NLC Project Management Plan

Next Linear Collider
Project Planning and Coordinating Group

May 1999
# Next Linear Collider
## Project Management Plan (PMP)

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Executive Summary:

The Next Linear Collider is an 0.5 to 1.0 TeV center-of-mass energy linear collider thought to be the next major step in the national high energy physics program. It will complement and extend the physics of the Large Hadron Collider under construction at CERN. It has been endorsed enthusiastically by U.S. and international high-energy physics review panels, and the U.S. High Energy Physics Advisory Panel has recommended initiation of a conceptual design.

This Project Management Plan (PMP) presents a roadmap for managing the technical, administrative and management work of the Next Linear Collider (NLC) Project through its Conceptual Design phase. The PMP covers activities initiated with the receipt of CD-1, Mission Approval and Permission to Start Conceptual Design, and concludes with CD-2, the acceptance of the Conceptual Design Report and permission to begin Project Execution.

The Project Team is organized into a Directorate, machine area leaders, mechanical and electrical systems leaders whose work cuts across and interfaces with the machine area work, a Planning and Coordinating group responsible for schedules, cost management and documentation, and an Administrative Group that also provides logistical support to collaborators. The Directorate and Administrative Group interface as needed with SLAC management and services, and the Directorate interacts with the Department of Energy Office of Science Program Manager and the DOE Oakland Field Office.

The work of the Project is organized through a two-branch work breakdown structure (WBS), branch one of which includes Project Total Estimated Cost (TEC) meaning the costs expected to be incurred during the Execution Phase but excluding R&D and start-up costs. Branch 2 includes the Other Project Costs (OPC) which are the costs of all activities during the Conceptual Design Phase and the costs of R&D and start-up during the Execution Phase. TEC and OPC together, when rolled up, provide the Total Project Costs (TPC). At this preconceptual phase of the project a rough estimate of the TPC has been developed. This will be honed as the conceptual design matures.

A sophisticated set of software tools including SUCCESS and ACCESS as data base managers, and Primavera Project Planner to manage project schedule, resource loading and distributed costs and funding profiles have been selected and are in place as the project management tools for this phase.

Project work teams are in place with the capability to carry out the work of developing a conceptual design for the NLC. The scope of work is based on work conducted during the preconceptual phase and consists of Conceptual Design of the collider facility, and in R&D to improve performance, cost and reliability of collider systems and components. The teams work collaboratively with staff from the Lawrence Livermore and Lawrence Berkeley National Laboratories (LLNL and LBNL) as well as with the Japanese National Laboratory for High Energy Physics (KEK). The NLC Directorate provides coordination for work done at LLNL and LBNL. New collaborations with the Fermi National Accelerator Laboratory and the Budker Institute for High Energy Physics in Russia are under negotiation and may be implemented before the initiation of the Conceptual Design phase. All work is coordinated through SLAC. In these collaborations the cost of work is shared.

Preconceptual design activities have resulted in a comprehensive “Zeroth Order” design for the NLC and R&D has established the feasibility of the collider. The organization, the personnel and the necessary project management and project management control tools are in place for conducting the Conceptual Design phase of the NLC project. The Project is ready to move to the Conceptual Design Phase.
1. The Next Generation Linear Collider Introduction and Overview

1.1 Physics Mission

The NLC is a physics experiment complementary to the Large Hadron Collider under construction at CERN in Geneva, Switzerland. The design targets a 1.0 TeV center-of-mass energy, but expects initial operation of 500 GeV and allows for expansion to 1.5 TeV. The planned first phase of the NLC at 0.5 TeV would already guarantee extensive new physics capabilities and potential for new discovery. Sitting at and above the top-antitop quarkonium threshold will allow unprecedented precision measurements of the top quark’s mass, partial decay widths and couplings to gauge and Higgs bosons. Direct observation and study of Higgs bosons in the mass range below 350 GeV or so will also be made at the first phase of the NLC. Higher-mass Higgs particles would be revealed as the energy of the collider is increased. More importantly, the experiments at the NLC will be able to determine completely the properties of these new states—their quantum numbers, decay patterns and the details of their couplings.

If supersymmetry (SUSY) manifests itself at the mass scale set by the electroweak gauge bosons, then a plethora of new particles awaits discovery. Unfolding the entire spectrum and its properties will require the full capabilities of both the LHC and NLC. While the LHC provides good access to the strongly interacting quarks and gluinos, the study of color-singlet superpartners is best carried out at the NLC. The unique experimental features of the NLC will allow production and isolation of each species of supersymmetric particle so that a complete determination of its properties can be made. High precision measurements of SUSY parameters will provide important insight and constraint on the mechanism of SUSY breaking, and a potential new window to the physics of grand unification and superstrings.

Studies of physics goals and requirements for the next-generation electron-positron collider began formally in 1987-88 with workshops held regionally in the United States in 1988 and 1990, in Europe in 1987 and 1990, and in Japan in 1989 and 1990. These meetings were followed rapidly by the initiation of a series of internationally organized workshops, the first of which was held in Finland in 1991 and with the most recent scheduled for April 1999 in Barcelona. From these there has emerged a broad picture of a collider with initial 500 GeV center-of-mass energy and luminosity in excess of $10^{33}$ cm$^{-2}$s$^{-1}$, built to be expandable to 1 to 1.5 TeV with luminosity in excess of $10^{34}$ cm$^{-2}$s$^{-1}$. See Figure 1.1. A machine such as NLC, with a start-up center-of-mass energy of a few hundred GeV, and expandable to 1.5 TeV would offer maximum flexibility and opportunity to explore unforeseen physics thresholds.

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1.2 NLC Design Choices and Supporting R&D

A next-generation linear collider will be modeled on its highly successful forerunner, the Stanford Linear Collider (SLC) which has been used by particle physicists to provide important information about the Standard Model – including the single most precise determination of the weak mixing angle. Since SLC’s success considerable international discussion and R&D have taken place to develop the design requirements for a next-generation linear collider. International collaboration and communication have been fostered by the International Linear Collider Technical Review Committee\(^5\) organized in 1994, and

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by the series of International Electron-Positron Collider workshops held biennially since 1991. These collaborative efforts and communications, discussed in detail in section 3.3, result in the assurance that a next-generation linear collider can be designed and constructed following a continued R&D effort to validate advanced technologies.

The need for the 0.5 to 1.5 TeV energy range to advance particle physics together with experience in design, construction and operation of the SLC at 100 GeV center-of-mass energy and using S-band technology provide guides to the choice of technologies for the NLC. There are in actuality only two items that can be addressed by accelerator technology to achieve the physics goals of a TeV energy range collider. One is high beam power and the other is a small beam spot. These parameters pose different and often contrary, challenges to accelerator design. The technologies being pursued in the design of the NLC represent differing degrees of compromise between beam power and spot size.

A schematic illustration of the collider is shown in Figure 1.2. Construction and operation of the main linac are the major factors in the cost of the collider complex, so the accelerator technology and design must be chosen to minimize the length of the accelerator, while still meeting the demands for particle physics research. A natural match to the TeV energy region is made with the choice of X-band microwave components at a frequency (11.4 GHz) four times that used in SLC. This approach requires the development of 50-100 MW klystrons and advanced rf pulse compression systems, but offers the possibility to use accelerating gradients of 50 – 85 MeV/m. The requirement that beam spots of several nanometers be created and collided is a significant challenge. The main linac of the NLC must accelerate bunch trains to high energy without diluting the beam emittance and must control the energy spectrum of the particles within each bunch and the energy differences between bunch. The technical risk of a machine built with X-band technology will be greater than that incurred at S-band, but the capital costs of initial installation at 0.5 TeV and the costs to upgrade the machine will be lower. CLIC, proposed by CERN, is based on a two-beam acceleration method that uses largely untried technologies. Implementation of these technologies and the associated risk increase are not warranted at this energy level, while the cost of a machine such as TESLA, based on superconducting cavities, will involve an unacceptably high cost profile. Development of these technologies during NLC design, construction and operation will prepare for machines with high TeV centers-of-mass needed toward the middle of the next century.

Research and development for the next-generation normal-conducting linear collider have been pursued actively over the past decade through both national and international collaborative work. The critical technological challenges to a collider of TeV center-of-mass energy have been identified and resolved largely through the work at three major test facilities - the Final Focus Test Beam (FFTB), the NLC Test Accelerator (NLCTA), and the Accelerator Test Facility (ATF) at KEK.

1.2.1 Final Focus Test Beam
The FFTB, the Final Focus Test Beam, has been used to validate the demagnification of the particle beam by an amount acceptable for the NLC. This project, a straight-ahead extension of the SLC beamline, was constructed by a large international collaboration. Appendix I lists the members of the coalition that built the FFTB, completed in 1993 and operated until 1998. The success of this facility, the achievement of a beam spot at the IR of tens of nanometers, was early validation that a critical NLC design parameter could be reached.

Although the facility is housed at SLAC, many components were built by the collaboration and delivered to the SLAC site for installation. Among these were beam size monitors (BSM) built at

6 Proceedings of the First International Workshop on Physics and Experiments with Linear Colliders, R. Orava, ed., Saariselka, Finland, 1991. Subsequent workshops have been held biennially.
Next Linear Collider
Project Management Plan (PMP)

Figure 1.2
Schematic Illustration
Next Linear Collider
LAL d’Orsay in France and at KEK in Japan, magnets built at BINP, the final doublet BSM at KEK, an alignment monitoring wire system built at DESY, and collimators that came from FNAL. Experiments conducted from 1994 to 1998 validate the needed beam demagnification of 320 or better and production of 60 nm spot sizes. Experimentation with the FTFB has demonstrated that the detailed chromatic and geometric properties of the beamlines are well understood. New techniques have been developed to streamline and improve the accuracy of the system tuning including refinement of beam-based lattice diagnostics and alignment strategies, as well as development of robust microwave monitors able to measure beam motions with resolutions of a few tenths of nanometers. These are significant for the implementation of the final focus system for the NLC.

1.2.2 The NLC Test Accelerator

The structures for the Next Linear Collider Test Accelerator (NLCTA) were built in collaboration with KEK and LLNL to a common design developed by SLAC and KEK. This collaboration continues actively and in 1999 as part of the preconceptual design R&D program there will be tests in ASSET and the NLCTA of the rounded, damped, detuned (RDDS) structures which will be built with cells manufactured by LLNL and assembly of the cells into structures done by KEK. Figure 1.3 shows an RDDS1 cell. Structure development is key enabling technology for the NLC.

The NLCTA has also been the test bed for NLC power delivery components including 50-MW periodic permanent magnet (PPM) klystrons and 75 MW solenoid-driven klystrons. Solid-state modulators and 75-MW PPM klystrons will be incorporated into the NLCTA and tested during the Conceptual Design phase.

Figure 1.3
A sample cell of the “rounded, damped, detuned” (RDDS1) type

1.2.3 The Accelerator Test Facility
To confirm experimentally the feasibility of a low-emittance beam with reasonable damping time essential for the next-generation linear collider, the Accelerator Test Facility (ATF) was built at KEK. The ATF consists of two major components: a 1.54 GeV S-band injection linac and a damping ring. The construction of the ATF is a principal ingredient of the second 3-year Japanese R&D program to determine TeV-scale $e^+e^-$ linear collider feasibility. The ATF at KEK was built as a collaborative undertaking with design input and component contributions from SLAC. In particular, SLAC built and installed an injector kicker system, loss monitors, wire scanner detectors, and provided modifications to the buncher layout. The ATF project started operation in 1997. During the 20 weeks per year of ATF operation at least one SLAC staff member is present to participate in the experiments. LBNL also participates in the experimental program.

1.3 Peer Review

The physics goals and technology status of the NLC were presented and endorsed by the U.S. High Energy Physics community at Snowmass, Colorado in the summer of 1996. The plans and status of the NLC were reviewed by the U.S. Department of Energy’s High Energy Physics Advisory Panel (HEPAP), which reported that “a TeV-scale electron-positron collider offers unique opportunities to extend and complement experiments done at the Large Hadron Collider.” Both the National Research Council and HEPAP recommend the production of a complete Conceptual Design Report (CDR). The HEPAP report “recommends that Stanford Linear Accelerator Center continue research and development with Japan’s National Laboratory for High Energy Physics (KEK) toward a common design for an electron-positron linear collider… and that SLAC be authorized to produce a Conceptual Design Report for this machine.”

1.3.1 Zeroth-Order Design Report

The Zeroth-Order Design Report published in May 1996 represents a comprehensive feasibility study for a TeV-scale linear collider that incorporates a room-temperature accelerator powered by rf microwaves. While the design presented is by no means an engineering design, it represents work that has examined critical technologies carefully. The report concludes that the NLC, while requiring further development of a number of mechanical and electrical systems, is within the scope of technical feasibility and that it can be expected to reach the performance levels required to perform research at the TeV energy scale. This design report was the result of work led by SLAC and supported by collaborators from numerous universities and laboratories the world over. Appendix II of this PMP lists the individuals and member organizations that contributed to the ZDR.

1.3.2 Snowmass’96

A report, Physics and Technology of the Next Linear Collider was presented at the Snowmass’96 Conference, sponsored by the American Physical Society Divisions of Particles and Fields, and Plasmas and Beams. The contributors, from 39 universities and laboratories worldwide, are listed in Appendix III of this PMP. The report summarizes the status in 1996 of the design and technological basis of a linear collider of center-of-mass energy 0.5 to 1.5 TeV, and lists opportunities in high-energy physics that this...
machine might address. These are summarized in section 1.1. Technologies critical to successful collider construction had been demonstrated experimentally and had met or exceeded requirements for the initial stage of NLC operation.

The reaction to this report by the Snowmass'96 meeting was that NLC work should move briskly toward a Conceptual Design Report. Almost three years of further R&D, prototype construction and operation, and test facility operation have validated the technological capability to operate NLC at full design energy of 1.5 TeV center-of-mass.

The consensus drawn from the HEPAP and the National Research Council reports and project reviews is that the community is ready to proceed with the initiation of formal conceptual design activities leading to a Conceptual Design Report.

1.4 Schedules and Milestones

Accelerator design and technology R&D of the last decade provide assurance that a next-generation, TeV–energy range, linear collider can be constructed and operated successfully. Therefore permission is now being sought (spring 1999) to begin the Conceptual Design process. This will allow inclusion to start the NLC CDR Project as an item in the FY01 budget.

In June 1997 DOE gave SLAC authorization to pursue preconceptual design and industrial integration activities for the NLC. In March 1998 HEPAP recommended start of a Conceptual Design Report and a DOE Program Manager was assigned. Development of Mission Need documentation has taken place in late 1998 and early 1999. Mission need approval from DOE (CD-1) has been requested by SLAC following meetings between DOE, represented by Ernest Moniz and Martha Krebs, and SLAC, represented by Burton Richter and David Burke.

If the finding is affirmative, the near-term major milestones will include the submittal of the CDR to DOE for HEPAP review in the summer of FY2002. This plan will allow inclusion of the NLC Project as a line item in the President’s FY2004 budget.

A detailed schedule of CDR milestones including technical, management, cost and schedule reviews is presented in Appendix IV.

1.5 Collider Detector and IR Program

While the NLC Project discussed herein is directed solely at the development of a next-generation linear collider, it is essential that detector development proceed in parallel and with excellent communication of needs and goals. A worldwide study of the Physics and Detectors for Future Linear e+e- Colliders is now underway. An International Organizing Committee (IOC) held its first meeting in Vancouver, Canada on July 29, 1998. The next meeting of the IOC is at Barcelona in April 1999. This committee has agreed to meet for the next several years as an International Steering Committee to guide and monitor the progress of the study. Regional committees were also formed to organize and coordinate detector research and modeling activities in Europe, Asia, and North America. Dr. Charles Baltay of Yale University, with whom the NLC leadership keeps in close contact, chairs the U.S/Canadian committee, to ensure compatible development of the accelerator and the detectors. Connection with NLC is led by Dr. T. W. Markiewicz, leader of the NLC Interaction Region Design Group. Detector design should be completed in a timeframe appropriate to the experimental program need. Similar groups coordinate interaction region and collider design within the scope of the World-Wide Study of Physics and Detectors.
for Future e+e- Linear Colliders and are led in Asia by Dr. Tauchi of KEK, and for Europe by Dr. O. Napoly (Saclay). These coordinate the studies and designs as they evolve in these three regions.
2. Project Management Plan

2.1 Context of this Project Management Plan

The Next Linear Collider is an international undertaking. The research and development activities needed to support and define this proposed next-generation collider are being led collaboratively by scientists and engineers from the United States (SLAC as lead laboratory) and Japan (KEK as lead laboratory). This R&D effort may lead to a collaborative project that would involve many countries, with construction and implementation at a site to be determined through intergovernmental negotiations among the participants. This Project Management Plan (PMP) describes only the U.S. participation in the Conceptual Design phase of this undertaking. While contributions of other nations to the R&D needed for the NLC are recognized in this PMP, the scope of international contributions to the construction of the facility is undefined at this time. Therefore, the CDR for the NLC will describe the project as if it were supported entirely by the U.S. alone. This PMP describes such a process. The PMP has been developed using the DOE Good Practice Guides, GPG-FM-001 to GPG-FM-033, the Life Cycle Asset Management order, O430.1A, and the Joint Program Office Direction on Project Management, DP40.

2.2 DOE Strategic Plan and Project Management

The NLC CDR Project will address issues typically included in an U.S. high-energy physics project, with modifications made as necessary to accommodate the international nature of the collaboration. There are, however, some issues, such as environmental impacts, which can only be addressed following completion of Conceptual Design (CD-1 to CD-2) and site selection. Negotiations among the participating countries, when roles are more fully defined, will determine the project site and permit the initiation of environmental impact studies.

The Next Linear Collider program is currently involved in Preconceptual Activities, which will lead to the Approval of Mission Need (CD-1) and the initiation of the Conceptual Design (CDR) activities, completed with the acceptance of the Conceptual Design Report (CD-2) and the initiation of the Execution phase of the project. During the CDR phase the need for a new-generation linear collider will be evaluated in light of the mission of the Department of Energy. Documentation of the mission need and its relationship to the mission, goals and objectives of the Department will be developed and submitted to the DOE Program Manager for evaluation. DOE approval of the Mission Need (CD-1) will confirm that the proposed program supports the Department’s mission, initiate a formal “project start,” and authorize Conceptual Phase activities. It is understood that at the CD-1 phase there is no commitment to construction. Figure 2.1 shows our understanding of the project phases.

2.3 Goals of the CDR Project Phase

During the Conceptual Phase, supporting studies will be undertaken and a conceptual design will be developed to define adequately the scope, schedule and cost of the proposed project. A Conceptual Design Report (CDR) will be developed to document a comprehensive analysis and detailed assessment of the project. The CDR documentation will address the following areas:

- Project objectives, functional requirements, and technical specifications;
- Conceptual design;
- Cost estimates, including Total Estimated Cost (TEC) and Other Project Costs (OPC) that together constitute the Total Project Cost (TPC);
- Integrated project schedule;
- Funding requirements;
Site requirements and evaluation factors;
Specific risk assessments;
Studies of project alternatives.
Evaluation of design candidates for critical components;
Value-engineering assessment and acquisition strategy (Design for Manufacture Model)
Preliminary ES&H evaluations.

This CDR will evaluate the NLC as if it were a project to be completed entirely by the U.S. The Conceptual Design Report will be submitted to the DOE Program Manager and evaluated to enable the Department to approve initiation of the Execution Phase (CD-2). This approval sets the scope, schedule and cost of the project and confirms that the project has been sufficiently well defined to allow the Execution Phase to begin. CD-2, permission to initiate project execution, will follow review by the U.S. high-energy-physics community (HEPAP) and approval of funding by Congress. Negotiations with potential international partners will be required.

The Execution Phase includes preliminary and final design, site selection and environmental assessment, in preparation for CD-3 – Approval to Start Construction. Construction activities then commence, leading to project acceptance, commissioning and operations (CD-4). These execution phase activities will be discussed in detail in future iterations of this Project Management Plan, which will address each subsequent phase.

2.4 Content and Intended Use of this Project Management Plan

This Project Management Plan is intended for use during the Preconceptual and Conceptual Design phases of the Next Linear Collider program. That is, it focuses primarily on the near-term activities, which will culminate at the submittal of the Conceptual Design Report for review and request for CD-2 approval. Subsequent iterations of the plan will be written as appropriate milestones are reached, with a more definitive plan for final design and construction to be prepared following CD-1 approval. As a “living document,” the Project Management Plan may be modified periodically to reflect new developments and to extend the time frame of its coverage.
Next Linear Collider
Project Management Plan (PMP)

NLC PROJECT FUNDING TIME LINE

CD 1
CD 2
CD 3
CD 4

Design
Implementation

Preconceptual Design
Conceptual Design
Execution
Operation

Preliminary Design (Title I)
Detailed Design (Title II)
Construction (Title III)

WBS 1 = TEC

Siting Activities
R&D

WBS 2.1 = Preconstruction OPC

WBS 2 = Execution-phase OPC
Design Review support, permits
M&O support, startup, spares

WBS 1 (TEC) + WBS 2 (OPC) = TPC

Figure 2.1
3. CDR Project Management Organization and Responsibilities

3.1 Department of Energy

Authority and responsibility for managing the Department of Energy programs and facilities lie with the Secretary of Energy. (See Figure 3.1) The Office of Science (SC) has been delegated responsibility for managing the Department’s basic research programs in high energy and nuclear physics, in support of the goals contained in the National Energy Strategy and DOE’s Strategic Plan. The Office of Science develops and implements overall program policy and guidance, provides technical oversight, and manages the funding for carrying out its assigned programs. Specific responsibility for the design, construction and operation of the proposed NLC has been assigned to the Office of High Energy and Nuclear Physics (SC-20). Within SC-20, the High Energy Physics Division (SC-22) has been designated as Program Manager. Dr. David F. Sutter has been designated as the normal DOE point of contact in SC-22 for NLC matters.

The roles and responsibilities of the High Energy Physics Division, as Program Manager, include:

- Defining programmatic mission requirements and objectives.
- Serving as DOE’s principal point-of-contact for project matters.
- Developing budgets for the funding to support the proposed project.
- Serving as principal interface with congressional staff, other agencies, and DOE Headquarters on issues relating to the proposed project and communicating the status of these issues to the SLAC Project Manager.
- Controlling changes to project baselines.

The Headquarters Program Manager carries out the NLC project through a local field office. James M. Turner, the Manager, Oakland Operations Office (OAK), has been delegated line management responsibility and authority for carrying out the proposed CDR-phase of the NLC project in a manner consistent with the Project Management Plan. The Oakland Operations Office, acting through the Stanford Site Office, will establish and staff an NLC Project Office, and appoint a Project Director with responsibility and authority for project execution.

The Oakland Operations Office, acting through the Stanford Site Office, will:

- Administer the Stanford Linear Accelerator Center (SLAC) management and operating contract as Contracting Officer’s Representative for matters pertaining to the proposed NLC project.
- Serve as field point-of-contact for NLC matters.
- Maintain communications among DOE, OAK and SLAC.
- Maintain communications among SLAC, LBNL and LLNL.
- Provide conceptual design and project baselines to Headquarters.
- Submit budgets to Headquarters to obtain funds for executing the proposed project.
- Ensure the NLC project team designs a facility meeting mission requirements.
- Maintain cognizance of project activities, anticipating potential problems and taking corrective action to minimize impacts.
- Assure adequate facility safety.
- Provide regular reports to OAK and Headquarters on project status.
Department of Energy - NLC Project Organization

- Secretary of Energy (S-1) - Bill Richardson
- Director, Office of Science (SC-1) - Martha A. Krebs
- Associate Director, Office of High Energy & Nuclear Physics (SC-20) - S. Peter Rosen
- Director, High Energy Physics Division (SC-22) - John R. O’Fallon
  - David F. Sutter - NLC Program Manager
- Manager, Oakland Operations Office - James M. Turner
- Director, Stanford Site Office/OAK - John S. Muhlestein
- NLC Project

Figure 3.1
3.2 Stanford University and Stanford Linear Accelerator Center Relationships

The Stanford Linear Accelerator Center functions as the lead laboratory for all national NLC collaborative R&D activities and coordinates and directs those activities as appropriate. At this time LLNL and LBNL are national partners with whom Memoranda of Understanding are in place. Collaboration with Fermi National Accelerator Laboratory is under negotiation.

Under the SLAC prime contract with DOE, Stanford University is responsible for design and R&D activities for the NLC. Within SLAC, the NLC Project Director, who reports to the SLAC Associate Director who heads the Technical Division, is responsible for all NLC activities. (See Figure 3.2.) In support of the NLC, SLAC will provide technical and administrative assistance primarily through the following organizations: Technical Division, Research Division, ES&H Division, Business Services Division, and the Personnel, Public Affairs and Affirmative Action offices.
SLAC - NLC Project Relationships

Director
Stanford Linear Accelerator Center
B. Richter
J. Dorfan, Director Designate

Personnel Director
L. Lyon

Public Affairs/ Education Services
H. Quinn

Affirmative Action Office
S. Gee

Associate Director
Research Division
D. Leith

Associate Director
SSRL Division
K. Hodgson

Associate Director
Technical Division
J. Paterson

Associate Director
Business Services Division
J. Jobe

Associate Director
ES&H
K. Kase

Project Director
Next Linear Collider
D. Burke

Figure 3.2
3.3 Collaborations with U.S. and International Laboratories

3.3.1 Collaboration on R&D

As discussed in section 1.2 above, there has been extensive national and international collaboration at the three test facilities, the FFTB, the NLCTA and the ATF, developed to qualify the advanced technology necessary for the next-generation linear collider.

3.3.2 International Committee on Future Accelerators

The International Committee on Future Accelerators (ICFA) began in 1991 to examine the possibilities for developing a memorandum of understanding to form an international collaboration to coordinate and review the R&D on linear colliders, and to put ongoing collaborative work on a more formal footing. The initiative for this action came from KEK, DESY and SLAC. A draft MOU was presented and endorsed at the May 1993 ICFA meeting held in Hamburg, Germany. At the first Linear Collider Interlaboratory Collaboration meeting held at SLAC in October 1993, a schedule was established to appoint a group of regional coordinators to organize and oversee elections to a Collaboration Council, and elections of members to regional councils. A goal was set to form the Councils by January 1994, to sign the MOU by April 1994, and to hold a first Council meeting at the European Conference on Future Accelerators (ECFA) in June 1994. While the ICFA-endorsed MOU was never signed, the Collaboration Council was formed and met at ECFA in June 1994 in London. The Council decided at that meeting to create a Technical Review Committee, the ILC-TRC described below.

3.3.3 International Linear Collider – Technical Review Committee

The International Linear Collider Technical Review Committee (ILC-TRC), one of the first missions of the Interlaboratory Collaboration Council, was charged “to consider the goal to design, build, and operate a TeV-scale linear electron-positron collider capable of satisfying the need to explore the particle physics of this energy range.” Specific charges included: 1) examine accelerator designs and technologies suitable for a collider that will initially have center-of-mass energy of 500 GeV and luminosity greater than $10^{33}$ cm$^{-2}$ s$^{-1}$; 2) built to be expandable to 1 TeV center-of-mass energies, with increased luminosity and the path to achieve that increase; 3) to comment on the potential of technologies available or needed to meet these goals; 4) to examine the potential to provide alternative physics capabilities such as $\gamma\gamma$ collisions; 5) to identify the physics and technological requirements for each approach to meet these goals; 6) to identify areas of further possible collaboration; and, 7) to submit a report draft in March 1995 following the LC95 in Japan.

The report$^{12}$ was submitted for review and completed in December 1995. Appendix V lists the Council members and the structure and membership of the Technical Review Committee. The report provides a comprehensive view of the goals and the technical requirements for four categories of 1 TeV center-of-mass-energy linear colliders. Since the 1995 report there have been periodic updates to the tables and figures presented in the report to keep information concerning the state of next-generation linear collider research up-to-date. The latest revisions dated December 1998 can be found on SLAC’s web site, as can the full text of the original report.

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3.3.4 SLAC-KEK Memorandum of Understanding and International Study Groups Formation

In February 1998, following a recommendation from HEPAP,13 the Directors of SLAC and KEK, Drs. Burton Richter and Hirotaka Sugawara, signed a Memorandum of Understanding, to pursue the development of a common research plan for a normal-conducting next-generation linear collider. Drs. Richter and Sugawara sought to develop collaboration on a linear collider in a way that is consistent with the independence and integrity of the participating communities. The NLC Zeroth-Order Design Report and the JLC Design Study14 formed a platform from which to initiate collaboration. Together, these studies and their supporting R&D provide the basis for optimizing the design of a collider that can be expected to address successfully the physics of the TeV range. The collaboration operates principally through the International Study Groups formed to define and optimize the technical foundations for the project, while recognizing that it is too early to address such issues that rely on selection of a host nation. Members address critical issues and at each semiannual meeting outline work to be done by each side for the subsequent period. To date, three meetings have been held, with a fourth planned for July 1999 at KEK. Documentation from each of these ISG meetings has been made available on the World Wide Web at http://www-project.slac.stanford.edu/lc/fic/ISG_Meetings/isg_index.html. At the end of CY1999 the first ISG comprehensive report will be issued. Interim documentation is provided through a series of Linear Collider Collaboration Technical Notes maintained at the SLAC NLC web site.

3.3.5 SLAC-LLNL-LBNL Collaboration

National collaboration has now been formalized through the signing of Memoranda of Understanding with Lawrence Livermore National Laboratory (LLNL) and Lawrence Berkeley National Laboratory (LBNL). These collaborations build directly on similar collaborations with these laboratories in R&D and construction activities for the PEP-II machine commissioned at SLAC in October 1998. Combining resources and capabilities was invaluable to the on-time, on-budget completion of PEP-II.

The Memoranda of Understanding with these laboratories are not exclusive and it is likely that other U.S. universities and laboratories will participate in the collaboration in the future. In particular it is possible that a Memorandum of Understanding will be signed with the Fermi National Accelerator Laboratory. These MOUs do not preclude new, or interfere with existing MOUs with international collaborators.

The scope of work with these laboratories will include elements of design and modeling, engineering, procurement and fabrication of prototypes, preparation of documentation, and participation in review and management processes. Work will occur in the following areas: Modulators, Accelerator Structures, Positron Target, Damping Rings, e+e- Interaction Region, and γγ Interaction Region. Other areas of work may be added by amendment.

3.4 Conceptual Design Phase Project Structure

The Project is organized into a Project Office that includes the Directorate, Administration, and the Project Planning and Coordinating Group, Accelerator Engineering and Development teams based on principal machine areas and teams responsible for Technical Systems Engineering. The Technical Systems Engineering Teams are responsible for the design and engineering of components installed across all machine areas. This approach follows the natural structure of the collider, and provides several benefits: 1) improved coordination of design and construction needs; 2) greatly improved cost efficiency

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through elimination of duplicate effort and of several designs for a single component type; 3) improved reliability and maintainability; and 4) the achievement of the best design at minimum cost. Figure 3.3 shows the relationship between the NLC Accelerator Engineering and Design Teams and the Technical Systems Engineering Teams. Figure 3.4 shows the WBS breakdown. Appendix VI contains a section of the more detailed WBS for beam lines. Various members of the NLC group and the departments of participating institutions may be tasked to participate in one or more of these physics and engineering teams.

<table>
<thead>
<tr>
<th>Accelerator Engineering and Design (WBS 1.x.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Systems Engineering Teams (WBS 1.-.-)</td>
</tr>
<tr>
<td>RF Systems</td>
</tr>
<tr>
<td>Magnet Systems</td>
</tr>
<tr>
<td>Vacuum Systems</td>
</tr>
<tr>
<td>Instrumentation</td>
</tr>
<tr>
<td>Global Controls</td>
</tr>
<tr>
<td>Installation and Checkout</td>
</tr>
</tbody>
</table>

Figure 3.3
Relationship of Technical Systems Engineering Teams and Accelerator Engineering and Design
3.5 Project-level Organization and Responsibilities

3.5.1 Project Director
Under the direction of the Associate Director, Technical Division, Stanford Linear Accelerator Center, and the DOE Stanford Site Office/OAK, the Project Director is responsible for directing the design activities of the Next Linear Collider and the research and development effort to support these preconceptual and conceptual design activities. The design and construction of the detector will be handled by an organization to be designated in the future. The Project Director coordinates the activities of the project at SLAC, and negotiates through group meetings, work done in support of the project at other U.S. laboratories and at KEK. The top-level functional organization of the U.S. project group by accelerator area and major systems (electrical and mechanical) is shown in Figure 3.5.

The NLC Project Director is responsible for approving the selection of staff for the conceptual design phase and if Project Execution is approved, may be responsible for construction, installation, commissioning and initial operation of the Next Linear Collider facility. Specific responsibilities include:

- Establishing centralized technical and administrative controls for NLC activities.
- Directing and coordinating research and development activities in support of NLC CDR.
- Directing long-term planning for the NLC.
• Representing the NLC in interactions with the DOE, with the joint SLAC/KEK International Study Groups, and with other laboratories.
• Controlling changes to the technical, cost and schedule baselines, within established authority, and seeking DOE approval for changes that exceed the Project Director’s authority.
• Providing an effective interface with the detector collaboration for design of the detectors and for integration of the detectors with the accelerator.

Once the CDR is complete and permission received (CD-2) to start the Execution Phase and initiate preparation of a Detailed Design Report, a final design and construction collaboration to be determined will be responsible for further milestones, including CD-3, Title 1 and Title 2 approval, and work to construction completion (CD-4).

3.5.2 Machine Advisory Committee
It is anticipated that a Machine Advisory Committee will be established by and responsible to the SLAC Director. Membership will be drawn from the broad U.S. HEP community. This Committee will indirectly advise the NLC Project Director.

3.5.3 Project Executive Committee
The Executive Committee advises the Project Director on technical and project management issues. During the Conceptual Design phase the Executive Committee members are the:
• Deputy for Accelerator Physics
• Deputy for Electrical Systems
• Deputy for Mechanical Systems
• Deputy for Conventional Facilities

During the Execution phases the Executive Committee will be reorganized to reflect the Execution Phase collaboration.
3.5.4 Accelerator Physics Group

The Accelerator Physics Group (AP) is responsible for developing a design to attain the collider performance goals. The group will provide performance requirements and conceptual solutions with supporting documentation for each of the principal collider areas: Injector, Main Linac, and Beam Delivery. In addition, the group will provide and maintain optical lattices for the beam transport lines and will develop the beam tuning procedures needed for commissioning and operation.

3.5.4.1 During the Preconceptual and Conceptual (CD-1 to CD-2) design phases, the AP group will provide:

- collider performance goals and upgrade scenarios
- requirements for the accelerator subsystems
- conceptual solutions for the accelerator subsystems with supporting documentation addressing all known beam dynamics limitations including:
  - beam transport
  - polarization transport
  - source dynamics
  - wakefields and impedances
  - beam loading compensation
  - beam instabilities
  - beam-based alignment and beam feedback systems
  - component errors including: mechanical alignment, mechanical stability, field quality, and component failure
- optical lattices specifying all beam-line magnets, accelerator structures, beam instrumentation, and control devices that directly affect the beam
- specification of the beam-line components including tolerances on magnetic field quality, accelerator straightness and field quality, instrumentation performance, and control elements
- specification of the beam tuning algorithms and operational procedures which directly impact specification of the collider components
- vacuum specifications and vacuum chamber and impedance requirements
- specification of ground-motion requirements for the prospective site
- support for the calculation and simulation programs needed for the above tasks

To perform these tasks members of the AP group will interact with the representative members of the Technical Systems Engineering Teams, in particular, the Magnet, Vacuum, and Instrumentation groups, as well as the leaders and coordinators of the collider areas: Injection, Main Linac, and Beam Delivery. Where needed, the Special Projects group will provide R&D to support the design. Figure 3.6 outlines the functional responsibilities of this group.

3.5.4.2 During the Execution Phase (CD-2 to CD-4) the AP group will:

- Maintain optical lattices and include adjustments as necessary
- Continue evaluation of known physics limitations given new R&D results
- Update component tolerances as necessary
- Update and improve impedance models using component measurements
- Begin implementing optics modeling, beam modeling, and alignment and tuning procedures in the control system
- Develop detailed commissioning plans, assist in the beamline commissioning, and evaluate results.
Figure 3.6
3.5.5 Injector Systems Group

The Injector Systems Group works with the Project Directorate to develop the design, cost estimate and construction schedule for the Injector Systems of the NLC. It also manages the injector systems R&D program together with the Program Directorate, the SLAC Technical Division department heads, and with the LBNL, LLNL, KEK, and BINP Collaborative Effort teams. The injector systems area responsibilities begin with the production of the primary polarized electron beams and the positron production drive electron beams and end at the septum magnets in the diagnostic regions at the entrances to the two main linacs.

3.6.5.1 Preconceptual Design (pre-CD1):

- Define requirements and baseline model with Accelerator Physics Group and disseminate the information to the appropriate groups in the NLC organization.
- Identify engineering tasks and set priorities for Technical Systems Engineering and Design teams and Collaborative Effort teams.
- Work with the Conventional Facilities group to ensure that the infrastructure will meet design requirements including the unique demands on temperature and position stability.
- Coordinate the various injector-related R&D efforts with the goal of demonstrating viable polarized electron beams, positron production targets, damping ring special magnet and rf systems by completion of the Conceptual Design phase of the Project.

3.6.5.2 Conceptual Design Phase:

- **Planning**: The injector group will work with the Technical System teams, the Collaborative Effort teams and the Project Planning and Coordinating group to generate a cost estimate and an installation and construction schedule. The initial cost estimate will be compiled from various system contributions: Modulators, Low Level Rf, Klystrons, Rf Distribution, Structures, Vacuum, Magnets, Instrumentation, Controls, and Installation.

- **Design**: The injector group will document the system requirements and help coordinate the injector-related work of the Technical System Engineering and Design (Mechanical and Electrical) teams and Collaborative Effort teams. They will also help the Mechanical Engineering teams design beamline components including the supports, movers and alignment systems. Finally, they will work with the Electrical Engineering teams to help integrate the various SLAC Controls Department activities, especially in regard to injector operational issues.
Injector Systems
Functional Organization

Area Manager

Sources
- Polarized Photo Guns
- Laser Systems
- e+ source

Damping Rings
- S-Band rf
- L-Band rf
- Structures
- Magnets
- Pulsed Magnets
- Structures
- Vacuum
- e+/e- Damping Rings
- Injection/Extraction

Linacs
- S-Band rf
- L-Band rf
- Structures
- Magnets
- Vacuum
3.5.6 Main Linac Systems
The Main Linac Systems Group works with the Project Directorate to develop the design, cost estimate and construction schedule for the Main Linacs of the NLC. It also assists in the management of the main linac R&D program together with the Program Directorate and the SLAC Technical Division department heads. The main linac systems responsibilities begin just after the septum magnet in the diagnostic region at the beginning of the linacs and end just upstream of the first bend in the diagnostic region leading to the beam delivery region.

3.6.5.1 Preconceptual Design (pre-CD1):
- Define requirements and baseline model with Accelerator Physics Group and disseminate the information to the appropriate groups in the NLC organization.
- Identify engineering tasks and set priorities for the linac-related work by the X-Band Rf System groups and Technical System teams.
- Work with the Conventional Facilities group to ensure that the infrastructure will meet design requirements including the unique demands on temperature and position stability.
- Coordinate the various linac-related R&D efforts with the goal of demonstrating a viable Rf system by completion of the Conceptual Design phase of the Project.

3.6.5.2 Conceptual Design Phase:
- **Planning:** The linac group will work with the Technical System teams, the X-Band Rf System groups and the Project Planning and Coordinating group to generate a cost estimate and an installation and construction schedule. The initial cost estimate will be compiled from various system contributions: Modulators, Low Level Rf, Klystrons, Rf Distribution, Structures, Vacuum, Magnets, Instrumentation, Controls, and Installation.

- **Design:** The linac group will document the system requirements and help coordinate the linac-related work of the Technical System (Mechanical and Electrical) teams and the X-Band Rf System groups. In particular, they will coordinate the design efforts of the X-Band Rf System groups (Modulators, Low Level Rf, Klystrons, Rf Distribution, Structures) whose members are located within the SLAC Technical Division Departments. They will also help the Mechanical Engineering teams design beamline components including the supports, movers and alignment systems. Finally, they will work with the Electrical Engineering teams to help integrate the various SLAC Controls Department activities, especially in regard to linac operational issues.

- **R&D:** The linac group will work with the Departmental R&D groups to provide engineering and project management support where needed. Examples include building and testing prototype DLDS components, upgrading the NLCTA for high power and future RF system tests, ASSET operation, and structure stability tests. The R&D activities will be coordinated with and supported by the Special Projects Group.
Main Linac Systems

Area Manager

Planning
- Cost Estimates
- Installation Planning
- Construction Schedules
- Reliability Estimates
- Reports

Design
- Requirements
- Mech. Systems Interface
- Elect. Systems Interface
- Eng. Analysis

R&D
- Engineering
- Departmental R&D Interface
- Special Projects
- Group Coordination
- Project Management

Figure 3.8
3.5.7 Beam Delivery Systems

The Beam Delivery Systems (BD) Group will ensure that a full-energy beam of the proper emittance, bunch size, and energy spread can be focused to the design spot size, transported to the interaction point (IP), and made to collide with the opposing beam so as to produce the design luminosity (see Figure 3.9). The beam will be delivered in a manner such that background radiation in the particle detectors in the interaction region (IR) halls will be sufficiently low to do the physics measurements proposed.

The BD geographic areas of responsibility begin after the end of the linac, with the diagnostic section and tune-up dump. Its accelerator subsections include the collimation system, IP switch, Big Bend, final focus, interaction region, and dump line for both electron and positron accelerators and both interaction points.

The BD group will rely on the services of the Accelerator Physics, Electrical Systems, Mechanical Systems, Special Projects, and Conventional Facilities groups and will provide system coordination and control to ensure that the conceptual solutions proposed and their engineered implementations meet the stated goals. This group will work closely with the experimental physics groups to ensure that the NLC design has been optimized without sacrificing any important parts of the experimental program.

The Accelerator Physics Group (AP) will provide to the BD group:

- the conceptual solutions required for each of the accelerator subsections and the machine protection system.
- an optical lattice, and specify the number, location, strength, effective length, and apertures of magnetic elements.
- Specifications for the lower and upper limits of magnet strength for the 0.5, 1.0, and 1.5 TeV machines
- Identification of magnets to be replaced to upgrade the machine energy.

The AP will investigate and provide appropriate tolerances for each element. These include:

- relative and absolute alignment tolerances,
- allowed vibrational jitter as a function of jitter frequency,
- magnetic field accuracy,
- stability,
- spatial tolerances, and
- BPM resolution and accuracy.

They will:

- specify the vacuum requirements along the length of the machine
- provide the strength, location, voltage, and timing requirements of the crab cavity rf system,
- specify the types, location, control, and readback of instrumentation (dither coils, correctors, wire scanners, BPMs, etc.) for beam tuning and beam spot optimization
- develop the strategy to optimize luminosity while maximizing available beam time.

The BD area manager will work with a group of engineers whose duties will be specified to ensure that the components that comprise the beam delivery system are adequately designed, will function together as a system, and will meet the specifications developed by the AP. Technical System Engineering Groups working with the BD group will have responsibility for one or more of the following subsystems:
• Magnets,
• Power Conversion,
• Vacuum,
• Instrumentation,
• Controls and DAQ,
• Facilities,
• Dumps,
• Crab Cavity,
• PPS,
• BMS, and
• Alignment.

The individual components used in each subsystem will be designed and costed by the subsystem engineers and technicians under the direction of the appropriate NLC project group: Electrical Engineering, Mechanical Engineering, or Conventional Facilities.

The BD subgroup responsible for the IR backgrounds will:

• ensure that adequate calculations and simulations of all machine-related and collision-related backgrounds have been performed;
• model the sensitivity of the proposed detectors to the machine backgrounds;
• evaluate the collimation scheme proposed by the AP; and
• design any additional masking and shielding that may be required to provide sufficiently clean running conditions for the experiments over a specified range of accelerator performance parameters.

Additionally, they will ensure that the tuning tools and accelerator instrumentation and control systems address adequately the measurement and control of backgrounds.

A BD subgroup will ensure that the final focus (FF) system can produce the spot sizes that correspond to the emittance delivered and that the spot sizes can be measured. In order to minimize the effects of ground vibration or bunch-to-bunch offsets, optical-mechanical, pure mechanical, and feedback-based schemes are to be considered, engineered, prototyped, and tested. A mechanical design for the inner radius part of the detector, which minimizes vibration of the final doublet while providing for its support and alignment, as well as that of any masks and detectors, will be provided. Appropriate instrumentation to measure spot size and luminosity and the procedures to use and calibrate the instrumentation will be developed. The BD system engineer will see to it that both engineering and technical support is provided for these projects.

The BD group will design the performance monitors that reside in the beam line between the IP and the beam dump. They will simulate the ability of these monitors to make their measurements in the face of the anticipated backgrounds. These include devices to measure the beam energy, polarization, luminosity, and spot size.

The BD group, working with yet to be designated representatives of the proposed experiments, will ensure that the design of the IR hall is consistent with both the requirements of the machine and the experiment.
Beam Delivery Functional Organization

System Coordination

Administration
Document Management
Data Base Entry

Accelerator Physics

Conceptual Solutions
Magnet Parameters, Collimation, IP Switch
Final Focus, Dump Line
Machine Protection

Component Specific
Magnet Apertures, Strengths, Locations
Vacuum & Crab rf Requirements

Tolerances and Ranges
Relative & Absolute Alignment
Vibrational Stability vs. Frequency
PS Accuracy & Stability, BPM Accuracy

Emittance Tuning Operational Plan
Instrumentation
Readback & Control Bandwidth
Tuning Strategy, Feedback

Engineering
Component Engineering, Cost, Reliability, and Quality
System Cost and Reliability

Interaction Region

Magnet Systems
Power
Vacuum System
Instrumentation
Control and Data Acquisition
Facility
Primary Beam Dumps
PPS
BCS
Crab Cavity System

Background Control
Small Spot Size Issues
Design of Performance Monitors
Definition of IR Hall requirements

Figure 3.9
3.5.8 Electrical Systems Group

3.5.8.1 General Scope: The Electrical Systems Group under the Deputy for Electrical Systems has responsibility for design, prototyping, testing and assisting in commissioning of all electrical and electronic subsystems and some associated beamline devices, except for AC power distribution. The general list includes the following:

- Pulse Power Modulators to drive linac klystrons.
- Kickers for injection, extraction and beam dumps.
- DC magnet power supplies for linacs, transport lines, sources and damping rings.
- DC high voltage supplies for Damping Rings CW klystrons.
- DC and pulsed power system cable plants.
- Central Controls Systems and data communication networks.
- Fast timing systems and main rf distribution fiber cable plants.
- Low Level Rf for klystron beam power phase and amplitude control.
- Beam Position Monitoring to drive magnet and structures position control.
- Fast feedback systems for control of all accelerator systems and the beam delivery area to the beam Interaction Point.
- Magnet and beamline structure mover systems for dynamic structure alignment including motors, drivers and controls.
- Vacuum pumping systems’ electronics and controls for all vacuum-ion pumps in rf, waveguide and structures assemblies.
- Machine Protection Systems with double redundancy to protect beamline structures and components.
- Beam Containment Systems with triple redundancy to prevent beam radiation from entering occupied areas.
- Personnel Protection Systems with double or triple redundancy to prevent personnel from accidental exposure when entering radiation areas.

In each of these subsystem technical areas, the Electrical Group is also responsible for cost estimating, scheduling, reliability engineering, quality assurance, systems integration, installation planning, and safety management.

3.5.8.2 Preconceptual Phase Activities (Pre CD-1): During this phase (in process now), the Electrical Systems Group is concentrating on selecting Baseline Technical and Cost Models for each generic Subsystem, including:

- Reviewing the contents of the Zeroth Order Design Report (ZDR).
- Defining Requirements, Baseline Descriptions and Functional Specifications.
- Identifying critical path technologies and developing R&D plans.
- Identifying major cost drivers and developing cost reduction plans.
- Training project engineers in Reliability Analysis via the Project Planning and Coordinating Group.
- Developing standards, forms and tools to support these analyses.

During this phase, all Subsystems have a structured group with a manager, a small supporting staff, and an assigned budget, to carry out the work. Reviews are held to authorize all preprototyping efforts. Each Subsystem has a scheduled weekly meeting, and all Subsystems are represented at a weekly coordinating meeting.
The goal for the Preconceptual Phase is to complete an updated technical and cost model for each subsystem listed above, with supporting information organized so the key assumptions used and the basis of estimates are documented and easily traceable. An important part of the cost analysis will be a Technical Schedule and Cost Risk Assessment that will be used for two important purposes:

- To calculate the Electrical Systems risk components to be used by the Project Directorate in calculating a Contingency Budget for the overall project; and
- To provide guidance when establishing the Electrical Systems R&D Plan, aimed at reducing technical, schedule and cost risks during the next phase and prior to final submission of the Conceptual Design Report.

3.5.8.3 Planned Conceptual Design Phase R&D Activities (CD-1 to CDR/CD-2): During this phase the Primary goal will be Risk Reduction of Electrical Systems through a directed R&D program with priorities set by the overall NLC project R&D Plan. Some key areas of investigation in planning are:

- Modulators: These elements are the major cost driver of the Next Linear Collider. Conventional designs in current use require improvements in reliability, energy efficiency and cost. These are the baseline modulators used in preliminary costing. A solid-state design is currently the focus of a promising R&D program, but other approaches are not ruled out. A complication is the need to support other R&D power testing during the Conceptual Phase, which impacts both manpower and materials funding. Another challenging activity will be to develop a plan for industrial participation in the construction of prototypes and the identification and qualification of multiple procurement sources during pre-production testing and production phases.

- Low Level Rf and Beam Monitors: The control of phase and amplitude of each power source into the structure of power combiners is particularly challenging, both technically and from a cost standpoint. R&D is focussed on making measurements on real rf sources to quantify key specifications, accompanied by building a simulation model of a complete Subsystem driving the canonical group of eight klystrons. Beam monitors provide the data needed to control and rapidly switch phase and amplitude of each rf source, to bring the combined power into the beamline precisely phased to the beam. Beam Position Monitors are challenging the state of the art of measurement techniques. Both subsystems require sophisticated detection, digital signal processing, and high bandwidth feedback loops, and a custom sampling chip development is planned to achieve both the necessary range and accuracy as well as to reduce costs.

- Damping Ring Kickers: The Damping Ring Kickers are particularly challenging because the CW nature of the machine requires extremely fast transitions of the Kicker pulse waveforms in order to do clean extraction. Simulation work has started and will continue during this phase. Novel magnetic structures and possible use of the newly developing solid state switches is being investigated. Both performance and high reliability are major goals. The few such devices in the entire complex are not a major cost driver.

- Timing System: The distribution of timing and rf clock information over the full length of the machine requires extensive use of fiber optics transmission, and phase and length control via a number of feedback techniques. R&D will concentrate on demonstration of feasibility, followed by a design for manufacturing cycle.
Next Linear Collider  
Project Management Plan (PMP)

- Control System: The main control system will be modeled after the Stanford Linear Collider (SLC) but with major improvements in the communication networks through a more extensive use of long-line fiber optics along with newly developed commercial switching technology. Studies will continue on the architecture, supported by R&D and SBIR programs to prove out various critical elements at the remote ends of the star networks feeding the various areas of the accelerator complex.

- Vacuum Electronics: Although an acceptable Baseline model based on the new PEP-II system is in hand, the system needs considerable reliability improvement to be acceptable for the NLC. An R&D approach being planned is that of developing a small pump supply which can be attached directly to a pump, eliminating the long haul high voltage cable plant entirely. An SBIR is in place to support the initial investigation.

Similar plans are in development for each of the Electrical Subsystems. The main goals are first, to develop prototypes of all new approaches; second, to establish feasibility of each design; and third, to revise the Cost and Contingency WBS Cost Estimate and Schedule, from conceptual design through installation and checkout. All the above is planned to be done prior to the submission of the CDR in preparation for CD-2.

3.5.8.4 Execution Phase (CD-2 through CD-3): During this phase, all Electrical Systems would continue toward final design and commercial manufacture of prototypes, with priority given to the critical, high-risk elements. Modulators, Kickers, Low Level Rf, Beam Monitoring, Timing, BPMs, Magnet Movers, Vacuum Electronics and the Central Control System should all be prototyped and in final design. Preproduction Design for Manufacture modulators should be procured commercially. Critical, custom radiation-hardened chips for BPM and LLRF systems should be prototyped and evaluated. All R&D will be completed. Protection systems will also be completed through preliminary design and prototyping of any new elements or design approaches. Engineering emphasis will shift to manufacturing and system integration issues to make sure all such activities are fully analyzed and properly counted in the cost model.

A final detailed, resource-loaded schedule, integrated to meet the critical milestones of the overall Project Schedule, would be developed during this phase.

A complete budget model including time-phased activities, major procurements and the contingency analysis would be finalized during this phase.

Reliability FMEA would be performed following CD-2 approval.
Electrical Systems

Figure 3.10
3.5.9 Mechanical Systems Group

Under the direction of the NLC Project Director, the Deputy for Mechanical Systems is responsible for the planning, design, analysis, and validation of all of the mechanical systems required for the NLC, exclusive of the areas covered by the Electrical Systems Group and the Conventional Facilities Group. The mechanical systems fall into the three areas of Injector, Main Linac, and Beam Delivery, as well as systems that are common to all three, such as vacuum and magnet systems. During the Preconceptual and Conceptual phases, the Mechanical Systems Group will work closely with these three major accelerator systems groups to convert accelerator functional performance requirements into preliminary designs, including alternative manufacturing, assembly, processing, and test concepts, as well as generating preliminary cost estimates for ED&I and B&H. Initial plans, schedules, and costs for early and sustained industrial base involvement on critical components will also be completed.

3.5.9.1 Preconceptual and Conceptual Design Phases: During the Preconceptual and Conceptual (CD-1 to CD-2) design phases the Mechanical Design Group will:

- Coordinate all mechanical systems engineering work for the entire project,
- Coordinate and communicate with all other groups to ensure that goals, resource assignments, schedules, plans, and areas of concern and emphasis are clearly defined and mutually coordinated,
- Ensure that goals and requirements are met through the appropriate identification, acquisition, assignment, and monitoring of resources and program needs,
- Convert accelerator performance and functional requirements into conceptual mechanical designs,
- Analyze designs for proper thermal, structural (alignment, stability, rigidity, flexibility), and material properties,
- Prepare plans for industrial base participation in component and assembly manufacturing and installation,
- Establish, document, maintain, and control engineering standards,
- Define and implement an engineering data management system that will provide accessibility, control, and archiving,
- Preliminary Reliability FMEA will be initiated for further development during the Execution Phase engineering activities for the project,
- Provide plans, schedules, budgets, reports, and cost estimates as required to support the Project Management Control System.

3.5.9.2 Execution Phase (CD-2 to CD-4): During the Execution Phase the responsibilities for the Mechanical Systems Group would expand to include:

- Completion of the preliminary, followed by final mechanical designs and design analysis for all mechanical components and systems,
- Completion of assembly, processing, handling, and installation planning for all mechanical components and systems,
- Completion of all Reliability, Maintainability and Availability (RMA) analyses, Value Engineering, Risk studies and analysis, and Reliability FMEA analysis,
- Completion of the industrial base source development activity,
- Implementation of Configuration and Change Control Systems,
- Conformance to all ES&H requirements.
Mechanical Systems Group

- Accelerator Technologies
  - Magnets
  - Vacuum Systems
  - RF Mechanical & Mfg Engineering
  - Cooling and Supports
  - Pre-Installation Processing

- Industrial Base Development
  - Supplier Development
  - Technology Demonstration
  - Installation

- Engineering Processes
  - Manufacturability
  - Design Standards
  - Concurrent Engineering
  - Engineering Data Management
  - Reliability
  - Maintainability
  - Availability
  - Risk
  - Stability and Alignment

- Project Controls/Management
  - Cost
  - Schedule
  - Change Control
  - ES&H

Figure 3.11
3.5.10 Conventional Facilities

Under the direction of the NLC Project Director, the Deputy for Conventional Facilities is responsible for planning, design and construction related to development of the NLC project site, the beamline housings, campus buildings, and all utility systems, roads and parking. During the Pre-Conceptual and Conceptual Phases, the Conventional Facilities Group will define the requirements for NLC facilities, develop concept designs and cost estimates, develop preliminary schedules and conduct studies in support of site characterization. During the Execution Phase, the Deputy for Conventional Facilities would direct the efforts of the architect-engineer/construction manager, a private sector contractor, to accomplish preliminary and detailed design of the facilities and manage the construction effort. The scope of the conventional facilities in WBS element 14 includes:

- Site preparation, including establishment of the network of survey monuments for site alignment.
- Tunnels to house the beamlines for the injectors, main linacs and the beam delivery systems, including associated cooling systems.
- Gallery buildings to house the klystrons and associated electronics.
- Underground halls to house the detectors at the interaction points.
- Campus buildings and facilities.
- Fire protection systems.
- Utility systems, including waste disposal.
- Roads, sidewalks, parking areas and landscaping.

Requirements for the conventional facilities will be defined in close coordination with the Accelerator Design and Engineering Area Managers responsible for the various elements of the accelerator.

3.5.10.1 Preconceptual and Conceptual (CD-1 to CD-2) Phases: The objective of the Conventional Facilities Group will be to define adequately the scope, cost and schedule of the NLC conventional facilities, so that the design and construction of the conventional facilities can be fully executed within the baselines established from the information in the Conceptual Design Report. To meet this objective, the following information will need to be developed for the conventional facilities:

- Generic Site Layout. (Selection of actual site probably will not occur until after CD-2.)

- Concept designs, outline specifications and construction cost estimates for all conventional facilities. The concept designs will include the following:
  - Beamline Housings: Concept designs will include cross sections and plan views of tunnel housings, dump housings, ramps and shafts, klystron galleries and support buildings, and penetrations for rf waveguide and cables.
  - Electrical load requirements and single-line conceptual drawings for the electrical system.
  - Cooling load requirements, single-line conceptual drawings and isometric sketches for the cooling systems.
  - Water demand, single-line conceptual drawings for the water and waste systems.
  - Natural gas demand, single-line conceptual drawings for the gas distribution system for campus facilities.
  - Communications requirements, single-line conceptual drawings for the communications systems, including the telephone system, the fire sensing and alarm system and the supervisory control and data acquisition system (SCADA). The SCADA system will be used to monitor and control the conventional systems, e.g., power, water, waste, beamline cooling systems and building HVAC systems.
- Campus buildings: space programs, single line conceptual plan views and elevations for all campus buildings. Because they will be on the critical path to support installation of the technical systems, the manufacturing facilities will be developed in greater detail to facilitate earliest possible start. For the manufacturing facilities and the associated treatment plants, the following items will be developed: work flow plans, equipment layouts, and detailed space programs; detailed plan views, elevations, equipment lists and isometric sketches of the treatment plant; and a detailed cost estimate.
- Conceptual layouts and a first draft of the specifications for the alignment networks of survey monuments. These monuments will be used for surveys in support of construction of facilities and the precision alignment of the beamlines.
- Conceptual site layout drawings for site preparation, roads, utility systems, and drainage.

- Detailed schedule for design and construction of each conventional facility\(^\text{15}\)
- Cost estimates for Engineering Design and Inspection (ED&I).
- Risk analysis.
- Compilation of Design Criteria for Conventional Facilities – applicable DOE criteria, codes and standards, material specifications, guidance concerning design loads, etc.
- Definitive Site Selection Criteria for use by DOE.
- Identification of Candidate Sites\(^\text{16}\).

3.5.10.2 Execution Phase (CD-2 to CD-4): The objective of the Conventional Facilities Group would be to carry out the final design and construction of the conventional facilities to meet fully the needs of the NLC, within the project’s technical, cost and schedule baselines. Specific responsibilities would include:

- Quality assurance for the conventional facilities, throughout the design, construction and acceptance of the facilities.
- Financial management of the design and construction of conventional facilities, including responsibility as Cost Account Manager for WBS elements in the 14 series.
- Management of the design of the conventional facilities by the Architect-Engineer/Construction Manager (A-E/CM).
- Coordination of design reviews, including participation by those who would occupy and use the specific facility.
- Management of the construction of the conventional facilities by the A-E/CM and acceptance of the completed facilities.
- Management of the construction safety program, including oversight of the A-E/CM construction safety performance in the field.
- Compliance with the environmental laws and regulations affecting conventional facilities.

Note: The Conventional Facilities Group will draw upon a task order contract with an Architect-Engineer firm for additional support as needed during the Preconceptual and Conceptual phases. During

\(^{15}\) The conventional facilities schedule will be a subset of the integrated project schedule for the total NLC and will support the major milestones for the project.

\(^{16}\) This requires compilation of basic site characterization information for potential candidate sites, such as land ownership and cost, topography, geology, potential environmental issues, regional and community support, etc.
the Execution Phases), additional support will be provided through a contract with an Architect-Engineer/Construction Manager.

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**Project Management Plan (PMP)**

**Conventional Facilities Group**

- **Conventional Facilities Manager**
  - **ES&H**
  - **Quality Assurance**
  - **Conventional Project Controls**
    - Cost Control
    - Scheduling
    - Budget
    - Reports
    - Administration
  - **Engineering**
    - Geotechnical
    - Civil
    - Electrical/Mechanical
    - Architectural
    - Cost Estimating
    - CAD
  - **Construction**
    - Construction Safety
    - Resident Engineer #1
    - . . .
    - Resident Engineer #n

*Figure 3.12*
3.5.11 Project Planning and Coordinating Group

The Project Planning and Coordinating Group provides technical and procedural support in the following areas:

3.5.11.1 Preconceptual Design Activities (Pre-CD-1):
1. Develop preliminary assessment of Project Management tools, especially WBS and scheduling software, and document management schemes.
2. Develop preliminary Cost Estimating and Management Plans for use during the Conceptual Design Phase

3.5.11.2 Cost, schedule, and contingency planning and coordination during the Conceptual Design phase (CD-1 to CD-2):
1. Develop and maintain integrated cost and contingency estimates and schedules and analysis and reporting techniques for project planning.
2. Develop a comprehensive project management database and control system.
3. Prepare cost, schedule and contingency reports for internal and external review.
4. Evaluate, select, and implement appropriate software tools.
5. Hire and manage program analysts, consultants, and data-entry personnel.

- Mission-assurance planning and coordination:
  1. Develop and coordinate project-wide programs for planning and evaluation of Reliability, Maintainability and Availability (RMA), Quality Assurance (QA), Quality Control (QC), and risk assessment.

- Information planning and coordination:
  1. Develop information-sharing systems for the project group.
  2. Develop and deliver information about the project to personnel and agencies in the scientific, public, and government communities.
  3. Collect, organize, prepare, and maintain project presentation materials including project proposals and reports.
  4. Plan and coordinate project reviews with Administrative staff.
  5. Work with members of other groups at SLAC, departments of Stanford University, government agencies, and international laboratories.

- Small Business Innovation Research (SBIR) Program planning and coordination:
  1. Assist the SLAC Technology Transfer Office and DOE with the development and processing of Small Business Innovation Research (SBIR) grant applications relevant to developing technologies and techniques for the NLC project.
  2. Facilitate communication among the SLAC Technology Transfer Office, Project Management and Engineering, small businesses, and DOE.

- ES&H planning and coordination:
  1. Develop a project-wide program for project ES&H planning and evaluation.
  2. Develop analyses and reports for NEPA, environmental impact, and safety analysis.
  3. Hire and supervise consultants and analysts as necessary.

- Coordinate Conceptual Design Report Preparation and Presentation

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3.5.11.3 Execution Phase (CD-2 to CD-4): During the Execution phase of the project the Project Planning and Coordinating Group would:

1. Deploy Project Management Tools
2. Ensure Schedule and Cost Compliance
3. Implement project-wide ES&H plan and coordinate NEPA and other reports as required, including DOE Progress Reports
4. Plan and coordinate project reviews with administrative staff

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**Figure 3.13**
3.5.12 Special Projects

Under the direction of the NLC Project Director, the Special Projects Group will:

- Plan, design and test special systems that are unique, innovative or span multiple subsystems within the collider;

- Plan, design and test collider-wide subsystems that require extensive system integration;

- Coordinate operation and commissioning of collider prototype accelerator test facilities, such as ATF, ASSET and NLCTA;

- Test and analyze mechanical and electrical subsystems that involve unusually tight tolerances.

3.5.12.1 Conceptual Design Phase (CD-1 to CD-2): During the Conceptual Design phase of the project, the group will develop functional specifications and designs for subsystems that require substantial system integration such as machine protection, fast abort kickers and safety systems. The group will also develop and test special instrumentation including optical and low-level microwave subsystems. This includes all laser-based systems, the lasers themselves, and special microwave instrumentation. The group will provide functional requirements for these systems to the Electrical, Mechanical and Conventional Facilities groups along with other groups as appropriate. The group will develop and provide proof-of-principle designs for these systems and will coordinate review and acceptance testing of the fully engineered systems as developed by the support groups.

The group will coordinate SLAC’s involvement in the operation and commissioning of the KEK Accelerator Test Facility (ATF) and coordinate the operation of the ASSET and NLCTA test facility with the Accelerator Department and the Accelerator Research Department.

3.5.12.2 Execution Phase (CD-2 to CD-4): In the execution phase of the project, the group would develop testing, acceptance criteria and perform reviews of the design and implementation of the above subsystems as developed by the support groups: Mechanical, Electrical and Facilities. The group would also test and analyze mechanical support systems, such as the linac quad and structure supports and magnetic systems such as the linac quad centering process.

Specific responsibilities of the Special Projects Group include:

I. Definition of requirements and preliminary design for special instrumentation such as

- Source laser
- Synchrotron light monitor
- Bunch length monitor
- Laser wire
- Profile monitor
- Beam phase monitor
- Precision range finder
- Vibration Suppression
- Durable collimators
II. Definition of requirements and preliminary design for collider-wide safety systems such as:
- Radiation Safety – e.g., access control
- Electrical Safety – e.g., remotely energized beamline component control
- Stored mechanical energy safety – e.g., remotely energized beamline component control

III. Definition of requirements and preliminary design for collider-wide subsystems such as:
- Timing and rf distribution
- Machine Protection
- Kickers and abort magnets, as well as
- Planning and coordination of SLAC participation in the KEK ATF commissioning
- Coordination of ASSET operation with Accelerator Department
Special Projects

Figure 3.14
3.5.13 Administrative Support

Under the direction of the NLC Project Director, the administrative Support group is responsible for administrative and clerical support for the NLC project. The Group interacts closely with management and staff within the project organization, with the on-site KEK Project Officer and with personnel throughout the SLAC community. In addition, they provide liaison with LBNL and LLNL staff members and facilitate their occasional space and computing requirements.

Responsibilities are divided into three areas:
- Clerical Support
- Administrative Support
- Buildings/Vehicles

Clerical support includes the following tasks:
- Travel
- Time Reporting
- Copying
- Office Supplies
- Scheduling Appointments
- Work Orders
- Purchase Requisitions
- Computer Support
- Software Installation
- Telecommunication Services
- Maintain Paper and Electronic Document Files

Administrative Support encompasses the following activities:
- Develop and write policy and procedure statements
- Prepare for major technical reviews and international meetings with Project Planning and Coordinating Group
- Allocate space
- Analyze budgets, report costs and financial commitments
- Personnel transactions
- Personnel and office management
- Personnel and Accounts data base management

Responsibilities for Buildings and Vehicles include:
- Personnel Safety Training and Safety Compliance
- Maintenance of Buildings and Vehicles

These responsibilities, already initiated in the preconceptual (pre-CD-1) phase will carry through the CDR (CD-1 to CD-2) phase. At the CD-2 transition to the Execution Phase (CD-2 to CD-4) there would be an additional focus supporting activities related to ES&H and NEPA requirements developed by the Project Planning and Coordinating group.
Administrative Support Group

Group Manager

Clerical Support
- KEK Office Support
- NLC Office Support
- Computer Support
- Software Installation
- Procurement
- Telecommunication Services
- LLNL/LBNL Support

Administrative Support
- Budget Analysis
- Meeting Scheduling
- Space Allocation
- Personnel Transactions
- Policy and Procedures
- Technical Reviews
- International Meetings

Buildings & Vehicles
- Safety
- Maintenance

Figure 3.15
3.5.13.1 KEK Liaison: KEK maintains an office at SLAC to supervise administration of KEK research funds at SLAC. The office has a staff member from KEK and a bilingual administrative associate provided by SLAC to assist with KEK communication and to assist in preparations for international meetings and to facilitate the needs of visitors.

3.5.13.2 ES&H Officer: The ES&H officer during the preconceptual and Conceptual phases will coordinate all ES&H activities related to NLC design and R&D. This includes compliance with SLAC safety programs and safety training requirements. DOE regulations will be evaluated and compliance with them will be ensured. The project ES&H officer assigned for the CDR phase works directly with the SLAC ES&H office at all times. This officer has been appointed during preconceptual phase activities. In the CDR phase resource requirements will be reassessed and if needed, ES&H staffing will increase. A Project Execution ES&H plan will be initiated and incorporated into the Conceptual Design deliverables package in coordination with and direction from the Project Planning and Coordinating group.
4. CDR Execution
   4.1 Resources and Resource Planning

   The Project Director together with the Deputy Directors will manage resources and resource planning during the CDR phase. Resource requirements will be based on the requests for manpower and materials provided by the engineering systems and machine area managers to complete the R&D and project goals of the CDR. Budget allocation will be based on the available budget and priorities set in consultation with the Engineering and Area Managers.

   4.2 Budget Authority and Responsibilities

   During the CDR phase budget authority will reside with the Project Director who will be assisted by the Laboratory and project administrative staff in tracking and reporting expenditures and in keeping expenditures on schedule. The Project Director may delegate authority to various Project Managers as appropriate, but will maintain signature authority on all large expenditures (presently defined as those in excess of $5000). Expense tracking and reporting is presently done through the Laboratory Technical Division Budget Office. The NLC Project Planning and Coordinating Group will monitor the progress of the work on the project against planned milestones, and will provide earned-value analysis to Project Management. They will also maintain schedules and coat-to-completion estimates.

   4.3 Project Management Control System

   The Project Management Control System (PMCS) provides integration with the work breakdown structure and the Resources Breakdown Structure of formal management control systems and processes – cost estimating, work scope structuring and authorization, scheduling, performance measurement reporting, funds management and baseline change control. These processes provide for the planning, budgeting, and authorizing of an integrated cost, schedule and technical baseline which facilitates timely comparisons of actual versus planned performance in relation to these project baselines.

   The PMCS will be developed as part of the CDR process and will include Work Authorization procedures, schedule development procedures, Performance Measurement Baseline, and the Project Execution and Status Assessment Reporting protocols, Variance Analysis procedures, and Accounts Management procedures, including management of Project Contingency. It will be developed in compliance with Interagency Joint Directive DP-40, DOE Orders 430.1A, 4700.1, Notice 4700.5, and the DOE Good Practice Guides, GPG-FM-001 through GPG-FM-033 and the recently signed contract between Stanford University and the US. Department of Energy.

   4.4 Project Summary Schedule

   The project Summary and Detail schedules will be maintained in Primavera software and will be updated on a monthly basis during performance of tasks leading to completion of the CDR. During the CDR phase this software and the accompanying SureTrak package will be assessed for utility during the Execution Phase of the project. Alternative and more powerful scheduling software will be identified if required.

   4.5 Financial Management

   Financial management occurs at several levels. A member of the SLAC Technical Division Budget Office has been assigned to the project to monitor and maintain spending profiles during the
preconceptual and early conceptual design phases. The administrative support group also performs in-house monitoring. Late in the CDR phase a Financial Manager will be hired to manage the increasing budgets and to meet the Project financial reporting requirements.

4.6 Project Monitoring and Assessment

The CDR phase does not require the formal reporting that is initiated at the inception of the Execution phase. Monitoring and assessment will take place through a series of internal and external project reviews. In the internal reviews knowledgeable members of the community will be invited by the Project Director to review the ongoing work. In External Reviews the DOE Program Manager together with the Laboratory Director will assemble and invite a review committee whose principal responsibility will be to report to DOE their evaluation of the ongoing work. In both cases the goal is to ensure that the work is progressing in the right direction, and meeting schedule and cost.

4.7 Engineering and Design

Engineering and design during the CDR phase will focus on work to refine the design of the components in each area of the collider. An emphasis will be placed on work toward common designs wherever possible for systems or components common to all collider areas such as magnet systems, magnet movers, dipole, quadrupole and sextupole magnets, vacuum systems, instrumentation, and modulators. Integration of industrial partners in the engineering and design will be an important central goal of the in-house engineering effort. The CDR execution plan allows for several iterations of the engineering and design of the collider, which provides significant opportunity for value engineering to optimize performance, reliability, cost and system efficiency. The R&D plan to be executed during the CDR phase has been designed to support the engineering and design activities. It is aimed at validating more reliable, cost-effective systems and components, and at identifying potential technology substitutions that would enhance the performance or reliability of the collider design.

4.8 U.S. Laboratories Collaboration Infrastructure

The NLC Project has been since its inception a collaborative effort. While SLAC will maintain the position of lead laboratory through the Conceptual Design phase, support from and collaboration with other laboratories will continue to be an important part of the Conceptual Design process. In specific, collaboration with the Lawrence Livermore National Laboratory (LLNL) and the Lawrence Berkeley National Laboratory (LBNL) provides scientific and technical resources in the development of key technologies. Each laboratory has a program manager who works with the project management at SLAC to develop work plans for the collaborating organizations. Technical and scientific staff are assigned by the LLNL and LBNL managers or may be specifically requested by SLAC project management. Support of these programs is also shared with SLAC. LLNL and LBNL will provide input as requested to the baseline design presented in the CDR. Copies of the Memoranda of Understanding with these laboratories are included as Appendices VII and VIII. It is expected that these and perhaps other U.S. laboratories will contribute to the Project Execution phase. Tasks and performance structure will be identified as part of the Conceptual Design phase.
5. Project Deliverables for CDR Phase

5.1 Conceptual Design Report

The Conceptual Design Report is a principal product of this phase of the project. It will contain updated functional and technical requirements for the NLC and will include a complete conceptual design for the NLC. The CDR will be supported by the documents identified separately as items 6.2 and 6.3 below. Risk analysis for the NLC conceptual design will be presented. The use of risk analysis results together with one or more risk-based algorithms to calculate project contingency will be discussed to support project contingency calculations. Value engineering as defined in DOE Order 430.1A, Attachment 1, ¶ 55 will be applied in developing cost, schedule, budget, risk analysis and RMA analysis and the structure of a value engineering plan for project execution will be developed from the CDR baseline. Areas covered include:

- Project objectives, functional requirements, and technical specifications;
- Conceptual design;
- Cost estimates, including Total Estimated Cost (TEC) and Other Project Costs (OPC) that together constitute the Total Project Cost (TPC);
- Integrated project schedule;
- Funding requirements;
- Site requirements and evaluation factors;
- Specific risk assessments;
- Studies of project alternatives.
- Evaluation of design candidates for critical components;
- Value-engineering assessment and acquisition strategy (Design for Manufacture Model)
- Preliminary ES&H evaluations.

5.2 Baseline Work Breakdown Structure

The baseline Project Work Breakdown Structure (WBS) has been defined. It will be an integral part of the Conceptual Design Report. The WBS defines the scope of the project in terms of all project elements including project conceptual design, R&D and execution. Project estimated costs at the elements level reside in the WBS and are the basis for both TEC and OPC cost roll-ups. Cost data from the WBS is migrated into the Project Schedule to ensure the use of consistent numbers.

5.3 Baseline Integrated Project Schedule

The baseline Integrated Project Schedule is the map to project execution. It identifies major milestones, points to critical path elements and shows the linkages among project elements. As a fully integrated schedule, the costs for project elements and full resource loading will also be integrated and tracked. The Integrated Project Schedule is used to develop funding profiles over the project’s Execution phase and to track cost and schedule compliance.

5.4 Preliminary Execution Phase R&D Plan

The Preliminary Execution Phase R&D Plan will describe R&D activities to continue from the Start of Execution (CD-2) to the approval of Start of Construction (CD-3). The plan will include the completion of R&D that has had yielded preliminary results during the Conceptual Design phase that indicate an increase in performance and/or reliability and/or reduced component cost.
5.5 Preliminary Safety Analysis Report (PSAR)

The Preliminary Safety Analysis Report will be a separate document in support of the CDR. It will provide a safety analysis of machine fabrication, installation and operation issues. It will supplement the NEPA analysis of a site or several sites to be performed by DOE. The full Safety Analysis Report would be developed during the Execution phase.

5.6 Preliminary Life Cycle Asset Management and Life Cycle Cost Plans

Life Cycle Asset Management (LCAM) and Life Cycle Cost (LCC) analysis will be developed to a preliminary level during the Conceptual Design phase of this project. Developing these assessments is complicated by 1) the lack of site selection and 2) the history of U.S. High Energy Physics laboratories where there has been no experience with facility decommissioning and return to green field status. However, it will be possible to perform analysis to a reasonable preliminary level based on the two U.S. sites to be examined by the Conventional Facilities Group.

5.7 Others Reports

Other reports will be presented as required and agreed in negotiation between SLAC and DOE.
## Acronyms Used in Project Management Plan

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP</td>
<td>Accelerator Physics</td>
</tr>
<tr>
<td>ASSET</td>
<td>Accelerator Structure Setup Facility</td>
</tr>
<tr>
<td>ASTA</td>
<td>Accelerator Structure Test Area</td>
</tr>
<tr>
<td>ATF</td>
<td>Accelerator Test Facility (at KEK)</td>
</tr>
<tr>
<td>BD</td>
<td>Beam Delivery</td>
</tr>
<tr>
<td>BINP</td>
<td>Budker Institute of Nuclear Physics</td>
</tr>
<tr>
<td>BSM</td>
<td>Beam Size Monitor</td>
</tr>
<tr>
<td>DLDS</td>
<td>Delay Line Delivery System</td>
</tr>
<tr>
<td>DDS</td>
<td>Damped Detuned Structures</td>
</tr>
<tr>
<td>DESY</td>
<td>Deutsches Elektronen Synkenron Laboratory</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
</tr>
<tr>
<td>ECFA</td>
<td>European Committee on Future Accelerators</td>
</tr>
<tr>
<td>FFTB</td>
<td>Final Focus Test Beam</td>
</tr>
<tr>
<td>FNAL</td>
<td>Fermi National Accelerator (FermiLab)</td>
</tr>
<tr>
<td>HEPAP</td>
<td>High Energy Physics Advisory Panel</td>
</tr>
<tr>
<td>ICFA</td>
<td>International Committee on Future Accelerators</td>
</tr>
<tr>
<td>ILC-TRC</td>
<td>International Linear Collider Technical Review Committee</td>
</tr>
<tr>
<td>ISG</td>
<td>International Study Groups (US-Japan)</td>
</tr>
<tr>
<td>JLC</td>
<td>Japanese Linear Collider</td>
</tr>
<tr>
<td>KEK</td>
<td>High Energy Accelerator Research Organization (Japan, at Tsukuba)</td>
</tr>
<tr>
<td>LAL</td>
<td>Laboratoire de l’Accelerateur Lineaire at Orsay, France</td>
</tr>
<tr>
<td>LCC</td>
<td>Linear Collider Collaboration (US/Japan)</td>
</tr>
<tr>
<td>LCD</td>
<td>Linear Collider Detector</td>
</tr>
<tr>
<td>LBNL</td>
<td>E.O. Lawrence Berkeley National Laboratory</td>
</tr>
<tr>
<td>LLNL</td>
<td>Lawrence Livermore National Laboratory</td>
</tr>
<tr>
<td>MOU</td>
<td>Memorandum (a) of Understanding</td>
</tr>
<tr>
<td>NAS</td>
<td>National Academy of Science</td>
</tr>
<tr>
<td>NLC</td>
<td>Next Linear Collider</td>
</tr>
<tr>
<td>NLCTA</td>
<td>Next Linear Collider Test Accelerator</td>
</tr>
<tr>
<td>OAK</td>
<td>Oakland Field Office, U.S. DOE Office of Science</td>
</tr>
<tr>
<td>PPM</td>
<td>Periodic Permanent Magnet</td>
</tr>
<tr>
<td>RAM</td>
<td>Responsibility Assignment Matrix for Technical Systems Engineering</td>
</tr>
<tr>
<td>RDDS1</td>
<td>Rounded Damped Detuned Structure version 1</td>
</tr>
<tr>
<td>RMA</td>
<td>Reliability, Maintainability, Availability</td>
</tr>
<tr>
<td>SBIR</td>
<td>Small Business Innovative Research program supported by DOE</td>
</tr>
<tr>
<td>SLAC</td>
<td>Stanford Linear Accelerator Center</td>
</tr>
<tr>
<td>SLC</td>
<td>Stanford Linear Collider</td>
</tr>
<tr>
<td>TeV</td>
<td>Tera electron Volts ((10^{12} \text{ electron volts}))</td>
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</tbody>
</table>