05-R-320, Linac Coherent Light Source,
Stanford Linear Accelerator Center, Menlo Park, California
Project Data Sheet is for Construction.

1. Significant Changes

The most recent DOE O413.3A Critical Decision (CD) is CD-3b (Approve Start of Construction) that was approved in March 2006 with a Total Project Cost of $379,000,000.

A Federal Project Director with certification level III has been assigned to this project.

This PDS is an update of the FY2008 PDS. Due to the FY2007 Continuing Resolution, the project experienced delay and a reduction of $8,000,000 in FY2007 funding. As a result of this Directed Change, the cost and schedule baseline is being revised for Acquisition Executive approval.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1 (Design Start)	(Design/PED Complete)	CD-2B	CD-3B (Construction Start)	CD-4[a] (Construction Complete)	D&D Start	D&D Complete
FY2001	06/13/2001	2QFY2002	1QFY2004	3QFY2002	1QFY2004	1QFY2007	N/A	N/A
FY2007	06/13/2001	10/16/2002	4QFY2006	4/11/2005	2QFY2006	2QFY2009	N/A	N/A
FY2008	06/13/2001	10/16/2002	3QFY2008	4/11/2005	2QFY2006	2QFY2009	N/A	N/A
FY2009	06/13/2001	10/16/2002	2QFY2008	4/11/2005	3/21/2006	3QFY2010	N/A	N/A

(fiscal quarter or date)

	Performance Baseline Validation	CD-2A (Approve Long-Lead Budget)	CD-3A (Approve Start of Long -Lead Procurements)	CD-4A[a]
FY2001	3QFY2002	N/A	N/A	N/A
FY2007	1QFY2005	3QFY2003	1QFY2005	2QFY2009
FY2008	1QFY2005	3QFY2003	1QFY2005	2QFY2009
FY2009	1QFY2005	3QFY2003	1QFY2005	3QFY2009

[a] Due to the impacts and reduced funding related to the FY07 Continuing Resolution, the project has been directed to prepare a revised cost and schedule baseline. Currently the project is proposing a phased CD-4, with CD-4a (photons in the Near Experimental Hall) in July 2009 and CD-4b (photons in the Far Experimental Hall) in May 2010. The revised cost and schedule is preliminary until approved by the Acquisition Executive. A review of the revised cost and schedule related to the FY07 CR and reduced funding is scheduled for July 2007.

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC[b]
FY2001	33,500	TBD	TBD	15,425	N/A	15,425	TBD
FY2007	35,974	279,000	315,000	64,000	N/A	64,000	379,000
FY2008	35,974	279,000	315,000	64,000	N/A	64,000	379,000
FY2009	35,974	303,026	339,000	70,000	N/A	70,000	409,000

4. Project Description, Justification, and Scope

This project is being conducted in accordance with the project management requirements in DOE O413.3A and DOE M413.3-1. Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

The purpose of the Linac Coherent Light Source (LCLS) Project is to provide laser-like radiation in the x-ray region of the spectrum that is 10 billion times greater in peak brightness than any existing coherent x-ray light source. This advance in brightness is similar to that of a synchrotron over a 1960's laboratory x-ray tube. Synchrotrons revolutionized science across disciplines ranging from atomic physics to structural biology. Advances from the LCLS are expected to be equally dramatic. The LCLS Project will provide the first demonstration of an x-ray Free Electron Laser (FEL) in the 1.5–15 Angstrom range and will apply these extraordinary, high-brightness x-rays to an initial set of scientific problems described below. This will be the world's first such facility.

The LCLS is based on the existing SLAC linac. The SLAC linac can accelerate electrons or positrons to 50 GeV for colliding beam experiments and for nuclear and high-energy physics experiments on fixed targets. At present, the first two-thirds of the linac is being used to inject electrons and positrons into Positron Electron Project-II (PEP-II), and the entire linac is used for fixed target experiments. When the LCLS is completed, the latter activity will be limited to 25 percent of the available beam time and the last one-third of the linac will be available for the LCLS a minimum of 75 percent of the available beam time. For the LCLS, the linac will produce high-brightness 5–15 GeV electron bunches at a 120 Hertz repetition rate. When traveling through the new 120 meter long LCLS undulator, these electron bunches will amplify the emitted x-ray radiation to produce an intense, coherent x-ray beam for scientific research.

The LCLS makes use of technologies developed for SLAC and the next generation of linear colliders, as well as the progress in the production of intense electron beams with radiofrequency photocathode guns. These advances in the creation, compression, transport, and monitoring of bright electron beams make it

[b] The full project TEC and TPC, established at Critical Decision 2b (Approve Performance Baseline), are $315,000,000 and $379,000,000, respectively, and include the costs for PED from project 03-SC-002. Due to the delay and reduced funding related to the FY07 Continuing Resolution, the project has been directed to prepare a revised cost and schedule baseline. The revised TEC and TPC have been estimated at $339,000K and $409,000K respectively. A review of the revised cost and schedule related to the FY07 CR and reduced funding is scheduled for July 2007.

possible to base this next generation of x-ray synchrotron radiation sources on linear accelerators rather than on storage rings.

The LCLS will have properties vastly exceeding those of current x-ray sources (both synchrotron radiation light sources and so-called "table-top" x-ray lasers) in three key areas: peak brightness, coherence (i.e., laser-like properties), and ultrashort pulses. The peak brightness of the LCLS is 10 billion times greater than current synchrotrons, providing 10^{11} x-ray photons in a pulse with duration of less than 230 femtoseconds. These characteristics of the LCLS will open new realms of scientific application in the chemical, material, and biological sciences.

The LCLS Project requires a 135 MeV injector to be built at Sector 20 of the 30-sector SLAC linac to create the electron beam required for the x-ray FEL. The last one-third of the linac will be modified by adding two magnetic bunch compressors. Most of the linac and its infrastructure will remain unchanged. The existing components in the Final Focus Test Beam tunnel will be removed and replaced by a new undulator and associated equipment. Two new buildings, the Near Experimental Hall and the Far Experimental Hall, will be constructed and connected by the beam line tunnel. Recent civil construction bids have been much higher than the baseline estimates. As a result, existing buildings at SLAC will be renovated to support LCLS operations. The conventional facilities scope will not include the planned Central Laboratory Office Complex, but will include renovations to existing buildings that fulfills the office functionality. There are no impacts to the project's capabilities and key technical operating parameters.

The combined characteristics (spectral content, peak power, pulse duration, and coherence) of the LCLS beam are far beyond those of existing light sources. The demands placed on the x-ray instrumentation and optics required for scientific experiments with the LCLS are unprecedented. The LCLS experimental program will commence with: measurements of the x-ray beam characteristics and tests of the capabilities of x-ray optics; instrumentation; and techniques required for full exploitation of the scientific potential of the facility. For this reason, the project scope includes a comprehensive suite of instrumentation for characterization of the x-ray beam and for early experiments in atomic, molecular, and optical physics. The experiments include x-ray multiphoton processes with isolated atoms, simple molecules, and clusters. Also included in the scope of the LCLS Project are the instrumentation and infrastructure necessary to support research at the LCLS, such as experiment hutches and associated interlock systems; computers for data collection and data analysis; devices for attenuation and collimation of the x-ray beam; prototype optics for manipulation of the intense x-ray beam; and synchronized pump lasers.

Beyond the scope of the LCLS construction project, an instrument development program has been implemented in order to qualify and provide instruments for the LCLS. The key element of this program is a Major Item of Equipment—the LCLS Ultrafast Science Instruments (LUSI) project. Instrument proposals will undergo a scientific peer review process to evaluate technical merit; those concepts that are accepted may then establish interface agreements with the LCLS Project. Expected funding sources include appropriated funds through the Department of Energy and other Federal agencies, private industry, and foreign entities. These instruments will all be delivered after completion of the LCLS line item project. The LCLS Scientific Advisory Committee, working in coordination with the broad scientific community, has already identified a number of high priority initial experiments that are summarized in the document, *LCLS: The First Experiments*. Five specific areas of experimentation are: fundamental studies of the interaction of intense x-ray pulses with simple atomic systems; use of LCLS to create warm dense matter and plasmas; structural studies on single nanoscale particles and biomolecules; ultrafast dynamics in chemistry and solid-state physics; and studies of nanoscale structure

and dynamics in condensed matter. The combination of extreme brightness and short pulse length will make it possible to follow dynamical processes in chemistry and condensed matter physics in real time. It may also enable the determination of the structure of single biomolecules or small nanocrystals using only the diffraction pattern from a single moiety. This application has great potential in structural biology, particularly for important systems, such as membrane proteins, which are virtually uncharacterized by x-ray crystallography because they are nearly impossible to crystallize. Instrument teams will form to propose instruments to address these and other scientific areas of inquiry.

Construction funding provided in FY 2006 was for starting physical construction of the LCLS conventional facilities including ground-breaking for the LCLS Near Experimental Hall, Undulator Hall, Beam Transfer Hall, and connecting beam transfer tunnels. In addition, the injector was completed and construction of the downstream linac and electron beam transport to the undulator hall began. Undulator module assembly was started along with construction of x-ray transport/optics/diagnostics systems.

The FY 2007 funding is for continuation of physical construction of the LCLS conventional facilities including the LCLS Near Experimental Hall, Undulator Hall, Beam Transfer Hall, connecting beam transfer tunnels, Far Experimental Hall, and the renovation of existing buildings at SLAC to provide office space requirements to support LCLS operations. In addition, the assembly and delivery of the undulators and undulator infrastructure to SLAC's Magnetic Measurement Facility is planned, as well as the procurements for the x-ray optics, diagnostics, and end stations. Delivery of the undulators in FY 2007 enables achievement of performance goals in FY 2009.

Construction funding requested in FY 2008 is for continuation of most of the LCLS conventional facilities and for continued procurement and installation and of the technical hardware.

Due to the FY2007 continuing resolution, the project was impacted by the delay and reduction in FY2007 funding. The project is revising the cost and schedule because of the DOE directed change and the revised baseline will be evaluated in July 2007. A phased CD-4 will be proposed. As a result, FY2009 funding is requested to complete the first phase of construction to allow the LCLS scientific program to begin while the second phase of construction continues through 2010.

This project will be conducted in accordance with the project management requirements in DOE Order 413.3A and DOE Manual 413.3–1, Program and Project Management for the Acquisition of Capital Assets.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED			
FY 2003	5,925[c]	5,925[a]	3,644
FY 2004	7,456[a]	7,456[a]	9,713

[c] PED funding was reduced by $75,000 as a result of the FY 2003 general reduction and rescission, by $44,000 as a result of the FY 2004 rescission, by $161,000 as a result of the FY 2005 rescission, and by $26,000 as a result of the FY 2006 rescission. This total reduction was restored in FY 2005, FY 2006, and FY 2007 to maintain the TEC and project scope.

FY 2005	19,914[a]	19,914[a]	16,805
FY 2006	2,518[a]	2,518[a]	5,066
FY 2007	161[a]	161[a]	746
FY2008	0	0	0
Total, PED (PED No. 03-SC-002)	35,974	35,974	35,974
Construction			
FY 2005	29,760[de]	29,760[de]	7,868
FY 2006	82,170[e]	82,170[e]	61,395
FY 2007	101,000[ef]	101,000[ef]	120,000
FY 2008	51,356[e]	51,356[e]	60,000
FY 2009	29,500[e]	29,500[e]	43,000
FY 2010	9,240	9,240	10,763
FY2011	0	0	0
Total, Construction	303,026	303,026	303,026
TEC			
FY 2003	5,925	5,925	3,644
FY 2004	7,456	7,456	9,713
FY 2005	49,674	49,674	24,673
FY 2006	84,688	84,688	66,461
FY 2007	101,161	101,161	120,746
FY 2008	51,356	51,356	60,000
FY 2009	29,500	29,500	43,000
FY 2010	9,240	9,240	10,763
FY2011	0	0	0
Total, TEC	339,000	339,000	339,000

[d] FY 2005 funding was for long-lead procurements. The scope of work in FY 2005 was expanded to include modification of existing facilities at the Stanford Linear Accelerator Center for testing of the long-lead equipment items.

[e] Construction funding was reduced by $240,000 as a result of the FY 2005 rescission and by $830,000 as a result of the FY 2006 rescission. This total reduction is restored in FY 2007 and FY 2008 to maintain the TEC and project scope.

[f] Construction funding was reduced by $4,740,000 in FY 2007 as the result of a budget reduction.

(dollars in thousands)

	Appropriations	Obligations	Costs
Other Project Cost (OPC)			
OPC except D&D			
Prior Years	3,500	3,500	3,500
FY 2005	4,000	4,000	3,131
FY 2006	3,500	3,500	2,461
FY 2007	13,000[g]	13,000	12,000
FY 2008	15,500	15,500	16,000
FY 2009	17,000	17,000	17,000
FY 2010	13,500	13,500	15,908
Total, OPC except D&D	70,000	70,000	70,000
D&D			
Total, D&D	N/A	N/A	N/A
OPC			
Prior Years	3,500	3,500	3,500
FY 2005	4,000	4,000	3,131
FY 2006	3,500	3,500	2,461
FY 2007	13,000	13,000	12,000
FY 2008	15,500	15,500	16,000
FY 2009	17,000	17,000	17,000
FY 2010	13,500	13,500	15,908
Total, OPC	70,000	70,000	70,000
Total Project Cost (TPC)			
Prior Years	16,881	16,881	16,856
FY 2005	53,674	53,674	27,804
FY 2006	88,188	88,188	68,922
FY 2007	114,161	114,161	132,746
FY 2008	66,856	66,856	76,000
FY 2009	46,500	46,500	60,000
FY 2010	22,740	22,740	26,672

[g] OPC funding was reduced by $3,000,000 in FY 2007 as the result of a budget reduction.

FY 2011	0	0	0
Total, TPC	409,000	409,000	409,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	35,974	35,974	35,974
Contingency	N/A	N/A	N/A
Total, PED (PED no. 03-SC-002)	35,974	35,974	35,974
Construction			
Site Preparation	9,000	9,000	9,000
Equipment	110,652	110,652	93,400
Other Construction	152,834	104,974	104,974
Contingency	30,540	54,400	54,400
Total, Construction	303,026	279,026	279,026
Total, TEC	339,000	315,000	315,000
Contingency, TEC	30,540	54,400	54,400
Other Project Cost (OPC)			
Conceptual Planning	7,700	7,700	7,700
Conceptual Design			
Start-up[h]	56,730	50,324	50,324
Contingency	5,570	5,976	5,976
Total, OPC except D&D	70,000	64,000	64,000
D&D			
D&D	0	0	0
Contingency	0	0	0
Total, D&D	0	0	0

[h] Costs in this category include start-up (pre-operations) and spares.

Total, OPC	70,000	64,000	64,000
Contingency, OPC	5,570	5,976	5,976
Total, TPC	409,000	379,000	379,000
Total, Contingency	36,110	60,376	60,376

7. Schedule of Project Costs

For schedule of project costs, see Section 5, "Financial Schedule."

8. Related Operations and Maintenance Funding Requirements

Start of Full Operations or Beneficial Occupancy (fiscal quarter or date)	3Q FY 2010
Expected Useful Life (number of years)	30
Expected Future start of D&D of this capital asset (fiscal year)	FY 2041[+]

[+]Assumption: No major upgrades to expand or extend LCLS capabilities and operational cycle will be implemented.

(Related Funding Requirements)

(dollars in thousands)

	Annual Costs		Life cycle costs	
	Current Estimate[i]	Prior Estimate	Current Estimate[j]	Prior Estimate
Operations	25,000	25,000	1,368,656	
Maintenance	25,000	25,000	1,368,656	
Total Related Funding	50,000	50,000	2,737,312	

FY 2011 is expected to be the first full year of LCLS facility operations. The current estimate is preliminary and based on historical experience with operating similar types and sizes of facilities. This estimate will be refined as the LCLS Project approaches completion.

The estimate includes LCLS facility operations only. It does not include operation of the SLAC linac which was funded by HEP in FY 2005 and prior years, but began transitioning to BES funding in FY 2006 and will be fully funded by BES in FY2009. Operation of the SLAC Linac is essential to the operation of the LCLS.

[i] LCLS is currently under construction and operation is expected to begin in FY 2009. The Annual Cost estimate shown in the table above is for a full year of operation.

[j] The life cycle cost estimate includes operations and maintenance annual costs escalated through the LCLS facility expected useful life of 30 years, in accordance with the DOE budget guidance. The cost estimate does not include D&D of the LCLS facility after useful life.

9. Required D&D Information

Not applicable. LCLS is an existing project and construction funding has been requested in the past. The “replacement of existing facilities” and the “one-for-one” requirements have been complied with (ref. FY2009 OMB Budget Call, Attachment H Project Data Sheet Guidance, Page H-7).

10. Acquisition Approach

A Conceptual Design Report (CDR) for the project was completed and reviewed. Key design activities were specified in the areas of the injector, undulator, x-ray optics and experimental halls to reduce schedule risk to the project and expedite the startup. Also, the LCLS management systems were put in place and tested during the Project Engineering and Design (PED) phase. These activities are managed by the LCLS Project Office at SLAC, with additional portions of the project being executed by staff at Argonne National Laboratory (ANL) and Lawrence Livermore National Laboratory (LLNL).

The design of technical systems is being accomplished by the three collaborating laboratories. The conventional construction design aspect was contracted to an experienced Architect/Engineering (A/E) firm to perform Title I and II design. Title I design was completed in FY 2004. Title II design began in FY 2005 and was completed in FY 2006. An experienced construction Manager/General Contractor is under contract to carry out conventional facilities construction.