LCLS

Stanford Linear Accelerator Center

Linac Coherent Light Source Monthly Report

December 2007

Stanford Linear Accelerator Center

LLNL

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Project Overview and Assessment

Highlights:

- Cover Page – LCLS Beam Transport Hall (BTH) looking east. Most major Turner-managed construction activities in the BTH are now complete, allowing SLAC to begin some of its initial installation activities (e.g., survey, monumentation, support stand layout). This initiates the Turner-SLAC 'co-occupancy' phase, which began on December 14th, and allows limited SLAC activities within Turner construction areas. All work is integrated into the Turner look-ahead schedule and is managed using Turner-SLAC Integrated Safety Management processes.

- All equipment (supports, magnets, hardware, electronics and cabling) associated with the LCLS second bunch compressor (BC-2) were successfully installed in SLAC's Linac during the three-month accelerator maintenance period. A replacement copper coil was received for the failed Bunch Compressor-2 (BC-2) magnet and has met specifications. The coils have been installed and magnetic measurement was performed successfully. Arrangements are being made to have the repaired BC-2 dipole installed at the first available Repair Opportunity Day (ROD). A generous commissioning schedule had been planned; therefore no impact to BC-2 commissioning is foreseen.

- LCLS major civil construction is being managed by the Turner Construction. Overall construction is ~78% complete. To date, $2,027K Field Change Orders have been negotiated and approved, which is <4% of construction progress to date.

Assessment and Issues:

- The December 2007 Cost Performance Report is the 46th month reporting earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are $285,597K. The LCLS cost and schedule indices are 0.91 and 0.87, respectively. The SPI ('yellow' on the PARS threshold) is primarily driven by CR impacts (which are unrecoverable and require replanning) and delays in civil construction. Civil construction effort continues to show a schedule delay of 4-6 weeks.

Project Office and Support

WBS 1.1, 2.1 Project Planning, Management and Administration

Highlights:

- LCLS Environmental, Safety & Health Status –
  - LCLS worked 208 days without a lost time injury and 48 days without an injury involving days of restricted work or job transfer. Total project hours are 1.55 M comprised of 1.17 M collaboration hours and 376 K subcontracted work hours.
  - The LCLS project DART rate for construction is currently 3.2[1], as compared to the general industry rate of 3.2 and the Department of Energy rate of 0.6. The total project DART rate is 1; this includes construction and laboratory hours.
  - Safety Training Metrics –
    - Mandatory safety training = 96% (goal = 93%). Corrective actions will be completed by month-ending November.
    - Supervisor required safety training = 95% (goal = 93%)
    - Compliance for training assessments = 97% (goal = 92%).
    - Medical exams for affected employees = 100% (goal = 90%)
  - 2008 Downtime Installation – The technical systems installations (Bunch Compressor #2, shielding, etc.) were completed during the September through December downtime with no lost time injuries, no recordable injuries or incidents.
  - Turner Construction –
    - Independent OSHA Assessment – LCLS hired an independent safety consultant to perform an OSHA compliance assessment of the conventional facilities construction. The assessment identified improvements in the area of loss control (injuries & incidents) consistent with the project's new initiatives.
    - Installation Readiness – A process of reviews has been initiated for technical system installations beginning in the Beam Transport Hall with subsequent reviews for the Undulator Hall, Front End Enclosure and beyond. The review process ensures that safety is addressed in sufficient detail for the co-occupancy of LCLS in Turner construction areas.
    - Work Planning & Control – Turner Construction voluntarily stopped its subcontracted work between 26-28 November. The purpose of the work stoppage was to improve its work planning and control to mitigate the frequency of injuries and incidents. During this period, Turner developed a corrective action plan with both short and long range objectives and is being monitored

[1] The number of injuries sustained by an average work crew of 100 individuals over a year.

closely for successful implementation and completion of the objectives.

- Biweekly Management Conference-call – A biweekly conference call to discuss current project safety data and trends has been established between DOE-SSO, SLAC, LCLS and Turner management. The first call occurred on 14 December and focused on the corrective action plan objectives to improve work planning and control processes.

- LCLS Procurements Status –
  - The LCLS Procurement Department experienced moderate level of activity in December 2007, due to managing new and on-going issues with the Turner subcontract, as well as issuing and negotiating several Field Change Orders (FCOs) and Change Order Requests (CORs).
  - A/E Design (Jacobs) – Subcontract expired 12/31/2007. A Draft Modification adding no funding, but extending the performance period through August 2008 was sent to Jacobs. A formal response is expected in January.
  - Construction Procurements –
    - SLAC and TCCO attorneys/staff continued to meet in an effort to settle claims disputes outside of arbitration. Weekly OAC meetings continue to be held and are very productive.
    - Field Change Orders and Change Order Requests (FCOs/CORs)–
      - A total of 215 FCOs and CORs have been settled through negotiation or agreement.
      - 89 FCOs and CORs are open in technical review, fact finding, or negotiation.
    - Central Utility Plant (CUP) Gas Line – Kickoff held, work progressing, submittals provided for SLAC review. Expected completion is mid January; however poor weather conditions could cause delays.
  - Technical Procurements –
    - Power Supply Racks version 3 – New requirement received. DOE approval of solicitation expected early January, with award planned for mid to late January.
    - Intermediate Power Supplies – Supplier relocated and balance of order delayed until mid January 2008. Several power supplies have been delivered.

Assessment and Issues:

- None.

Electron Beam Systems

WBS 1.1, 1.x.2 Controls System

Highlights:

- Injector Controls Commissioning – Complete. All goals met.

- Linac Controls Commissioning –
  - The BC2/L3 installation, testing and integration to allow system commissioning were completed. This included the commissioning of the new linac networks, the timing system and the front-end computers (IOCs) for the control of the beamline devices including magnets, profile monitors, and wire scanners.
  - The testing of the SLAC Linac PPS using the latest versions of the ESD Safety Assurance Test Procedure was completed. Also completed was the testing of the SLAC LCLS Injector PPS using the latest version of the LCLS Controls PPS Initial Acceptance Test (IAT) procedure.
  - Both the machine protection (MPS) and the beam containment system (BCS) for BC2/Linac were successfully certified for operation.

- Preparation for BTH – NEH Installation –
  - The design, documentation and the review of the long haul cable plant for the 2008 installation for the LTU, Undulator, E-Dump and the FEE regions was completed. The bid package for the Davis Bacon installation of the cable plant was submitted.
  - Design and procurement for 2008 installation including 80% of the cable plant, the vacuum control, Beam Position Monitor (BPM) system, and toroid charge monitors has been completed. Design, documentation and review of the long haul cable plant for the 2008 installation for the LTU, Undulator, E-Dump and the FEE regions was completed.

- Controls Software Support –
  - Servers and operator consoles in the Main Control Center (MCC) (accelerator operations center) were brought online following the shutdown. All subsystems including alarm facility, data archiving, electronics logbook, etc. were setup for BC2 commissioning.
  - The configuration control (save/restore) software was successfully tested and installed in the MCC. The feedback control loops for the LCLS Injector Launch, Longitudinal and Bunch Charge control were installed.

Assessment and Issues:

- None

WBS 1.2, 1.3, 2.2, 2.3 Injector and Linac Systems

Highlights:

- Injector Commissioning – Complete. All goals met.

- Linac-To-Undulator (LTU) Design and Procurement Progress –
  - The E-dump seismic calculations were presented to the SLAC earthquake committee and approval from the committee is pending. The LTU and Undulator supports seismic calculations are in progress and will be presented to the earthquake committee in January.
  - The E-Dump installation drawings are complete and 80% of drawings for supports and related components are also complete.
  - A Preliminary Design Review was held on the Tune-Up-Dump shielding and the detail drawings are being generated.
  - All alignment stages for the LTU have been received and preparations are underway to assemble super assemblies (components to the alignment stages).

Assessment and Issues:

- In September, the Linac group found both coils of the fourth BC-2 dipole magnet to be out of specification. SLAC has received the replacement coils from the vendor (Everson Tesla). The coils have been installed and magnetic measurement was performed successfully. Arrangements are being made to have the repaired BC-2 dipole installed at the first available Repair Opportunity Day (ROD). A generous commissioning schedule had been planned; therefore no impact to BC-2 commissioning is foreseen.

WBS 1.4, 2.4 Undulator System

Highlights:

- Undulator Components & System Integration –
  - Supports – Eighteen Support Mover systems have been delivered to SLAC. Final deliveries will be late due to an error in the girder sub contractor's scheduled contract. Resolution of outstanding Support Mover system QA issues is in process.
  - Vacuum Chamber –
    - The first article of the vacuum chamber support was inspected at the vendor's shop. All dimensions were met, travelers were reviewed, and material certifications were examined.
    - Recent success in polishing and machining of the undulator vacuum chambers should allow the first six completed articles to be shipped to SLAC by the end of January.
  - Quadrupole Magnets – Six production quads have been delivered to SLAC and all meet magnetic performance specifications.
  - Electronics & Controls –
    - All 35 Control racks have been delivered. Production of the inter undulator cables is almost complete and the wiring interface unit is ready for procurement.
    - The BPM electronics procurement contract was awarded just before Christmas. The first article BPM body was cold tested and was in spec with out additional polishing.

- Undulator Assembly & Measurement (SLAC) –
  - Eight Undulator quadrupoles were received from Everson Tesla. Issues with alignment tooling ball sockets are being resolved with ANL.
  - The undulator girder moving and installation cart has been completed.
  - The fiducialization of the 20th undulator was completed.

Assessments and Issues:

- There are yield rate problems with the BPM RF window to transition braze joint. An integrated task force has been assembled to expedite the problem.

- The positional accuracy of fiducials for production quads appears out of spec. A minimum of seven quads are on hold at the vendor. This has caused a schedule delay of a few weeks.

- Undulator s/n 20 was recently remeasured, after being stored more than 4 months, and showed a significant shift in the magnetic center. This shift is being investigated and plans are in place to re-measure two more undulators to determine if this problem could potentially apply to all measured undulators.

Photon Beam Systems

WBS 1.5, 2.5 X-ray Transport, Optics & Diagnostics (XTOD)

Highlights:

- Management and Safety –
  - Final details to the new performance measurement baseline are being implemented. These details included updating the XTOD schedule and labor rates, both SLAC and LLNL, and setting up an XTOD controls account at SLAC for the ED&I, fabrication, and cable installation.
  - Progress against planned activities indicates some cost overruns in several areas. Increases are partly due to the large increase in LLNL labor rates in FY2008 and partly to unexpected late design problems. Plans are being developed to reduce costs later in FY2008.

- XTOD Design & Production Status –
  - Slit – Work continued on the problem of bonding the B_4C protection layer to the Tungsten Heavy Alloy slit block. The TiCuSil (copper, silver, 4.5% titanium) looks promising and is the leading contender for bonding. Wetting studies will be performed on the WHM alloy.
  - Soft X-ray Offset Mirror System (SOMS) – One of the three polished coupons was coated with 50 nm of B_4C and its mid-spatial-frequency roughness (MSFR) and high-spatial-frequency roughness (HSFR) were measured before and after coating by Optical profilometry and AFM respectively. The coating appears to have minimal effect on roughness.
  - Hard X-ray Offset Mirror System (HOMS) – Bids were received for the HOMS mirrors and are under consideration.
  - Controls –
    - An EPICS Linux server with host names for all XTOD crates, terminal servers, and IOCs was configured at LLNL. The EPICS/RTEMS installation was upgraded to include all recent fixes from SLAC and the "SSI" module for the absolute encoder. The server includes EPICS application areas and IOC boot areas.
    - Long-haul cable schematics were completed and delivered to SLAC in preparation for the Davis-Bacon installation contract.
  - Total Energy Detector – The Total Energy (Thermal Sensor) Final Design Review was held in December. 8 sensors include 2 slow sensors with very high sensitivity, 2 medium speed sensors with moderate sensitivity, and 2 fast sensors with lower sensitivity. The review was favorable, and drawings are now in the checking process.

Assessment and Issues:

- None.

WBS 1.6, 2.6 X-Ray Endstation Systems (XES)

Highlights:

- Management and Safety – A Cost Performance Review (CPR) against planned activities shows good performance with minor delays related to slightly longer design phases.

- XES Personnel Protection Systems (PPS) –
  - PPS Stoppers**:** A Final Design Review of the photon/electron stoppers in the electron dump area and hutches was held in December. The stopper Engineering Specifications Documents (ESD) are approved.
  - Hutch Doors: The PPS hutch door Final Design Review was held in December. It was decided to pursue in-house fabrication at SLAC.

- Detector Project at Cornell –
  - The LCLS Detector Advisory Committee meeting was held at SLAC on December 13-14. A standardized set of tests was developed and agreed upon among the detector groups to be followed for characterizing the single bump-bonded sensor prototype. Test results will be made available in time for the next LDAC meeting tentatively scheduled for May.
  - The bump-bonded single module sensor is expected in early January. Detector housing design and fabrication was completed. Progress continued on full-scale readout tests and the full-lot ASIC functionality.
  - SLAC will take the lead role in designing the mechanical interface and packaging of the detector for the integration into the Coherent X-ray Imaging (CXI) instrument.

- Atomic, Molecular and Optics (AMO) Instrument – The Preliminary Design Review report was received. It identified several issues which are being addressed although none of them critical. The final design phase has begun. Preparations are also underway for the PDR of the Controls of the AMO instrument planned for February.

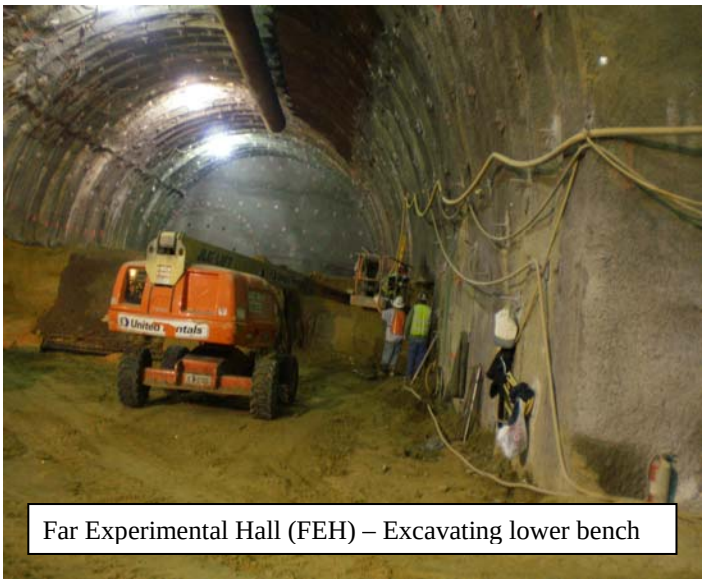
- XES Controls and Data Systems – Power requirements for the server room in the Near Experimental Hall are defined and various routing options for implementation are being explored. Missing sections of the cable trays, in particular the trays leading to the FEE alcove, are being added. Rack cooling solutions and choices for heat exchangers are being considered.

Assessment and Issues:

- None.

Conventional Facilities (CF)

WBS 1.9, 2.9 Conventional Facilities (CF)



Far Experimental Hall (FEH) – Excavating lower bench

Central Utility Plan – Siding Installation

Highlights:

- Construction Progress –
  - Construction is approximately 78% complete. To date, $2,027K Field Change Orders have been negotiated and approved, which is <4% of construction progress to date.
  - Beam Transport Hall (BTH) – Roof waterproofing, concrete finishing, painting, LCW and Fire Protection piping at east-end of facility. Installation of exterior steel stairs.
  - Undulator Hall (UH) – Continue layout/mobilization for MEP installations.
  - Near Experimental Hall (NEH) – Backfill of exterior walls is nearly complete. Continued progress on final installation of MEP in basement and sub-basement.
  - 12 KV Substation – Substation block building complete. Delay of completion due to DC battery system delivery.
  - Far Experimental Hall (FEH) – Top heading, bench 1 complete. Final bench removal still in progress. Tunnel excavation is ~85% complete.
  - X-Ray Tunnel – Excavation continues towards FEH. Tunnel excavation is ~80% complete.

Issues and Assessments

- Safety – the LCLS CF staff has developed an internal plan to provide a more robust oversight for the on-site staff. For this reporting month the internal staff provided 96 observations, however it is anticipated that this will increase in the coming months.

- Civil Construction Schedule – Overall, civil construction lags behind its baseline schedule by 4-6 weeks. The most critical area is the Central Utility Plant which could impact the commissioning (but not the initial installation activities). Opportunities exist for recovery during concrete and metal building stages and re-sequencing of MEP installations.

- December is a short month for some of the sub-trades. Tunneling trades were off for nearly two weeks due to the holiday break. Therefore monthly progress for tunneling activities was less than trends indicated in previous months.

- Natural Gas Line – Progress is being made with contract between SSO and the utility company. It is anticipated that a final contract will be signed at the beginning of January. LCLS has issued a contract for the onsite gas line scope of work. Subcontractor has commenced operations and it is anticipated that work will be complete in January.

LCLS Cost and Schedule Performance – December 2007

LCLS Cost/Schedule Status Report									31-Dec-07
WBS	Cumulative to Date ($K)							Budget At Complete ($K)	% Complete
	Budgeted Cost		Actual Cost Work Performed	Variance		Performance Indices			
	Work Scheduled	Work Performed		Schedule	Cost	SPI	CPI		
1.1 Project Management	16,804	16,750	18,177	-54	-1,428	1.00	0.92	18,013	93%
1.2 Injector	16,760	16,713	20,229	-47	-3,516	1.00	0.83	16,760	100%
1.3 Linac	19,019	16,017	21,441	-3,002	-5,424	0.84	0.75	19,940	80%
1.4 Undulator	35,850	28,722	35,534	-7,128	-6,812	0.80	0.81	37,398	77%
1.5 X-ray Transport	21,155	14,800	19,263	-6,355	-4,463	0.70	0.77	22,803	65%
1.6 X-ray Endstations	5,272	2,293	2,228	-2,979	65	0.43	1.03	8,735	26%
1.9 Conventional Facilities	108,325	100,787	101,362	-7,537	-575	0.93	0.99	128,987	78%
1.X LCLS Controls	28,419	19,942	24,214	-8,477	-4,272	0.70	0.82	32,366	62%
1 LCLS Total Base Cost	**251,602**	**216,024**	**242,449**	**-35,579**	**-26,425**	**0.86**	**0.89**	**285,002**	**76%**
					LCLS Total Estimated Cost			**315,000**	
					Contingency			**29,998**	
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	14,012	14,064	13,113	52	951	1.00	1.07	30,195	47%
2.2 Injector (OPC)	4,545	3,505	5,064	-1,040	-1,559	0.77	0.69	5,317	66%
2.3 Linac (OPC)	1,058	422	620	-636	-197	0.40	0.68	3,232	13%
2.4 Undulator (OPC)	4,088	4,648	2,659	560	1,989	1.14	1.75	6,852	68%
2.5 X-ray Transport (OPC)	1,290	1,233	1,189	-57	44	0.96	1.04	4,544	27%
2.6 X-ray Endstations (OPC)	2,514	1,950	1,245	-564	705	0.78	1.57	5,559	35%
2.9 Conventional Facilities (OPC)	85	81	90	-4	-9	0	0	683	12%
2.X LCLS Controls (OPC)	828	366	371	-462	-5	0.44	0.99	1,129	32%
2 LCLS Total Other Project Cost	**28,420**	**26,269**	**24,350**	**-2,151**	**1,919**	**0.92**	**1.08**	**57,511**	**46%**
					LCLS Other Project Cost			**64,000**	
					Management Reserve			**6,489**	
LCLS Total Project Cost	**280,022**	**242,293**	**266,799**	**-37,729**	**-24,506**	**0.87**	**0.91**	**379,000**	**71%**

Cost and Schedule Performance (con't)

Overall Cost and Schedule Assessment

December 2007 Project Performance	AYK$
Total Project Cost (TPC)	**$379,000**
% Planned (Cumulative)	81.8%
% Complete (Cumulative)	70.7%
Total Estimated Cost (TEC)	**$315,000**
Cost and Commitments to Date	$259,348
Work Remaining	$72,553
Outstanding Phase-Funded Awards	$25,685

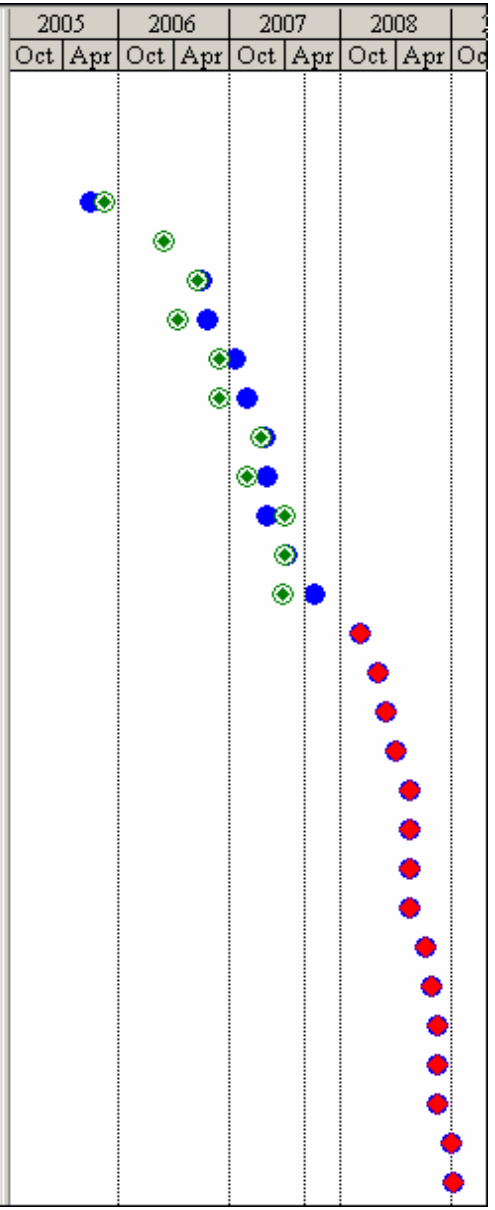
The LCLS cost and schedule are consistent with a CD-4 milestone of March 31, 2009, a Total Estimated Cost (TEC) of $315M and a Total Project Cost (TPC) of $379M. All costs are in actual-year dollars and out-year costs are escalated.

The December 2007 Cost Performance Report is the 46th month reporting earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are $285,597K. The LCLS cost and schedule indices are 0.91 and 0.87, respectively. The SPI ('yellow' on the PARS threshold) is primarily driven by CR impacts (which are unrecoverable and require replanning) and delays in civil construction. Civil construction effort continues to show a schedule delay of 4-6 weeks.

The project critical path runs through the Undulator Facility Co-(early) Occupancy followed by installation of undulators followed by FEL beam commissioning and finally photons in the FEH. The rebaseline exercise will also require a replanning of the project critical path.

DOE (Level 2) Milestones

System	Level	Milestone	Baseline	Projected	Variance
		Level 2 DOE (SSO) Milestones	**8/29/08**	**10/8/08**	**28 days**
PM	ML2	Prelim Safety Assessment (PSAD) Doc Complete	4/30/04	4/30/04	0 days
PM	ML2	DOE External Independent Review (EIR) Complete	6/15/04	6/15/04	0 days
PM	ML2	Fire Hazard Analysis Approved	6/30/05	8/15/05	32 days
PM	ML2	Prelim Safety Assessment (PSAD) Doc Approved	2/28/06	2/28/06	0 days
UN	ML2	Delivery of Undulator 1st Articles to MMF	7/3/06	6/15/06	-12 days
CF	ML2	Sector 20/Alcove Beneficial Occupancy	7/21/06	4/14/06	-70 days
CF	ML2	Research Yards Mods Beneficial Occupancy	10/20/06	8/30/06	-37 days
UN	ML2	MMF Qualified & Ready to Measure Prod Undulators	11/27/06	8/28/06	-65 days
IJ	ML2	Start Injector Commissioning (Drive Laser)	1/29/07	1/16/07	-9 days
IJ	ML2	Injector Laser Commissioning Review Complete	1/31/07	12/1/06	-34 days
IJ	ML2	Injector Accelerator Readiness Review (ARR) Comp	1/31/07	3/30/07	42 days
IJ	ML2	Start Injector Commissioning(UV Beam to Cathode)	4/9/07	4/5/07	-2 days
CF	ML2	Linac Water/Power Available	7/11/07	3/29/07	-74 days
XE	ML2	2-D Pixel Detector Production Start	12/5/07	12/5/07	0 days
LN	ML2	Linac ARR (Li20-Li30) Complete	1/31/08	1/31/08	0 days
LN	ML2	Start Linac (Li20-Li30) Commissioning	3/3/08	3/3/08	0 days
PM	ML2	Final Safety Analysis Document (FSAD) Approved	3/31/08	3/31/08	0 days
CF	ML2	Start Installation of Front End Enclosure	5/20/08	5/20/08	0 days
CF	ML2	Start Installation of Undulator Facility	5/20/08	5/20/08	0 days
CF	ML2	Start Installation of Beam Transport Hall	5/20/08	5/20/08	0 days
CF	ML2	Start Installation of Near Experimental Hall	5/20/08	5/20/08	0 days
PM	ML2	LCLS ARR Complete (BTH thru FEH)	7/11/08	7/11/08	0 days
LN	ML2	Start Linac-to-Undulator (LTU) Commissioning	7/31/08	7/31/08	0 days
UN	ML2	Start Undulator Commissioning (1st Light)	8/18/08	8/18/08	0 days
CF	ML2	Start Installation of X-Ray Transport	8/20/08	8/20/08	0 days
CF	ML2	Start Installation of Far Experimental Hall	8/20/08	8/20/08	0 days
XE	ML2	Start XES Commissioning	10/2/08	10/2/08	0 days
XTOD	ML2	Start XTOD Commissioning	10/8/08	10/8/08	0 days



Glossary

Actual Cost of Work Performed (ACWP) – Actual cost reported through the LCLS cost accounting systems, plus any accruals, for a specific WBS#, subproject, or project.

Budget Authority (BA) – Cumulative funds currently allocated and authorized by the Department of Energy that may be committed and spent by LCLS for project-related activities.

Budget at Completion (BAC) – The total budgeted cost at completion for a given WBS, subproject, or project. BAC is the budgeted cost of the project excluding contingency.

Budgeted Cost of Work Performed (BCWP) – Budgeted value of planned work for a WBS#, subproject, or project physically accomplished.

Budgeted Cost of Work Scheduled (BCWS) – Budgeted value of planned work time-phased to the schedule for a specific WBS#, subproject, or project.

Commitments – Funds allocated to subcontractors where work has been authorized but not yet expensed.

Cost Performance Index (CPI) – The ratio of the value of the work performed to actual cost; CPI = BCWP/ACWP. Values less than 1.0 represent "cost overrun" condition, and values greater than 1.0 represent "cost underrun" condition.

Cost Variance (CV) – Difference between the estimated value of the physical work performed and the actual cost expended for a specific WBS#, subproject, or project. CV = BCWP-ACWP. A negative result is unfavorable and indicates the potential for a cost overrun.

Estimate at Completion – Forecast of the final cost for a specific WBS#, subproject, or project based on the current ACWP plus a management assessment of the cost to complete the remaining scope of work.

Estimate to Complete (ETC) – A realistic appraisal of the cost to complete the remaining scope of work.

Other Project Cost (OPC) – LCLS "supporting" costs not directly contributing to the construction project. OPC costs generally include research and development and pre-operation (start-up) activities.

Percent Complete – The ratio of the work accomplished (earned-value) to the Budget at Completion for any WBS#, subproject, or project. % Complete = BCWP/BAC.

Percent Contingency Remaining – The ratio of remaining contingency dollars to remaining line item (TEC) work calculated as follows: the numerator is equal to the contingency available (after consideration of the EAC) less 5% of outstanding technical phase-funded awards and less 10% of outstanding conventional facilities phase-funded awards. The denominator is the EAC less ACWP less outstanding phase-funded awards.

Percent Planned – The ratio of the current plan to the Budget at Completion. % Planned = BCWS/BAC.

Project Engineering and Design (PED) – Funding used to support the engineering and design effort for the LCLS.

Schedule Performance Index (SPI) – The ratio of the value of work performed to work scheduled, SPI = BCWP/BCWS. Values less than 1.0 represent a "behind schedule" condition, and values greater than 1.0 represent "ahead of schedule" condition.

Schedule Variance (SV) – Difference between the value of the physical work performed and the value of the work planned (scheduled). SV = BCWP-BCWS. A negative result is unfavorable and indicates a behind schedule condition.

Total Estimated Cost (TEC) – The total capital budget authorized for the LCLS project for the construction phase of the project. TEC includes contingency but does not include OPC.

Total Project Cost (TPC) – The total capital budget authorized for the LCLS project, including TEC and OPC.

WBS (Work Breakdown Structure) – A method of hierarchically numbering tasks in a traditional outline numbering format. The WBS provides a basis for the LCLS work plan which is used to track all resources, schedules, and cost