

Linac Coherent Light Source Monthly Report November 2007



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Project Overview and Assessment

Highlights:

- Cover Page – LCLS Technical Staff Ed Akerstrom, James Post, Nicholas Horton and John Ward set up prototype undulator girders and pedestal supports for integration and quality checks in SLAC's Building 750. Qualification of undulator components (motors, RF BPMs, vacuum chamber, etc.) arriving from ANL are assembled onto girders prior to final alignment and installation in the LCLS Undulator Tunnel. Full girder assembly production is planned to begin in February 2008.
- LCLS received a Corrective Action Plan (CAP) shell from DOE's Office of Engineering and Construction Management External Independent Review (EIR) committee identifying the findings from the review of the revised baseline. The CAP shell identified one major finding that need correction before endorsing the LCLS revised cost and schedule baseline. LCLS will prepare a response to the CAP shell which addresses the EIR committee's findings and implement the corrective actions in the LCLS revised baseline.
- 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. Due to the failure of the fourth dipole magnet, a replacement will need to be 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.
- The construction phase for the LCLS major civil activities is being managed by the Turner Construction. Overall construction is ~73% complete. To date, \$1,773K Field Change Orders have been negotiated and approved, which is less than 4% of construction progress to date.

Assessment and Issues:

- The November 2007 Cost Performance Report is the 45th month reporting earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$277,795K. The LCLS cost and schedule indices are 0.91 and 0.88, 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. The civil construction effort continues to show a schedule delay but is projected to recover to near its original schedule over the next few months.

Project Office and Support

WBS 1.1, 2.1 Project Planning, Management and Administration

Highlights:

- LCLS Environmental, Safety & Health Status –
 - LCLS worked 177 days without a lost time injury and 16 days without a DART (Days Away, Restricted Time). Total project hours are 1.50 M comprised of 1.2 M collaboration and 356 K subcontracted work.
 - The LCLS project DART rate is currently 3.90¹, as compared to general industry rate of 3.2 and DOE rate of 0.6 for similar work. The total project DART rate is 1.2; this includes construction and laboratory hours.
 - Safety Training Metrics –
 - Mandatory safety training = 94% (goal = 93%). Corrective actions will be completed by month-ending November.
 - Supervisor required safety training = 96% (goal = 93%)
 - Compliance for training assessments = 97% (goal = 92%).
 - Medical exams for affected employees = 100% (goal = 90%)
 - DOE Stanford Site Office (SSO) Construction Project Walkthroughs – Due to an upward trend in safety incidents (see Issues and Assessments), the SSO is planning an increased field presence on the LCLS construction site. The LCLS safety group in conjunction with CF has developed a process to coordinate these regular walkthroughs in an integrated manner. The SSO Manager, Paul Golan, regularly attends the Turner Owner/Architect/Contractor (OAC) meeting to explain and reinforce DOE expectations for the project.
 - Beam Dump Shielding – Over 300 tons of steel shielding was installed safely and ahead of the planned schedule between the Front End Enclosure, Near Experimental Hall and Electron Beam Dump. This coordinated effort was successful due the execution of Integrated Safety/Environmental Management core functions by the LCLS Conventional Facilities Group, Turner Construction, and Turner's installation subcontractors.
- LCLS Procurements Status –
 - The LCLS Procurement Department experienced a heavy level of activity in November 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) – No changes to existing contract.
 - Construction Procurements –

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

- 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 193 FCOs and CORs have been settled through negotiation or agreement.
 - 84 FCOs and CORs are open in technical review, fact finding, or negotiation.
- Central Utility Plant (CUP) Gas Line – DOE portion of scope awarded in late November. Schedule to be determined post award. SLAC portion of scope awarded mid-November with kickoff delayed pending receipt and approval of subcontractor safety documentation.
- Electrical S522 Substation construction – Additional work delayed scheduled completion date until mid-November.
- Technical Procurements –
 - Cable Plant Installation Phase 3 (BC2/BSY) – Shutdown related. Two change orders were issued mid October. Field changes required the completion date to be extended to the end of January.
 - Quad Stands – Many different items involved. SLAC visited vendor and all items should be done by late December; however, the vendor will store the items pending SLAC request for JIT delivery after beneficial occupancy has been achieved.
 - Bunch Compressor-2 Chicane Dipole Magnets - Replacement coils due first week of December.
 - BYD Dipole Magnets – Awarded with delivery date of 5/31/08.

Assessment and Issues:

- Construction Work Stoppage (Turner Construction) – Turner Construction’s portion of the LCLS project construction work is performing at double the industry average DART rate. This trend does not show up in LCLS collaboration work or in LCLS-managed contractor work. Due to this unacceptable rate, LCLS formally put Turner on notice of an impending work stoppage. Turner voluntarily stopped its subcontracted work for two days beginning 26 November with work resuming 28 November. During the work stoppage, Turner developed a corrective action plan and reviewed the plan with LCLS management. Work has resumed based on the corrective actions taken and increased field oversight by LCLS, SLAC and DOE SSO. The corrective action plan has both short and long range objectives that will be monitored closely to ensure their successful implementation.

Electron Beam Systems

WBS 1.1, 1.x.2 Controls System

Highlights:

- Injector Controls Commissioning – Complete. All goals met.
- 2007 Shutdown Installation Progress –
 - The installation of all cable plant including instrumentation and controls, networks and timing was completed, with the exception of the redundant timing system fiber which will be done in January. Punch list items are complete, including comments from SLAC's Electrical Safety Officer.
 - The installation of the Sector 24 Beam Containment System (BCS) was completed, including electrical connections and gas line plumbing.
 - The Solid State Sub-Booster (SSSB) Trigger Chassis in Sector 24 was installed, including necessary cables between this chassis and the BCS.
 - The Low-Level RF (LLRF) installed new hardware at S24 including reference Phase and Amplitude Controller (PAC). Testing of the reference line in the tunnel was also completed. The Sector 24 RF distribution and long haul RF cables have been installed.
 - BC2 toroids have been electrically tested and all electronics including two BLM Digitizer chassis and IOC are tested and installed.
 - All new IOCs for Profile Monitors, Toroids, Bunch Length Measurement system are installed and operational. Profile Monitors of BC2 were checked out and verified.
- Controls Design and Procurement Progress –
 - Great progress was made on the cable plant design and documentation for the 2008 installation, including the entry of ¼ million feet of cables in the CAPTAR database. Cable specification is 70% complete, and over 50% of the cable plant material has been procured.
 - Production of BPM VME ADC Modules for the Undulator cavity BPMs; was started. Orders of parts for AFE, PAD, Clock, and VME ADC boards were completed. Most parts were received by the end of the month; orders for BPM chassis (and integration parts) were completed.
- Controls Software Support – BC2 PLC programming and IOC setup is complete. Test plans were written and executed for the PLC and IOC; verified long haul cables, finished rack wiring, connected all devices, and turned everything on.

Assessment and Issues:

- None

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

Highlights:

- Injector Commissioning – Complete. All goals met.
- 2007 Shutdown Installation Progress –
 - The 2007 installation period started on September 4th. To date, all Linac components have been installed per the planned 2007 downtime schedule.
 - Earthquake restraining supports and radiation shielding for Bunch Compressor-2 (BC-2) center table were installed. The center table is locked to straight ahead beam until the main strut above the dipole magnets is installed during a January Repair Opportunity Day (ROD).
 - Cables termination and control check-out was also completed in November.
- Linac-To-Undulator (LTU) Design and Procurement Progress –
 - The core drilling and stand installation for the LTU is out for quotation. Hilti has re-certified epoxy anchors and the LCLS design is being prepared for review with SLAC's Seismic Committee.
 - The LTU stands are in fabrication with Allied Engineering Production Corp.

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) for the magnet and the repair and magnetic measurement will be accomplished in December. 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 – Undulator support pedestals were aligned in the ANL Long Term Test and the short girder sections are mounted.
 - Vacuum Hardware – Purchase orders for spool fabrication, mini-bellows, plating & electro-polished have been placed. The design of the Quad Spool with the mini-bellows has been approved for use in LCLS.
 - Electronics & Controls – The first article inter-Undulator cabling was fitted to the Undulator system in the Long Term Test.
 - RF Beam Position Monitors (BPMs) –
 - The BPM body vendor is making excellent progress and may finish ahead of their contract schedule.
 - The order for the production brazing of the RF BPM was awarded on November 1.
 - Quadrupole Magnets – Two first article quadrupole magnets arrived at ANL. One of them was tested, met spec, and was shipped to SLAC. Four additional quadrupoles should be shipped to SLAC in December.
 - Vacuum Chamber – The undulator vacuum chamber first stage extrusion polishing has gone well (See Issues & Assessments). All extrusions have gone through the 220 grit polishing cycle and the contractor is ahead of schedule. 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.
- Undulator Assembly & Measurement (SLAC) –
 - The girder assembly area at SLAC's Building 750 was setup including epoxy painting the floor and installation/setup of three sets of pedestals.
 - Load testing of the girder installation tooling was successfully completed.

Assessments and Issues:

- Investigation into RF BPM window breakage required investigating methods of joining the window to the transition at a lower temperature than the accepted process. Four windows were brazed and two cracked. The other two had vacuum leaks in the braze joint. A flaw has been found along the glass where it joins with the Kovar frame and will be investigated further.
- The undulator vacuum chamber first article extrusion polishing second stage appears to not meet the roughness specification. Two solutions are being worked and test results will be available in December.

Photon Beam Systems

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

Highlights:

- Management and Safety –
 - Cost and schedule variances are being accrued in all areas against the current, approved performance baseline. Measured progress against the new (proposed) performance baseline is good.
 - A detailed list of scheduled XTOD procurements was assembled and sent to the Project Office. The pace of XTOD spending continues as scheduled.

- XTOD Design & Production Status –
 - Fixed Mask – The Fixed Mask Assembly was received at LLNL at the end of November. Unfortunately it suffered some damage during shipment. It has been partially disassembled and sent back to the vendor for repair and replacement.
 - Gas Detector – High-voltage modules to power the photomultiplier tubes were tested at SLAC. Two of the modules work but one failed, and all boards are very sensitive to the -12V supply on the VME crate. The vendor is working to resolve these issues.
 - Soft X-ray Offset Mirror System (SOMS) – The vendor for the SOMS mirrors is currently polishing the reflective surfaces on all 6 optics, which include 4 SOMS mirrors, 1 spare polished to X-ray specifications, and 1 surrogate mirror with a lower grade polish for prototype work. They are ahead of schedule, which shows the 5 mirrors due in February.
 - Hard X-ray Offset Mirror System (HOMS) – The Final Design Review (FDR) for the HOMS mirrors was successfully conducted in mid November. The FDR covered only the mirror elements, so that the mirror substrate design could be finalized allowing these long-lead items to be ordered soon. The HOMS mirrors procurement package subsequently went out for bid with a scheduled award date in early January.
 - Controls – Details of the Machine Protection System (MPS) cabling were added to the overall planning documents. In addition, the issue of PLC-to-PLC contact signals for 'shared' isolation valves was addressed by adding six 24 volt inter rack lines to the FEE.

Assessment and Issues:

- None

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

Highlights:

- Management and Safety – Variances are being accrued against the outdated baseline plan in all control accounts, but performance is good against the new rebaseline plan.
- XES Personnel Protection Systems (PPS) –
 - Vendor bids for the PPS hutch door fabrication for Near Hall hutches are under evaluation.
 - Photon/electron stopper drawings in the electron dump and hutch areas have been completed and are ready for fabrication, awaiting the Final Design Review scheduled for 12 December. Engineering Specification Documents (ESDs) for the stoppers are in the final approval.
- Detector Project at Cornell –
 - The detector diode and wafers are in bump-bonding. Complete bump-bonded detector prototype modules are expected by the end of December.
 - The full-speed readout of the ASIC with the Cornell stand-alone DAQ system was confirmed. Areas for improvement, such as the lateral analog power distribution across the bonding-pad side of the chip, are being identified for the next chip submission.
 - An LUSI/LCLS team visited Cornell to discuss the mechanical interface with the LUSI CXI instrument: vacuum, cooling, modularity, packaging, and mounting. The data acquisition interface has also been discussed and defined in an Interface Control Document (ICD) between LUSI/LCLS and Cornell. Interfaces and responsibilities are being fine tuned in the next month to ensure seamless integration into the final instrument.
- Atomic, Molecular and Optics (AMO) Instrument – AMO instrumentation underwent a Preliminary Design Review (PDR) on November 26. A few issues were identified and are being addressed. The reviewers expressed concern regarding the compressed schedule to deliver a functional AMO instrument and were particularly concerned with insufficient time for the testing phase.
- XES Controls and Data Systems –
 - Cable tray installation in the Near Experimental Hall is being completed and sample racks were ordered for test purposes.
 - Data acquisition module prototype for the detector readout is in assembly and data acquisition module's first software version is being debugged.

Assessment and Issues:

- None.

Conventional Facilities (CF)

WBS 1.9, 2.9 Conventional Facilities (CF)

Highlights:



Central Utility Plant – Steel columns and partial roof deck



Electron Beam Dump – Looking upstream into Undulator

- Construction Progress –
 - Construction is approximately 73% complete. To date, \$1,773K Field Change Orders have been negotiated and approved, which is <4% of construction progress to date.
 - Beam Transport Hall (BTH) – Painting, strip forms and shoring from final location of concrete pour.
 - 12 KV Substation – Substation block building in progress. CMU installed, roofing in progress, overhead roll door in progress. Switchgear is set in place, cables pulled and tested. Control wiring in progress.
 - Far Experimental Hall (FEH) – Top heading and mid-section excavation 100% complete. Commenced final bench excavation. Favorable ground conditions continue to be encountered during the tunneling operations.
 - X-Ray Tunnel – Temporary tunnel complete. ~500' excavation has advanced into the X-Ray tunnel.

Issues and Assessments

- Safety – There has been a recent negative trend of safety incidents. Due to the seriousness of this matter, Turner has performed a mandatory stand-down and has suspended all work in the field. This 4 day pause has resulted in the Turner/LCLS team to reassess the current plans and procedures that may require updating. In addition, Turner has made some management changes in the field and has introduced additional safety staff to support the field management. In addition, the LCLS CF team has begun a more rigid review of safety

observations in the field on a daily basis. All SLAC University Technical Representatives (UTRs) conduct several daily observations.

- Civil Construction Schedule – Overall, civil construction lags behind its baseline schedule by 3-4 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.
- 12 KV Substation – The DC battery system used for the main breaker on the substation has not been ordered by the general contractor. This will cause a delay to their contractual completion date but is not anticipated to have an impact on the Central Utility Plant permanent power.



LCLS Cost and Schedule Performance – November 2007

LCLS Cost/Schedule Status Report									30-Nov-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	16,700	16,663	17,929	-37	-1,266	1.00	0.93	18,013	93%	
1.2 Injector	16,760	16,713	20,215	-47	-3,502	1.00	0.83	16,760	100%	
1.3 Linac	17,949	15,538	20,740	-2,411	-5,202	0.87	0.75	19,940	78%	
1.4 Undulator	35,041	28,538	34,499	-6,502	-5,961	0.81	0.83	37,398	76%	
1.5 X-ray Transport	20,721	14,418	18,820	-6,302	-4,401	0.70	0.77	22,803	63%	
1.6 X-ray Endstations	4,639	2,236	2,181	-2,403	54	0.48	1.02	8,735	26%	
1.9 Conventional Facilities	101,622	95,946	97,490	-5,676	-1,544	0.94	0.98	128,987	74%	
1.X LCLS Controls	28,184	19,454	23,392	-8,730	-3,938	0.69	0.83	32,366	60%	
1 LCLS Total Base Cost	241,615	209,506	235,267	-32,109	-25,761	0.87	0.89	285,002	74%	
LCLS Total Estimated Cost								315,000		
Contingency								29,998		
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	13,455	13,615	12,733	159	881	1.01	1.07	30,195	45%	
2.2 Injector (OPC)	4,397	3,505	5,037	-892	-1,532	0.80	0.70	5,317	66%	
2.3 Linac (OPC)	742	422	556	-320	-133	0.57	0.76	3,232	13%	
2.4 Undulator (OPC)	3,885	4,512	2,537	627	1,975	1.16	1.78	6,852	66%	
2.5 X-ray Transport (OPC)	1,263	1,206	1,153	-57	53	0.95	1.05	4,544	27%	
2.6 X-ray Endstations (OPC)	2,416	1,897	1,225	-519	672	0.79	1.55	5,559	34%	
2.9 Conventional Facilities (OPC)	58	36	0	-23	36	0	0	683	5%	
2.X LCLS Controls (OPC)	790	380	335	-410	45	0.48	1.13	1,129	34%	
2 LCLS Total Other Project Cost	27,007	25,574	23,577	-1,433	1,996	0.95	1.08	57,511	44%	
LCLS Other Project Cost								64,000		
Management Reserve								6,489		
LCLS Total Project Cost	268,622	235,080	258,844	-33,542	-23,764	0.88	0.91	379,000	69%	

Cost and Schedule Performance (con't)

Overall Cost and Schedule Assessment

<u>November 2007 Project Performance</u>	<u>AYK\$</u>
Total Project Cost (TPC)	\$379,000
% Planned (Cumulative)	78.4%
% Complete (Cumulative)	68.6%
Total Estimated Cost (TEC)	\$315,000
Cost and Commitments to Date	\$252,464
Estimate at Complete (EAC)	\$313,655
Work Remaining	\$78,388
Outstanding Phase-Funded Awards	\$29,977

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 November 2007 Cost Performance Report is the 45th month reporting earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$277,795K. The LCLS cost and schedule indices are 0.91 and 0.88, 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. The civil construction effort continues to show a schedule delay but is projected to recover to near its original schedule over the next few months.

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.

The LCLS EAC incorporates all overruns and potential BCR's into the performance baseline to provide a realistic assessment of the project's final cost.

DOE (Level 2) Milestones

System	Level	Milestone	Baseline	Projected	Variance	2005		2006		2007		2008		2009
						Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	
		<input type="checkbox"/> 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. $\% \text{ Complete} = BCWP/BAC$.

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