

Linac Coherent Light Source Monthly Report March 2009



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Project Overview and Assessment

Highlights:

- Cover Page (LCLS Undulator Tunnel) – The March shutdown at SLAC, primarily to install the undulator magnets on the LCLS beamline, is now complete. Twenty-one undulators, numbers 13 through 33, were installed, checked out, and made ready for commissioning. Full commissioning of the LCLS X-ray Free Electron Laser is scheduled to begin early in April 2009. Standing left to right are: Don Schafer, LCLS Mechanical Engineer, Heinz-Dieter Nuhn, LCLS Undulator System Physicist, David Schultz, E-Beam System Manager, Paul Emma, LCLS Commissioning Group Leader, Geoff Pile, LCLS-ANL Project Director and Mike Zurawel, Undulator Area Manager.
- Technical Systems Installations - Installations continue in the FEE, NEH Basement and Subbasement, and Laser Hall. Work includes installation of cables associated with Cable Plant Phase VI, laser installation and process cooling line installation. Hardware from LLNL has been installed and now LLNL technicians are starting cable installation. Work is being performed by SLAC shops and subcontractors and is scheduled and reviewed at Work Planning & Control meetings held every morning at 7AM in B751.
- Atomic, Molecular and Optics (AMO) Instrument – AMO components and subsystems drawings have been submitted to the SLAC Fabrication Department and are on schedule. Overall, the schedule for early AMO science in September is tight, but doable and is being managed aggressively.
- Construction Progress –
 - All areas (BTH thru FEH) – all field activities including punch list items and handover of red-lined markups have been submitted and are now 100% complete.
 - Field Change Orders on the order of \$3,825K have been negotiated and approved. This remains at <5% of the original construction cost.

Assessment and Issues:

- The March 2009 Cost Performance Report is the 61st month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$367,203K. Cost and schedule indices are 1.00 and 0.97, respectively.

Project Office and Support

WBS 1.1, 2.1 Project Planning, Management and Administration

Highlights:

- LCLS Environmental, Safety & Health Status –
 - The project has worked 248 days without a restricted or lost time injury and 162 days without a recordable injury. Total project hours are 2.16M comprised of 1,566K collaboration hours and 597K subcontracted hours.
 - The project DART rate for construction is currently 3.0¹, as compared to the general industry rate of 3.2. The total project DART rate is 1.0; this includes construction and collaboration hours.
 - Turner Construction (TCCo) - Remaining punch list items include interior drain repair in the CUP and a few other minor actions. Completion of firewalls in the CUP involves work at height, requiring an elevated work plan; this is high hazard work. The work has been planned with the assistance of SLAC ES&H subject matter experts and CF has directed TCCo to provide full time safety support to their superintendent for this work.

- Procurements Status –
 - Construction Procurements (Turner) –
 - No contract modifications were issued during March, but various change order issues were addressed.
 - A total of 494 Field Change Orders and Change Order Requests have been settled, through negotiation or agreement.
 - Technical Procurements –
 - Orders continued to be placed and expedited for several AMO technical instruments and assembly parts throughout the month.
 - An Invitation for Bid - Blanket Purchase Order agreement was issued to 6 bidders to decrease procurement time for misc. small construction projects associated with LCLS start up.
 - Cable Plant Phase 6 continued on schedule for June 2009 completion.
 - Award was made for fabrication and installation of Structural Steel mezzanine in the FEH for completion in early July.

Assessment and Issues:

- None.

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

Electron Beam Systems

Injector, Linac, Undulator and E-Beam Controls Systems

Highlights:

- Management and Safety –
 - Electron beam commissioning continues to make excellent progress. A maintenance period began mid-month to install undulator magnets.
 - The post-start action items from the Undulator Complex ARR are closed out. Further preparations continue for authorization to transport the x-ray beam out of the electron dump area and into the Front End Enclosure (FEE).

- BTH – NEH Controls Installation –
 - The Machine Protection System is fully certified and commissioned. The EPICS software for the Beam Loss Monitors has been successfully deployed.
 - The Cavity BPM software has been successfully commissioned and calibrated to support the FEL commissioning effort.
 - The Undulator Motion Controls EPICS software is fully commissioned.
 - The PPS FEE hardware and signs are complete. The Cold Checkout Test Plan and the PLC Maintenance Procedure is now complete. The network and FEE cables are installed, terminated and tested.
 - An EPICS IOC reliability program has been established and successfully started. The first phase was to analyze the state before and after a reboot operation to analyze abnormalities in startup configuration.
 - A new and more robust version of the RTEMS operating system was rolled out to support the EPICS control system software.

- Undulator Assembly and Measurement (SLAC) –
 - Work continues to replace the BCS toroids in the Dump. The shielding for beam missteered through the QUE-1&2 quadrupoles is being fabricated. Both will be installed in May. Work continues on the installation drawings for two phase cavities in the dump line. Detail drawings are finished and parts are ordered.
 - The undulator magnet that was installed on the beamline was removed to check for magnet degradation due to radiation effects. No degradation was found.
 - The Beam Finder Wire “out” limit switches were connected to the Machine Protection System.
 - The quad magnet terminal corrosion problem has been repaired. Some terminals were replaced and some cleaned. All are now corrosion free.
 - 21 undulator magnets were installed on undulator girders U13-U33. They were checked out and are ready for beam.

- The temperature sensors on each girder that are placed at the beginning, middle, and end of the undulator magnet were re-installed and calibrated. They will be used to correct the dependence of field strength on temperature of the undulator magnets.
- The ANL Beam Loss Monitor brackets have been installed. These connect the undulator magnet to the BLM.
- Three dosimeters per undulator were installed to measure radiation dosage. Additional TLDs were installed around the beam pipe.

Assessments and Issues:

- None.

Photon Beam Systems

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

Highlights:

- Management and Safety – XTOD continues to experience schedule delays during March, however there has been some improvement. In particular, the schedule variance in the installation activity was reduced, as components began to be installed at SLAC. Readiness for first light at the end of May is still planned. A final cost variance for WBS 1.5 of ~ \$2M is still anticipated. There are several causes: unplanned extra work due to late changes in shielding requirements, unplanned work debugging the controls system, and many task durations that exceeded expectations. Efforts are underway to reduce the cost variance by finalizing all designs, simplifying some remaining tasks, and transferring some work from LLNL to SLAC.
- Mechanical & Vacuum –
 - The collimator drawings have been checked and are in re-work. Design of the Shadow Wall and Wall 2 continues.
 - The triple-bay vacuum rack and the 4 instrument racks were anchored in the FEE at SLAC. Wiring of the triple bay vacuum rack began.
- XTOD Design & Production Status –
 - Fixed Mask and Slit - The Fixed Mask and Slit were baked out at SLAC. The Fixed Mask was installed into the FEE. The Slit must be reassembled, fiducialized, installed, surveyed, and aligned.
 - Gas/Solid/Attenuator – The anchor bolts were extended after completing seismic analysis. The Gas Attenuator was installed into the FEE.
 - Direct Imager – The Direct Imager was shipped to SLAC and installed into the FEE.
 - HOMS – Two of the HOMS mirrors were coated with SiC. The HOMS electronics racks were completed and shipped to SLAC.
 - Total Energy Thermal Sensor - The Pulse Tube cold head was shipped back to the vendor for UHV modifications. It is expected to be returned in 4 to 5 weeks. Disassembly of the Total Energy apparatus has begun in preparation for bakeout.
 - Pop-ins – A Preliminary Design Review for the Pop-Ins was held this month.

Assessment and Issues:

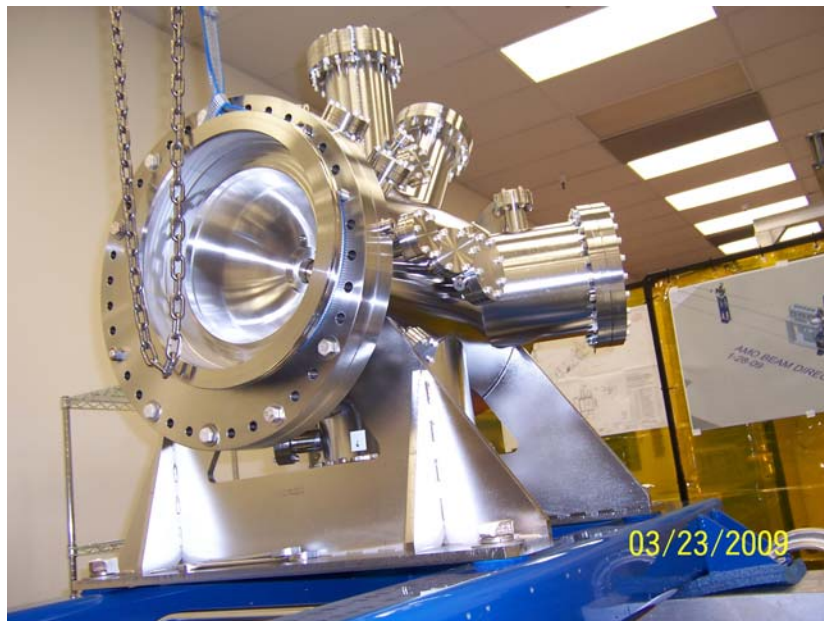
- None.

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

Highlights:

- Management and Safety – Cost and schedule performance for WBS 1.6 continues to improve as procurements and fabrication for the AMO instrument hardware and controls are advancing, and the cabling installation work is catching up. The SPI schedule index is now at 0.90 (from 0.85) and the CPI is at 1.04. The fabrication and assembly schedules continue to be managed very closely. WBS 2.6 performance shows an SPI of 0.92 and a CPI of 1.38. The positive cost variance comes from being slightly behind in building up the Commissioning staff, and from eliminating a chip fabrication run associated with the X-ray Detector development. As the Commissioning hiring catches up, the positive CPI will be reduced in the upcoming months.
- Mechanical Systems -
 - The fabrication of the hutch stoppers for the X-ray tunnel and the FEH hutches is progressing according to schedule. Shielding designs are being reviewed by the Radiation Physics Group.
 - The installation contracts for items such as the PPS and laser doors in the Near Hall hutches and an overhead crane in Hutch 1 have been placed and are progressing on time.
- LCLS Detector Contract with Cornell University - Cornell continues to develop a digital circuit board with a full readout system for the prototype module detector. The fabrication of the 2x1 module assembly tool is ongoing. SLAC has received four 2x1 modules from Cornell. The dimensions of the 2x1 modules have been measured with a Coordinate Measuring Machine. The 3D model prints of the assembly tooling for the bump/wire bonder have been completed. The instrument interface drawings for the CXI experiment have started.
- XES Laser System – The commercial components of the XES laser system were installed in March. The installation was performed under a temporary SOP, because the engineered laser safety system (LSS) had not yet been installed. The oscillator and the amplifier systems were placed on the NEH laser table, and both met their vendor’s operational specifications. HEPA filters and fans were also installed on the laser table enclosures to purify the air around the laser systems. The Photon Controls group began the component installation for the Laser Hall LSS.
- Atomic, Molecular and Optics (AMO) Instrument –
 - All AMO designs have been submitted to the SLAC Fabrication Department. Fabrications are on schedule. The High Field Physics chamber is in bake-out and other piece parts are in pre-bake. Delivery of the vendor-supplied components such as the Time-of-Flight Detectors is being coordinated with the hardware assembly schedule.

- Installation drawings and templates for floor anchors have been completed and are being fabricated. The dry pumps have been received and will be installed in the AMO Hutch 1 of the Near Hall.
- The Final Design Review for the Magnetic Bottle Spectrometer built by Ohio State University was held on March 11. Fabrication and procurement of the components have begun.
- The Preliminary Design Review for the Refocus Optics System took place in the beginning of the month. The review went well and fabrication and procurement of most of the parts are underway. The mirror substrates have been received and the metrology results (confirmed independently at LBNL) have exceeded specifications.
- Procurement of the Energy Gas Monitor built by LLNL has started. A slight design modification specific to integrating the detector to the AMO instrument is being implemented.



The AMO High Field Physics Chamber and Stand

- XES Controls and Data Systems – The accelerator timing fibers from the Near Hall server room to the Front End Enclosure have been activated. Several servers have been installed in the NEH server room, plus a redundant switch card for the NEH to SCCS connection. The data exchange between the photon and electron section of LCLS has been tested using the EPICS gateway server. AMO controllers were tested in preparation for the NEH installation. Continued progress is being made on the data acquisition software for the ATCA control and data readout and processing electronics.

- Soft X-Ray Material (SXR) Instrument -
 - After the signing of the Memorandum of Understanding between DESY, the University of Hamburg, and SLAC, financial details are being resolved so as to make funds available for starting procurement of hardware.
 - A Request for Proposal has been issued for the mechanical system of the monochromator. Bids are expected mid of April. The monochromator mirror and grating have been ordered.
 - The requisition for the Exit Slit is being prepared.
 - Milestones for level 2, 3 and 4 for have been established and integrated into the LCLS project plan.

Assessment and Issues:

- None.

Conventional Facilities (CF)

WBS 1.9, 2.9 Conventional Facilities (CF)

Highlights:

- Construction Progress –
 - All areas (BTH thru FEH) – all field activities including completion of punch list items and handover of red-lined markups are now 100% complete.
 - Field Change Orders amounting to \$3,825K have been negotiated and approved. Field change orders have amounted to less than 5% of the original construction cost.
- Design Far Experimental Hall Hutches – FEH hutch design has successfully reached the 100% completion milestone.
- Office Space –
 - Conceptual Design Report for the Office Space Alternative is complete. This fast-track design effort developed the Conceptual Design Report for a new building. The final CDR will be a part of a Request for Proposal for the construction of a new office building in lieu of the baseline scope. Should the guaranteed maximum price and schedule fit within the LCLS baseline, LCLS management will consider this as an option to the baseline office space plan. This will require a BCR with DOE approval to change the scope.
 - Building 028 and Building 751 remodeling: The Architect/Engineer is advancing towards the 50% design submittal which is due early May. The IFB documents are due end of April, 2009.
 - The selection of LCLS office space alternative will be made by June 1, 2009.

Assessment and Issues:

- A BCR was submitted and approved to incorporate the construction of Hutch 6. This will be a part of the Issue for Construction set scheduled to release for bid in the next reporting period. The incorporation of this hutch will not delay the current schedule for the FEH project.
- A BCR is planned for DOE approval to expand the rehabilitated floor space in building 28.
- The structural steel design for the FEH has been completed and will be managed directly by the LCLS CF group. This steel construction package (columns, beams, stairs and metal decking) was awarded below the estimated budget to San Joaquin Steel (a local vendor) who has previously performed work at the SLAC site.

- Red-lined mark-ups by TCCo and the subcontractors that are a part of the close-out phase and are 100%. Drawings have been submitted to Jacobs Engineering for final as-builts.



LCLS Cost and Schedule Performance – March 2009

LCLS Cost/Schedule Status Report								31-Mar-09		
WBS	Cumulative to Date (\$K)							Budget At Complete (\$K)	Estimate At Complete (\$K)	Variance At Complete (\$K)
	Budgeted Cost		Actual Cost Work Performed	Variance		Performance Indices				
	Work Scheduled	Work Performed		Schedule	Cost	SPI	CPI			
1.1 Project Management	21,177	21,185	20,472	9	714	1.00	1.03	22,599	21,885	714
1.2 Injector	20,239	20,239	20,240	0	0	1.00	1.00	20,239	20,240	0
1.3 Linac	27,948	27,948	27,999	0	-51	1.00	1.00	27,948	27,999	-51
1.4 Undulator	45,813	45,720	45,827	-92	-107	1.00	1.00	46,030	45,922	108
1.5 X-ray Transport	27,712	24,885	27,612	-2,827	-2,727	0.90	0.90	28,858	31,852	-2,993
1.6 X-ray Endstations	7,298	6,629	6,903	-670	-275	0.91	0.96	10,669	11,144	-475
1.9 Conventional Facilities	131,283	127,797	128,679	-3,486	-882	0.97	0.99	142,794	143,676	-882
1.X LCLS Controls	38,312	37,508	37,821	-804	-314	0.98	0.99	41,937	42,251	-314
1 LCLS Total Base Cost	319,782	311,911	315,553	-7,871	-3,642	0.98	0.99	341,074	344,968	-3,894
								LCLS Total Estimated Cost		352,000
								Contingency		10,926
								% Contingency on ETC		37.5%
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	19,789	19,790	18,967	1	823	1.00	1.04	24,438	23,615	823
2.2 Injector (OPC)	5,892	5,891	6,199	-1	-308	1.00	0.95	5,892	6,200	-308
2.3 Linac (OPC)	2,118	2,117	2,207	-2	-90	1.00	0.96	2,334	2,425	-90
2.4 Undulator (OPC)	8,811	8,023	7,555	-787	468	0.91	1.06	10,169	9,950	218
2.5 X-ray Transport (OPC)	3,038	3,064	3,339	26	-275	1.01	0.92	4,185	4,460	-275
2.6 X-ray Endstations (OPC)	5,202	5,121	3,419	-81	1,702	0.98	1.50	10,408	9,505	902
2.9 Conventional Facilities (OPC)	1,571	1,485	1,358	-86	127	0.95	1.09	2,688	2,561	127
2.X LCLS Controls (OPC)	3,088	2,489	2,211	-599	278	0.81	1.13	3,541	3,263	278
2 LCLS Total Other Project Cost	49,510	47,981	45,255	-1,529	2,726	0.97	1.06	63,656	61,980	1,676
								LCLS Other Project Cost		68,000
								Management Reserve		4,344
								% Management Reserve on ETC		27.7%
LCLS Total Project Cost	369,292	359,892	360,808	-9,400	-916	0.97	1.00	420,000	89%	

Cost and Schedule Performance (con't)

<u>March 2009 Project Performance</u>	AYK\$
Total Project Cost (TPC)	\$420,000
Planned % Complete	91.2%
Actual % Complete	88.9%
Total Estimated Cost (TEC)	\$352,000
Cost and Commitments to Date	\$321,635
Estimate at Complete	\$344,968
Work Remaining	\$29,415
Outstanding Phase-Funded Awards	\$5,354
Remaining Contingency (Based on EAC)	\$7,032
% Contingency on uncommitted work remaining	27.5%

Overall Cost and Schedule Assessment

The LCLS cost and schedule are consistent with the approved baseline with a Total Estimated Cost (TEC) of \$352M and a Total Project Cost (TPC) of \$420M. The CD-4 milestone is July 2010. All costs are in actual-year dollars and out-year costs are escalated.

The March 2009 Cost Performance Report is the 61st month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$367,203K. Cost and schedule indices are 1.00 and 0.97, respectively.

The critical path to meet CD-4 technical performance runs through the scheduled Linac shutdown, then FEL commissioning and has 76 working days (~5 months) of float. Near critical path activities are the FEH PPS and FEE installation activities. The critical path to meet CD-4 overall performance runs through the LCLS space renovation has 80 working days.

The Estimate at Complete (EAC) provides the most current estimate of the TEC projected final cost. Contingency on EAC is considered adequate for this stage of the project. LCLS is evaluating possible enhanced capabilities to the baseline. Any added capabilities will be presented to the Change Control Board for approval prior to being added to the baseline.

DOE (Level 2) Milestones

Activity Description	Base Date	Base vs Curr	Current Date	Fiscal Year							
				FY04	FY05	FY06	FY07	FY08	FY09	FY10	
DOE Milestone - Level 2											
Preliminary Safety Assessment (PSAD) Doc Comp	04/30/04	0	04/30/04A								
DOE External Independent Review (EIR) Complete	06/15/04	0	06/15/04A								
Fire Hazard Analysis Approved	06/30/05	-31	08/15/05A								
Preliminary Safety Assessment (PSAD) Doc Appvd	02/28/06	0	02/28/06A								
Delivery of Undulator 1st Articles to MMF	07/03/06	12	06/15/06A								
Sector 20 Alcove Beneficial Occupancy	07/21/06	68	04/14/06A								
MMF Qualified & Ready to Measure Prod Undulators	08/28/06	0	08/28/06A								
Research Yards Mods Beneficial Occupancy	10/20/06	36	08/30/06A								
Start Injector Commissioning (Drive Laser)	01/29/07	19	12/15/06A								
Injector Laser Commissioning Review Complete	01/31/07	31	12/01/06A								
Injector Accelerator Readiness Review (ARR) Comp	01/31/07	-41	03/30/07A								
Start Injector Commissioning(UV Beam to Cathode)	04/09/07	2	04/05/07A								
Linac Water/Power Available	07/11/07	72	03/29/07A								
Linac (LI20-LI30) Ready for Commissioning	12/01/07	0	12/01/07A								
Start Installation of Undulator Facility	05/16/08	-62	08/14/08A								
Beam Transport Hall Beneficial Occupancy	07/21/08	-18	08/14/08A								
Undulator Facility Beneficial Occupancy	07/21/08	-18	08/14/08A								
Front End Enclosure Beneficial Occupancy	07/21/08	-21	08/19/08A								
Near Experimental Hall Beneficial Occupancy	07/21/08	-19	08/15/08A								
Central Utility Plant Beneficial Occupancy	07/21/08	-19	08/15/08A								
Linac (LI20-LI30) Commissioning Complete	07/30/08	84	04/01/08A								
Safety Analysis Document (SAD) Approved	08/29/08	-19	09/28/08A								
Start Installation of Beam Transport Hall	09/26/08	-2	09/30/08A								
X-Ray Transport Beneficial Occupancy	10/22/08	-18	11/17/08A								
Far Experimental Hall Beneficial Occupancy	10/22/08	-17	11/16/08A								
XT Start FEE Installation	01/13/09	-40	03/12/09A								
Beam Path Project Close Out	02/13/09	53	11/17/08A								
LCLS ARR Complete (BTH thru FEH)	04/17/09	13	03/31/09A								
Start Linac-to-Undulator (LTU) Commissioning	04/20/09	82	12/12/08A								
XT Start Tunnel Installation	05/27/09	0	05/27/09*								
Start Undulator Commissioning (1st Light)	07/06/09	0	07/06/09*								
XE Start Installation In NEH	07/24/09	35	06/04/09*								
Start FEE Commissioning with Beam	08/06/09	0	08/06/09*								
First X-Rays Into NEH, ready to start Expt1 Ops	09/10/09	0	09/10/09*								
XE Start Installation In FEH	09/17/09	0	09/17/09*								
2-D Detector Shipped to SLAC	02/26/10	0	02/26/10*								
First X-Rays Into FEH	02/26/10	0	02/26/10*								
SXR Instrument Installed	03/01/10	0	03/01/10*								

Start Date	07/19/08	Fiscal Year	FY04
Finish Date	08/02/10	Project Name	LCLS PROJECT Milestone Level 2
Date Date	04/01/09	Page No.	PL-X3

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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 under run” 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. $\% \text{ Complete} = BCWP/BAC$.

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. $\% \text{ Planned} = BCWS/BAC$.

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.