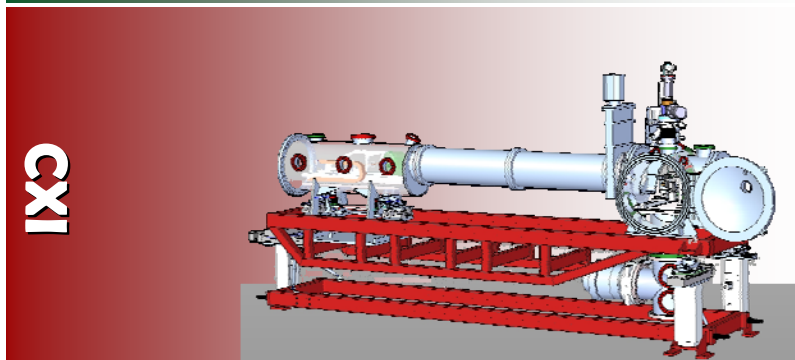
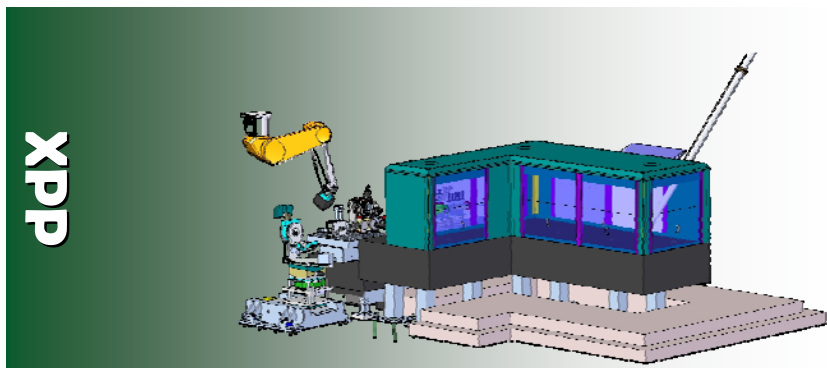


LCLS Ultrafast Science Instruments Monthly Report May 2009



Contents

WBS 1.1 and 2.1 Project Management.....	3
WBS 1.2 X-ray Pump Probe (XPP) Instrument.....	4
WBS 1.3 Coherent X-ray Imaging (CXI) Instrument.....	6
WBS 1.4 X-ray Correlation Spectroscopy (XCS) Instrument.....	8
WBS 1.5 Diagnostics and Common Optics (DCO).....	11
WBS 1.6 Controls and Data Acquisition (CDA).....	13
LUSI Cost and Schedule Performance- December 2008.....	14
LEVEL 1 & 2 MILESTONES.....	17
GLOSSARY.....	18

WBS 1.1 and 2.1 Project Management

- Management and Safety

LUSI received all of its expected funding for the remainder of the project. This includes the \$33.6M from the American Recovery and Re-investment Act (RA) received in April. Total Project Cost is still \$60M. May is the second month with ARRA actual costs. BCRs were processed in May to complete the ARRA changes started in April. The May changes included the addition of an “Early Science” detector for the XCS instrument. This detector is provided by Brookhaven National Laboratory and is almost identical to the XPP detector. The May changes also included the addition of a Large Offset Monochromator to the XPP instrument scope.

Responses were prepared to the recommendations and comments from the April Independent Project Review by the DOE Office of Project Assessment.

The CD-3 review for LUSI has been scheduled for July 15, 2009.

- Assessment and Issues:

The May 2009 Cost Performance Report is the 8th month of reported earned-value on LUSI. MIE cumulative obligations to date (actual costs + accruals) are \$8,499K. Schedule and cost indices for the MIE are 0.98 and 1.05 respectively.

WBS 1.1 cumulative obligations to date (actual costs + open commitments) are \$2,332K. Schedule and cost indices for WBS 1.1 are 1.00 and 1.05, respectively.

All planned OPC (WBS 2) work has been completed. OPC cumulative actual costs to date are \$4,852K.

WBS 1.2 X-ray Pump Probe (XPP) Instrument

- Management and Safety

WBS 1.2 cumulative obligations to date (actual costs + accruals) are \$2,202K. Schedule and cost indices for WBS 1.2 are 0.99 and 1.04 respectively.

- General

The top candidate for the XPP 2nd Scientist position accepted the SLAC offer. Dr. Marco Cammarata (University of Copenhagen) will join the XPP staff in October.

- Design

A design review for the robot support base was successfully held. Fabrication drawings are being created.

The robotic software statement of work was approved and released.

A purchase specification was created and released for the XPP fast oscilloscope.

- Detector

The LCLS Detector Advisory Committee met on May 7-8, 2009. The final report is expected in June.

- Procurement

Requisitions were submitted to SLAC procurement for the robot software statement of work, XPP fast oscilloscope, and portions of the laser system optomechanics.

Purchase orders were placed for various X-ray optics support table components.

We anticipate delivery of the Robotic Detector Mover in June.

- Component Status

Holes were successfully drilled in the hutch floor for component anchoring.

The laser optical tables were received and are in storage at SLAC. Workbenches were received and installed in hutch 3.



Figure 1. XPP workbenches installed in Hutch 3.

- Assessment and Issues:
None.

WBS 1.3 Coherent X-ray Imaging (CXI) Instrument

- Management and Safety

WBS 1.3 cumulative obligations to date (actual costs + accruals) are \$1,147K. Schedule and cost indices for WBS 1.3 are 1.01 and 1.19, respectively.

A layout of the CXI hutch was provided to the XFD Safety Officer to begin the process of layout out the hutch search procedure and the location of the search buttons.

- General

None.

- Design

Since CXI has multiple configurations with different detector positions and different beam directions depending on the focusing optics, multiple layouts are being created in the model and temporary vacuum spools required are being identified.

Ray-tracing as it relates to the Reference Laser and differential pumping is complete.

The design work for a differential pumping system was mostly completed with the incorporation of a B₄C disk to guard against beam misteering.

- Detector

The CXI detector, which falls under the LCLS construction project, is progressing as planned. Communication is ongoing between the CXI team and the group working on the mechanical design of the detector.

The CXI team attended the LCLS Detector Advisory Committee on May 7 and 8.

- Procurement

A winning bid was selected by a panel of experts for the 1 micron KB System back in April. Since that time, there have been protracted negotiations between SLAC and the selected vendor to agree on acceptable contract terms. This took most of May. Once the contract terms are agreed on, the contract needs to be approved by the DOE Site Office and DOE-Oak Ridge.

- Component Status

- **1 micron Sample Chamber:**

Vibration analysis of the internal components of the chamber continued. Detailing of components was started and possible collisions between components were eliminated.

Detailing of parts continued with emphasis on the base plate assembly and the telescope support to the new stand.

A large number of cables will be present inside the Sample Chamber and it will be important to route and support them to make sure they are not damaged. A cable routing plan was developed which takes care of all motions.

- **0.1 micron KB/Sample Chamber System:**
Design work on the 0.1 micron KB/Sample Chamber System will begin once the option on the KB contract is officially picked up.
- **Precision Stands:**
The stand was modified to allow mounting the detector upstream of the sample chamber. The support structure was modified from 4 support points to 3 and analysis was redone for the new structure.

The truss and cross beams were slightly modified based on calculated stress and deflections at key locations.

The Preliminary Design Review for the CXI 1 micron Precision Instrument Stand was held on May 15.

The Stand was made more compact and robust by using a spherical thrust bearing on the support ball system.

Work was started on the seismic report needed for the seismic safety committee.

- **Detector Stage:**
The Preliminary Design Review for the CXI Detector Stage was held on May 15. After careful examination of the mechanical analysis, it was decided to explore the possibility to stiffen the structure by moving the entire vacuum chamber instead of moving the stage internally.
- **Particle Injector:**
The bulk of the effort on the particle injector focused on the design details of the custom made manipulator and optimizing the stage assemblies for functionality while minimizing the overall size.
- **KB Mirrors:**
A winning bid was selected by a panel of experts for the 1 micron KB System. The award is pending a SLAC procurement decision based on contract discussions with the selected vendor.
- **Ion Time-Of-Flight:**
No change.
- **Reference Laser:**
The revised optical system for the Reference Laser was updated to respond to the Preliminary Design review comments. In particular, a different laser with lower power and a class 2 rating was selected. The Reference Laser model was checked and corrected when necessary in order to prepare for drafting the parts.
- **Controls:**
The Preliminary Design Review for the CXI Controls System was held on May 11.

- Assessment and Issues:

None.

WBS 1.4 X-ray Correlation Spectroscopy (XCS) Instrument

- Management and Safety

WBS 1.4 cumulative obligations to date (actual costs + accruals) are \$923K. Schedule and cost indices for WBS 1.4 are 0.90 and 1.03 respectively.

- General

The XCS Instrument Integrated Team concentrated its effort to the completion of the items required for the Final Instrument Design Review of the XCS instrument scheduled on June 17-18.

As a predecessor for this review, the XCS Instrument Integrated Team conducted and completed two Preliminary Design Reviews:

- The XCS Controls were reviewed on May 11.
- The components located on top of the carriage mover of the Large Angle Detector Mover (which is one of the three long lead items that were reviewed during the Advanced Procurement Review on April 23)

On April 23rd, the XCS Instrument Integrated Team conducted an Advanced Procurement Review for its long-lead items: the XCS diffractometer, the XCS Large Angle Detector Mover and the XCS Large Offset Monochromator. The XCS instrument integrated team addressed the comments and recommendation in the report, and is in the process of modifying the documentation as suggested by the review committee in order to move forward with the procurement process for these items.

The XCS instrument has one job opening for a second scientist position, provided by the Experimental Facility Division of LCLS. Action was taken to identify qualified candidates. Interviews should be conducted in June 2009.

The XCS Instrument Scientist, Dr. A. Robert, traveled to the European Synchrotron Radiation Facility (Grenoble, France), to join the DESY Team of Dr. Gerhard Grübel, in order to participate in an accepted proposal beamtime. The ESRF allocated LUSI some beamtime to continue the commissioning of the Split and Delay unit (that will be installed at the XCS instrument, as described in the recently signed SLAC/DESY MoU). The goal of the commissioning was to test the performance of the Split and Delay unit when using Bragg silicon crystal instead of Laue crystals. The experiment was successful and we could operate the device with this new configuration, which is the preferred one for the XCS instrument. The performances of the Laue configuration are now accepted for publication as described later in this document.

The XCS Instrument Scientist, Dr. A. Robert published in the *Brazilian Journal of Physics*. This work investigated the magnetic field induced anisotropic dynamics of a ferroglass by mean of X-ray Photon Correlation Spectroscopy.

“Repulsive and attractive ferroglasses: a SAXS and XPCS study”, E. Wandersman, Y. Chushkin, E. Dubois, V. Dupuis, G. Demouchy, A. Robert and R. Perzynski, *Brazilian Journal of Physics* **39 (1A)**, 210 (2009)

The XCS Instrument Scientist, Dr. A. Robert, is part of the collaboration regarding the Split and Delay development from DESY. The DESY team has submitted a scientific article to *Optics Letters* (describing the performances of the prototype) in which the XCS instrument scientist is co-author. The article is now accepted for publication and will appear in the June edition of *Optics Letters*:

1768 OPTICS LETTERS / Vol. 34, No. 12 / June 15, 2009

Performance of a picosecond x-ray delay line unit at 8.39 keV

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A prototype device capable of splitting an x-ray pulse into two adjustable fractions, delaying one of them with the aim to perform x-ray photon correlation spectroscopy and pump-probe type studies, was designed, manufactured, and tested. The device utilizes eight perfect silicon crystals in vertical 90° scattering geometry. Its performance has been verified with 8.39 keV synchrotron radiation. The measured throughput of the device with a Si(333) premonochromator at 8.39 keV under ambient conditions is 0.6%. Time delays up to 2.62 ns have been achieved, detected with a time resolution of 16.7 ps. © 2009 Optical Society of America
OCIS codes: 340.0340, 340.6720, 140.2600, 320.7100.

- Design

The XCS Instrument Team continued to interact intensively with LCLS Conventional Facility staff regarding the design effort for the hutches located in the Far Experimental Hall. The XCS Instrument Team reviewed the FEH hutches drawings: Issued For Bid and Issues for Construction. A list of comments was generated.

- Detector

The suggested update of the requirement for the pixel size (i.e. 55µm) of the XCS detector developed by BNL was presented at the LDAC Review Committee (May 7-8, 2009). The review committee agreed and validated the change of specification. BNL presented the early concept of a detector which already incorporated this change.

The scope addition of an “Early Science” XCS detector (i.e. a duplicate of the XPP detector) which would be delivered at a date consistent with the “Early Science” XCS milestone was discussed with BNL. The details (BCR, cost and schedule) are being finalized.

- Procurement

There are no ongoing procurements for the XCS instrument. However, the completion of the XCS Advanced Procurement review (held on April 23), allowed LUSI to start the procurement process for the three XCS long lead items:

- XCS Diffractometer
- XCS Large Angle Detector Mover
- XCS Large Offset Monochromator

The purchase orders of these three items will be initiated when LUSI receives the DOE approval to procure these long lead items.

- Component Status

There is no specific status to report on any XCS component.

- Assessment and Issues:
None.

WBS 1.5 Diagnostics and Common Optics (DCO)

- Management and Safety

WBS 1.5 cumulative obligations to date (actual costs + accruals) are \$1,319K. Schedule and cost indices for WBS 1.5 are 0.94 and 0.98, respectively

- General

During the month of May efforts were concentrated on finishing the drawings for the Profile Intensity Monitor (PIM) and the Intensity Positioning Monitor (IPM). Details on the Attenuator design are being worked on. The Pulse picker blade bounce was determined to be within an acceptable range. A desire to use mechanical limit switches on the actuators was expressed by the controls group. We are working to accommodate this request.

- Design

- **Monitors:**

Based on the recommendations from the final design review held on April 17, design details were finalized. Updates are being incorporated to the 6 DOF alignment stand and the IPM, PM, and PIM chambers based on the feedback received on the fabrication of the first article items. The wave front monitor detailing will start toward the end of June.

- **X-Ray Lenses:**

The lens holder assembly drawing package was completed. The first article holder assembly order has been placed. The system repeatability and accuracy could be tested using the first articles of the IPM.

- **Slits:**

Contract award is expected in June. Once the contract is awarded, LUSI can start to obtain the vendor information needed to create the drawings for the assembly and the stand.

- **Attenuator/Pulse Picker:**

Specs on the pulse picker were relaxed. Pulse picker aperture requirement is now 3 mm and the open/close cycle is 11 ms.

We are waiting on an order of epoxy to start validation of bonding process for the pulse picker blade.

The inspection mirror alignment concept was validated with a prototype.

Detailing of the mirror holder model and drawings are in process.

Vendor drawings for the attenuator actuator were revised to incorporate changes needed for our application. Our test actuator was sent back to the vendor for inspection.

Drawing for chamber assembly and holders are in work.

- **Harmonic Rejection Mirrors:**
Design efforts continue in preparation for the PDR. The current approach employs the use of in-vacuum stages to tilt the mirrors. The progress is in line to have PDR prior to the Final Instrument Design Review for XCS.
- Procurement
 - Two 6 DOF stands for the IPM and PIM first articles were received.
 - Two chambers for monitor first articles are being made by the Klystron group. Delivery is expected in the middle of July.
 - Ordered Silicon wafers for attenuators, 25.4 mm dia, 20, 40 and 80 micron thick. Requisition number is [0000144348](#). This is an ARRA order.
 - Ordered lens pack holder for first article of the Be-lens system, requisition [0000144629](#). This is an ARRA order.
 - Placed requisition for the rotationally parabolic refractive Be lenses, requisition [0000144423](#). This is foreign procurement not funded with ARRA money.
 - Selection process for the Responses to RFP 2611 was performed. Selection memo was drafted.
 - There were two responses to the Beryllium focusing lens Fed Biz Ops posting.
- Component Status
 - HRM Preliminary Design Review is scheduled for June 15.
 - XFLS Final Design Review is scheduled for June 25.
- Assessment and Issues:
Pulse Picker speed performance results were deemed acceptable. The IPM, PIM and PM first articles are progressing well.

The rules associated with ARRA funding are taxing the procurement schedule with an addition of four to six weeks on items that could have been ordered on blanket orders. An example of this is the Beryllium lens holder.

WBS 1.6 Controls and Data Acquisition (CDA)

- Management and Safety

WBS 1.6 cumulative obligations to date (actual costs + open commitments) are \$577K. Schedule and cost indices for WBS 1.6 are 0.94 and 0.96, respectively.

- Design

The CXI and XCS Controls and Data Systems Preliminary Design Reviews were held on May 11. Material and the review report are posted at:

https://confluence.slac.stanford.edu/display/PCDS/CXI_XCS-PDR

There were no major findings during the review.

Work on off-line data management continued this month. The work concentrated on defining the data-format translator to convert on-line data formats to HDF5 data formats. We also started to investigate an electronic logbook, see:

<https://confluence.slac.stanford.edu/display/PSDM/Electronic+Logbook>

Controls personnel are continuing the discussions with LUSI scientists regarding data processing. A draft of the Engineering Specification Document for the common portion of the data processing system for the three instruments was prepared.

- Detector

We are continuing to perform noise measurements on the XPP detector readout integrated circuit at SLAC. We also continue to interact with BNL to bring up their test setup which also has one of the circuits.

The layout of the next application specific integrated circuit (ASIC) planned for fabrication was finished. This ASIC was submitted to design-rule and layout-versus-schematic verification. The ASIC came back without issues and is now awaiting fabrication. ASIC fabrication is expected to take about 6 weeks.

- Procurement

We are continuing to order the control hardware for the XPP instrument.

- Assessment and Issues:

None.

LUSI Cost and Schedule Performance- May 2009

SLAC Linear Accelerator Center Menlo Park, California	LUSI Cost/Schedule Status Report (May 2009)								Date:	6/17/2009
Performance Data										
WBS[2]	Cumulative to Date					At Completion			Indices	
	Budgeted Cost		Actual Cost	Variance		Budgeted	Latest Revised Estimate	Variance	SPI	CPI
	Work Scheduled	Work Performed	Work Performed	Schedule	Cost					
	0	0	0	0	0	0	0	0	0	0
1.1 PROJECT MANAGEMENT	2,443,223	2,443,223	2,332,191	0	111,032	4,955,382	4,902,222	53,160	1.00	1.05
1.2 X-RAY PUMP PROBE (XPP)	2,317,210	2,297,731	2,202,126	-19,479	95,605	5,728,269	5,741,719	-13,450	0.99	1.04
1.3 COHERENT X-RAY IMAGING (CXI)	1,348,551	1,360,514	1,146,651	11,963	213,863	9,526,715	9,689,388	-162,673	1.01	1.19
1.4 X-RAY CORRELATION SPECTROSCOPY (XCS)	1,062,774	953,953	922,572	-108,821	31,380	7,169,717	6,879,132	290,586	0.90	1.03
1.5 DIAGNOSTICS & COMMON OPTICS	1,369,054	1,292,268	1,318,860	-76,786	-26,592	8,888,058	8,700,592	187,466	0.94	0.98
1.6 CONTROLS AND DATA ACQUISITION	587,906	553,996	576,786	-33,910	-22,790	7,223,124	7,283,924	-60,800	0.94	0.96
Gen. and Admin.	0	0	0	0	0	0	0	0		
Undist. Budget						0	0	0		
Sub Total	9,128,718	8,901,685	8,499,186	-227,034	402,498	43,491,265	43,196,977	294,287		
Management Resrv. (MIE)						11,608,735	11,903,023	-294,287		
Total MIE	9,128,718	8,901,685	8,499,186	-227,034	402,498	55,100,000	55,100,000	0	0.98	1.05
2.0 Other Project Costs (OPC)	4,851,861	4,851,861	4,851,861	0	0	4,851,861	4,851,861	0		
Management Resrv. (OPC)						48,139	48,139	0		
Total OPC	4,851,861	4,851,861	4,851,861	0	0	4,900,000	4,900,000	0		
Sub Total (MIE+OPC)	13,980,579	13,753,546	13,351,047	-227,034	402,498	48,343,126	48,048,838	294,287		
Total Management Reserve						11,656,874	11,951,162	-294,287		
Total Project Cost (TPC)	13,980,579	13,753,546	13,351,047	-227,034	402,498	60,000,000	60,000,000	0		

LUSI ACTUAL COSTS – May 2009

LUSI MIE Project			
WBS Level 2	Actual Cost of Work Performed - May 2009		
	Non-ARRA	ARRA	Total
1.1 PROJECT MANAGEMENT	\$2,265,471	\$66,720	\$2,332,191
1.2 X-RAY PUMP PROBE (XPP)	\$2,139,687	\$62,439	\$2,202,126
1.3 COHERENT X-RAY IMAGING (CXI)	\$968,106	\$178,545	\$1,146,651
1.4 X-RAY CORRELATION SPECTROSCOPY (XCS)	\$821,320	\$101,253	\$922,573
1.5 DIAGNOSTICS & COMMON OPTICS	\$1,192,513	\$126,347	\$1,318,860
1.6 CONTROLS AND DATA ACQUISITION	\$490,235	\$86,551	\$576,786
Total	\$7,877,332	\$621,855	\$8,499,187

May 2009 Performance	AYK\$
Total Project Cost (TPC)	\$60,000
Planned % Complete (MIE)	21.0%
Actual % Complete (MIE)	20.5%
Total MIE Cost	\$55,100
ACWP (MIE)	\$8,499
Budget at Complete (MIE)	\$43,491
Work Remaining (MIE)	\$34,992
MIE Remaining Management Reserve (Based on BAC)	\$11,609
% Management Reserve on Work Remaining (MIE)	33.2%

The LUSI cost and schedule are consistent with the approved baseline with a Total Estimated Cost (TEC) of \$42.7M and a Total Project Cost (TPC) of \$60M. The CD-4 milestone is August 2012. All costs are in actual-year dollars and out-year costs are escalated.

The May 2009 Cost Performance Report is the eighth month of reported earned-value on LUSI. Schedule and cost indices are 0.98 and 1.05, respectively.

The projected Estimate at Complete (EAC) of \$43,197K provides the most current estimate of the MIE final cost. Management reserve on EAC is considered adequate for this stage of the project. LUSI is evaluating possible scope changes to the approved baseline. Scope changes will be presented to the LUSI Technical Configuration Control Committee (TCCC) and the LCLS Change Control Board for approval prior to being added to the baseline.

LEVEL 1 & 2 MILESTONES

MILESTONE DESCRIPTION	Baseline	Projected	Variance		CY 2008	CY 2009	CY 2010	CY 2011	CY 2012
LUSI - Project Management									
Level 1 DOE HQ Milestones									
CD-0 MISSION NEED APPROVAL	08/10/05A	08/10/05A	0 days						
APPROVED: CD-1 COST RANGE	09/27/07A	09/27/07A	0 days	▼					
APPROVED: CD-2 PERFORMANCE BASELINE	10/22/08A	10/22/08A	0 days		▼				
APPROVED: CD-3 FABRICATION START	4/12/10	10/12/09	120 days				▲ ▲		
APPROVED: CD-4 START OF OPERATIONS	8/31/12	8/31/12	0 days						▼
Level 2 - DOE Local Milestones									
COMPLETE: CD-2 REQUIREMENTS - XPP / CXI / XCS	08/18/08A	08/18/08A	0 days		▼				
APPROVED: ADVANCE PROCUREMENT-XPP&CXI	01/30/09	12/19/08A	20 days (A)			▼			
APPROVED: FAB START - XPP	05/07/09	3/12/2009A	37 days (A)			▼			
APPROVED: ADVANCE PROCUREMENT-XCS&DCO	08/03/09	6/15/2009A	32 days (A)			▼			
COMPLETE: CD-3 REQUIREMENTS	01/15/10	09/24/09	72 days			▼			
COMPLETE: XPP PHASE 1 INSTL-START EARLY SCIENCE	10/20/10	10/20/10	0 days				▼		
COMPLETE: CXI PHASE 1 INSTL-START EARLY SCIENCE	08/30/11	08/30/11	0 days					▼	
COMPLETE: XCS PHASE 1 INSTL-START EARLY SCIENCE	08/05/11	08/05/11	0 days					▼	
APPROVED: FINAL INSTRUMENT READINESS REVIEW	03/30/12	03/30/12	0 days						▼
BASELINE - ▼ PROJECTED (Early) - ▲ PROJECTED (Late) - ▼ ACTUAL - ▼									

GLOSSARY

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 LUSI 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 management reserve.

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.

Major Item of Equipment (MIE) - Capital equipment or automated information system components with a total estimated purchase value of \$2,000,000 or more, including costs that are capitalized and not related to construction.

Other Project Cost (OPC) – LUSI “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 Management Reserve Remaining – The ratio of remaining management reserve dollars to remaining line item (TEC) work calculated as follows: the numerator is equal to the management reserve 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 LUSI.

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 MIE budget authorized for the LUSI project for the construction phase of the project. TEC includes management reserve but does not include OPC.

Total Project Cost (TPC) – The total budget authorized for the LUSI project, including MIE 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 LUSI work plan which is used to track all resources, schedules, and cost.