

Linac Coherent Light Source Monthly Report January 2009



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Project Overview and Assessment

Highlights:

- Cover Page (LCLS Undulator Hall) – LCLS reached another milestone on January 28th when a beam of electrons wiggled through the first undulator and produced X-rays. "This is the first time we actually had an electron beam going through an undulator," said SLAC physicist Heinz-Dieter Nuhn, who has been with the project since 1991. "It's pretty exciting." For more on the first LCLS x-rays, go to: <http://today.slac.stanford.edu/feature/2009/lcls-undulator-test.asp>
- Electron beam commissioning continues to make excellent progress. With the resumption of Linac operations after the holiday shutdown, the beam quality observed during the last run was quickly reestablished. In addition, the beam quality was maintained as electrons were transported through the undulator systems and the electron beam dump. The beam was operated at several differing energies to test the breadth of LCLS operating conditions. The process for beam based alignment of the Undulator magnets was commissioned successfully.
- The Soft X-Ray Material (SXR) Instrument Steering Committee meeting took place January 27th at DESY in Hamburg, Germany. Representatives of the participating institutes SLAC, DESY-CFEL, Hamburg University, and LBNL attended. The main issues pertinent to XES discussed in Hamburg were the integration of external equipment into LCLS, planning for SXR commissioning and the mechanism by which the German funding will be transferred to SLAC.
- Turner Construction Co.-managed activities are complete with the exception of punch list items and demobilization of construction trailers.
 - Overall progress is over 99% complete.
 - Field Change Orders on the order of \$3,757K have been negotiated and approved. This is <5% of construction progress to date.

Assessment and Issues:

- The January 2009 Cost Performance Report is the 59th month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$358,726K. 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 –
 - LCLS has worked 207 days without a lost time injury (days away) and 121 days without a recordable injury. Total project hours are 2.1M comprised of 1,528K collaboration hours and 593K subcontracted hours.
 - The LCLS 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; this includes construction and laboratory hours.
 - Work Planning & Control – Work is ramping up in the FEE, NEH Hutch 1 & 2 and the NEH Laser Hall. Work is performed by both SLAC personnel and subcontractor and is scheduled and reviewed at Work Planning & Control meetings held every morning at 7am in B750.

- LCLS Procurements Status –
 - Construction Procurements (Turner) –
 - A total of 491 Field Change Order (FCOs) and Change Order Requests (CORs) have been settled, through negotiation or agreement, with issuance of Modifications.
 - The FCO process, a construction expediting process to address urgent field activities, has worked well for the main construction effort. With this effort now complete, LCLS will process a BCR to close out the FCO process and return unused budget to contingency.
 - Technical Procurements –
 - FEH Hutch # 4 and #5 design continues on schedule for completion in March.
 - FEH Hutch #6 design was awarded for Title I & II to be completed in March.
 - Cable Plant Phase 6 was awarded to be completed in June 2009.
 - Electric utilities installation of I & C racks and FEE awarded with a completion in February.
 - NEH Electrical AC distribution to racks awarded with a February completion date.

Assessment and Issues:

- None.

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

Electron Beam Systems

WBS 1.2, 1.3, 1.4, 2.2, 2.3, 2.4 Injector, Linac and Undulator Systems

Highlights:

- Management and Safety – Efforts began to close out the post-start action items from the Undulator Complex ARR. This is in preparation for authorization to transport the x-ray beam into the Front End Enclosure (FEE).
- BTH – NEH Controls Installation –
 - New High Level Applications Software feedback loops were installed to stabilize the beam in the LTU region. Also, a full online accelerator model for the LCLS through the Undulator system is now available.
 - The first Beam Loss Monitor and Protection ion Chamber beam tests were performed for the Machine Protection System.
- Linac-To-Undulator (LTU) Design, Procurement and Installation Progress –
 - Commissioning and characterization of the beamline components is going well with all systems functional. Optimization continues.
 - A new design for permanent shielding and a Burn-through monitor (BTM) for beam missteering cases through the quadrupoles is complete and will be installed in March.
 - An investigation is underway into a problem with the Beam Containment System toroid comparator system at the main electron dump.
- Undulator Assembly and Measurement (SLAC) –
 - Fourteen undulator magnets are Ready-For-Installation (RFI) and scheduled for installation in March. Ten additional RFI magnets are stored in the Undulator Tunnel.
 - One of the RFI undulator magnets was installed at location U-25 to test for any effect on the electron beam, or on the support hardware. The tests showed no problems.

Assessments and Issues:

- None.

Photon Beam Systems

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

Highlights:

- Management and Safety – Cost and schedule impacts continue to affect the XTOD System. A recovery plan has been developed with XTOD management and the LCLS Project Office.
 - The new plan forward is expected to recoup the schedule significantly starting in February. Installation completion in March and readiness for first light in May, on schedule, is projected.
 - A total cost variance for WBS 1.5 of approximately \$2M (roughly 10% variance) is projected at this point, due to labor charges that have exceeded the budgeted amounts. Additional labor was needed to incorporate late changes in shielding requirements, additional work debugging the controls system, and several task durations exceeded the baseline estimate. Efforts are underway to reduce the overall cost variance by finalizing all designs, simplifying remaining tasks, and transferring work from LLNL to SLAC.

- XTOD Design & Production Status –
 - *K*-monochromator – The Canberra diode mounting scheme was finalized. Meanwhile the stand and vessel remain on order.
 - Fixed Mask and Slit - Based on RGA scans, the Fixed Mask and Slit did not meet SLAC ultra-high vacuum cleanliness requirements. The Fixed Mask and Slit were partially disassembled in preparation for shipment to SLAC where they will be baked, tested, and reassembled.
 - Gas/Solid/Attenuator/Detector – Ready for transport to SLAC.
 - Direct Imager –The Scintillator Insertion Assembly and cameras were installed and tested. Final details of the software will be completed and tested in the next two weeks. The system is on schedule to be shipped to SLAC the first week of February.
 - SOMS/HOMS – SOMS mirrors 3 and 5 were coated with B4C. This completes the coating of all 5 of the SOMS mirrors. All 5 sets of the mirror mounting and positioning hardware (3 SOMS and 2 HOMS) were received at LLNL and assembled.
 - Pop-ins - Vacuum chamber design is complete, and work on the support structure is underway. Having been delayed in order to push up work required for the early operation of the diagnostics, the detailed design of the Pop-in systems is now planned to be complete in May.

Assessment and Issues:

- None.

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

Highlights:

- Management and Safety – The XES schedule variance is due to delayed procurements for the Controls and AMO instrumentation and for cable installation. The schedule variance for the installation is due to a delayed start of the cable installation for the Near Hall experimental areas. This work has started now and should be completed without adverse impact to overall program.
- Mechanical Systems - The hutch stoppers will be ready for installation in February on time for installation. These stoppers will be located in the Front End Enclosure on the hard and soft X-ray beamlines to control access to the three hutches in the Near Hall. The second set of stoppers for the Far Hall hutches is being fabricated. Shielding requirements of the upstream stopper of the X-ray tunnel have been incorporated into the stopper tank design.
- LCLS Detector Contract with Cornell University - The Cornell group is continuing with detailed testing and characterization of the prototype detector. The overall functionality of the prototype has been established. Specific performance parameters are being improved and incorporated into the final ASIC design to be submitted in spring. This submission date is later than originally planned, but will not affect the final delivery schedule of the detector. The final diode design was submitted for fabrication this month. Weekly meetings between LCLS and Cornell continue in order to coordinate mechanical and electrical integration.
- XES Laser System – The laser group began the first technical equipment installation into the Near Experimental Hall. This included installation of the optical tables for the laser hall and for experimental hutches 1 and 2, and installation of the optical transport tube assemblies for transporting the laser beam from the laser hall to each of the experimental hutches. The installation of laser enclosures on the tables is slated for early March. Finally, the laser group began the design of the opto-mechanical transport for the AMO experimental line. This includes modeling the optical beam line, plus specifying and procuring all of the assemblies.
- Atomic, Molecular and Optics (AMO) Instrument –
 - The AMO engineering group has completed all drawings for the High Field Physics and Diagnostics instruments. Jobs for these assemblies have been submitted to the SLAC MFD shop for fabrication. All orders for long-lead components have been placed with the purchasing department, and delivery schedules are closely monitored.
 - The clean room in the onsite vacuum assembly building was prepared for initial assembly and testing of the AMO instruments.

- XES Controls and Data Systems –
 - The majority of the AMO controls and DAQ items have been ordered. Work continues on the mock-up for testing motion control of the AMO tables that position the chambers relative to the LCLS beam.
 - Detailed specifications have been developed for the online dataflow, data-acquisition, and processing storage for online and offline data.
 - The network fibers between control room and hutches will be installed as part of Phase 6 installation in the coming months. Wireless access points to enable wireless communication in FEE and NEH were installed. EPICS servers for the NEH server room were received and await installation in February.

- Soft X-Ray Material (SXR) Instrument -
 - The SXR Steering Committee meeting took place January 27 at DESY in Hamburg, Germany. Representatives of the participating institutes SLAC, DESY-CFEL, Hamburg University, and LBL attended. The main issues pertinent to XES discussed in Hamburg were the integration of external equipment into LCLS, planning for SXR commissioning and the mechanism by which the German funding will be transferred to SLAC.
 - Work on the monochromator specification progressed and will be finalized soon. The design of the monochromator interconnecting vacuum hardware, in particular the collimators, was fully modeled.
 - The decision was made that SXR would build a duplicate of the AMO focusing mirror system, with only a minor modification of the mirror profiles to fit the SXR focal lengths. This should save considerable design effort.

Assessment and Issues:

- None.

Conventional Facilities (CF)

WBS 1.9, 2.9 Conventional Facilities (CF)



Central Utility Plant



Near Experimental Hall

Highlights:

- Construction Progress –
 - All areas (BTH thru FEH) – continued progress on final seven punch-list items, and close-out of all bid packages and trade subcontractors.
 - Field Change Orders on the order of \$3,757K have been negotiated and approved. This is <5% of construction progress to date.
- Design - Far Experimental Hall Hutches
 - FEH design was awarded to DGA Architects, a local design engineering firm. FEH design has commenced and successfully reached the 60% completion milestone.

Issues and Assessment:

- FEH engineer of record (DGA Architects) conducted a Value Engineering (VE) session during this reporting period. The VE session in collaboration with the design team, LCLS civil engineering group, and LCLS technical team yielded over \$100K of savings.
- During this reporting period the Hutch 6 design was added to the contract of DGA. It is anticipated that the Hutch 6 design will be completed with the remaining design scope on schedule.
- Red-lined mark-ups by TCCo and the subcontractors are a part of the close-out phase and are roughly 25% complete during this reporting period. After review by the LCLS CF staff, there has been several items identified that either require correction or is not included in the red-lined mark-up drawings by TCCo. LCLS CF will continue to monitor and verify the data for completeness in order to provide a final and accurate as-built package to be delivered to the laboratory.



LCLS Cost and Schedule Performance – January 2009

LCLS Cost/Schedule Status Report										31-Jan-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	20,847	20,858	20,252	11	606	1.00	1.03	22,599	21,992	606	
1.2 Injector	20,239	20,239	20,240	0	0	1.00	1.00	20,239	20,240	0	
1.3 Linac	27,941	27,948	27,956	7	-9	1.00	1.00	27,948	27,956	-9	
1.4 Undulator	45,657	45,667	45,682	10	-14	1.00	1.00	46,030	45,830	200	
1.5 X-ray Transport	26,483	23,834	26,110	-2,649	-2,276	0.90	0.91	28,345	30,621	-2,276	
1.6 X-ray Endstations	6,523	5,081	5,317	-1,442	-237	0.78	0.96	10,528	11,006	-478	
1.9 Conventional Facilities	129,206	126,280	125,823	-2,926	457	0.98	1.00	139,849	139,392	457	
1.X LCLS Controls	36,468	35,488	36,076	-980	-588	0.97	0.98	41,671	42,259	-588	
1 LCLS Total Base Cost	313,363	305,395	307,456	-7,968	-2,061	0.97	0.99	337,209	339,297	-2,088	
								LCLS Total Estimated Cost		352,000	
								Contingency		14,791	
								% Contingency on ETC		46.5%	
2.1 LCLS Project Mgmt, Planning & Admn (OPC)	18,980	18,981	18,184	1	798	1.00	1.04	24,438	23,641	798	
2.2 Injector (OPC)	5,890	5,886	6,189	-3	-303	1.00	0.95	5,892	6,195	-303	
2.3 Linac (OPC)	2,073	2,073	2,184	0	-111	1.00	0.95	2,334	2,445	-111	
2.4 Undulator (OPC)	7,927	6,761	6,802	-1,166	-40	0.85	0.99	10,169	10,459	-290	
2.5 X-ray Transport (OPC)	2,981	2,928	3,238	-53	-311	0.98	0.90	4,185	4,496	-311	
2.6 X-ray Endstations (OPC)	4,146	3,643	2,750	-503	893	0.88	1.32	10,408	9,514	893	
2.9 Conventional Facilities (OPC)	1,089	1,092	1,147	2	-55	1.00	0.95	2,632	2,687	-55	
2.X LCLS Controls (OPC)	2,661	2,210	1,962	-451	249	0.83	1.13	3,541	3,292	249	
2 LCLS Total Other Project Cost	45,747	43,574	42,454	-2,172	1,120	0.95	1.03	63,599	62,729	870	
								LCLS Other Project Cost		68,000	
								Management Reserve		4,401	
								% Management Reserve on ETC		22.0%	
LCLS Total Project Cost	359,110	348,969	349,910	-10,141	-941	0.97	1.00	420,000	87%		

Cost and Schedule Performance (con't)

Overall Cost and Schedule Assessment

<u>January 2009 Project Performance</u>	AYK\$
Total Project Cost (TPC)	\$420,000
Planned % Complete	89.6%
Actual % Complete	87.1%
Total Estimated Cost (TEC)	\$352,000
Cost and Commitments to Date	\$314,418
Estimate at Complete	\$339,297
Work Remaining	\$31,841
Outstanding Phase-Funded Awards	\$5,747
Remaining Contingency (Based on EAC)	\$12,703
% Contingency on uncommitted work remaining	46.9%

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 January 2009 Cost Performance Report is the 59th month of reported earned-value on the LCLS. TPC cumulative obligations to date (actual costs + open commitments) are \$358,726K. Cost and schedule indices are 1.00 and 0.97, respectively.

The critical path to meet CD-4 technical performance runs through the Soft X-ray Offset Mirrors and has 108 working days (~5 months) of float. Near critical path activities are the XES PPS and XTOD Pop-Up Cameras. The critical path to meet CD-4 overall performance runs through the LCLS space renovation has 83 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	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 (L120-L130) 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 (L120-L130) 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	-13	02/02/09*							◆	
Beam Path Project Close Out	02/13/09	0	02/13/09*							◆	
LCLS ARR Complete (BTH thru FEH)	04/17/09	0	04/17/09*							◆	
Start Linac-to-Undulator (LTU) Commissioning	04/20/09	0	04/20/09*							◆	
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*							◆	

Start Date 07/19/06
 Finish Date 09/17/10
 Data Date 02/01/09

FBF_Level 2 Milestones

**LCLS PROJECT
 Milestone Level 2**

FL-X3

BASELINE (A) ACTUAL
 CURRENT Constrained/Target Date

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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.