control engineer assigned to the Main Control Center (MCC) to oversee this process and the position is rotated on a weekly basis to provide continuity.

Progress has been good on the photon and experimental controls since the last review. It is pretty clear something will be up and running for the early experiments. We are concerned that the high data rates needed for later phases of the experiments will require considerable lead time to develop the DAQ, online and especially offline computing power and software. This is complicated by the fact that these are new types of experiments and people are not sure how or if the data can be zero suppressed or how it will be processed. It is complicated still more by the fact that different experimental groups will be using the facility each week and each may have its own unique requirements and we cannot afford the lost beam time of multiday transitions. Some planning involving the experimenters and controls people and then explaining of how these concerns will be addressed would be helpful.

- ➢ RESPONSE: LCLS will be adding staff in FY09 to work on data management and data analysis. A data management working group has been created at SLAC to develop protocols for dealing with LCLS data. Data acquisition and analysis was discussed at the user workshops last summer, and will be included in future user workshops.

High level applications (HLA) remain a significant concern. They are now suffering from the (proper) choice of delaying work on them in favor of more urgent matters. Concentrated work started only a year ago and the management and plan of what tools to use was changed only a few months ago. The plan has changed from taking most applications from XAL (the SNS HLA suite) and using Eclipse to taking only the model calculation from XAL and writing everything else from scratch in Java and Swing. This may well be the right thing to do, but it leaves us with several concerns:

- Writing things from scratch will take longer than adapting an existing HLA suite (on the uncertain assumption that such a suite exists that is good enough and adaptable enough).
- The resulting applications will not be easily modifiable by the physicists so changes they will certainly decide they want at the last minute will be slow in coming.
- There will be difficulties weaning the physicists away from the Matlab codes they have developed and grown accustomed to.

On the positive side, the functional requirements are being based on the existing Matlab applications and input from the physicists and operators. On the negative side, this committee is too ignorant to know if the best path has been taken. We certainly cannot say that the planned path will not work. In fact, it certainly can work. With all this considered, we renew our recommendation from the last FAC review that an *external* review should be held to go over the plans for HLA implementation. We would suggest having a reviewer representing each of the major HLA suites including SPEAR III, SNS and a couple of others.

- RESPONSE: We conducted a review of the HLA suites on November 10 with reviewers from SNS (3), SSRL and APS. Their report should be available shortly. The plan for HLA is described in greater detail in Appendix C.

Conventional Facilities Subgroup Summary

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

5.1 *General*

5.1.1 Oct. 2007 Review Recommendations & LCLS Responses

Design: Four recommendations resulted from the October 2007 review. All have been satisfactorily addressed.

Construction: Three recommendations were made. All have been satisfactorily addressed. However, the issue of construction delays due to budgetary reasons should be revisited for the remaining CF work.

Installation and Commissioning: One recommendation which was satisfactorily addressed.

Safety: Two recommendations were made. The first was accepted and implemented; the second consisted of a Report on LCLS Safety Performance containing six sections, each of which contained additional recommendations. The initial response from the Project Team was that some FAC safety comments weren't being addressed because LCLS safety had to be consistent with SLAC safety as a whole. Additional feedback from LCLS was that some FAC safety comments weren't being addressed because there was only a short time remaining to completion of the CF construction. FAC expects more. SLAC's own internal reviews have identified systemic safety problems at SLAC that still must be corrected and the Laboratory Director is pursuing solutions. Further, the LCLS project safety program needs to continue through construction of technical systems, testing and commissioning, and into operations although it will likely feature different emphasis than during CF construction since the participants will have changed.

- RESPONSE: LCLS has taken what was believed to be the most expedient path possible in its efforts to manage safety in LCLS civil construction and other technical activities such as equipment installation, checkout and commissioning. This was done by augmenting SLAC safety policies and procedures with LCLS policies/procedures where this was deemed useful. LCLS is participating actively in SLAC's ongoing effort to redesign the work planning process, led by a recently recruited expert in work planning control systems.
- RESPONSE: Contracted work and self-performed work directly managed following LCLS work planning processes have been completed without personal injury since the start of the LCLS project. Where LCLS has experienced difficulties with achieving its desired safety objectives has been in the contracts managed by the CM/GC. In these cases, the Project has increased the safety oversight in the field, obtained additional supervision from the CM/GC and instituted safety awareness programs for the workers including refresher training in the Job Safety Analysis (JHA)

preparation, UTR attendance at pre-task meetings, training in CM/GC proprietary safety programs (Live Injury Free Everyday (LIFE)), and safety reward programs for the individual person (Safety Stars and Safety Bingo) which provide rewards for safe work practices. These measures are in addition to and complement the Contract Requirements.

5.2 *Design*

5.2.1 Findings:

The Conventional Facilities has experienced low change order rates during construction, reflecting positively on the quality of the Jacobs design issued for construction. There were significant problems during design with construction bids exceeding the engineer's cost estimates. Construction contract awards exceeded estimates and budgets by ~50%. Other DOE projects were experiencing similar problems.

The LCLS Project reports good performance from Jacobs on Title III engineering support during construction, and has extended the duration of the Jacobs contract through the first quarter of CY 2009. Some of the testing to demonstrate the design function of Jacobs designed operating systems will not be completed during conventional facility construction because the Laboratory technical systems and equipment will not yet be in place. Jacobs has a limited role in Conventional Facility commissioning and testing, but will participate in reviewing selected test results such as for fire protection and vibration testing. Jacobs prepared the Commissioning Plan document issued with construction bid documents. This Plan specifies the selection and award of a contract for a Commissioning Agent. That contractor has been selected and is on-Site: Engineering Economics Inc (EEI).

The Project Office declined to accelerate design of Buildings 028 and 751 improvements because of other project priorities. Modifications to these building are slated to replace the function of the $25 Million LCLS Support Buildings (CLOC) that were deleted from the Project during earlier budget cuts. The CLOC buildings were to accommodate 176 users. The design of Buildings 028 and 751 modifications will start in September, 2008, under a new design contract awarded by LCLS. The LCLS Conventional Facilities staff will also perform the construction management of these building modifications. The construction scope is estimated at ~ $5 Million and the space will accommodate 171 users.

5.2.2 Recommendations:

None

5.3 *Construction*

5.3.1 Findings:

The site tour on the first day of FAC review confirmed the Conventional Facility construction status, reported to be ~85% completed overall (the Turner scope is ~90% completed). The visual quality of the Conventional Facility concrete and utility installations is impressive; however, there are some dimensional problems with concrete placed.

The tunnel walls at the location of the beam dump are 1" from where the beam designers expected them to be. The construction location of the embed for the beam dump will have to be evaluated for serviceability. There is no construction nonconformance identified, construction tolerance is ± ¼". Survey coordinates and benchmarks used for beam line and for CF construction should be cross checked for conformance.

The floor plane elevation variations in the undulator hall required grinding of concrete in order to place technical equipment. The surface variations exceed construction specifications and exceed the adjustment range of technical equipment pedestals.

The usual cleanliness problems in most remaining Conventional Facility construction areas will preclude use of co-occupancy to install sensitive Laboratory technical equipment until Turner has completed construction. Installation of temporary barriers to prevent migration of particulates could allow a progressive cleanup, but presents ventilation problems.

Conventional Facility construction is behind schedule, but Turner is expected to complete construction in less than the 28 months provided by contract. There is a net delay of 3-4 months in the scheduled completion of the conventional facility construction due primarily to late Turner contract award. To date, co-occupancy with Turner has lessoned the impact of construction delays on the installation of LCLS technical systems.

The Conventional Facility project staff reports significant progress on negotiating a resolution to an early Turner claim. The CF staff also reports that Turner accepted the concept of co-occupancy as a no cost change order and has not submitted delay claims to date.

An accrual system has been implemented, so the progress payment schedule for Turner matches the construction completion quantities measured by field walkdowns. This was recommended by FAC to resolve conflicting progress reports.

Conventional Facilities contingency on remaining work is ~28%, broken down into three parts: Contracts Underway, Contracts To Be Placed, and Expected

Claims. Resolution of pending claims should allow a significant reduction in CF contingency.

5.3.2 Recommendations:

If post-project beam line equipment is installed in tunnel areas where concrete surfaces out of spec have been accepted as-is, consideration should be given to increasing the adjustment ranges of new equipment to avoid concrete grinding and associated concrete dust.

- RESPONSE: Because of the tight tolerances in the Undulator system the floor height in the Undulator Hall was critical. In other electron beam areas support adjustment ranges are larger, and there have been no other problems.

The beam dump embed must be evaluated for serviceability. The survey coordinates for the CF construction and for the beam line should be cross-checked for conformity. If the survey coordinates for CF and beam line are different, there may be other ramifications than the beam dump embed location**.**

- RESPONSE: The coordinate system was verified and confirmed to be the same between the CM/GC surveyor and the SLAC Metrology Group. Minor modifications to the beam dump device opening were required and the beam dump structure is completely serviceable.

5.4 *Installation and Commissioning*

5.4.1 Findings:

The conventional facilities commissioning appears to be progressing as planned. A third party Commissioning Agent was selected by competitive bid and the contract awarded to Engineering Economics Inc. The Commissioning Agent is charged with preparing a detailed Commissioning Plan and Report.

Jacobs prepared an initial Commissioning Plan that was issued with the construction bid documents. This plan specifies a limited role for Jacobs during Commissioning. Jacobs will review test results for Fire Protection Systems and Vibration, but will not review all test procedures and test results. Further, some of the Jacobs designed systems will not be tested until after CF construction contractors have been demobilized.

The FAC was not provided with a clear description of where responsibility has been placed for establishing testing configurations and engineering acceptance criteria in the absence of Jacob's participation in the testing of all Jacob's engineered systems. Further, there was no clear recognition that some Conventional Facility designed and constructed systems cannot be fully tested until well after completion of CF construction and demobilization of CF contractors because technical systems are not complete.

During the design phase, Conventional Facilities asked for a relaxation in tunnel floor settlement criteria, so a conventional tunnel cross-section and structural configuration could be built in the interest of cost and schedule. Though tunnels have been completed for several months in areas critical to beam alignment such as the undulator hall, only one set of data has been taken to date, so no settlement trends are yet available. Settlement is an identified risk to beam alignment and alignment frequency. Further, there is an expected settlement profile that cannot be verified without periodic data points.

5.4.2 Recommendations:

Clear lines of custody need to be established for equipment handoff to operations following testing.

The project has now prepared a strategy, as part of the transition to operations, to ensure that lines of custody for transferring the equipment are clearly defined. The transition plan includes the protocol to transfer from Conventional Facilities to installation to owner.

The commissioning sequence should consider operational needs, including the required safety systems.

- RESPONSE: Installation and checkout of all systems, including safety systems, is underway and scheduled in detail. The beam commissioning schedule is well developed and does include significant time for the necessary radiation measurements.

Allow sufficient time in the commissioning schedule for documentation preparation and approval process associated with partial or full operational readiness reviews.

Commissioning of the facilities and systems installed under Conventional Facilities is managed and coordinated closely with the CM/GC. The testing is performed by the CM/GC and monitored by CF and SLAC technicians. The tests are scheduled during a Commissioning planning and status meeting held weekly. Commissioning reports are received from the commissioning agent and uploaded the Projects Sharepoint web site.

Verify that Jacobs has provided engineered acceptance criteria for planned test configurations on the systems designed by Jacobs Engineering.
Acceptance criteria are defined in the Commissioning Plan included in the Contract. Design changes included revisions to the engineered acceptance criteria where required.

Identify the CF designed and constructed systems that cannot be fully tested before CF contractors are demobilized. Document and mitigate as appropriate the contractual and technical risks to the Project.

- RESPONSE: The transition to operations plan includes all the systems required for operations. Each system is evaluated and any additional activities to complete the system are identified and assigned to ensure readiness for operation. As noted by the Committee parts of some systems were installed by the CM/GC and full testing cannot be performed until the equipment is connected. This additional testing is beyond the scope of the CM/GC contract. The transition plan identifies the group that is to receive the partial system and the responsibility to ensure readiness.

Take settlement data early and periodically to monitor and quantify the risk to beam alignment, and to determine the alignment frequency that will be required during operation

- RESPONSE: Data on the settlement of the new facilities was taken during construction. Following the back-fill of dirt over the electron beam dump area, the facility sank considerably. With the installation and alignment of technical equipment underway the settlement of the network will be checked again.

5.5 *Safety*

5.5.1 Findings:

Since the last FAC safety review, the Conventional Facilities has again experienced two significant lost time injuries. One was a serious hand injury that resulted from losing control of an improperly rigged hoist load. Rigging intended for incremental loads was attempted on combined loads. The rigging plan did not consider the method of hoisting the combined load.

On the second lost time injury, a backhoe operator lost control of the backhoe, striking his own observer. The operator had placed a roll of tape on a control lever for storage, and inadvertently hit the roll of tape with his leg, rotating the backhoe into his observer. The observer was said to be distracted, speaking to his supervisor at the time, and did not take evasive action.

For the last two months, there have been no lost time injuries reported. The project has implemented the FAC recommendation to assign LCLS CF resources to participate in the implementation of the Turner safety program and process. LCLS Project Management has added three University Technical Representatives (UTRs), an on-site medical professional and two Turner superintendents to improve Turner's safety performance. LCLS Management has identified a clear need to improve pre-task planning and enforcement of LCLS standards.

The project has successfully implemented joint occupancy with Turner to date without reported safety incidents. Though Turner maintains area control, the joint planning meetings with Turner for work in co-occupied areas provide CF staff another opportunity to participate in Turner safety planning. Attendance at daily planning meetings is required to work in co-occupied areas.

The SLAC Director recognizes the role LCLS plays in the future of the Laboratory and the SLAC safety culture. She has stated her support for initiatives on the LCLS that impact and improve SLAC safety culture. She has stated there is a need for changes and improvements. With the shift from civil construction to commissioning and operations, the LCLS and the SLAC safety culture are expected to become increasingly integral and co-dependent. Future FAC safety reviews will place greater emphasis on commissioning, operations safety, and the safety culture that is evident on-site at SLAC.

The SLAC Job Safety Analysis (JSA) process works when followed. CF has implemented a Safety Stewardship Committee. Turner has increased its presence in the field by meeting with individual work crews daily.

The only indicator of safety performance presented to the LCLS FAC was the DART (**D**ays **A**way from work, **R**estricted **T**ime or transfer from job) rate. When the FAC asked to breakout separately and discuss other indicators being tracked to identify the success of the safety program, no time could be found to talk to the committee.

- RESPONSE: LCLS has tracked all procedural and injury incidents and has used (and continues to use) this information as lagging indicators of performance and leading indicators for corrective action [SHOW TABLE]. Historically, only DART information has been shown to status the project against industry and DOE; charts have been used to demonstrate overall performance but from this FAC report it is clear they were not well understood as presented so more effort will be applied to present this information in an understandable and useful way. //// In addition, the Project has performed several Assessments, internal & external, to assess performance and develop corrective actions as needed; this has been discussed briefly with the FAC but clearly not in sufficient detail to be of value – this will be corrected.
- RESPONSE: Contracted work and self-performed work directly managed following LCLS work planning processes has been completed without personal injury, since the start of the LCLS project. As to the perceived unresponsiveness to a reviewer's request, LCLS Management regrets having created this impression with the FAC. LCLS has arranged for a group of FAC members to meet with SLAC and LCLS representatives from management and the ES&H program to ensure that, at this review, all information desired by the FAC is available.

- RESPONSE: LCLS has been challenged in achieving its desired safety objectives in contracts managed by Turner Construction Company. After significant effort by both the SLAC Site Office and LCLS Turner managed contracted activities worked four consecutive months without a lost time injury. This is the result of eight months of extensive meetings with Turner Corporation Executives who eventually agreed to implement the elements of their own site safety program and staffed the project with additional personnel as had been originally requested. The latter was achieved at additional cost to the LCLS project.

- RESPONSE: LCLS continues to apply its safe work planning and control processes to the installation of technical systems. Results continue to be positive.

LCLS directly managed construction activities, though not as extensive as Turner's, have a zero DART rate, while Turner's safety performance has been unacceptable**.** CF Technical Representatives manage by subcontract so the safety performance of the subcontractor is more directly accountable to an individual. In contrast, Turner superintendents manage by construction geographical areas that generally include work performed by multiple subcontractors.

Several of the FAC recommendations for safety program improvement were not implemented by LCLS because of the relatively short time to completion of Turner construction. The LCLS project will continue for two more years, and Conventional Facility construction will continue into CY 2009. There is ample time remaining on the Project duration to improve the LCLS project safety program.

- RESPONSE: The FAC recommendations, which were similar to the OIO and LCLS Assessments, focused on ISM related Work Planning and Control. The Project has not done an adequate job communicating to the FAC that not only do we agree with their findings and recommendations, the Project has come to the same conclusion via its assessments. The Project does differ from the FAC in the corrective actions chosen based on its contractual relationship with the general contractor (GC). The Project found that, for example, if the GC performed to its Health & Safety Plan that there would have been a marked improvement in ES&H performance. The Project formed its corrective action plan based on contractual agreements, meetings with the GC, consultation and guidance development with the Lab's ES&H Division and the DOE site office. From all of this action it decided to more strongly enforce the contract, deploy more field personnel and meet weekly with the GC on specific ES&H issues to improve performance. As stated earlier, clearer communication to the FAC on issues and action taken is needed and will be performed.

5.5.2 Recommendations:

Continue to support Turner safety practices and initiatives with LCLS resources to reduce the risk of additional safety violations and personnel injuries through the completion of the Turner construction scope.

- Additional LCLS oversight and TCCo field personnel were added to the project at LCLS expense. The DOE SLAC Site Office also contributed to this effort by scheduling a person to be present 8 hours a day in the field to monitor both TCCo and LCLS performance.

LCLS should take the lead in establishing the safety culture the Laboratory Director has targeted for the Laboratory as a whole. The LCLS and the Lab safety cultures will become increasingly integral and inseparable as commissioning and operation of LCLS systems progress.

- RESPONSE: LCLS Michael Scharfenstein and Richard Hislop have both been working with SLAC where they have been evaluating of the integration of safety into SLAC work planning and control processes with the objective of developing a standardized process for the entire Laboratory. This process is based on LCLS practices. – Examples include the development of an LCLS ES&H Plan for construction because the Lab did not have such a plan; then LCLS helped right the Lab plan; LCLS developed a Safe Performance Observation process that has been adopted by the Lab and expanded to meet management assessment policy.

SLAC safety violations identified during LCLS reviews should be addressed and promptly corrected whether specific to the LCLS project, or SLAC generic. The three SLAC safety issues identified and reported to LCLS safety representatives during the June 2008 FAC review of LCLS should be justified or corrected. If LCLS management prefers the FAC safety reviewers deal directly with SLAC's safety department on such issues, they should identify the SLAC interface personnel to be contacted by the FAC.

- RESPONSE: LCLS agrees with the FAC on this important point. The representatives contacted followed Lab protocol in reporting the items but did not follow up. LCLS takes responsibilities for its areas of operation as well as the Lab as a whole and as such the FAC should continue to communicate with the LCLS and expect that the LCLS will take appropriate action, include tracking safety issues to closure.

Track and report the precursors to lost time injuries in order to take corrective actions in time to prevent them. DART statistics are not sufficient if zero lost time injuries is the goal, and it is. To monitor precursors requires monitoring minor injuries, property damage, near misses, non-compliances, and then taking corrective action. Herbert Heinrich wrote in his 1930's book that no safety procedure is complete or satisfactory that does not provide for the correction or elimination of physical hazards. Heinrich found that there was a constant ratio between fatal, light and near-accident of 1:29:300. This conclusion is useful when analyzing the frequent near-accidents (or less severe hazards) to detect organization problems and intervene before a serious or fatal accident happens.

- RESPONSE: LCLS has tracked all procedural and injury incidents and has used (& continues to use) this information as lagging indicators of performance and leading indicators for corrective action – this will be shown and details discussed with Keith on 11/10

The DOE Lessons Learned database should be utilized as a tool to improve JSA preparation. At the present, this database is only used by reviewers. Further, do not underestimate the time required to prepare safety related documentation and the time it takes for the approval process. As an example, the DOE level 2 milestone for completion of the Injector ARR was 42 days late.

- RESPONSE: Planning for the ARR for commissioning the LCLS Undulator Complex is now well advanced. The review is scheduled for Dec 2-4. The DOE SSO is being kept fully informed of the preparations to minimize the time needed for their approval. The DOE Lessons Learned database was examined as a part of this planning, looking for commissioning problems that others might have encountered. The level 2 milestone for completing the Injector ARR was late due to delays in installation.
- RESPONSE: The use of the DOE LL database is a great idea! It is an idea that also came about from the Lab's investigation into a serious incident. There has been a challenge in obtaining access into the data base that is being resolved. If the FAC has experiences it can share with the LCLS on how it has used this information that would be most appreciated.

5.6 *CF Closeout*

5.6.1 Findings:

Conventional facilities is rapidly approaching the beginning of the closeout phase of the project that will include a myriad of new activities including field walkdowns, spare parts and excess materials, contract closeouts, administration of punchlists, preparation of lessons learned, assembly of a CF closeout report, and retaining key personnel to complete work while destaffing unneeded resources.

Inadequate attention has been paid to "lessons learned". The project staff needs to track these. Include in these lessons learned the procurement strategy used in award of the design contract and the CM contract, both of which subsequently presented LCLS management with significant cost, schedule, and safety performance problems. The goal of lessons learned is to repeat the successes on future projects, and to preclude the failures by doing things differently next time.

Conventional Facilities has a detailed plan for destaffing of lab personnel, but Turner does not have an updated destaffing plan approved by LCLS. Turner has not provided a demobilization plan.

Conventional Facilities reports they have started a closeout punchlist, but did not present this list to the FAC for review.

5.6.2 Recommendations:

Develop a detailed, comprehensive CF closeout list and provide that list to FAC for review.
The close out process will be presented including status at the time of the next committee meeting.

Request Turner submit a detailed de-staffing plan for LCLS review and approval. Update and maintain de-staffing plans so they are always current. Assure that Turner's de-staffing plan best serves the needs of the LCLS project to completion. Anticipate that Turner may have incentive to release key personnel early for their future/on-going projects elsewhere.
This has been done. We have a de-staffing plan for Turner personnel. Turner has requested that the list be kept confidential for the protection of their staff; however, we have received permission to share this information with the CF subcommittee during the next meeting.

Obtain and review Turner's demobilization plan.

The demobilization schedule is currently under preparation. The plan includes the close-out activities extending approximately 3 months beyond the completion of the physical work. The staff to remain on site has been named and CF is working to identify office space where they can be housed on site. The site plan for demobilization is under review.

Identify the lessons learned, both successes and failures, on the CF scope of the project and provide these lessons learned to the FAC for review. In seeking the root causes for successes and failures, consider asking the question "why" several times to converge more precisely on the root cause.

- RESPONSE: The lessons learned task has been initiated with safety. The lessons learned on the CF scope including the contracting strategy are pending due primarily to the demands of the effort remaining to complete the physical work within the 28 month construction period. It is projected that a complete lessons learned report will be available at the time of the February Lehman Review. It will be forwarded to the FAC at that time.

Appendix A

LCLS Facility Advisory Committee Members

LCLS Facility Advisory Committee Members

Kem Robinson
Chairman FAC
Undulators Subgroup
Lawrence Berkeley National Laboratory (LBNL)
KERobinson@lbl.gov

Harry Carter
Conventional Facilities Subgroup
Fermi National Accelerator Laboratory (FNAL)
HFCarter@fnal.gov

Anthony (Tony) Chargin
Conventional Facilities Subgroup
Lawrence Livermore National Laboratory (LLNL)
Chargin@llnl.gov

John (Jack) Cleary
Conventional Facilities Subgroup
Stanford University (SU)
JCleary3@stanford.edu

John Corlett
Electron Systems Subgroup (Lead)
Lawrence Berkeley National Laboratory (LBNL)
JNCorlett@lbl.gov

Massimo (Max) Cornacchia
Electron Systems Subgroup
Stanford Linear Accelerator Center (SLAC)
Cornacchia@slac.stanford.edu

Roger Falcone
X-Ray Subgroup
UC Berkeley
rwf@physics.Berkeley.edu

Josef Feldhaus
X-Ray Subgroup
Deutsches Elektronen-Synchrotron (DESY)
Josef.feldhaus@desy.de

Paul Fuoss
X-Ray Subgroup (Lead)
Argonne National Laboratory (ANL)
fuoss@anl.gov

Thomas Himel
Controls Subgroup
Stanford Linear Accelerator Center (SLAC)
thimel@slac.standord.edu

August (Gus) Kugler
Conventional Facilities Subgroup (Lead)
kuchleran@astound.net

Wim Leemans
Electron Systems Subgroup
Lawrence Berkeley National Laboratory (LBNL)
WPLeemans@lbl.gov

John W. Lewellen
Electron Systems Subgroup
Argonne National Laboratory
Lewellen@aps.anl.gov

Patrick O'Shea
Electron Systems Subgroup University of Maryland
poshea@umd.edu

Joachim Pflüger
Undulators Subgroup
Deutsches Elektronen-Synchrotron (DESY)
Pflueger@desy.de

Thomas Rabedeau
X-Ray Subgroup
Stanford Linear Accelerator Center (SLAC)
Rabedeau@slac.stanford.edu

Joerg Rossbach
Electron Systems Subgroup
Deutsches Elektronen-Synchrotron (DESY)
joerg.rossbach@desy.de

Keith Schuh
Conventional Facilities Subgroup
Fermi National Accelerator Laboratory (FNAL)
Schuh@fnal.gov

Thomas Tschentscher
X-Ray Subgroup
Deutsches Elektronen-Synchrotron (DESY)
Thomas.tschentscher@desy.de

Karen White
Controls Subgroup (Lead)
Thomas Jefferson National Accelerator Facility (TJNAF)
Karen.White@jlab.org

Appendix B

Facility Advisory Committee Meeting Agenda

LCLS Facility Advisory Committee Meeting Agenda

June 16-18, 2008

Monday, June 16th

Plenary Session

Location: *Redwood Conference Rooms, Building 48*

Time	Topic	Presenter
8:00	*Executive Session*	*Committee*
9:00	Welcome	P. Drell
9:15	Project Status Update, and Charge to Committee	J. Galayda
9:45	Project Management	M. Reichanadter
10:15	***Break***	
10:30	Commissioning Results and Plans	P. Emma
11:00	2009 Commissioning Plans	P. Emma
11:30	Undulator Commissioning Plans	H. D. Nuhn
12:00	***Lunch (FAC members only)***	
1:30	FEE Diagnostics & Commissioning	R. Bionta
2:00	X-Ray Commissioning	H. Tompkins
2:30	***Break***	
3:00	*Construction Site Tour*	
4:30	Executive Session	*Committee*
7:00	*Dinner – Compadres, Palo Alto*	*Committee/Speakers*

Tuesday, June 17th

Breakout Sessions

Time	Topic	
7:30	*Executive Session*	Redwood A
8:00	*Breakout Sessions Begin*	(see below for listing)
3:30	*Executive Session*	Redwood A

Wednesday, June 18th

Executive and Closeout Session

Location: *Redwood Conference Rooms, Building 48*

Time	Topic	Presenter
7:30	Executive Session	Redwood C/D
8:00	Executive Session, *or More Breakouts if Required*	Redwood C/D
9:30	Executive Session	Redwood C/D
11:00	Closeout – Plenary	Redwood Rooms

Breakout Session Schedule
Tuesday, June 17th

Breakout Session 1 – Accelerator Systems

Location: *Redwood C, Bldg 48*

Time	**Topic**	**Presenter**
8:00	Overview	D. Schultz
8:30	Drive Laser and Hand-Over to Operations	B. White
9:00	RF Gun(s) Status	A. Brachmann
9:30	RF Systems, Diagnostics, and Feedback	J. Frisch
10:00	***Break***	
10:30	High-Level Applications Software	H. Loos
11:00	TU/Dump Installation Status & Schedule	J. Chan
11:30	LTU Installation Coordination	K. Ratcliffe
12:00	***Lunch (FAC members only)***	
2:00	Discussion	*all*
3:30	Executive Session	

Breakout Session 2 – Undulator Systems

Location: *Red Slate, Bldg 280C, Room 112*

Time	**Topic**	**Presenter**
8:00	Undulator System Overview & Fabrication Schedule	G. Pile
8:30	Undulator Vacuum System	D. Walters
9:00	RF BPM Status and Production Test Results	B. Lill
9:30	BFW Production Experience and Test Results	V. Srinivasan
10:00	***Break***	
10:30	Girder Control Production Status	J. Stein (video)
11:00	WPM/HLS Status and Schedule	F. Peters
11:30	BLM System Design	B. Berg
12:00	***Lunch (FAC members only)***	
1:30	Undulator Tuning and Fiducialization Schedule	Z. Wolf
2:00	Girder Assembly and Installation Schedule	J. Krebs
2:30	Undulator Controls Status	A. Alarcon
3:00	Discussion	
3:30	Executive Session	

Breakout Session 3 – X-Ray Systems, Including LUSI

Location: *Redwood B, Bldg 48*

Time	Topic	Presenter
8:00	AMO Instrument	J. Bozek
8:30	LUSI Overview	T. Fornek
9:00	XPP Instrument	D. Fritz
9:45	CXI Instrument	S. Boutet
10:30	***Break***	
10:45	XCS Instrument	A. Robert
11:30	LUSI Diagnostics and Optics	Y. Feng
12:15	***Lunch (FAC members only)***	
1:15	XTOD mirrors	T. Mccarville
1:45	Fast imaging detectors	N. van Bakel
2:30	X-ray commissioning	H. Tompkins
3:15	Discussion	*all*
3:30	*Executive Session*	

Breakout Session 4 – Controls

Location: *Redwood A, Bldg 48*

Time	Topic	Presenter
8:00	BC2/Linac commissioning	H. Shoaee
8:30	LCLS MPS	S. Norum., P. Krejcik
9:00	Undulator BLM system	J. Stein
9:30	Undulator Controls	A. Alarcon
10:00	***Break***	
10:30	Application Software Status and Plans	P. Krejcik, D. Rogind
11:00	Beam-Based Feedback Systems	D. Fairley
11:30	High Level Applications	H. Loos
12:00	***Lunch (FAC members only)***	
1:30	LTU/Undulator Installation Status	E. Carrone
2:00	Photon Area Control & Data Acquisition	G. Haller
3:00	Discussion	*all*
3:30	*Executive Session*	

Breakout Session 5 – Conventional Facilities

Location: *Redwood D, Bldg 48*

Time	Topic	Presenter
8:00	Status of Construction	J. Albino
8:30	Far Experimental hall Hutches	D. Saenz
9:00	Space Conversion to Offices	D. Saenz
9:30	Commissioning Plan	J. Sevilla
10:00	***Break***	
10:30	Construction Safety	M. Scharfenstein
11:00	Discussion	*all*

Appendix C

A Transitioning Plan for High-Level Applications from the Physics Group to the Controls Software group.

The LCLS commissioning has made good use of high-level applications (HLAs) prototyped in Matlab along with existing applications written in the SCP for the old SLC control system. As we move towards the operational phase of LCLS, and with the shutting down of the old SLC control system, it is necessary to develop a suite of high-level applications supported by the controls software group.

The controls group has provided software tools that allow users to access control system variables from within the Matlab program. This has proved to be an ideal platform for prototyping beam-based measurement routines and tuning algorithms for commissioning the LCLS. As we enter the operational phase of the LCLS more robust application software is required for routine setting up and tuning of the LCLS by the operators and physics staff. Our plan is to further develop a software architecture for high-level application programs with the following features:

- An intuitive Graphical User Interface that allows the application task to be performed on any appropriate section of the machine (and not hard coded to one part of the beamline)
- Exception handling, so the application doesn't crash when unexpected events occur.
- Multi-threaded for higher performance and ease of management of program modules.
- Central system message logging that archives system events
- Well developed Application Programming Interfaces (APIs) so that
    - Code duplication is minimized.
    - Code maintainability is optimized.
    - Applications can integrate with other HLAs.
    - Higher level applications can be built hierarchically from other smaller applications.
    - HLAs can be executed from a script so that whole procedures can be written.
- Similar look and feel for applications so that operators can quickly understand how to use them
- a unified framework for the application software so that they may share common features such as restoring setups, data saving and access to various software tools on the Operator Interface workstation screens (OPIs)
- continue to allow Matlab to access the APIs so that new applications can be rapidly prototyped by physicist programmers when new physics needs arise.

A High Level Applications group has been put in place to design the architecture and write the new applications. The group will take over responsibility for writing and maintaining the application software from the physics group so that they may concentrate more on the physics challenges during commissioning and operation. The structure of the new group and the work plan are described here.

Management structure

The group is made up at present of a team of 6 ½ software programmers to which recently a controls physicist has been added as supervisor. The group has been relieved of their responsibility for maintaining the old control system software and has been directed to work on developing new application software to support LCLS. Under the new physicist supervisor the team will work closely with other physicists and control room staff to define the requirements and priorities for the applications. Two of the team members have been appointed as technical leads to evaluate the best architecture and programming solutions for the applications and these will then be uniformly adopted by the rest of the team.

Work plan

The HLA team writes a formal requirements document for each high level application planned which includes use cases and dependencies on other applications. At the time of this writing, the requirements for nearly all the major HLAs have been gathered. In some cases these requirements have been modeled on Matlab applications that were written during LCLS commissioning. In other cases we used existing applications on the SCP as a template for requirements, and some applications will be entirely new.

The HLA team solicits input from physicists and operators during the requirements writing phase and circulates the requirements document before holding a review presentation for final comments. The requirements are then categorized as primary ones or as nonessential requirements that may require more effort and could be addressed in a later version of the application.

The second phase of the work plan is to lay out all the common requirements of the applications together so that a rational software architecture, or framework, can be proposed within which the applications can be developed. This architecture should address how data is shared between the applications and how they use the software infrastructure.

Once all the major high level application requirements have been gathered the HLA team works with the physicists to prioritize the list of applications, based on need, availability of an existing Matlab application and the estimated time to complete the application.

The HLA technical leads will plan the work for each application and will assign members of the team to parts or all of each application. Each team member produces a Software Design Document for applications assigned which is reviewed amongst software peers. Any graphical user interfaces (GUIs) are first mocked up (using a Java-based Visual GUI Builder tool) and reviewed with the physicists and operators to ensure it meets their needs and that it meets the requirements. The technical leads will make some general choices on the software programming languages and tools to be used by the team.

The HLA team members will participate in the control room commissioning of the new applications so that they can experience first hand the practical implementation and usage issues associated with the new programs. They will be responsible for teaching control room people how to use the applications and gathering feedback on any future enhancements to the applications.

Software platform

The choice for writing the HLAs in the Java programming language is based on the following:

- modern, object-oriented, multi-threaded high level language
- platform independent
- Java applications can be called from within Matlab
- connectivity tools with the Oracle Relational Database
- works with scripting languages such as (J)Python for scripting control room procedures
- established within the EPICS community with Java Channel Access (JCA)
- can make use of existing programs written in the XAL framework at other laboratories
- does not require expensive licenses, as is the case with Matlab.

Specific Applications

The online model is the most central of all the applications. It reads the actual settings of all the beamline devices and then runs a simulation code for the accelerator optics and the output is used to calculate, fit, compare and correct a number of essential beam parameters along the beamline.

Up to now, during LCLS commissioning we used the online model within the SCP from the old control system. This has been awkward and inefficient since it required combining data from the old SCP and new EPICS controls systems and then getting the model data into the Matlab programming environment.

A new XAL version of the online model has now been installed in the LCLS control system. This online model is quite powerful in that it generates a beamline directly from the LCLS Oracle RDB, which in turn is generated from the original MAD beamline design program output. The current values of the "live" machine are read through EPICS Channel Access. Since this XAL online model is written in Java, the output from the online model is immediately available from within Matlab for use by physicists in their application codes. The XAL simulation output has been successfully benchmarked against the standard MAD output to test for consistency.

The online simulation output is written back to the Oracle database where it can be picked up by other application programs, including those written in Matlab. The interface to the Oracle database allows the user to choose versions of the model output run under different machine settings and compare them to the design optics.

The November 2008 commissioning run will also make use of the new orbit display developed by the Controls Software team. This will display BPM orbit data from the injector to the final dump. It offers many operational aids such as flagging obstructions and out of tolerance devices in a very flexible z-plot package which optionally allows a beamline map to be drawn below the data. Beam synchronous acquisition of the data is integrated into the application and the user may select and analyze buffered data up to the last 2800 beam pulses.

The High Level Applications controls software team will also take on the development of the new fast beam-based feedback system. Beam based feedback has been successfully prototyped under Matlab but in order to run at 120 Hz it needs both a new software and hardware architecture. The High Level Application group is coordinating with controls hardware engineers to implement the most appropriate communications network to transmit feedback information between EPICS controllers.

Not all of the new High Level Applications to be developed by the Controls Software group are listed here. The software group will continue to work with the physics commissioning team to formulate and prioritize which applications should be developed next. If a Matlab version of the application is already available and does a reasonable job we will continue to use it during commissioning and allow the controls software team to work on new applications. However, in the long term the goal is to gradually convert all the permanent applications to the new Java based architecture for the reasons of performance and efficiency listed above.