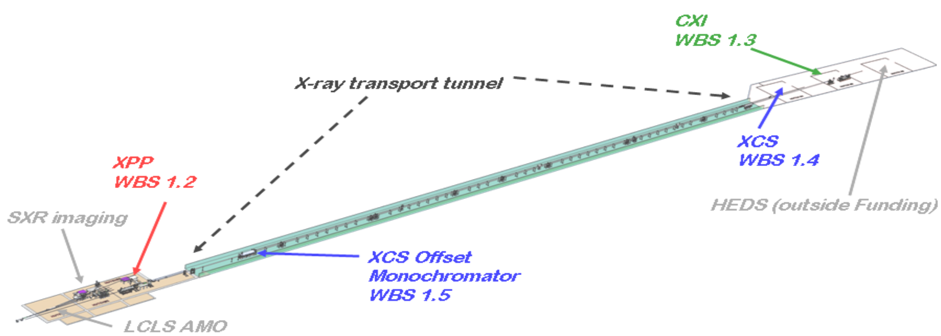
PROJECT EXECUTION PLAN

For
The Linac Coherent Light Source
Ultrafast Science Instruments (LUSI) Project,
Stanford Linear Accelerator Center
Revision (1)

Lead Program Office:

Office of Basic Energy Sciences
Office of Science



Department of Energy
Stanford Site Office

August 2008

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Revision Record

Rev	**Description**	**Date**
0	Preliminary Project Execution Plan for Critical Decision 1 (CD-1), Approval of Alternative Selection and Cost Range	August 2007
1	Project Execution Plan for Critical Decision 2, Approval of Linac Ultrafast Science Instruments (LUSI) Performance Baseline including X-ray Pump Probe (XPP), Coherent X-ray Imaging (CXI), and X-ray Correlation Spectroscopy (XCS)	August 2008

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1.0 MISSION NEED

The mission of the Department of Energy's (DOE) Office of Science (SC) is "To advance basic research and the instruments of science that are the foundations for DOE's applied missions, a base for U.S. technology innovation, and a source for remarkable insights into our physical and biological world, and the nature of matter and energy." Within SC, the Office of Basic Energy Sciences (BES) program's responsibilities include planning, constructing, and operating major scientific user facilities to serve researchers from universities, Federal laboratories, and industry.

Throughout its history, DOE's Office of Science has designed, constructed, and operated many of the nation's most advanced, large-scale research and development user facilities, of importance to all areas of science. These state-of-the art facilities are shared with the science community worldwide and contain technologies and instruments that are available nowhere else. Each year, these facilities are used by more than 18,000 researchers from universities, other government agencies, private industry, and foreign nations.

The mission of the Stanford Linear Accelerator Center (SLAC) is to advance the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to probe the structure of matter at the atomic scale with x-rays and at much smaller scales with electron and positron beams.

Under the DOE M&O Contract (DE-AC02-76-SF00515), the Linac Coherent Light Source (LCLS) as described in the "*Facilities for the Future of Science: A Twenty-Year Outlook" dated November 10, 2003,* is currently under construction for the Office of Science at the Stanford Linear Accelerator Center (SLAC) . The LCLS is building upon and utilizing DOE's extensive knowledge, strengths and experience as the steward of the world's greatest collection of shared, multidisciplinary scientific user facilities. It is also leveraging upon core competencies in accelerator science and technology at the collaborating institutions. When SLAC, and its collaboration with six national laboratories and universities, completes the LCLS in FY 2010, there will be no other facility in the world able to match its scientific power as a new x-ray tool for discovery.

The LCLS will serve as a research and development center for X-ray Free Electron Laser (XFEL) physics in the hard x-ray regime and as a scientific user facility for the application of XFEL radiation to experimental science. It will bring a completely new dimension to the use of x-rays to study matter through its unique properties never before available. Currently synchrotron light sources produce x-rays to study how their atomic structures affect the properties of materials but the synchrotron light sources cannot produce ultra-short pulses, so they cannot resolve the ultra-fast motions of atoms during chemical reactions. The LCLS is a revolutionary advance within the synchrotron radiation world, since it produces the x-rays associated with synchrotron light sources, and these x-rays are produced in ultra-short, ultra-intense pulses. The tremendous brightness of the LCLS x-ray pulse will also be invaluable for imaging the atomic structures of small static objects. Individual single molecules or small clusters of molecules may be able to be imaged.

The purpose of the Linac Coherent Light Source Ultrafast Science Instruments (LUSI) project is to expand the unique scientific capability of the LCLS by building three x-ray instruments over a period of six fiscal years (2007 – 2012). As LCLS, LUSI Project will be executed under the DOE M&O Contract (DE-AC02-76-SF00515) at SLAC. LUSI will deliver the X-Ray Pump Probe diffraction (XPP) on time during the LCLS readiness for operation in 4Q FY2010. The second instrument, Coherent X-ray Imaging (CXI) will be delivered in 4Q FY2011, and the third instrument, X-Ray Correlation Spectroscopy (XCS), along with the first two instruments, will be completed in FY2012. After each delivery, LCLS Operation will initiate the commissioning of each instrument.

2.0 PROJECT DESCRIPTION

2.1 TECHNICAL OBJECTIVE

The LUSI project will augment, with three x-ray instruments the LCLS construction project's initial instrument. These three instruments, managed as one Major Item of Equipment (MIE) Project, will be built over a period of six fiscal years (2007 – 2012) and are planned to be phased into operation between 2010 and 2012. The instrument concepts have been developed based on the advice of the LCLS Science Advisory Committee in response to an open call for letters of intent from the breadth of the scientific community. One of the two instruments will be optimized for hard x-ray studies of ultrafast dynamics at the atomic level, addressing basic problems in chemistry and materials science; another will concentrate on hard x-ray coherent imaging of nano-particles and large bio-molecules. The third will study the equilibrium dynamics on the nanometer scale using hard x-rays. These instruments will complement the other instrument at LCLS, which is directed towards atomic physics. In keeping with the guidelines for Project Management for the Acquisition of Capital Assets (DOE O 413.3A), these instruments are grouped as a set of deliverables under a single MIE project work breakdown structure (WBS).

2.2 PROJECT SCOPE

The three instruments contained in the LUSI MIE project and their capabilities are described as follows:

<u>X-ray Pump / Probe Instrument</u>

The X-Ray Pump Probe instrument will predominantly use a fast optical laser to generate transient states of matter, and the hard x-ray pulses from the LCLS to probe the structural dynamics initiated by the laser excitation. The laser pump will have the ability to conduct precise optical manipulations, in order to create the desired excited states. An ultrafast laser pulse excites a brief change in the positions of the atoms in the sample. This change is studied using scattering of the LCLS x-ray pulse, which follows the laser pulse after a precise time delay.

The instrument design will emphasize versatility. These experiments require the union of four experimental capacities: the generation and delivery of x-ray and laser pulses to the sample, the preparation of the excited state in the sample, and the detection of the x-ray scattering pattern. To maximize the range of phenomena that can be excited, it will be necessary to be able to manipulate the laser pulse energy, frequency, and temporal profile. X-ray scattering will be the dominant tool for probing the laser-induced changes. LUSI will provide the x-ray spectrometer and two-dimensional detector as well as x-ray diagnostics and experimental controls to record the x-ray scattering patterns.

Facilities for carrying out time-resolved x-ray scattering measurements exist at every synchrotron light source, since this is such an important and wide field of research. What makes this instrument unique is that no existing facility can come close to matching the brightness and time resolution at LCLS. This will be the only instrument capable of mapping out the progress of complex structural changes associated with technologically-important chemical reactions on the sub-picosecond time scale that is most relevant for them.

Coherent X-ray Imaging Instrument

The Coherent X-ray Imaging instrument will take advantage of the extremely bright, ultrashort LCLS pulses of hard x-rays to allow imaging of non-periodic nano-scale objects, including single bio-molecules or small clusters, at or near atomic resolution. A coherent pulse of x-rays illuminates the sample, producing a continuous diffraction pattern from a non-crystalline specimen. The diffraction pattern is recorded by a pixel array detector, which has high quantum efficiency and dynamic range. When such a coherent diffraction pattern is sampled at spacings sufficiently finer than the inverse of the sample size, the phase information can be directly retrieved by using an iterative process.

In combination with the LCLS, coherent x-ray imaging can potentially provide a new horizon of imaging nanoscale materials and large single macromolecules at or near atomic resolution in three dimensions. Resolution in these experiments would not depend on sample quality in the same way as in conventional crystallography, but would be a function of radiation intensity, pulse duration, wavelength, and the extent of ionization and sample movement during the exposures. The full peak brightness of the LCLS is exploited when imaging biological materials such as viruses and single macromolecules. The penetration depth of hard x-rays in combination with the coherent nature of the radiation will permit detailed 3D study of large, non-periodic structures, and provide capabilities that will go beyond conventional scanning probe microscopy, electron microscopy or x-ray crystallography.

X-ray Correlation Spectroscopy Instrument

The unprecedented brilliance and narrow pulse duration and unique coherence properties of the LCLS provides a unique opportunity to observe dynamical changes of large groups of atoms in condensed matter systems over a wide range of time scales using x-ray photon correlation spectroscopy . In contrast to the study of stimulated dynamics (pump-probe), the x-ray photon correlation spectroscopy technique studies equilibrium fluctuations excited by the thermal energy of the sample. Images of the speckle scattering pattern are taken with various time delays between images, and the change in the speckle pattern as a function of time delay is used to study the sample dynamics.

The technique of correlation spectroscopy was first applied to visible light scattering. Using time- or energy-resolved light-scattering techniques, it is currently possible to probe the full range of time scales, from fractions of a microsecond through kiloseconds. However, measurements with visible light are generally not sensitive to the atomic length scales relevant for intermolecular interactions in condensed matter. Third-generation synchrotron sources have provided enough coherent x-ray flux to use x-ray photon correlation spectroscopy in cases where the dynamics are relatively slow and the scattering power of the sample is relatively large. These measurements are severely limited, however, by the low coherent flux available from even the brightest existing synchrotron source, and from time resolution limitations imposed by the relatively long synchrotron pulse length. The high coherent flux (many orders of magnitude above that available today) and short pulse lengths produced by LCLS will allow the technique to be extended to much more weakly-scattering systems and to much faster time scales opening up new opportunities for the investigation of dynamical phenomena ranging from several femtoseconds to several nanoseconds.

3.0 MANAGEMENT ORGANIZATIONS AND RESPONSIBILITY

An Integrated Project Team (IPT) comprised of the DOE, SLAC, and other participants as appropriate, is in place. SLAC is responsible for instrument design, fabrication, installation and inspection, and overall day-to-day management of the project. The roles and responsibilities of project participants are summarized in the following subsections.

The LUSI project instruments will be commissioned and operated by the LCLS facility. The IPT will establish coordinated interfaces with the LCLS project including those related to design, installation, and construction interfaces, quality assurance, systems engineering, and environment, safety, and health (ES&H).

3.1 DEPARTMENT OF ENERGY

Within the DOE Office of Science, the Director for the Office of Basic Energy Sciences (BES) will serve as the Acquisition Executive (AE) and approve Critical Decisions subsequent to CD-0 (reference R. L. Orbach memorandum, subject: Action: Approval of the Mission Need Statement for a Linac Coherent Light Source Ultrafast Science Instruments (LUSI) Major Item of Equipment project, dated August 15, 2005), approve Level 1 baseline changes, and conduct quarterly project performance reviews.

A LUSI Program Manager in the DOE Office of Basic Energy Sciences has been assigned to carry out day-to-day program management of the project. The LUSI Program Manager's responsibilities include:

- Define program mission requirements and objectives;
- Function as DOE HQ point of contact for project matters;
- Oversee project progress and help organize reviews as necessary;
- Coordinate with other DOE HQ organizations as needed to execute the project;
- Participates in Quarterly Reviews, ESAAB Equivalent Board meetings, and project reviews;
- Ensures ES&H requirements are implemented by the project;
- Budget for funds to execute the project; and
- Control changes to project baselines in accordance with this preliminary PEP.

A LUSI Federal Project Director (FPD) at the DOE Stanford Site Office (SSO) has been assigned and the FPD's responsibilities include:

- Provide overall project management oversight;
- Function as the DOE Field point of contact for project matters;
- Lead and manage all IPT matters requiring coordination with SSO;
- Maintain effective communications between SC and the SLAC project staff;
- Provide project baselines to SC and assess contractor performance against them;
- Issue Project Directives to authorize work within funding levels provided in approved Financial Plan Changes;
- Approves Level 2 change control proposals as delegated by the AE. Review and provide recommendations to the AE for Level 0 and 1 change control proposals;
- Authorizes use of project contingency in accordance with the levels described in this preliminary PEP;
- Participates in Quarterly Project Reviews, ESAAB Equivalent Board meetings, and project reviews conducted by the LUSI project and DOE HQ;
- Conducts management meetings to monitor and review status of project activities;
- Ensure that the project complies with applicable ES&H requirements;
- Submit budget requests to SC for funds to execute the project;
- Submit key project documents to SC for concurrence/approval;
- Ensure that the contractor delivers instruments meeting mission requirements;
- Report progress and update LUSI project data in the DOE Project Assessment and Reporting System (PARS);
- Coordinates matrix support from SC Integrated Support Centers; and
- Prepares and submits budget and funding documents to the BES program manager.

3.2 STANFORD LINEAR ACCELERATOR CENTER (SLAC)

SLAC is organized into six directorates, Engineering and Technical Support, Operations, LCLS, SSRL, Photon Sciences, and Particle Physics and Astrophysics. The LUSI project is lead by a Project Manager (PM) who reports directly to the LCLS Project Director to ensure effective coordination and to reduce the risks associated with system integration. The LUSI Project Manager is responsible for achieving the LUSI project scope of work and for execution of all activities required by the project to meet technical, schedule and cost objectives. Specific responsibilities include:

- Manages day-to-day execution of the project at SLAC and at collaborating institutions;
- Establishes technical and administrative controls to ensure project is executed within approved cost, schedule and technical scope;
- Ensures that project activities are conducted in a safe and environmentally sound manner;
- Ensures ES&H responsibilities and requirements are integrated into the project;
- Directs overall project planning;
- Ensures that an earned value management system is utilized to monitor project performance
- Oversees technology development program, design, fabrication, installation and instrument acceptance testing;
- Represents the project in interactions with DOE. Participates in management meetings with DOE and communicates project status and issues;

- Chairs Change Control Board;
- Approves Level 3 change control proposals. Prepares and provides recommendations to the Federal Project Director for Level 0, 1 and 2 change control proposals; and
- Identifies and manages project risks.

3.3 INTEGRATED PROJECT TEAM

The purpose of the Integrated Project Team (IPT) is to support the Federal Project Director (FPD) during the acquisition process. The IPT Charter identifies the team members and their roles and responsibilities for the oversight and management of the LUSI project.

IPT Charter

The LUSI IPT is committed to meeting the scope, cost and schedule baselines of the project while maintaining safety of the workers, the public and the environment. The membership of the IPT will change as the project progresses and support needs change. If required, additional support will be provided by SSO, SC Integrated Service Center and SLAC.

The members of the LUSI IPT include:

DOE/Office of Science:
LUSI Federal Project Director, SSO
LUSI Program Manager, BES
DOE Contracting Officer, SSO
DOE ES&H Coordinator, SSO

SLAC:
LCLS Project Director, SLAC/LCLS
LUSI Project Manager, SLAC/LUSI
LUSI Chief Engineer, SLAC/LUSI
LUSI ES&H Coordinator, SLAC/LCLS
LUSI Procurement Manager, LCLS/LUSI
LUSI Project Control Manager, LCLS/LUSI
LUSI Budget/Finance Manager, LCLS/LUSI
LUSI Quality Assurance Manager, LCLS/LUSI
LUSI Instrument Scientists SLAC/LUSI
LUSI External Team Leaders (TL) & Co-Team Leaders for each instrument

Roles and Responsibilities

The FPD is assigned the leader of the IPT in executing the life cycle management of the project. The FPD has the following responsibilities:

- Provide IPT guidance
- Communicate project requirements
- Conduct regular IPT meetings

- Facilitate issue resolution
- Assess project performance with IPT input

IPT members are drawn from DOE and SLAC to work together in reaching the common goal of successfully executing the LUSI project within cost and schedule in a safe and responsible manner. IPT member responsibilities are as follows:

- LUSI Program Manager, DOE-BES. The Program Manager serves as the DOE-BES representative on the IPT.

- DOE Contracting Officer, DOE-SSO. The Contracting Officer is responsible for administering the M&O contract with Stanford University for SLAC and will monitor the contractor's execution of the LUSI project under the terms of DOE's contract with Stanford University.

- DOE ES&H Coordinator, DOE-SSO. The ES&H Coordinator provides DOE oversight of LUSI project ES&H implementation and provides subject matter expertise.

- LCLS Project Director, SLAC/LCLS reports to the SLAC Director and is responsible for ensuring LCLS/LUSI integration only.

- LUSI Project Manager, SLAC/LUSI. As Project Manager, reporting to the LCLS Project Director, the LUSI Project Manager is directly responsible for the overall project management and ensuring the project's objectives in terms of technical parameters, cost and schedule are achieved. LUSI Project Manager has the authority to direct changes in accordance with the established Baseline Change Control thresholds.

- Chief Engineer, SLAC/LUSI is responsible for all engineering aspects of the project including design, fabrication, assembly and installation efforts.

- ES&H Coordinator, SLAC/LCLS. Provides/obtains subject matter expertise in all areas of environment, safety and health to the project.

- Project Procurement, LCLS/LUSI is responsible to ensure procurement activities are in full compliance with all federal regulations to acquire goods and services in the most cost effective manner.

- Project Controls, LCLS/LUSI is responsible for maintaining the Performance Baseline and implementing the earned value management system. He/she will also be responsible for generating monthly project progress reports.

- Finance, LCLS/LUSI. The LUSI Finance person is responsible for the LUSI project's financial arrangements.

- Quality Assurance, LCLS/LUSI is responsible for ensuring compliance with the SLAC Quality Assurance Program which implements the requirements of DOE Order 414.1C

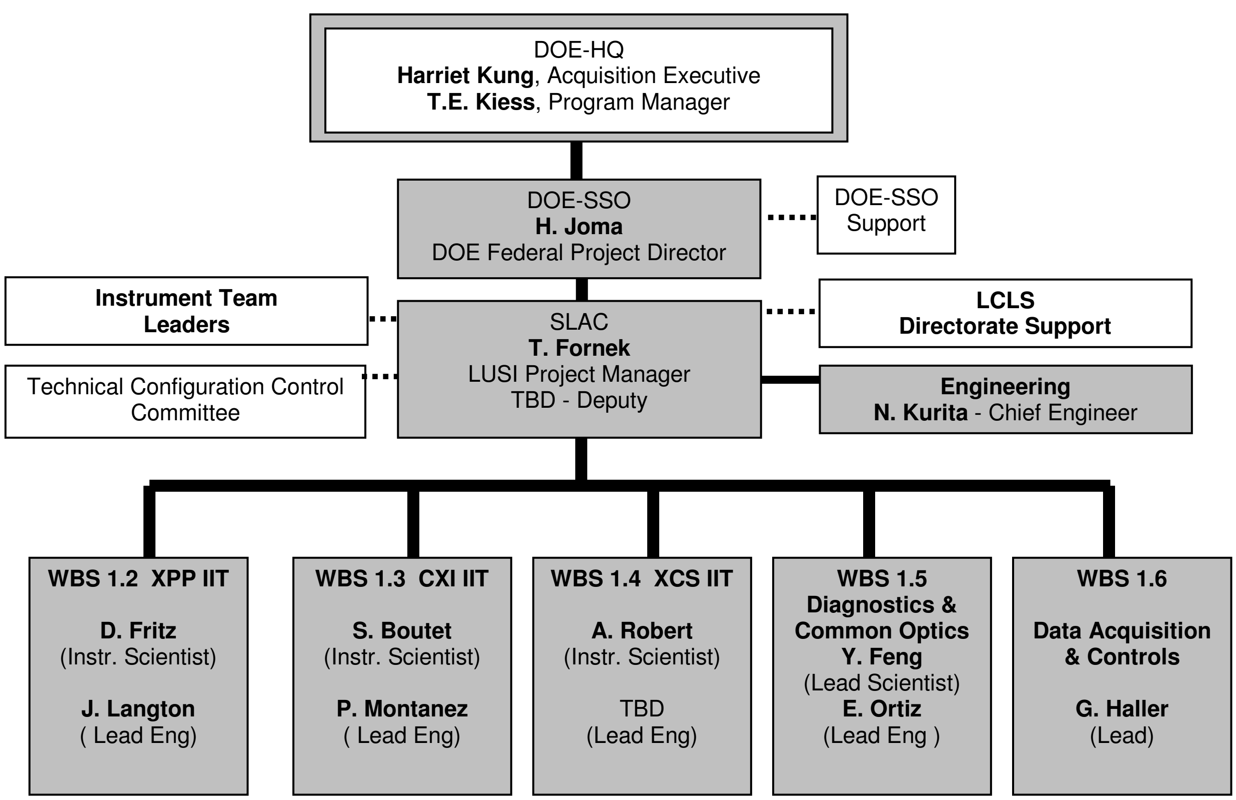
- Instrument Scientists, SLAC/LUSI. These individuals are responsible for coordination and oversight of technical construction activities including instrument design, component specification, procurement, installation and testing of the equipment and instruments.

- External Team Leaders (TL), various organizations. Each TL leads a Science Team that represents the interests of the user community for that specific instrument. Each Team consists primarily of external users, and will participate in defining the instrument technical performance parameters and instrument conceptual design to achieve the scientific goals for that instrument.

- If required, additional support will be provided by SSO and SLAC staff in the areas of ES&H; equipment procurement and inspection; budgeting and accounting; and overall quality assurance.

The functions of key IPT members are shown in Figure 3.1. For the LCLS Organization and its interface with LUSI Project refer to Appendix C.

Figure 3.1: LUSI Project's IPT organizational breakdown structure



3.4 WORK BREAKDOWN STRUCTURE (WBS)

The project has been organized into a Work Breakdown Structure (Figure 3.2) for purposes of planning, managing, and reporting project activities. Consistent with discrete increments of project work and the planned method of accomplishment, the Level 2 Work elements are defined as following:

WBS 1.1 – Project Management
WBS 1.2 – X-ray Pump Probe (XPP) instrument
WBS 1.3 – Coherent X-ray Imaging (CXI) instrument
WBS 1.4 – X-ray Correlation Spectroscopy (XCS) instrument
WBS 1.5 – Diagnostics and Common Optics
WBS 1.6 – Controls and Data Acquisition

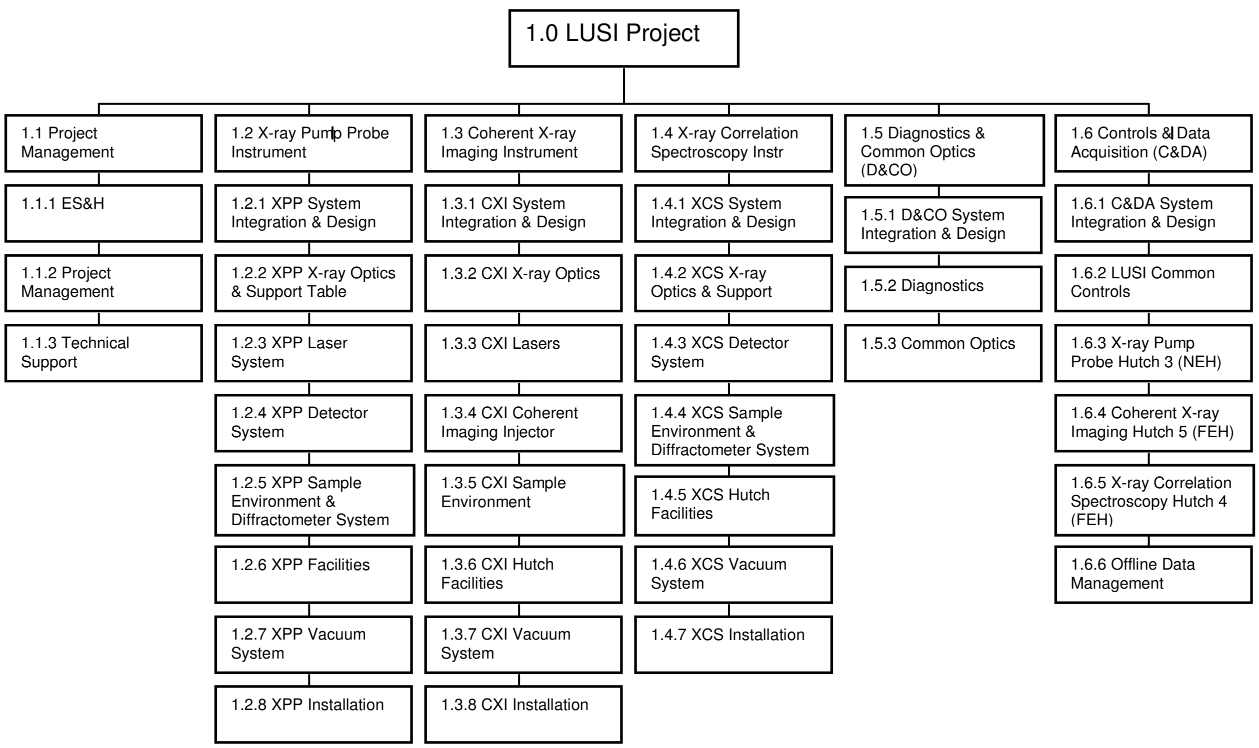


Figure 3.2 LUSI Project Work Breakdown Structure

4.0 RESOURCE REQUIREMENTS

The LUSI project is a Major Item of Equipment (MIE). The TPC for the LUSI project is estimated at $60.0 million in at year (escalated) dollars. Table 4.1 shows the most current funding profile for the LUSI project with a TPC of $60M. In order to meet the baseline schedule within the established TPC, funding has been budgeted in the BES program beginning in FY 2005 and extending through FY 2012 as follows:

Table 4.1 Projected Funding Profile for the LUSI Project

LUSI Project Funding Profile	**Prior Years**	**FY 2007**	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**	**FY 2012**	**Total**
TEC (WBS 1.0)		500	6,000	15,000	15,000	13,500	5,100	55,100
OPC (WBS 2.0)	3,400	1,500						4,900
Annual Total	3,400	2,000	6,000	15,000	15,000	13,500	5,100	60,000

5.0 PERFORMANCE BASELINE: XPP, CXI, XCS, DIAGNOSTICS, DATA ACQUISITION, CONTROL & COMMON OPTICS

The following technical scope, cost, and schedule discussion is in support of the XPP, CXI, XCS, and related Diagnostic/Common optics, and Data Acquisition/Control Performance Baseline. The three instruments performance baselines, once approved, will only be modified by approved Baseline Change Proposals, refer to Section 6.0.

5.1 TECHNICAL SCOPE

The LUSI project scope comprises designing, building, and installing three instruments. It does not include commissioning with beam which occurs as part of LCLS operations. Technical scope is defined in Table 5.1: Essential parameters for LUSI Instruments to achieve their respective Critical Decision (CD)-4. Although it is not possible to directly measure the parameters listed in Table 5.1 without beam, the capability of an instrument to eventually achieve these parameters will be demonstrated as part of the CD-4 process for each device using results of acceptance tests and/or calculations. Using this approach, CD-4 approval for each LUSI instrument is based on: demonstrating the capability to achieve the technical parameters shown below, either by acceptance testing, calculations, or some combination of testing and calculation, and successful completion of an Instrument Readiness Review (IRR).

Upon completion of CD-4 for each instrument, the LCLS operations organization will assume ownership of the instrument and will support the full cost of commissioning and operating. All LUSI project funding for the instrument/system ceases with acceptance at CD-4. With this well defined LUSI project completion milestone, there is no period of time when dual ownership of an instrument occurs.

Tables 5.1 and 5.2 describe the key performance parameters (KPPs) that are essential for each instrument as well as parameters for Controls & Data Acquisition, and Diagnostics & Common Optics, all of which are required for full operational capabilities at CD-4C.

Table 5.1: Instrument Key Performance Parameters

INSTRUMENT	PARAMETER	CAPABLE OF ACHIEVING	ACTUAL MEASUREMENT
WBS 1.2 X-ray Pump/Probe	Energy range Energy resolution	4keV-20keV* 0.1 – 0.01%	
Diffraction	X-ray detector		1000 x 1000 pixels
WBS 1.3 Coherent X-ray Imaging	Energy range Energy resolution	4keV-20keV* 0.1 – 0.01%	
	Particle injector	10-1000nm particle size	
WBS 1.4 X-ray Correlation Spectroscopy	Energy range Energy resolution	4keV-20keV* 0.1 – 0.01%	
	X-ray detector		1000 x 1000 pixels

* Using the fundamental and third harmonic

Table 5.2: Diagnostics/Common Optics, and Controls/Data Acquisition Performance Parameters

SYSTEM	KEY PERFORMANCE PARAMETER
WBS 1.5 Diagnostics & Common Optics	Attenuation – Capable of attenuating up to five orders of magnitude above the LCLS-supplied attenuation
	Pulse Selection – Ability to select single pulses from 120 Hz LCLS source
WBS 1.6 Controls & Data Acquisition	Up to 5Hz display of instrument control and data acquisition parameters. Acquire instrument and detector data at up to 120Hz pulse rate. Transport and process up to 250 Mbytes/sec initially, fully scalable as needs increase. Provide Pico-second Timing System with less than 20 ps jitter.

5.1.1 X-ray Pump Probe (XPP):

The XPP instrument will predominantly use a short pulse optical laser to generate transient states of matter and the hard X-ray pulses from the LCLS to probe the structural dynamics initiated by the laser excitation. The laser pump will have the ability to conduct precise optical manipulations in order to create the desired excited states. To maximize the range of phenomena that can be excited, capability to manipulate the laser pulse energy, frequency, and temporal profile becomes very important. X-ray scattering will be the dominant tool for probing the laser-induced structural changes, while X-ray emission spectroscopy will probe changes in electronic structure.

These experiments require integration of three (3) experimental capacities: 1) the generation and delivery of X-ray and laser pulses to the sample, 2) the preparation of the excited state in the sample, and 3) the detection of the X-ray scattering pattern or X-ray emission.

XPP will be installed in LCLS Near Experimental Hall (NEH) Hutch #3 and includes the following major systems and components:

- Diffractometer & Wide Angle Detector Mover for orienting samples and moving the 2D detector;
- 2D X-ray Detector for collecting x-ray scatter at 120 Hz;
- Laser system including multipass amplifier and pump, optics for beam transport, diagnostics and safety system; and
- Beam diagnostics, x-ray optics, controls and data acquisition.

5.1.2 Coherent X-ray Imaging (CXI)

CXI will provide for two distinct sample environments. One would be for fixed targets with a sample mounted on a holder (e.g., a thin membrane or a grid). The second would be for injection of samples with individual micron and submicron particles in the gas phase or droplets flying through the interaction region. In addition, CXI will accommodate several experimental configurations for both fixed and injected samples based on Forward Scattering as well as Time-Delay Holographic geometries.

CXI will be installed in LCLS Far Experimental Hall (FEH) Hutch #5 and includes the following major systems and components:

- *1.0 Micron Focus KB Mirrors*: KB pairs taking the full direct beam will be used to produce a 1 micron focus at the interaction plane. Provisions for the addition of a 0.1 micron focus KB mirror shall be included.
- *Room Temperature Sample Vacuum Chamber* to accommodate multiple types of samples and experimental geometries as described above.
- *Particle Injector* - with a differentially pumped nozzle - to produce a focused beam of submicron particles delivered from an aerosol at atmospheric pressure to the high vacuum of the chamber.
- *X-ray Detector (Provided by LCLS)* to measure the diffraction pattern from the sample which will have a central hole to let the direct beam pass. This will be accomplished using a tiled design. The detector will be read out after every LCLS pulse, at 120 Hz.

- Detector Stage to allow for changing the distance between sample and the Detector; larger samples will require a larger distance to allow for the diffraction pattern to be properly sampled.

5.1.3 X-ray Correlation Spectroscopy Instrument (XCS)

The XCS instrument will use the unique coherence properties and unprecedented peak and time-average brightness from the hard X-ray pulses from the LCLS. XCS will probe dynamical phenomena in condensed matter system down to atomic length scales. Small Angle X-ray Scattering, Grazing Incidence Diffraction and X-ray Diffraction techniques will be routinely operated on the XCS instrument.

These experiments require integration of three (3) experimental capacities: 1) the generation and delivery and coherence preservation of coherent X-ray pulses to the sample, 2) the control of the thermodynamic parameters of the investigated system of interest, and 3) the detection of the coherent X-ray scattering pattern.

XCS will be installed in LCLS Far Experimental Hall (FEH) Hutch #4 and includes the following major systems and components:

- Offset monochromator for narrowing the FEL spectrum, potential beam multiplexing, and control of the longitudinal coherence length;
- Diffractometer for orienting samples, including a local alignment detector;
- Wide Angle Detector Mover; and
- 2D X-ray Detector for collecting x-ray scatter at 120 Hz.

5.1.4. Diagnostics and Common optics

In order to allow the instrument to deliver their full scientific capabilities, a suite of X-ray diagnostics devices will be built to fully characterize the intensity, spatial, and temporal fluctuations of the LCLS X-ray pulses. These pulses are expected to be of much higher intensity than storage-ring based synchrotron X-ray sources. The diagnostic devices provided include pop-in profile monitors, a wavefront monitor, pop-in intensity monitors, and high precision intensity-position monitors. These devices are capable of taking measurements on a pulse-by-pulse basis.

Driven by common experimental needs and performance requirements, common X-ray optics will also be provided for manipulating LCLS X-ray pulses before being delivered to the sample. There will be precision slits for shaping and cleaning the X-ray beam, attenuators to reduce incident intensity, pulse-pickers to select single pulses or any desired pulse pattern, high harmonic rejection mirrors to remove high order components from the incident X-ray spectrum, and Beryllium refractive lenses for coarse focusing, and a monochromator for the XCS instrument to provide optimal longitudinal coherence length, and the potential capability of beam sharing with the CXI instrument. These common optics are all designed to sustain the full LCLS flux in the operating energy range of 2 to 25 keV, and to be capable of preserving the spatial coherence to the extent possible.

5.1.5 Controls and Data Acquisition

A common controls and data acquisition system for the LUSI instruments will be implemented. Controls requirements for this system for XPP, CXI and XCS will include:

- User interface to operate the LCLS Hutch Protection System (HPS) for access to LUSI instruments in the end-stations.
- User interface to operate the LCLS Laser Safety System for authorized access to LUSI laser systems in the end-stations.
- Instrument Control interface for control of LUSI instrument components including motion, vacuum, vision, and power subsystems. This control interface will include password protection for operation and allow for loading of pre-set instrument configurations.
- Instrument interface to the LCLS Machine Protection System (MPS) for the safe operation of beamline components of LUSI instruments.
- Trigger signal to all endstations with controlled delays. The jitter in the trigger signal shall be better than 20 ps with appropriate dynamic range.
- Integration of the sub-picosecond timing system being developed by the Lawrence Berkeley National Laboratory team with the LUSI ultra-fast timing measurement system.
- Compatibility with the LCLS controls system to perform exchange of information on the electron beam and the X-ray beam at a rate that shall permit real-time feedback at 120 Hz.

Data Acquisition requirements for this system for XPP, CXI and XCS will include:

- Common user interfaces for data acquisition for LUSI instruments specified in 2.2.1, including, but not limited to, the 2-dimensional detectors.
- Capability of acquiring experimental measurement data (science data) at a rate of greater than 2 Gbit/s, and scalable to 32 Gbit/s as needs increase.
- Ability to display the science data at a rate of 5 frames/s for 2-dimensional detectors of about 1 Mpixels.
- A total capacity of 20TB of local storage with the possibility of expanding to 320TB when needs increase, as well as allowing the operators in the instrument control room to browse the directory structure and the file contents of the local storage.
- Capability of acquiring auxiliary data (metadata) at a rate that is the same or higher than that for the science data for proper processing.
- Merging and linking the metadata to the associated science data before processing the science data.
- Capability of transferring data from the local storage to the long term storage system to perform data archiving and data retrieval in a manner that will not disrupt the on-going experimental measurements and will allow for network (local-to-long term) downtime for up to one week.

5.2 COST PERFORMANCE BASELINE

The cost of performance baseline for XPP (WBS 1.2), CXI (WBS 1.3), XCS (WBS 1.4) and related support systems including Diagnostics/Common optics (WBS 1.5), and Acquisition/Data Control (WBS 1.6) is established as indicated in Table 5.3. The estimate is prepared by LUSI project staff in FY 2006 and subsequently revised in FY 2007/FY2008 based on numerous factors ranging from engineering estimates to quotes from other DOE laboratories and commercial vendors.

Table 5.3 Performance Cost Baseline for XPP, CXI, XCS, and Related Diagnostics, Data Acquisition/Control

WBS	Description	CD-2 Est. ($M)
1.1	Project Management	5.5
1.2	X-ray Pump Probe (w/BNL)	5.9
1.3	Coherent X-ray Imaging (w/LLNL)	9.5
1.4	X-ray Correlation Spectroscopy (w/BNL)	7.7
1.5	Diagnostics & Common Optics	6.4
1.6	Controls & Data Acquisition	7.1
	Contingency	13.0
2.0	Other Project Costs	4.9
LUSI Total Project Costs		60.0

The cost estimates for XPP, CXI, XCS, and related Controls and Diagnostics have been derived from knowledge of the component systems further defined during the preliminary design as well as assembly, management, contingency and Other Project Costs. There is a high confidence in the estimates for the instruments because of a solid basis-of-estimates built upon actual quotes as well as existing cost benchmarks of similar instruments recently built worldwide. Within Other Project Costs (OPC), only costs for limited readiness review and acceptance testing (based on calculations and simulations) are included in the LUSI project. Costs associated with full commissioning are not part of the Project and will be born by LCLS Operation.

5.3 SCHEDULE PERFORMANCE BASELINE

LUSI Project baseline schedule for XPP, CXI and XCS Critical Decisions are shown in Table 5.4 below.

LUSI Project CD-0 Mission Need Approved: August 2005 Description	CD-1 Cost Range Approval	CD-2 Performance Baseline Approval	CD-3 Construction Start Approval	CD-4 Start of Operations Approval
X-Ray Pump/Probe Diffraction (XPP)	09/27/2007	4Q FY2008	(A) JUN2009	(A) DEC 2010
Coherent X-Ray Imaging (CXI)			(B) APR 2010	(B) DEC 2011
X-Ray Correlation Spectroscopy (XCS)			(C) APR2010	(C) AUG 2012
PROJECT COMPLETE				AUG 2012

Table 5.4 LUSI Project XPP, CXI Critical Decision Schedule

6.0 BASELINE CHANGE CONTROL PROCESS

6.1 PHASING CRITICAL DECISION APPROVALS: A TAILORED APPROACH

Typically for these types of instruments/systems, the period for design, construction and installation will take 3 – 4 years beyond the development of the preliminary design. In order to accommodate the constrained funding profile and the risk associated with anticipated Continuing Resolutions throughout the life of the project, the LUSI project will use a phased approach for approval of the baseline (CD-2), construction start (CD-3) and start of operations (CD-4). This phased approach is consistent with the methodology recommended by DOE Order 413.3A.

As part of CD-0 approval, the Director for Basic Energy Sciences was delegated as the Acquisition Executive (AE) responsible for all subsequent Critical Decision (CD) approvals for the project. Hence, the AE will approve the phased CDs associated with the individual instruments. CD-2, planned for 4th quarter of FY 2008, is for baseline approval of the XPP, CXI and XCS instruments. Approvals for the start of construction of instruments are phased as follows:

1- XPP, planned for the 3rd quarter of FY 2009 (CD-3A), and
2- CXI and XCS (CD-3B and CD-3C) planned for the 3rd quarter of FY 2010.

Approvals of the initial operations for XPP and CXI are planned for the 1st quarter of FY 2011 (CD-4A) and the 1st quarter FY 2012 (CD-4B), respectively. For initial operations, the planned configuration is for CXI to be installed in the Far Experimental Hall with a 1 micron focus, its detector, and related diagnostics and controls, and for the XPP to be installed in the Near Experimental Hall using a shared laser system, its detector, and related diagnostics and controls. Although these two instruments will have limited capabilities, this initial phase of operation will allow early experiments to be conducted at LCLS beginning in FY 2010. Upon approval of CD-4C and project completion in the 4th quarter of 2012, all instruments, including XCS, will be fully operational.

6.2 APPROVAL LEVELS FOR CHANGE CONTROL

Change approval levels listed in Table 6.1 control the project baselines. Baseline Change Requests (BCRs) will be approved as necessary to modify the baseline. Any Level 1 and 2 BCRs will be reviewed by the project's Baseline Change Control Board (BCCB) prior to submittal to DOE for approval. The BCCB will include the LUSI Federal Project Director, the LUSI Project Manager, the instrument scientist and the Chief Project Engineer.

6.3 CONTINGENCY MANAGEMENT

Contingency is budgeted to cover costs that may result from incomplete design and uncertainties associated with market conditions, technical difficulties, schedule delays, and other circumstances commonly encountered during project execution. The amount of contingency budgeted will depend on the level of risk associated with each instrument/system at the time it is baselined. Contingency is not included in the baseline for external factors that cannot be reasonably foreseen or quantified, such as major regulatory changes, annual funding shortfalls (appropriation less than baseline funding level). When such circumstances occur, they are treated as “Directed Changes”, requiring work-around plans and/or additional schedule and budget allowances.

Upon CD-2 approval, the LUSI performance baseline is established, as a funding level for each of the major WBS elements, and a contingency estimated for the project. This overall contingency estimate was derived as the sum of individual contingency contributions that were developed for each major cost element, at work breakdown structure (WBS) element level 4 or below, using a risk-based approach. This approach is described in the LUSI Risk Management Plan. Each contribution to the total contingency is based on an assessment of the technical, cost, and schedule risk combined with a weighting factor that reflects the type of cost (labor or material). This yields the contingency percentage for this element of the project. The contingency contribution is determined by multiplying the base cost by the calculated contingency percentage.

The use of contingency funds will be managed by the LUSI Federal Project Director and the SLAC/LUSI Project Director. Formal baseline changes will be made through the baseline change control process. BCR approval levels are based on the Baseline Change Control Thresholds described in Table 6.1. The LUSI Project Manager approves Level 3 changes, the Federal Project Director approves Level 2 changes, and the SC Acquisition Executive approves Level 1 changes. Level 0 changes are approved at the Secretarial level. Approval of a BCR will increase the baseline cost estimate(s) for that WBS element, and unless there are any offsets, it will reduce the available contingency by an equal amount. During project execution post CD-2, the LUSI Project Manager will make every effort to find offsets within the project, without impacting the technical performance baseline, to minimize use of contingency. A change control log will be maintained by the project to document all approved BCRs.

Upon establishment of the performance baseline for XPP, CXI and XCS (CD-2), the EAC for completing the baseline scope will be developed to reflect management's best judgment of the forecast final cost of each WBS element. The EAC will be revised based on updated individual WBS elements whenever information becomes available that will impact the final cost of that element. By comparing to the TPC, a contingency based on EAC can be calculated at any point in time.

During project execution, the project will use a formal risk management process to evaluate cost, schedule and technical risks. Risk items are those conditions, beyond the ones recognized in the EAC, which may require future allocations of contingency.

	Performance Baseline Deviations	Routine Project Changes		
	Deputy Secretary (Level 0)	DOE-HQ Acquisition Executive (Level 1)	DOE Federal Project Director (Level 2)	SLAC/LUSI Project Manager (Level 3)
Technical Scope	A change in scope or performance that affects the ability to satisfy the mission need, or that is driven by a significant disparity between the baseline funding profile and available resources provided by Congress to the program sponsor	Any change affecting the LUSI project scope (instrument functionality and capability) as defined in PEP Section 2.2.	Any change affecting the LUSI project technical scope as defined in PEP Section 5.1. This includes any change to a KPP specification of a major technical system.	Any significant change to LUSI as defined in an instrument's Physics Requirements Document (PRD)
Schedule	A delay of 6 months or greater (cumulative) from the original project completion date	Any delay > 1 month in a Level one schedule milestone (Table 5.4)	Any delay < 1 month in a Level 1 schedule milestone or any delay ≥ 1 month in a Level 2 Milestone (Appendix A)	Any delay in a Level 3 Milestone (Appendix A)
Cost	An increase in excess of the lesser of $25M or 25% (cumulative) of the original CD-2 cost baseline (TEC or TPC)	Any increase in the baseline TEC or TPC	The smaller of the cumulative change of ≥ $600K or 20% of any WBS Level 2 cost element[1]	Any change to the Baseline

[1] *Level 2 approval is necessary when the cumulative change in cost of a WBS level 2 element increases above $600K or 20%, whichever is less. After a level 2 BCR is approved, the WBS level 2 baseline is set at the higher approved budget level and resets the cumulative changes to zero.*

Table 6.1 Summary of Baseline Change Control Thresholds for the LUSI Project

7.0 PROJECT EXECUTION AND MAJOR ASSUMPTIONS

7.1 SYSTEM ENGINEERING

System engineering principles will be employed throughout the project, especially to ensure good interface control in the development of the project from conceptual design through transition to operations. Systems engineering will be used to capture all significant interrelationships with internal and external factors that affect mission success.

7.2 RISK MANAGEMENT

Risk management is based on a graded approach in which levels of risk are assessed for project activities and elements. This assessment is based upon the potential consequences of activity or element failure, as well as the probability of occurrence. The level of formality of the quality assurance requirements is tied to the potential failure consequences. Risk minimization is implemented by conducting research and development activities, prototyping components, first article procurements, and advance procurement planning and planning alternatives.

Risk assessments are conducted throughout the project lifecycle. Risks identified include technical, cost and schedule risks. The project Risk Management Plan details the process for identifying, evaluating, mitigating, and managing risks in compliance with DOE Order 413.3A. The project Risk Registry is reviewed and updated monthly.

7.3 VALUE ENGINEERING

Value Engineering (VE) will be applied to the LUSI project with the purpose of achieving the instruments essential functions at the lowest total cost, consistent with the needed performance, safety, security, reliability, quality and maintainability requirements.

7.4 ENVIRONMENT, SAFETY, AND HEALTH

BES is committed to conducting work (research and projects) in a manner that ensures protection of workers, the public, and the environment. Protecting the workers, the public, and the environment is a direct and individual responsibility of all BES managers and BES-supported workers and their staff. Funds provided by BES will be applied as necessary to ensure that all BES work is conducted safely and in an environmentally conscientious manner. Only work conducted in this way will be supported. The LUSI IPT is committed to this stated BES policy for conducting work in a safe and environmentally conscientious manner.

The LUSI instruments will be designed, fabricated, and installed in a manner to protect the safety of workers, the public and the environment. Environmental consequences of LUSI instruments were addressed in the Environmental Assessment for the LCLS Experimental Facility (DOE/EA1426) dated December 2002. No additional National Environmental Policy Act (NEPA) documentation is required. Design, procurement, installation, and testing of the instruments will be in accordance with the principles of Integrated Safety Management.

The LCLS ES&H Coordinator will be responsible for coordinating ES&H support for the LUSI project. He/she is a key member of the LUSI Integrated Project Team, and this person's effort is included in the project's cost and will be charged to the appropriate LUSI project cost account. LUSI project will require no site development, special permits, or licensing.

7.5 INTEGRATED SAFETY MANAGEMENT

SLAC's Integrated Safety and Environmental Management System (ISEMS) is designed to ensure compliance and support the integration of ES&H consideration into all efforts executed at the Laboratory. The LUSI project will adhere to this system by following and incorporating the LCLS ISEMS principles into the project's planning and execution. A primary objective of the LUSI project is to protect the environment and the safety of workers and the general public. This will be accomplished through: (1) defining the work and understanding the potential hazards, (2) analyzing potential hazards and designing the devices to appropriately mitigate potential hazards, (3) developing operational controls for hazards that cannot be eliminated through design features, (4) operating in accordance with prescribed limits and procedures; and (5) evaluating the effectiveness of the resultant safety program.

The SLAC hazard screening process will be used to identify and analyze potential safety hazards associated with the LUSI project. The results of this process will be documented in a subsequent LUSI Project Hazard Identification and Analysis report.

7.6 CONFIGURATION MANAGEMENT

Configuration of LUSI project baselines and associated documents will be maintained through a formal change control process. Baseline documents for the project consist of the following:

- Field Work Proposal (FWP)
- Acquisition Strategy
- Preliminary Project Execution Plan
- Project Controls Manual
- Physics Requirement Documents
- Approved Baseline Change Requests (BCRs)
- Work Breakdown Structure Dictionary
- LUSI Parameters List
- Risk Management Plan

7.7 RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE

Engineering, fabrication, and installation of the LUSI project instruments will follow the LUSI Quality Implementation Procedure (QIP). This procedure is in accordance with SLAC Assurance Program description (SLAC-1-770-01a7B-001) and the applicable requirements of DOE Order 414.1C. The QIP provides the outline for how QA will be integrated into the design and fabrication process in order to ensure reliability and maintainability. It governs the following:

- Responsibilities and authorities
- Stop activity authority
- Training and job proficiency
- Corrective action
- SLAC Occurrence Reporting
- Non-conforming items
- Disposition and tracking of quality problems
- Documents and records
- Work processes
- Design and design reviews
- Procurements
- Inspection and Acceptance testing
- Project Assessments

7.8 ACQUISITION STRATEGY AND TAILORED PROCUREMENT APPROACH

LUSI project, being executed under the DOE M&O Contract (DE-AC02-76-SF00515) with Stanford University, plans to design and build the 3 instruments described in this document over a period of six fiscal years (2007 – 2012). The LUSI Project Acquisition Strategy has been approved by Dr. R. Orbach, Under Secretary for Science (SC-1) in September 2007. To manage risk and achieve the project objectives efficiently, a tailored approach to procurement and acquisition of services from DOE national labs and international institutions is employed.

7.8.1 Procurement

As part of the planning process given the recent changes in the project funding profile, it is determined that Long Lead procurements are critical in order for the Project to deliver the basic instruments for early science experiments to LCLS as scheduled. The long lead procurements planned include 1) the XPP Diffractometer System Components, and 2) CXI KB Mirror System. It is planned to secure an approval for these long lead procurements as part of the CD-2 AE approval currently planned in October 2008..

7.8.2 Memorandum of Understanding (MOU)

LUSI has established MOU between the Project, Brookhaven National Laboratory (BNL) and Lawrence Livermore National Laboratory (LLNL) for the delivery of Detectors and particle Injector System. Specifically:

BNL MOU Scope: Detectors for XPP and XCS

- XPP Detector Estimated Delivery – February 2010 (assumption: BNL is funded at the planned level)
- Estimated Cost – $1.2M (TEC)

- XCS Detector Estimated Delivery – September 2011 (assumption: XCS funding starts in October 2008 and is funded at the planned level beginning in FY 2009)
- Estimated Cost – $1.9M

DESY MOU Scope: Split and Delay System for XCS

- Estimated Delivery – March 2011
- Estimated Cost – No cost except installation support

7.9 PROJECT CONTROLS AND REPORTING SYSTEMS

Similar to LCLS, The LUSI project will utilize the SLAC Earned Value Management System for performance tracking and evaluation. SLAC EVMS received its certification in July 2008. The Project Controls Manual and related documents describe the project's earned value management processes and procedures as well as baseline change control procedures.

The project will issue monthly project performance reports after CD-2. These reports will be supplemented with periodic teleconferences with Office of Science, Office of Basic Energy Sciences. Once the performance baseline is approved (at CD-2), cost and schedule variance reporting will conform to the thresholds established by the DOE Project Assessment Reporting System (PARS). The project will use these same thresholds at WBS Level 2 to give an early warning of potential variances to cost and schedule.

Overall project progress and performance will be reviewed semi-annually by the Acquisition Executive. The quarterly project review will cover cumulative cost and schedule performance through the quarter being evaluated. Project status information will also be entered into PARS.

Project technical performance will be monitored to assure conformance to approved project requirements. Design reviews, inspections and performance testing will be used to ensure that the devices meet all project requirements. All design reviews will be documented.

7.10 MAJOR PROJECT ASSUMPTIONS

The following major assumptions are built into the performance baseline:

- FY2008 $4M shortfall will be restored in FY2011
- FY 2009 Continuing Resolution:
    - Duration: 6 months
    - FY2009 Spending plan based on 1/12 of the FY2008 budget of $6.0M (i.e., $500k/month)
- MOUs are funded as planned
- Long-lead procurements are approved as planned
- LUSI Project will:
    - Design, procure, fabricate the 3 instruments
    - Assemble all components
    - Install instruments at the designated hutches
    - Complete instrument check-out
    - Conduct Instrument Readiness Review (based on calculations and computer simulations)
- LCLS Operation will:
    - Conduct instrument commissioning and beam testing
    - Operate the instruments

8.0 LIFE CYCLE COST ANALYSIS (LCCA)

The operational service lifetime of the LUSI instruments is expected to be about 15 years, and each instrument will cost approximately $2 million annually to operate and maintain. Decommissioning costs are anticipated to be modest (< $1 million per device), and will take into account salvage and recycling of components wherever feasible and proper disposal of any contaminated components as waste. Conservatively assuming a LUSI TPC of $60 million (i.e., top of the current range) and all of the above, the total life cycle cost for the three LUSI instruments would amount to approximately $153 million.

9.0 TRANSITION TO OPERATIONS

As detailed in Section 6.1, Phased Critical Decision Approvals, the instruments will be installed and phased into operations as detailed in this document. Prior to CD-4A and CD-4B, basic XPP and CXI instruments will be ready for commissioning and initial operation by LCLS in 4Q FY2010 and 4Q FY2011, respectively. The LUSI project will complete the XPP and CXI as well as XCS by 4th quarter of 2012 (CD-4C) when all 3 instruments are fully functional. Instrument Readiness Reviews, consistent with the LCLS approved Accelerator Safety Envelope, will be completed for each instrument prior to their CD-4 approvals. LUSI will complete the required transition-to-operation steps and documentation including verification of instrument performance parameters, project transition-to-operations plan, and the required technical, operational and maintenance manuals and procedures.

Appendix A

List of Level 1, Level 2 and Level 3 Milestones for XPP, CXI and XCS

Milestone Description	MS Level	Late Finish
CD-0 MISSION NEED APPROVAL	L1	08/10/05A
CD-1 COST RANGE APPROVAL	L1	09/27/07A
CD-2 PERFORMANCE BASELINE APPROVED	L1	3/2/2009
COMPLETE CD-2 REQUIREMENTS - XPP / CXI / XCS	L2	1/5/2009
PROJECT READY FOR CD-2 APPROVAL	L3	12/1/2008
LONG LEAD PROCUREMENT APPROVED-Early Science	L1	4/27/2009
LONG LEAD AWARD - XPP DIFFRACTOMETER	L3	7/21/2009
LONG LEAD AWARD - CXI KB MIRROR SYSTEMS	L3	12/8/2009
CD-3A CONSTRUCTION START APPROVED - XPP	L1	7/2/2009
COMPLETE CD-3A REQUIREMENTS - XPP	L2	5/7/2009
PROJECT READY FOR CD-3A APPROVAL - XPP	L3	3/12/2009
CD-3B CONSTRUCTION START APPROVED - CXI	L1	4/1/2010
COMPLETE CD-3B REQUIREMENTS - CXI	L2	2/4/2010
PROJECT READY FOR CD-3B APPROVAL - CXI	L3	11/24/2009
CD-3C CONSTRUCTION START APPROVED - XCS	L1	10/5/2010
COMPLETE CD-3C REQUIREMENTS - XPP / CXI / XCS	L2	8/10/2010
PROJECT READY FOR CD-3C APPROVAL - XCS	L3	6/15/2010
CD-4A START OF OPERATIONS APPROVED XPP	L1	12/17/2010
APPROVED: Instrument Readiness Review - CD-4A	L2	10/20/2010
PROJECT READY FOR CD-4A APPROVAL	L3	7/28/2010
CD-4B START OF OPERATIONS APPROVED-CXI	L1	9/30/2011
APPROVED: Instrument Readiness Review - CD-4B	L2	8/5/2011
PROJECT READY FOR CD-4B APPROVAL	L3	5/13/2011
CD-4C START OF OPERATIONS APPROVED-XPP/CXI/XCS	L1	8/31/2012
APPROVED: Instrument Readiness Review - CD-4C	L2	7/6/2012
PROJECT READY FOR CD-4C APPROVAL	L3	4/13/2012

Appendix B

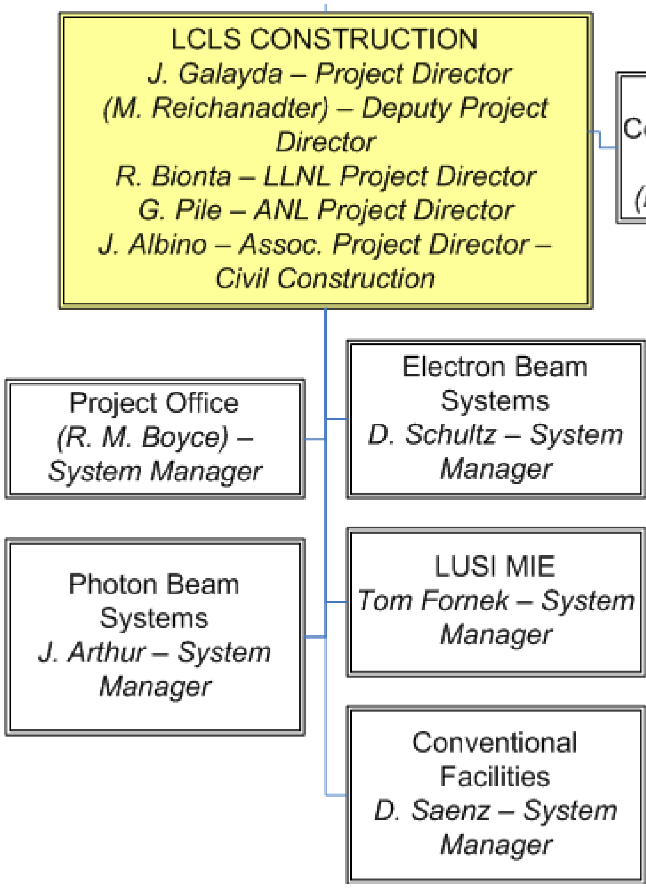
List of Physics Requirement Documents (PRD) and Engineering Specification Documents

WBS	Type	Doc Number	Title
1.2	PRD	391-000-13	Diffractometer
1.2	PRD	391-000-18	XPP Laser System
1.2	PRD	391-000-33	XPP Overall
1.2	PRD	391-001-15	XPP Instrument Start-up Plan
1.2	PRD	391-000-97	XPP 2D Detector
1.3	PRD	391-000-19	Physics Requirements for the CXI Instrument
1.3	PRD	391-000-20	CXI Sample Chamber
1.3	PRD	391-000-21	CXI Reference Laser System
1.3	PRD	391-000-24	CXI 0.1 micron KB System
1.3	PRD	391-000-25	CXI 1 micron KB System
1.3	PRD	391-000-28	CXI Detector Stage
1.3	PRD	391-000-63	CXI Precision Instrument Stand
1.3	PRD	391-001-16	CXI Instrument Start-up Plan
1.3	PRD	391-000-30	CXI Ion TOF
1.3	PRD	391-000-26	CXI Particle Injector System
1.4	PRD	391-001-17	XCS Instrument Start-up Plan
1.4	PRD	391-001-33	XCS Wide Angle Detector Stage
1.4	PRD	391-001-35	XCS Instrument
1.4	PRD	391-001-32	XCS Diffractometer system
1.4	PRD	391-000-98	XCS 2D Detector
1.5	PRD	391-000-04	Pop-in Profile Monitor
1.5	PRD	391-000-07	Wave front Sensor
1.5	PRD	391-000-08	Intensity-Position Monitor
1.5	PRD	391-000-09	Pop-in Intensity Monitor
1.5	PRD	391-000-14	Slit System
1.5	PRD	391-000-15	Wavefront Monitor
1.5	PRD	391-000-23	Pulse Picker
1.5	PRD	391-000-34	Harmonic Rejection Mirror System
1.5	PRD	391-000-10	LUSI Attenuator System
1.5	PRD	391-000-11	X-Ray Focusing Lens System
1.5	PRD	391-000-16	Offset Monochromator
1.6	PRD	391-000-03	Controls and Data System
1.6	PRD	391-000-06	Data Management

WBS	Type	Doc Number	Title
1.2	ESD	391-000-57	Diffractometer
1.2	ESD	391-000-62	Diffractometer Detector Mover
1.2	ESD	391-000-84	XPP instrument specification
1.3	ESD	391-001-40	Common Room of the FEH
1.3	ESD	391-001-36	Hutch 5 of the FEH
1.3	ESD	391-001-37	CXI Room of the FEH
1.3	ESD	391-000-67	CXI Sample Chamber
1.3	ESD	391-000-69	CXI Precision Instrument Stand
1.3	ESD	391-000-70	CXI Detector Stage
1.3	ESD	391-000-65	CXI 1 micron KB System
1.3	ESD	391-000-68	CXI Ion TOF
1.3	ESD	391-000-75	CXI Particle Injector System
1.3	ESD	391-000-73	CXI Reference Laser System
1.3	ESD	391-000-85	CXI Instrument
1.4	ESD	391-001-38	Hutch 4 of the FEH
1.4	ESD	391-001-39	XCS Room of the FEH
1.4	ESD	391-001-20	XCS diffractometer system
1.4	ESD	391-001-30	XCS Diffractometer
1.4	ESD	391-001-29	XCS Instrument Specification
1.4	ESD	391-001-31	XCS Detector Mover
1.5	ESD	391-000-54	Slit System
1.5	ESD	391-000-60	Attenuators
1.5	ESD	391-000-80	Intensity-Position Monitor Mechanical Requirements
1.5	ESD	391-000-81	Pop-In Intensity Monitor Mechanical Requirements
1.5	ESD	391-000-82	Wave front Monitor Mechanical Requirements
1.5	ESD	391-000-83	Pop-In Profile Monitor Mechanical Requirements
1.5	ESD	391-000-58	X-Ray Focusing Lens System
1.5	ESD	391-000-61	Harmonic Rejection Mirror System
1.5	ESD	391-000-66	Pulse Picker
1.6	ESD	391-001-13	CXI Controls ESD
1.6	ESD	391-001-18	CXI Data Acquisition ESD
1.6	ESD	391-001-19	LUSI Common Diag. & Optics Controls ESD
1.6	ESD	391-001-21	XPP Controls ESD
1.6	ESD	391-001-23	XPP Data Acq. ESD
1.6	ESD	391-001-24	XCS Controls ESD
1.6	ESD	391-001-26	XCS Data Acq. ESD
1.6	ESD	391-001-27	LUSI Intensity-Position/Intensity Monitor Front End Electronics

Appendix C

LCLS Organization and Interface with LUSI Project



Appendix D

List of Acronyms

AE	Acquisition Executive
BCR	Baseline Change Request
BCCB	Baseline Change Control Board
BES	Basic Energy Sciences
CD	Critical Decision
CXI	Coherent X-ray Imaging
DOE	Department of Energy
EAC	Estimate at Completion
ESAAB	Energy Systems Acquisition Advisory Board
ES&H	Environment, Safety, and Health
FPD	Federal Project Director
FWP	Field Work Proposal
HQ	Headquarters
IPT	Integrated Project Team
ISEMS	Integrated Safety and Environmental Management System
IRR	Instrument Readiness Review
LCCA	Life Cycle Cost Analysis
LCLS	Linac Coherent Light Source
LUSI	Linac Coherent Light Source Ultrafast Science Instruments
M&O	Management & Operation
MIE	Major Item of Equipment
NEPA	National Environmental Policy Act
PARS	Project Assessment and Reporting System
PEP	Project Execution Plan
PD	Project Director
PRD	Physics Requirements Document
QA	Quality Assurance
QIP	Quality Implementation Procedure
SC	Office of Science
SLAC	Stanford Linear Accelerator Center
SSO	Stanford Site Office (DOE)
SXR	Soft X-ray Scattering
TEC	Total Estimated Cost
TL	Team Leader
TPC	Total Project Cost
VE	Value Engineering
WBS	Work Breakdown Structure
XCS	X-ray Correlation Spectroscopy
XFEL	X-ray Free Electron Laser
XPP	X-ray Pump Probe