CD-1, Approval of Preliminary Baseline Range for the Linac Coherent Light Source at the Stanford Linear Accelerator Center

Office of Basic Energy Sciences
Office of Science

A. Purpose

The purpose of this paper is to document the review by the Office of Science Ene gy Systems Acquisition Advisory Board-equivalent for the Critical Decision "Approval of Pr liminary Baseline Range (CD-1)" for the Linac Coherent Light Source (LCLS) project at t ie Stanford Linear Accelerator Center (SLAC). The review certifies that all of the CD-1 requ rements prescribed by DOE Order 413.3 (Program and Project Management for the Acqu sition of Capital Assets) have been satisfied.

B. Mission Need

The mission of the Office of Science is "To advance basic research and the instru nents of science that are the foundations for DOE's applied missions, a base for U.S. techi ology innovation, and a source of remarkable insights into our physical and biological v orld and the nature of matter and energy." The Linac Coherent Light Source (LCLS) project i : a unique opportunity for a major advance in carrying out that mission.

The LCLS will be the world's first x-ray free electron laser (XFEL), serving as a esearch and development center for XFEL physics in the hard x-ray regime and as a facility fi r the application of XFEL radiation to experimental science.

The LCLS will provide coherent radiation of unprecedented intensity and pulse d ıration in the wavelength range 1.5 - 15 Å. It is based on the SLAC linac, which can accelerat electrons or positrons to 50 billion electron Volts (GeV).

The LCLS will be the first XFEL in the world operating in the 1.5 - 15 Å wavele gth range utilizing the first harmonic of the undulator (shorter wavelengths are possible usi ıg higher harmonics). The emitted coherent x-rays will have unprecedented brightness wit ı 10^{12} - 10^{13} photons/pulse in a 0.2 - 0.4% energy bandpass and an unprecedented time structu e with a design pulse length of 230 femtoseconds.

The unique characteristics of the LCLS will open new realms of scientific applic: tions in the chemical, materials, and biological sciences.

The first five areas of experimentation currently envisaged for the LCLS are: (1) undamental studies of the interaction of intense x-ray pulses with simple atomic systems; (2) ıse of the LCLS

as a pump source to create warm dense matter and plasmas; (3) structural studies on single nanoscale particles and biomolecules; (4) ultrafast dynamics in chemistry and sol d-state physics; and (5) studies of nanoscale structure and dynamics in condensed matter. The ex eriments fall into two classes. The first follows the traditional role of x-rays to probe matter w thout modifying it while the second utilizes the phenomenal intensity of the LCLS to e: cite matter in fundamentally new ways and to create new states in extreme conditions.

C. Project Preliminary Scope Baseline

The LCLS project will build an x-ray FEL facility at SLAC based on their existin g linac. The LCLS requires a new 150 MeV injector to be built at Sector 20 of the 30-sector S LAC Linac to create the high brightness electron beam required for the FEL. The last kilometer of the linac will be modified by adding two magnetic bunch compressors. Most of the linac, and i s infrastructure, will not be changed. The existing components in the Final Focus Test Beam tunn el will be removed and replaced by a new 120 meter undulator and associated equipment. T wo new experimental halls (50,000 – 70,000 gross square feet total) will be constructed. ' he Near Hall will be built approximately 40 meters downstream of the Undulator Hall. The sin gle-story near hall will be 30 meters wide by 55 meters long. The Far Hall will be built approxi nately 322 meters downstream of the Undulator Hall. The two-story far hall will be 35 mete: s wide by 57 meters long and will accommodate office and laboratory areas on the second floo '. Provisions will be made for housing instrumentation and controls for the initial experiments.

The LCLS project will be a collaboration between SLAC, Argonne National Lab ratory (ANL), and Lawrence Livermore National Laboratory (LLNL). SLAC will provide overa l management of the project along with technical responsibilities delineated in the work breakdo wn structure (WBS), ANL will be responsible for the Undulator and LLNL will be responsible for the x-ray transport, optics and diagnostics. The scope of work of these two collaborating la oratories will be controlled by the LCLS Project Execution Plan (PEP) and associated Memora da of Understanding.

Key Design Operating Parameters

0.8 – 8 KeV Self-Amplified Spontaneous Emission (SASE) Free Electron Laser
Electron Beam Energy 4.54 – 14.35 GeV, from SLAC Linac
Peak Power in SASE bandwidth 8 Giga Watts
Peak Brightness 1 x 10^{33} photons/(mm^2 $mrad^2$ 0.1%BW)
Pulse Duration 230 femtoseconds
Pulse Repetition Rate 120 Hertz

D. Project Preliminary Cost and Schedule Baseline

Based on the completed conceptual design, the preliminary Total Estimated Cost (TEC) range is $200 million - $240 million and the preliminary Total Project Cost (TPC) range i: $245 million - $295 million. The performance cost and schedule baselines will be established at CD-2b

(Approval of Performance Baseline). Project Engineering and Design (PED) func s for the LCLS are in the FY 2003 budget request. The PED funding profile follows:

Fiscal Year	Project Engineering and Design	Other Project Costs	Total Project Funding
2002		1,500	1,500
2003	6,000		6,000
2004	15,000	4,000	19,000
2005	10,000	4,000	14,000
2006	2,500		2,500
Total	33,500	9,500	43,000

The preliminary schedule baseline is as follows:

CD-0	Mission Need Approval	June 13, 20)1
CD-1	Preliminary Baseline Range Approval	September :002
CD-2a	Long-Lead Procurement Budget Approval	February 2(03
CD-2b	Performance Baseline Approval	April 2004
CD-3a	Long-Lead Procurements Approval	August 200 4
	Authorize Long-Lead Procurement Funds	October 20)4
CD-3b	Start Construction Approval	August 200 5
	Authorize Construction Funds	October 20)5
CD-4	Start Operations Approval	2008

E. Acquisition Execution Plan

The acquisition of the LCLS will be conducted through Stanford University - SL AC as a prime contractor. The project is similar in scope to the recently completed B-Factory a SLAC, which was conducted successfully by SLAC management. SLAC is capable of directin ; this project, and together with the resources of its collaborators (ANL and LLNL), it also has he means to execute the project.

The LCLS project, in close cooperation with SLAC's Technical and Stanford Sy: chrotron Radiation Laboratory Divisions, will be responsible for accomplishing the projec under the terms of Stanford University's M&O contract with the Department of Energy. S AC will execute those parts of the project associated with conventional facilities and the a :celeration and control of the electrons as well as overall system integration and management. T ie Advanced Photon Source Division at ANL will design and fabricate the undulator and asso(iated systems. The Physics and Advanced Technologies Directorate at LLNL will design, fabric ate, qualify, and commission the front-end x-ray optics. Project management at SLAC will contr l work at these laboratories in accordance with the PEP.

Project activities will be accomplished to the extent feasible using fixed-priced su bcontractors selected by SLAC and the collaborating laboratories on the basis of best value, pr ce and other factors.

F. Environmental Strategy

The LCLS will be designed, constructed and operated in compliance with all requ irements of the National Environmental Protection Act (NEPA) and its implementing regulations Construction and operation activities have been evaluated in the NEPA Environmental Assessr ient (EA) for the LCLS Project. No negative impacts to the environment are anticipated as a re ult of this project.

G. Preliminary Hazard Analysis

A preliminary hazard screening for the LCLS facility was conducted in June 200 . The purpose was to identify potential hazards associated with the design, fabrication, construc ion, and testing phases the project. This assessment concluded that the LCLS requirements are w ll within existing safety and operating envelops, the risks of all hazards will be similar in n ature and magnitude to those already found in the present accelerator and synchrotron radia ion programs, and the hazard impact will have only the potential for minor on-site and negligibl off-site impacts to people or the environment. The project will evaluate hazards and deve op controls for the operation and research activities during the development of the Safety Assess nent Document.

H. Energy Conservation and Sustainable Design

Sustainable building design principles will be applied to the siting, design, and cc nstruction of the LCLS conventional facilities. Additionally, standard practices, including the se of recycled material, the purchase of energy-efficient and water-efficient equipment, and sub titution of less hazardous input materials, will be utilized. Project waste disposal and recycling n quirements will be incorporated into the project procurement documents.

The conventional facilities will be designed and constructed to meet energy conse rvation performance standards. The analysis will be conducted during Titles I and II desi n phases to comply with California Title 24 and 10 CFR, Part 435.

I. Elimination of Excess Facilities

Starting with new construction projects in FY 2003, Congress is requiring DOE t eliminate an equivalent amount of excess facility space at the site of a proposed project, or go hrough a Secretarial waiver process to instead allow excess space to be eliminated at anoth r DOE site. In the case of LCLS, there does not appear to be enough excess space at SLAC to of set the amount

of new space constructed for LCLS (50,000 – 70,000 gross square feet). SC ther fore intends to pursue a Secretarial waiver to eliminate equivalent space elsewhere in the DOE l: boratory complex.

J. Risk Assessment

Risk management for LCLS is based on a graded approach in which levels of r sk are assessed for project activities and elements. This assessment is based upon the potential (onsequences 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 c)mponents, and planning alternatives.

A risk assessment was conducted during the conceptual design, which identifie technical, cost and schedule risks. At this stage, technical and cost risks appear to be low, and schedule risk is assessed to be low to moderate. Further risk assessment activities will be dor ? as part of the Title I design process and in planning for LCLS acquisitions in compliance with the DOE Order 413.3 and SC project management procedures.

Submitted by:

Hanley W. Lee
DOE Federal Project Manager
Stanford Site Office

9/12/02
Date

John S. Muhlestein
Site Manager
Stanford Site Office

9/12/02
Date

Jeffrey C. Hoy, LCLS Program Manager
Materials Sciences and Engineering Division
Basic Energy Sciences
Office of Science

9-12-02
Date

Iran L. Thomas
Director, Materials Sciences and Engineering Division
Basic Energy Sciences
Office of Science

9-12-02
Date

Patricia M. Dehmer
Associate Director, Basic Energy Sciences
Office of Science

9-12-02
Date

Recommendations

The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approv l of CD-1, Approval of Preliminary Baseline Range, for the Linac Coherent Light Source at SLAC as noted below, subject to the Acquistion Execution Plan being approved by the Under Se retary.

D R Lehman 9/12/02 Yes ✓ No
ESAAB Secretariat, Construction Mgmt Support Division Date

See attached. Yes No
Representative, Non-Proponent SC Program Office Date

See attached. Yes No
Representative, Financial Mgmt. Division Date

See attached. Yes No
Representative, Environmental, Safety and Health Division Date

Mark Thornock 9-12-02 Yes ✓ No
Representative, Security Mgmt. Team Date

9/12/02 Yes ✓ No
Representative, Laboratory Infrastructure Division Date

Yes No
Representative, Grants and Contracts Division Date

Recommendations

The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-1, Approval of Preliminary Baseline Range, for the Linac Coherent Light Source at SLAC as noted below, subject to the Acquistion Execution Plan being approved by the Under Secretary.

ESAAB Secretariat, Construction Mgmt Support Division	Date	Yes__ No____
Lenny Mucciaro/ac Representative, Non-Proponent SC Program Office	9/12/02 Date	Yes_✓_ No____
Representative, Financial Mgmt. Division	9/12/02 Date	Yes_✓_ No____
Representative, Environmental, Safety and Health Division	9/12/02 Date	Yes_✓_ No____
Representative, Security Mgmt. Team	Date	Yes__ No____
Representative, Laboratory Infrastructure Division	Date	Yes__ No____
Representative, Grants and Contracts Division	Date	Yes__ No____

Approval

Based on the material presented above and at this review, Critical Decision-1, Ap ɔrove Preliminary Baseline Range, is approved. Therefore, the Office of Basic Energy Sciences is authorized to proceed with expenditure of Project Engineering and Design funds : or the design of the Linac Coherent Light Source at the Stanford Linear Accelerator Center.

Raymond L. Orbach
Director
Office of Science

10-16-02
Date