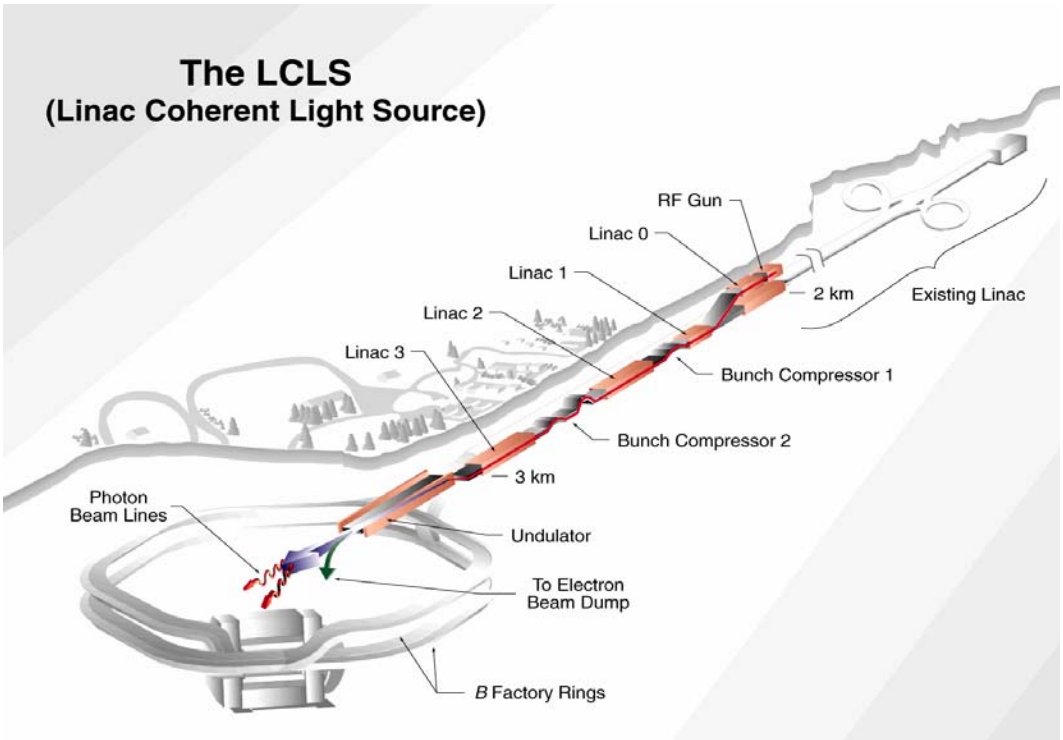
# *Linac Coherent Light Source (LCLS)*

## *An X-Ray Free Electron Laser*




# Risk Management Plan

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# Section 1 - Scope

## 1.1 Identification

The philosophy of the Linac Coherent Light Source (LCLS) management team is that risk is an inherent part of any large-scale scientific project. To be successful, a risk management process is needed such that risk can be continually evaluated so that risk is controlled such that the consequences of adverse events can be minimized.

This document, the LCLS Risk Management Plan (RMP), describes the management processes used on the LCLS project to identify, categorize, quantify and handle risks associated with the achievement of the project requirements and goals for the LCLS x-ray free-electron laser, which is being constructed at the Stanford Linear Accelerator Center (SLAC).

## 1.2 Document Overview

This document establishes the policies, procedures and methodologies for evaluating and tracking cost, schedule and technical risks to the LCLS project mission. Section 2 will define the methodology for risk assessment. Risks will be categorized in terms of probability and consequence. In section 3, a format for a risk registry will be established. Appendices are attached which provide worksheets for each identified risk. The LCLS RMP provides the guidance to the LCLS Risk Registry, which is a controlled document updated semiannually over the life of the LCLS project.

## 1.3 Applicable Documents

### 1.3.1 Government Documents

*CD-0 Approval of Mission Need for the Linac Coherent Light Source*
http://www-ssrl.slac.stanford.edu/lcls/documents/LCLS_CD-0_final.pdf

*CD-1 Approval of Preliminary Baseline Range*
http://www-ssrl.slac.stanford.edu/lcls/documents/Final_LCLS_CD-1_Approval_Document_09-12-02.pdf

*U.S. Department of Energy Project Management Practices, Chapter 8, Oct-01*
http://www.science.doe.gov/SC-80/sc-81/practices.html

*DOE M 413.3-1, Project Management for the Acquisition of Capital Assets, Mar-03*

### 1.3.2 SLAC Documents

Reserved

### 1.3.3 LCLS Documents

*LCLS Advance Procurement Plan, Mar-04*
*LCLS Global Requirements Document, 1.1-001, May-04*
*LCLS Preliminary Safety Assessment Document (draft), Apr-04*
*LCLS Project Management Plan (draft), Rev-0 May-04*
*LCLS Quality Assurance Plan (draft), Rev-0, May-04*
*LCLS Risk Registry, Rev-0, May-04*

Copies of all documents can be obtained in the LCLS Project Office. Additional Information on the LCLS project and its scientific program can be found on the LCLS website at http://www-ssrl.slac.stanford.edu/lcls.

# Section 2– Risk Identification & Assessment

Managing risk is a key element of the project management process for both planning and performance phases of the LCLS. As such, this LCLS RMP develops a methodology to identify and quantify specific risks to the LCLS project, determine their consequence and associated probability, and develop mitigation and correction strategies should risks become reality.

## 2.1 Project Requirements Document

The LCLS Global Requirements Document (GRD 1.1-001) forms the basis for the risk identification. Goals and requirements, consistent with GRD 1.1-001, are used to identify risk as described in Appendix A (Risk Identification Reference). These goals/requirements are categorized as;

- *Project performance requirement* for the LCLS: the key performance deliverable prerequisite for Critical Decision 4, *Approval of Start of Operations*
- *Performance goals*: intended to serve as guidance for the design of the LCLS
- *Functional requirements*: other requirements, such as compatibility with other functions of the SLAC Linac, that must be satisfied by the LCLS
- *Functional goals* intended to serve as guidance for the design.

## 2.2 Risk Categories

Risks to the LCLS project are identified according to the following categories;

- Technical
  - Design and Equipment Complexity
  - Environment, Safety & Health (ES&H)
  - Procurements
  - Programmatic (Scientific Mission)
  - Resources (Funding and Staffing)
- Cost (includes currency and inflation)
- Schedule

ES&H hazards associated with the LCLS Project are well within the range of normal SLAC operations, as indicated in the LCLS Preliminary Safety Assessment Document. SLAC will apply its well-developed management systems for handling all the ES&H risks entailed in the LCLS Project. However, ES&H impacts that increase the risk severity level of technical parameters or facilities will be managed and mitigated by the LCLS management team.

## 2.3 Risk Consequences

In terms of risk consequences, each risk category has four assessment levels:

Technical Consequence Level

Level 0- negligible impact
Level 1- minimal impact on, or delay to fulfillment of mission need
Level 2- moderate impact on, or delay to fulfillment of mission need
Level 3- considerable impact on, or delay to fulfillment of mission need

Schedule Consequence Level

Level 0- negligible potential for delay to Level 1 (L1M) or Level 2 (L2M) milestone
Level 1- potential delay to L2M is < 3 month or L1M of < 1 month
Level 2- potential delay to L1M is < 3 months or L2M of ≥ 3 months
Level 3- potential delay to L1M is > 3 months

Cost Consequence Level

Level 0- estimated cost of corrective action is < $100K
Level 1- estimated cost of corrective action is < $1M
Level 2- estimated cost of corrective action is > $5M
Level 3- estimated cost of corrective action is > $10M

Overall Consequence Level

An overall consequence level is derived using the greatest of the technical, cost and schedule consequence levels.

## 2.4 Risk Probabilities

The following risk probability levels are assessed for each risk category:

Risk Probability Level

Level 0- <1% probability that the consequences of the risk will be realized
Level 1- < 5% probability that the consequences of the risk will be realized
Level 2- < 25% probability that the consequences of the risk will be realized
Level 3- > 25% probability that the consequences of the risk will be realized

## 2.5 Risk Severities

Finally, a risk severity matrix determined from the Overall Consequence Level and the Risk Probability Level provides the overall assessment of each identified risk to the LCLS project, as shown below:

| Risk Severity Levels in colored boxes | | Consequence Level | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 |
| Probability Level | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 2 | 3 |
| | 2 | 0 | 2 | 2 | 3 |
| | 3 | 0 | 3 | 3 | 3 |

Items with risk severity level of 2 or greater must be entered in the LCLS Risk Registry.

# Section 3 Risk Management & Documentation

## 3.1 Risk Documentation

Each identified risk shall be documented using the Risk Assessment Worksheet, shown in Appendix B. Consequences and probabilities should be described as detailed as possible to support the level of assessment.

The approach to each identified risk shall be documented using the Risk Management Worksheet, shown in Appendix C. Consequences and probabilities should be described as detailed as possible to support the level of assessment.

LCLS WBS managers are responsible for identification and assessment of risks. This responsibility includes providing regular re-evaluation and a status update of risk registry entries to the LCLS Project Office.

## 3.2 Risk Registry

The LCLS Project Office is responsible for maintenance of the Risk Registry, and for ensuring that LCLS WBS managers are monitoring and reassessing risks regularly. Data from the Risk Assessment and Risk Management Worksheets will be transcribed to the Risk Registry spreadsheet.

As mentioned previously, risk items with severity level of 2 or greater must be entered in the LCLS Risk Registry. Level 1 risks, or risks which have been down-rated to level 1 as a result of a management action, may or may not be retained in the Registry. Risks reduced to level 0 will not be recorded in the Registry.

### 3.3 Risk Management

The LCLS RMP assesses and quantifies risks to the LCLS project and documents the high risk areas in the LCLS Risk Registry (separate document). The LCLS Risk Registry is a living document used throughout the life of the LCLS project and is under configuration control. The LCLS RMP and Risk Registry are reviewed semiannually and updated by the LCLS Change Control Board (CCB) to reflect any reassessment of risks to the LCLS project.

# Appendix A – Risk Identification Reference

Risks to the LCLS project are identified and categorized according to their impact on the CD-1, CD-4 and/or the LCLS GRD 1.1-001 in terms of performance goals and/or requirements. To facilitate reference, goals/requirements are assigned alphanumeric abbreviations (PG1-1 thru PG1-6, PR1-1, A1-1 thru A1-4, FR1-1 thru FR1-4, and FG1-1 thru FG1-5).

## A.1 Global Performance Goals (PG1-X)

The key global performance goals of the LCLS have been listed in the *CD-1 Approval of Preliminary Baseline Range for the Linac Coherent Light Source*. The same parameters are listed in the LCLS Project Execution Plan, as "Key Design Parameters at Full Routine Operation".

Self-Amplified Spontaneous Emission (SASE) Free Electron Laser

| | | |
|---|---|---|
| PG1-1 | X-ray Photon Energy | 0.8 - 8 keV |
| PG1-2 | Electron Beam Energy | 4.4 – 14.1 GeV from Linac |
| PG1-3 | Peak Power in SASE Bandwidth | 8 GW |
| PG1-4 | Peak Brightness | $1 \times 10^{33}$ |
| PG1-5 | Pulse Duration | 230 femtoseconds |
| PG1-6 | Pulse Repetition Rate | 120 Hz |

These key performance goals form the basis for approval of CD-0 and CD-1.

## A.2 Project Performance Requirements (PR1-1, A1-X)

PR1-1 The Project Execution Plan states the summary requirement for achievement of Critical Decision 4, Start of Operations.

"The top-level commissioning goal is to generate x-rays in the LCLS undulator and detect them in the Far Hall." The Far Hall is one of two locations where x-ray experiments may be carried out with the LCLS beam. This milestone is to be achieved by 30 September 2008.

The Project construction schedule is constrained by this requirement. Achievement of CD-4 entails;

- achievement of commissioning goals for the injector
- achievement of commissioning goals for the linac
- achievement of commissioning goals for the undulator systems
- beneficial occupancy of the Near Experiment Hall
- beneficial occupancy of the Far Experiment Hall
- completion of beam path from the undulator to the Near Experiment Hall
- completion of the beam path from the Near Experiment Hall to the Far Experiment Hall
- operational personnel protection systems for all electron beam enclosures
- operational personnel protection systems for the hutches in the Near Experiment Hall
- operational personnel protection system for the center hutch in the Far Experiment Hall
- a functional x-ray detector in the center hutch of the Far Experiment Hall
- achievement of commissioning goals and requirements for all level 2 WBS elements
- successful transport of an x-ray beam from the undulator hall to the Far Experiment Hall
- detection of x-ray photons in the Far Experiment Hall

A1-1 (Injector Commissioning Goals)

- Repetition rate — 10 Hz or greater
- Nominal Charge/pulse — 0.5 nC or greater
- Nominal pulse length — 3-10 ps
- Projected emittance — 2.0 mm-mrad or less

A1-2 (Linac Commissioning Goals)

- Repetition rate — 10 Hz or greater
- Nominal Charge/pulse — 0.5 nC or greater
- Nominal pulse length — 3-10 ps
- Projected emittance — 2.0 mm-mrad or less

A1-3 (Undulator Commissioning Goals)

- Transport of electrons without loss to beam dump, 4.4-14.1 GeV
- Diagnostics and machine protection systems functional 1-10 Hz

A1-4 (Project Commissioning Goal for Project Completion (CD-4))

- Detect x-rays in Far Hall

## A.3 Key Functional Requirements (FR1-X)

FR1-1 Operation of the LCLS linac for the x-ray experiment program and LCLS-related FEL and electron beam physics studies will be scheduled for at least 75% of the scheduled operating time of the Two-Mile Linac as a whole. Maintenance to the LCLS linac requiring entry to the linac enclosure may only be carried out when the entire linac is shut down for access.

FR1-2 Operation of the LCLS will be completely compatible with simultaneous operation of the linac in support of the PEP-II program.

FR1-3 It will be possible to switch from LCLS operation to acceleration of beam from the damping rings (e.g. to End Station A) without the need to enter the linac tunnel.

Acceleration of beam from the CID guns may require removal of the x-band accelerating structure in sector 21 of the LCLS Linac. It will be possible to remove this accelerating structure and make the linac ready for beams from CID in 24 hours or less.

FR1-4 Operations control of the LCLS linac and the electron beam will be carried out from the SLAC Main Control Center. Necessary data for monitoring and control of the LCLS will be available to the SLC controls system.

## A.4 Functional Goals (FG1-X)

FG1-1 The LCLS linac and undulator systems should be designed to operate with bunch charges in the range 0.2 – 1.0 nanocoulombs.

FG1-2 Operational availability should be greater than 90%. The linac is typically operated about 6600 hours per year for all purposes (PEP, FFTB, End Station A, tune-up/training/studies)

FG1-3 The traditional tolerance for transverse beam stability in a synchrotron source is 10% of beam size. This will be a challenging goal due to the small emittance of the LCLS beam.

FG1-4 EPICS controls should be implemented where practical; it is expected that the injector, undulator systems, x-ray transport/optics/diagnostics and end station systems will implement EPICS for device control.

FG1-5 Achievement of the CD-0 performance goals PG1-1, PG1-3, PG1-4, and PG1-5 will be verified using devices that are part of WBS 1.4, X-ray Transport, Optics and Diagnostics. The brightness measurement requires that an upper limit be determined for the x-ray pulse duration, and that the total energy of the photon pulse be measured. The measurement will depend on calibration of the x-ray attenuators, which must reduce the x-ray intensity by a factor of 10,000. Nonlinearity in the attenuator will itself be the subject of early atomic physics experiments at LCLS. For this reason, it is to be expected that the uncertainty in peak power output of the LCLS will be approximately a factor of 10, through the first year of operation of the facility.

# Appendix B – Risk Assessment Worksheet

| | | |
|---|---|---|
| **WBS # (X.X.X)** | **Key Requirement/Goal:** **Enter alphanumeric goal or requirement from Appendix A: FR1-X or PG1-X or FG1-X** | **Identification Number:** **Enter alphanumeric ID R-WBS @ L2-Ref #** |
| **Title:** *short title by which the risk can be referenced* | **Date Submitted:** *the date that the entry is submitted* | **Submitted By:** *person who submits the risk* |
| **Owner:** *list the person who is responsible for managing the identified risk* | | **Date Last Revised:** *enter each date that the entry is revised* |
| **Risk Overview – "IF" Statement:** *restate the specific risk event as an "If (this happens) due to (cause)"* | | **Risk Overview "THEN" Statement:** *restate the specific risk even as a "Then (that will happen) statement"* |
| **Risk Timeframe:** *this issue or event could occur in which phase of the project (check all that apply)*<br>☐ Design<br>☐ Construction<br>☐ Commissioning<br>☐ Operations | | **Probability Level:** *based on the scenario listed, estimate the probability percentage that this event will occur.* |
| **Cost Consequence Level:** *based on the scenario listed, estimate the cost impact using dollars*<br>Optimistic: _____<br>Most Likely: _____<br>Pessimistic: _____ | **Schedule Consequence Level:** *based on the scenario listed, estimate the schedule impact using time*<br>Optimistic: _____<br>Most Likely: _____<br>Pessimistic: _____ | **Technical Consequence Level:** *based on the scenario listed, if applicable, estimate the performance impact using the appropriate technical consequence level*<br>Optimistic:_____<br>Most Likely: _____<br>Pessimistic: _____ |

# Appendix C – Risk Management Worksheet

| **WBS # (X.X.X)** | **Key Requirement/Goal:** | **ID Number:** |
|---|---|---|
| **Title:** | **Date of Initial Plan:** *list the date that the plan is first developed* | **Handling Plan Led By:** *list the owner of the handling plan* |
| **Overview of Handling Plan:** *provide an overview of the handling plan* | | |
| **Risk Handling Approach:** *check whichever applies*<br>☐ **Avoid** ☐ **Mitigate** ☐ **Transfer** ☐ **Accept** | | |
| **Steps for Handling the Plan:** *list the steps involved in the risk handling approach* | **Schedule for the Steps:** *list the dates associated with each of the steps listed* | |
| **Comments:** *List relevant comments such as resources needed for the plan, estimated cost and schedule or implementing the plan, and rationale behind the plan* | | |
| **Total Estimated Cost:** *what is the total estimated cost of the resources involved* | **Risk Retired:** *note if the risk has retired. The risk is retired when the risk is realized, handled, or passed.* | |