LCLS Project Management Document # 1.1-002	Project Office	Rev. 4	

Risk Management Plan

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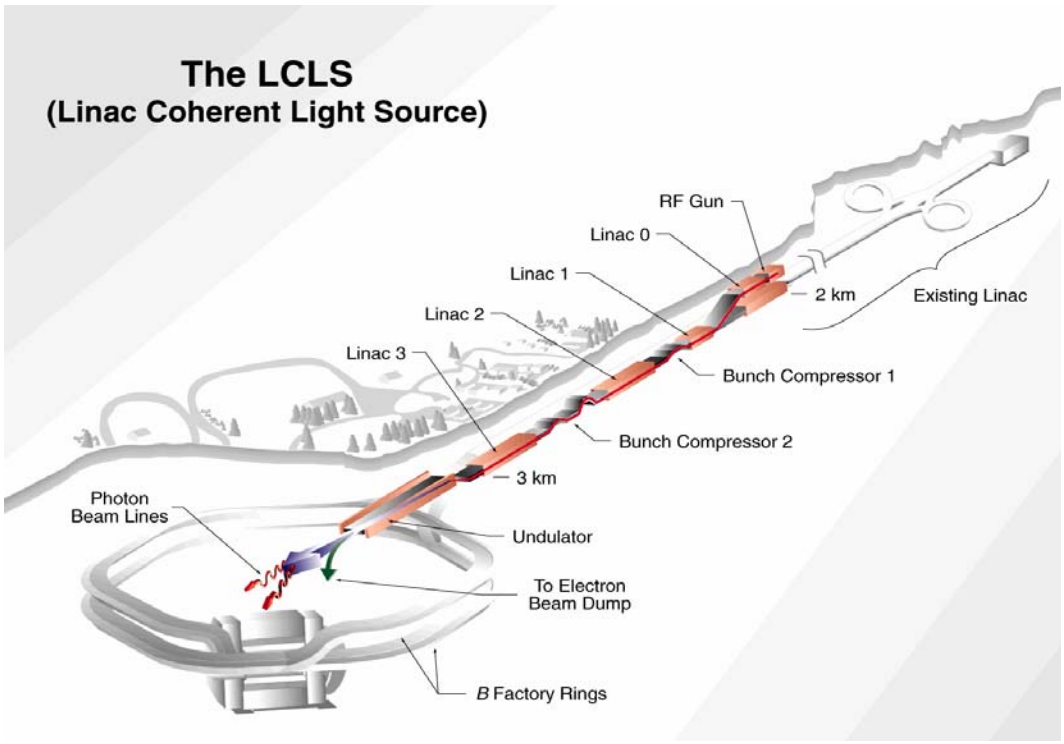
Change History Log

Rev Number	Revision Date	Sections Affected	Description of Change
000		All	Initial Version
001	5-23-2007	All	Reworked the entire plan
002	9-5-2007	All	Enhanced the methods for assessing risk based contingency
003	4-7-2008	Section 2 – Management Approach	Change the frequency of updating the Risk Registry from monthly to quarterly plus minor edits
004	6-10-2008	Section 3 – Risk Identification & Assessment Add Addendum	Added guidance for assessing the Risk Probabilities in Section 3, Table 1. Added Addendum – LUSI Project Summary and LUSI Risk Consequences

An X-Ray Free Electron Laser



Risk Management Plan

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Section 1 – Scope

1.1 Identification

This document, the Linac Coherent Light Source (LCLS) Risk Management Plan (RMP), describes the management processes used at the Stanford Linear Accelerator Center (SLAC) to plan, identify, assess, quantify, handle and report/track risks associated with the achievement of the project requirements for the LCLS x-ray free-electron laser. The LCLS RMP is consistent with DOE O 413.3A, *Project Management for the Acquisition of Capital Assets*, and strives to incorporate 'best practices' from other large-scale first of a kind large scale science projects around the DOE complex.

The philosophy of the LCLS management team is that risk is inherent in all activities of any large-scale scientific project. To be successful, a risk management process is necessary such that risk can be continually evaluated and managed in order to minimize the consequences of adverse events.

The ultimate goal of risk management is to increase the probability of project/ activity success by focusing attention on problem areas early and reducing the amount of costly rework in the future. For each and every risk, there is the potential impact of cost overruns, schedule delays and compromises in quality and/or safety if the risk occurs. Hence, risk management will be applied continuously throughout the LCLS project life cycle and will evolve and adapt to accommodate the various project phases.

Section 2 – Management Approach

2.1 Roles and Responsibilities

LCLS management has established specific roles and responsibilities to support project risk management processes and control over the life cycle of the project. The specific roles/responsibilities relating to the LCLS RMP are as follows:

- LCLS Project Risk Manager – The LCLS Project Risk Manager is the project team member assigned responsibility for implementing the overall Risk Management Program and ensuring that it meets the intent of DOE Order 413.3A. The LCLS Project Risk Manager works with risk, quality and safety subject matter experts and the Risk Manager Points-Of-Contact (POCs) to execute the risk management process. The LCLS Project Risk Manager updates the RMP, conducts the risk reviews, and is responsible for the development of risk reports and registers. Currently the LCLS Project Risk Manager is the LCLS Deputy Project Director.

- LCLS System Risk Managers – The Project Office, Electron Beam, Photon Beam and Conventional Facility System Managers are the System Risk Managers and have responsibility for risk identification, assessment, handling, impact determination and documentation for their approved scope of work. Each System Risk Manager is responsible for ensuring that the management method chosen for a risk can be implemented with reasonable confidence of success, resources are sufficient to perform the control actions, and risk management and handling actions are executed for each risk.

- At least quarterly, the Project Risk Manager and the System Risk Managers update the status of assigned risks, identify any new risks and retire any risks that can no longer impact the project.

2.2 Risk Management Process

The LCLS project risk management process is summarized in the following steps and described in more detail in Section 3.

1. Risk Management Planning – Prior to the initiation of risk management, activities in the proposed baseline (scope, schedule and cost) are evaluated

to determine their potential for risk. This evaluation (or risk screening) assesses all activities against a set of screening categories typically in the areas of technology, interface control, safety, regulatory/environmental, security, design, resources, etc. Activities which would normally be addressed by the project's configuration control processes are considered low risk and are not tracked as project risks. Activities which are identified as having project risks which would not be handled by the project's controls are identified as project risks and tracked within the LCLS RMP.

2. Risk Identification – Identify risks that may impact the successful completion of the project. Risks are identified for the entire life cycle of the project. Risks associated with project work scope, cost, and schedule are identified by systematically challenging the assumptions, logic, and scope of the project and examining the identified uncertainties associated with each stage of the project.

3. Risk Assessment – Assess the risks to determine their likelihood and impact on the project's cost, schedule, and/or work scope. This includes a qualitative and quantitative assessment of the consequences (impact) of the risks as well as the risks probability of occurring.

4. Risk Handling – Determine the risk-handling strategy, whether (in order of preference) it is to eliminate, transfer, prevent, mitigate, or assume (accept the risk).

5. Risk Management Impacts and Control Actions – Assesses the risk impact on the project and the effect of the risk handling strategies. Risk handling strategies will be reflected in the project's baseline, whereas residual risks will be reflected in the project contingency.

6. Risk Reporting and Tracking – Risk reporting and tracking is the documentation of the risk management process. For the LCLS project, this is the LCLS Risk Registry.

Risk management is an iterative process in which the effectiveness of control actions is constantly evaluated, new risks are discovered, and existing risks are reassessed. New or revised control actions are implemented as needed. By managing risks, the process helps minimize cost impacts, schedule delays, or the

impact of other issues that could impede a project's progress. The iterative process continues until all the risks are closed or the project is completed.

Section 3 – Risk Identification & Assessment

3.1 Risk Identification

Risk identification requires a methodical process to ensure that the list of identified risks is comprehensive. In this process, the Risk Project Manager, Risk System Manager, supporting project staff, including subject matter experts, and Control Account managers, are queried to identify project risks in their area of responsibility. The risk identification approach is two-pronged: 1) top-down to identify higher-level programmatic risks such as funding, scope, and political considerations and 2) bottom-up to identify project-specific risks such as cost, schedule, regulatory, and technical uncertainties. To ensure that all project-level risks are identified, risk elicitation is performed by systematically walking down through each element of the Work Breakdown Structure (WBS). Identified risks are listed in the project Risk Registry.

3.1.1 Risk Categories

Risks to the LCLS project are typically found in one of the following categories:

- Technology
  - Design and/or Technology Complexity
  - Installation and/or Integration Complexity
- Environment, Safety & Health (ES&H)
  - Regulatory/Environmental Controls
  - Safeguards/Security
- Design Issues
  - Functional Requirements
  - Design Maturity/Complexity
- Cost (includes currency and inflation)
  - Resources (includes funding and staffing)
- Schedule (includes major milestones)
- Management
  - Configuration Processes
  - Interface Management
  - Procurements and Procurement Processes

- Programmatic (scientific mission)

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 (PSAD). SLAC will apply its Integrated Safety Management (ISM) System for handling all the ES&H risks entailed in the LCLS Project (see LCLS ISM plan for more detail). 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.

3.1.2 Project Requirements Documents

The basis for risk identification is the LCLS Global Requirements Document (GRD 1.1-001). All related LCLS requirements documents* are consistent with GRD 1.1-001 and can be used to identify project risks. Other requirements which can be used to identify project risks can be found in the following categories:

- *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
- *Interface requirements*, such as compatibility with other functions of the SLAC Linac that must be satisfied by the LCLS.

3.2 Risk Assessment and Quantification

Risk level assessment is done by determining the probability of the occurrence and cost and schedule consequence of each risk. Consequence must consider foreseeable cumulative impact on project scope, cost and schedule.

Each risk is qualitatively assessed/ranked using the categories provided in Figure 1. Likelihood is the subjective probability that the risk event will occur. The likelihood of identified risks is qualitatively characterized as Very Likely, Likely, Unlikely or Very Unlikely based on expert judgment. These categories are defined in Table 1.

* Physics Requirement Documents (PRDs), Engineering Specification Documents (ESDs), Interface Control Documents (ICDs) and Room Specification Documents (RSDs). For additional information on LCLS functional requirements documents, refer to the LCLS Quality Implementation Plan, PMD-003.

Guidance for assessing probability of risk is provided in Section 3, Table 1. The Risk Levels correspond to the Qualitative Assessment of Occurrence. The assessor can generally use the worst case from Technology Maturity, Work Scope Definition and Inter-Organizational Dependency as the corresponding Qualitative Assessment of Occurrence in Table 1. This is only a guide and the Risk Assessor can modify the Assessment based on judgment.

Table 1. Risk Probabilities and Guidance

			Guidance for Assessing Risk Probability		
Risk Levels	**Qualitative Assessment of Occurrence**	**Criteria**	**Technology Maturity**	**Work Scope Definition**	**Inter-Organizational Dependency**
4 (High)	Very Likely	The probability of occurrence over the project life cycle is greater than 80%	• The technology required for the system, component or to accomplish the planned activity does not exist. • Concepts for the system, component or process have been formulated • Basic system, component or process technology principles observed and reported	• Project requirements are not determined or supported by the client and/or stakeholders • Project operations are not identified or supported by stakeholders • Mission Need Statement approved and Functional Analysis Completed	• Activity involves multiple organizations and/or sites • No formal concurrence has been reached among organizations • Stakeholders are opposed to involvement in the activity • Procurement Applicable – no details formally approved
3	Likely	The probability of occurrence over the project life cycle is greater than 40% but less than or equal to 80%	• Development of the technology is only at the laboratory level. • Bench scale system, component or process has been demonstrated in a relevant environment • System, component or process analysis and proof of concept demonstrated in a simulated environment	• Project requirements are determined but may be controversial to client and/or stakeholders • Project operations are identified but may be controversial to stakeholders • System level design requirements completed; Conceptual Design Review (CDR) completed	• Activity involves multiple sites, site concurrence has been verbally reached • No funding has been identified and no schedule for receipt or treatment of the waste/material exists • The site's involvement may be controversial to stakeholders • Procurement planning is complete, potential vendors identified
2	Unlikely	The probability of occurrence over the project life cycle is greater than 10% but less than or equal to 40%	• Technology is in full scale development and demonstration. • Actual system, component or process successfully operated in the expected operational environment (Cold Commissioning)	• Project requirements are determined and are expected to be acceptable to stakeholders • Project operations are identified and expected to be acceptable to stakeholders • Component level design requirements complete; Preliminary Design Review (PDR) Complete	• Activity impacts another site, site concurrence has been verbally reached • Site involvement is expected to be acceptable to stakeholders • Procurement: : SOW completed, specifications approved, package completed, procurement package issued
1 (Low)	Very Unlikely	The probability of occurrence over the project life cycle is less than 10%	• The required technology has been fully developed and demonstrated at a similar site and/or project. • Actual equipment/process successfully operated in an operational environment (Hot Commissioning and Operations)	• Project requirements are determined and supported by stakeholders • Project operations are identified and supported by stakeholders • Final project requirements are identified • Final Design Review (FDR) Completed	• Activity doesn't impact another site or site concurrence has been documented if multiple sites are impacted • Site involvement is supported by stakeholders • Procurement: Bids received, Discussions held, Specifications can be met; Contract awarded

Table 2. Risk Consequences

Risk Consequences	
Qualitative Consequence of Occurrence	**Criteria***
Negligible	Scope/Technical: Minimal or negligible impact Cost: Some potential transfer of money, but estimated cost of impact consequence is <$100K Schedule: Slilght potential for schedule change, but compensated by schedule float
Marginal	Scope/Technical: Small reduction in project technical requirements or performance. May require minor facility redesign or modification. Cost: Estimated cost of impact consequence is >$100K but <$1M Schedule: Potential delay to L3 milestone is <3 months or L2 milestone is <1 month
Significant	Scope/Technical: Moderate impact on project technical performance. Can pose threat to facility mission, environment, or people. Can require some facility redesign or repair, or change in technical performance. Cost: Estimated cost of impact consequence is >$1M but <$5M Schedule: Potential delay to L3 milestone is >3 months or L2 milestone is <3 months
Critical	Scope/Technical: Considerable impact on project. Technical goals of project cannot be fully achieved. Serious threat to facility mission, environment, or people. Possibly completing only portions of the misson or requiring major facility redesign or repair, or change in technical performance. Cost: Estimated cost of impact consequence is >$5M but <$10M Schedule: Potential delay to L2 milestone is >3 months or L1 milestone is <3 months
Crisis	Scope/Technical: Project cannot be completed. Technical goals of project cannot be achieved. Cost: Estimated cost of impact consequence is >$10M Schedule: Potential delay to L1 milestone is >3 months

3.3 Risk Severities

A risk severity matrix determined from the Severity of the Risk Consequence and the Risk Probability Overall Consequence Level provides the overall assessment of each identified risk to the LCLS project, as shown in table 3.

Table 3. Risk Severity Matrix

Risk Severity Matrix		Severity of Risk Consequence				
		Negligible	Marginal	Significant	Critical	Crisis
Probability of Risk	Very Likely >80%	**Low**	**Medium**	**High**	**High**	**High**
	Likely 40-80%	**Low**	**Medium**	**High**	**High**	**High**
	Unlikely 10-40%	**Low**	**Low**	**Medium**	**Medium**	**High**
	Very Unlikely <10%	**Low**	**Low**	**Low**	**Low**	**High**

The Risk Severity Matrix allow the management team to differentiate a wide set of risk activities across the project and identify those risks that can have the greatest impact on the project.

Section 4 – Risk Management Impacts and Controls Actions

4.1 Risk Handling

Risk management is the process used to identify risks and implement actions to reduce the likelihood of a risk materializing and/or to reduce or eliminate the potential consequences of identified project risks. Risk mitigation strategies generally fall into one of four categories: 1) risk avoidance, 2) risk transfer, 3) risk reduction or mitigation (either likelihood or consequence or both), and 4) risk acceptance. Each of these strategies is described in more detail in Table 4, as are general methods used to manage identified risks.

A management strategy (handling plan) is selected for each identified risks. Control actions are specified for each identified project risk based on the management strategy selected, unless the risk is accepted (i.e., not mitigated). Also specified for each identified risk is the date by which the control action is to be completed, the responsible-action POC, probability and consequence of the risk (pre- and post-handling), a cost estimate of implementing the control actions, the status of each control action, and indication as to whether or not the risk is closed.

The management strategy and control actions selected for each identified risk are tracked in the risk register (discussed in Section 5). The baseline budget includes the funding required to implement the mitigation actions for the risks to achieve the confidence level set by the project.

4.2 Risk Impact Determination

Risk impact determination is the process of evaluating and quantifying the effect of risk(s) on the project. Risk impacts a project in two different ways:

- Handling strategy implementation. If the risk is "handled" using a risk reduction or mitigation strategy, there may be a cost and schedule impact associated with the implementation of that strategy. The implementation cost and schedule impacts of the "handling" strategy must be included in the baseline project cost and schedule.

- Residual risk. Even after risk-handling strategies have been implemented, there may be remaining risk impacts (residual risks). The cost and schedule

impacts of residual risks must be included in the contingency calculations. This is accomplished by determining a cost and/or schedule impact probability distribution for each residual risk. These probability distributions are then combined statistically through a Monte Carlo process to produce the contingency estimate. At all times, the project's available cost contingency should be greater than the statistical calculation of residual cost risk.

Table 4. General Methods for Handling Project Risks

MANAGEMENT METHOD	OBJECTIVE	FEATURES
Avoidance	Risk is eliminated or avoided by changing the parameters of the project	• May change the project plan to eliminate conditions creating the risk (risky requirement, work scope, technology, or contractor) or eliminate the risk entirely. • May trade one risk for another lesser risk. • If a lower risk option is available, revise baseline to favor it. • Check that the lower risk is the better choice considering the project as a whole.
Transfer	Risk remains viable but is shifted to another project or organization. Often called risk allocation.	• If full transfer is not possible, consider a partial shift (e.g., insurance, performance bond, PI, warranty, or contract guarantee). • Often, results in risk being shared between project and others. • Often best with funding risks. • Must consider costs and benefits of transfer. Must ensure recipient is best equipped and prepared to assume the risk (in whole or in part). • Risk is not avoided. Recipient must be willing to assume the risk, in whole or in part.
Mitigation	Reduces likelihood and/or consequences of a risk (preferably both) by series of control actions.	• Most common form of risk management. • Best management *simultaneously* reduces both likelihood *and* consequences (with separate or identical actions). • Must systematically and carefully identify and attack root causes of the risk. • Control actions are comprehensive and feasible. • *Early* actions often required for success. • Actions can affect cost, scope, and schedule. • Cost/benefit analysis can be useful in selecting best control action from a list of alternatives (but this is not mandatory). • Confidence levels for control actions derived from Monte Carlo, Crystal Ball, or other analysis can be useful, but *are not* mandatory.
Assumption (Acceptance)	Risk is recognized and simply taken on by the project.	• "Last option" for controlling a risk. No feasible means to mitigate or otherwise control the risk is available. • Benefit is that no changes in project plans are required to address the risk. • Sometimes used when a compellingly large reward could be gained by taking the risk. • Typically used for obdurate, distant, or least-predictable risks (e.g., funding levels). • Residual (remaining) risk is always accepted. • Requires special diligence in monitoring, because nothing was done to reduce the risk. • Alternative or acceptable "fall-back" positions are especially crucial if the risk is critical to project success. • Worst case is "passive" acceptance, when no fall-back plans are considered.

Section 5 – Risk Tracking & Documentation

5.1 Risk Registry

The LCLS Risk Registry tracks and monitors the status of all project risks including each risk POC, probability and consequence of each risk (pre-and post-mitigation) and details on the risk control actions. The LCLS Risk Registry is a living document used throughout the life of the LCLS project and is under configuration control.

Project risks and the management actions to control them are reviewed and updated monthly by the LCLS Senior Management team which consists of the LCLS Project Risk Manager and the System Risk Managers. New and imminent risks are added into the registry when identified. Risks are closed when *the risk is no longer credible* or *when the risk has been realized and no residual risk remains*.

LCLS System Risk Managers are responsible for identification and assessment of risks. This responsibility includes providing regular re-evaluation and a status update of risk entries via the LCLS Risk Registry to the LCLS Project Office.

The LCLS Project Risk Manager is responsible for maintenance of the Risk Registry and for ensuring that contingency is adequate to address residual risk.

Addendum 1 to LCLS Project Management Document # 1.1-002

PROJECT SUMMARY

The LUSI project is a Major Item of Equipment (MIE) consisting of the design, acquisition, assembly, and installation of three x-ray instruments that will complement the initial instrument provided by the LINAC Coherent Light Source (LCLS) construction project

The LUSI project's complement of x-ray instruments, coupled with the LCLS's initial instrument, which is directed towards atomic physics, will provide the tools to exploit the unique scientific capability of this new facility. LUSI plans to build these instruments and beam delivery systems over a period of six fiscal years (2007 – 2012). One of the three instruments will be optimized for hard x-ray studies of ultrafast dynamics at the atomic level, addressing basic problems in chemistry and materials science. The second instrument will concentrate on hard x-ray coherent imaging of nano-particles and large biomolecules. The beam delivery systems are aimed at the use of soft x-rays to study magnetic structures and surface chemistry and the study of equilibrium dynamics on the nanometer scale using hard x-rays.

The LUSI project is being managed as a System under the LCLS Construction project.

This addendum to LCLS Project Management Document # 1.1-002 is intended to modify the plan's requirements to meet the requirements of the LUSI project.

The following modifications/clarifications to 1.1-002 apply to the LUSI project:

Section 1 – Scope

Include the LUSI project in the scope section

Section 2 – Management Approach

Include the LUSI system under the LCLS System Risk Manager section

Section 3 – Risk Identification & Assessment

Substitute the following LUSI table for Table 2. Risk Consequences

Addendum 1 to LCLS Project Management Document # 1.1-002

LUSI Risk Consequences

Risk Consequences	
Qualitative Consequence of Occurrence	**Criteria***
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Significant	Scope/Technical: Moderate impact on project technical performance. Can pose threat to facility mission, environment, or people. Can require some facility redesign or repair, or change in technical performance. Cost: Estimated cost of impact consequence is >$500K but <$1M Schedule: Potential delay to L3 milestone is >3 months or L2 milestone is <3 months
Critical	Scope/Technical: Considerable impact on project. Technical goals of project cannot be fully achieved. Serious threat to facility mission, environment, or people. Possibly completing only portions of the mission or requiring major facility redesign or repair, or change in technical performance. Cost: Estimated cost of impact consequence is >$1M but <$3M Schedule: Potential delay to L2 milestone is >3 months or L1 milestone is <3 months
Crisis	Scope/Technical: Project cannot be completed. Technical goals of project cannot be achieved. Cost: Estimated cost of impact consequence is >$3M Schedule: Potential delay to L1 milestone is >3 months