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), which 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 Project Data Sheet (PDS) is an update of the FY 2008 PDS. Due to the FY 2007 Continuing Resolution, the project experienced a reduction of $7,740,000, including $4,740,000 in construction funds and $3,000,000 in Other Project Costs, and a six month delay in receiving FY 2007 appropriated funding. As a result of this directed change, the cost and schedule baseline has been revised and submitted for Deputy Secretary approval. This revision will increase the TEC by 11.7%.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1 (Design Start)	(Design/PED Complete)	CD-2a (Approve Long-Lead Budget)	CD-2b	CD-3a (Approve Start of Long -Lead Procurements)
FY 2003	06/13/2001	1Q FY 2003	2Q FY 2005	N/A	N/A	N/A
FY 2004	06/13/2001	10/16/2002	4Q FY 2006	3Q FY 2003	N/A	1Q FY 2005
FY 2005	06/13/2001	10/16/2002	4Q FY 2006	3Q FY 2003	N/A	1Q FY 2005
FY 2006	06/13/2001	10/16/2002	4Q FY 2006	07/02/2003	N/A	1Q FY 2005
FY 2007	06/13/2001	10/16/2002	4Q FY 2006	07/02/2003	4/11/2005	12/10/2004
FY 2008	06/13/2001	10/16/2002	3Q FY 2008	07/02/2003	4/11/2005	12/10/2004
FY 2009	06/13/2001	10/16/2002	2Q FY 2008	07/02/2003	4/11/2005	12/10/2004

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2a – Approve Long-Lead Budget
CD-2b – Approve Performance Baseline
CD-3a – Approve Start of Long-Lead Procurements

(fiscal quarter or date)

	CD-3b (Construction Start)	CD-4 (Construction Complete)	Performance Baseline Validation
FY 2003	1Q FY 2004	1Q FY 2007	3Q FY 2002
FY 2004	1Q FY 2004	1Q FY 2007	3Q FY 2002
FY 2005	1Q FY 2004	1Q FY 2007	3Q FY 2002
FY 2006	1Q FY 2004	1Q FY 2007	3Q FY 2002
FY 2007	2Q FY 2006	2Q FY 2009	1Q FY 2005
FY 2008	2Q FY 2006	2Q FY 2009	1Q FY 2005
FY 2009	3/21/2006	4Q FY 2010[a]	1Q FY 2008

CD-3b – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC, Total	TPC
FY 2003	33,500	TBD	TBD	1,500	TBD	TBD
FY 2004	36,000	TBD	TBD	7,500	TBD	TBD
FY 2005	36,000	279,000	315,000	64,000	64,000	379,000
FY 2006	36,000	279,000	315,000	64,000	64,000	379,000
FY 2007	35,974	279,026	315,000	64,000	64,000	379,000
FY 2008	35,974	279,026	315,000	64,000	64,000	379,000
FY 2009	35,974	316,026	352,000	68,000	68,000	420,000[b]

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.

[a] Due to the delay and reduced funding related to the FY 2007 Continuing Resolution, the project has been directed to prepare a revised cost and schedule baseline. Currently the project has proposed a CD-4 in 4Q FY 2010. The revised cost and schedule is preliminary until approved by the Deputy Secretary. Office of Science IPR and OECM EIR reviews of the revised cost and schedule baseline were conducted in September and October 2007, respectively. The project has submitted a baseline change proposal/request for action and expects approval in 2Q FY 2008. This column reflects CD-4 (Start of Operations), not Construction Completion.

[b] The full project TEC and TPC, established at Critical Decision 2b (Approve Performance Baseline), were $315,000,000 and $379,000,000, respectively, and include the costs for PED from project 03-SC-002. Due to the FY 2007 Continuing Resolution, the project experienced a reduction of $7,740,000 and a six month delay in receiving FY 2007 appropriated funding. The project was directed to revise the cost and schedule baseline. The preliminary revised TEC and TPC have been estimated at $352,000,000 and $420,000,000 respectively. The revised baseline was independently evaluated by Office of Science, Office of Project Assessment, in September 2007 and by the Office of Engineering and Construction Management External Independent Review in October 2007. As a result of the reviews, the project has submitted the baseline change proposal and request for the Energy Systems Acquisition Advisory Board (ESAAB) decision in 1Q FY 2008. A Pre-ESAAB was conducted on December 12, 2007 and the Office of Engineering and Construction Management recommended an Action Memorandum in lieu of a formal ESAAB. The Action Memorandum was sent to the Deputy Secretary on January 2, 2008.

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 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 was for continuation of construction of the LCLS conventional facilities including the LCLS Near Experimental Hall, Undulator Hall, Beam Transfer Hall, connecting beam transfer tunnels, and Far Experimental Hall. 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 2010.

Construction funding requested in FY 2008 is for continuation of most of the LCLS conventional facilities and for continued procurement and installation of the technical hardware. The FY 2009 funding is for completion of the LCLS installations, Experimental halls installations, renovation of existing buildings at SLAC to provide office space in support of LCLS operations, and installation of technical hardware for x-ray transport system.

Due to the FY 2007 Continuing Resolution, the project experienced a reduction of $7,740,000 and a six month delay in receiving FY 2007 appropriated funding. The project revised the cost and schedule baseline as directed by DOE. The revised baseline was independently evaluated by Office of Science, Office of Project Assessment, in September 2007 and by the Office of Engineering and Construction Management External Independent Review in October 2007. The project has prepared the baseline change proposal for the Energy Systems Acquisition Advisory Board (ESAAB) and Deputy Secretary decision in 1Q FY 2008. A Pre-ESAAB meeting was conducted on December 12, 2007 to assess the proposed baseline. The Office of Engineering and Construction Management (OECM) recommended an Action Memorandum in lieu of an ESAAB meeting to approve the proposed baseline change. This Action Memorandum was sent to the Deputy Secretary on January 2, 2008.

This project is being executed 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[a]	5,925[a]	3,644
FY 2004	7,456[a]	7,456[a]	9,713
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]	725
FY2008	—	—	21
Total, PED (PED no. 03-SC-002)	35,974	35,974	35,974
Construction			
FY 2005	29,760[bc]	29,760[bc]	7,868
FY 2006	82,170[c]	82,170[c]	61,395
FY 2007	101,000[cd]	101,000[cd]	99,148
FY 2008	50,889[c]	50,889[c]	91,852
FY 2009	36,967[c]	36,967[c]	35,000
FY 2010	15,240	15,240	20,763
Total, Construction	316,026	316,026	316,026

[a] 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.
[b] 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.
[c] 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 and $467,000 as a result of FY 2008 rescission. This total reduction is restored in FY 2007, FY 2008, and FY 2009 to maintain the TEC and project scope.
[d] Construction funding was reduced by $4,740,000 in FY 2007 as the result of a budget reduction.

(dollars in thousands)

	Appropriations	Obligations	Costs
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	99,873
FY 2008	50,889	50,889	91,873
FY 2009	36,967	36,967	35,000
FY 2010	15,240	15,240	20,763
Total, TEC	352,000	352,000	352,000
Other Project Cost (OPC)			
OPC except D&D			
FY 2002	1,500	1,500	700
FY 2003	—	—	800
FY 2004	2,000	2,000	2,000
FY 2005	4,000	4,000	3,131
FY 2006	3,500	3,500	2,461
FY 2007	13,000[a]	13,000[a]	12,460
FY 2008	15,500	15,500	15,540
FY 2009	17,000	17,000	17,000
FY 2010	11,500	11,500	13,908
Total, OPC	68,000	68,000	68,000
Total Project Cost (TPC)			
FY 2002	1,500	1,500	700
FY 2003	5,925	5,925	4,444
FY 2004	9,456	9,456	11,713
FY 2005	53,674	53,674	27,804
FY 2006	88,188	88,188	68,922
FY 2007	114,161	114,161	111,873
FY 2008	66,389	66,389	107,873
FY 2009	53,967	53,967	52,000
FY 2010	26,740	26,740	34,671
Total, TPC[a]	420,000	420,000	420,000

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

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED) (PED no. 03-SC-002)			
Design	35,974	35,974	35,974
Construction			
Site Preparation	9,000	9,000	9,000
Equipment	122,052	110,652	110,652
Other Construction	152,834	104,974	93,400
Contingency	32,140	54,400	65,974
Total, Construction	316,026	279,026	279,026
Total, TEC	352,000	315,000	315,000
Contingency, TEC	32,140	54,400	65,974
Other Project Cost (OPC)			
OPC, except D&D			
Conceptual Planning[a]	7,700	7,700	7,700
Start-up[b]	52,300	50,324	50,324
Contingency	8,000	5,976	5,976
Total, OPC	68,000	64,000	64,000
Contingency, OPC	8,000	5,976	5,976
Total, TPC	420,000[c]	379,000	379,000
Total, Contingency	40,140	60,376	71,950

7. Schedule of Project Costs

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

[a] Costs in this category include NEPA, conceptual design, and R&D.
[b] Costs in this category include start-up (pre-operations) and spares.
[c] The full project TEC and TPC, established at Critical Decision 2b (Approve Performance Baseline), were $315,000,000 and $379,000,000, respectively, and include the costs for PED from project 03-SC-002. Due to the FY 2007 Continuing Resolution, the project experienced a reduction of $7,740,000 and a six month delay in receiving FY 2007 appropriated funding. The project was directed to revise the cost and schedule baseline. The preliminary revised TEC and TPC have been estimated at $352,000,000 and $420,000,000 respectively. The revised baseline was independently evaluated by Office of Science, Office of Project Assessment, in September 2007 and by the Office of Engineering and Construction Management External Independent Review in October 2007. As a result of the reviews, the project has submitted the baseline change proposal and request for the Energy Systems Acquisition Advisory Board (ESAAB) decision in 1Q FY 2008. A Pre-ESAAB was conducted on December 12, 2007 and the Office of Engineering and Construction Management recommended an Action Memorandum in lieu of a formal ESAAB. The Action Memorandum was sent to the Deputy Secretary on January 2, 2008.

8. Related Operations and Maintenance Funding Requirements

Start of Full Operations or Beneficial Occupancy (fiscal quarter or date)	4Q FY 2010
Expected Useful Life (number of years)	30
Expected Future start of D&D of this capital asset (fiscal year)	FY 2041[a]

(Related Funding Requirements)

(dollars in thousands)

	Annual Costs		Life cycle costs	
	Current Total Estimate[b]	Previous Total Estimate	Current Total Estimate[c]	Previous Total Estimate[d]
Operations	12,500	25,000	684,328	—
Maintenance	12,500	25,000	684,328	—
Total, Operations & Maintenance	25,000	50,000	1,368,656	1,909,000

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 FY 2009. Operation of the SLAC Linac is essential to the operation of the LCLS.

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 satisfied.

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).

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[a] The assumption is that no major upgrades to expand or extend LCLS capabilities and operational cycle will be implemented.

[b] LCLS is currently under construction and operation is expected to begin in FY 2010. The Annual Cost estimate shown in the table above is for a full year of operation.

[c] 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. The project has better defined operational and maintenance (O&M) needs for the experimental facilities as it approaches Critical Design 4. The cost estimates for O&M are updated annually.

[d] Previous estimates calculated O&M together rather than separately. Therefore, O&M costs do not have separate estimates.

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.