Cost Estimate and Schedule Development for the Linear Collider Project

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SLAC / NLC

MAC Review, June 25, 2003
Cost Estimating & Scheduling Activity

- Cost & Schedule Task Force effort, directed by the USLC Steering Group.

- Analyzing and comparing the cost and schedule of the Warm X-band and Cold L-band LC Options.

- Representative sites in California and Illinois
  - Warm LC: near Copper Mountain (CA) and DeKalb (IL)
  - Cold LC: near Logan Ridge (CA) and DeKalb (IL)

- Configurations defined by Accelerator Task Force
  - Warm and Cold Options, plus variants.
  - Equivalent luminosity, energy and upgradability.
  - Two Interaction Regions with crossing angle.
  - Electrons polarized, positrons polarizable by upgrade.
Cost & Schedule Task Force Members

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Cost Estimating Assumptions/Bases

- The LC will be built in the U.S. by DOE-contractor labs and universities using the services of global industry on a competitive basis.
- DOE financial practices will apply “Project Management for the Acquisition of Capital Assets,” DOE M 413.2-1, Approved 3/28/03, Mandatory on 10/1/03.
- As much scope as is reasonable will be contracted out.
- All civil construction will be U.S. content.
- Ignore the cost impact of any in-kind or politically directed contributions or purchases.
- Use base-year estimates without escalation.
- Cost-risk calculations will be Monte Carlo based.
Practical Matters

- Use previous cost analyses as much as possible.
- **Warm Option:** NLC 2002-2003, G(J)LC 2003.
- **Cold Option:**
  - Use Warm LC cost equivalents where they suffice.
  - Use TDR costs for cryomodules, RF, cryogenic facilities.
  - $1 per Euro.
  - Add 6% to TDR costs to approximate the “Buy American” penalty where appropriate.
  - Incorporate appropriate labor content across the board.
  - No mark-up to European labor, because salaries are commensurate with FTE productive hours.
WBS for Cost Analysis/Comparison
- Parallel at High Level -

1. WARM LC OPTION
   1.1 Warm LC Injector Complex
   1.2 Warm Main Linacs
   1.3 Warm LC Beam Delivery
   1.4 Control System
   1.5 Cryogenics Placeholder
   1.6 Site/Campus Facilities
   1.7 Technical Services
   1.8 Acc. Preops/Physics
   1.9 Management Services

2. COLD LC OPTION
   2.1 Cold LC Injector Complex
   2.2 Cold Main Linacs
   2.3 Cold LC Beam Delivery
   2.4 Control System
   2.5 Cryogenic Systems
   2.6 Site/Campus Facilities
   2.7 Technical Services
   2.8 Acc. Preops/Physics
   2.9 Management Services

Cross-cuts

Employee Labor versus Material/Services/Subcontracts.
R&D/EDI&A costs.
Conventional Facilities costs.
Probabilistic Cost Estimates

• Use probability distributions to communicate the cost estimates for major cost items.

• Allows for wide ranges of possible/probable costs.

• Reduces or eliminates lack-of-consensus problems.

• Combine the cost items using Monte Carlo method.

• Allows for consideration of systematic effects such as correlations between items.
Preferred Approach to Cost Risk
(Based on DOE M 413.3-1, Ch. 14)

- Risks are contingent cost items that measure inability to achieve overall project objectives within the defined scope, cost, schedule, technical, and external constraints.

- Risk Assessment approach being considered:
  - Identify each risk.
  - Estimate the probability of its occurrence.
  - Estimate the cost-range of its consequences, if it occurs.
  - Quantify its contingent cost range (by confidence level using Monte Carlo methods).

- Risk Management approach being considered:
  - Reduce or eliminate the probability or consequence of each risk where possible.
  - And/or include its contingent cost range in the total cost (by confidence level using Monte Carlo methods).
Cost Scrutiny and Triage

- There are 1450 cost items (as of Version 13).
- Validation or vetting of the costs is not feasible.
- Most items are being reviewed by someone other than the estimator.
- Relatively small costs are inconsequential.
- Warm and Cold costs are effectively set equal where possible.
- Established technologies are less critical.
- Probabilistic cost estimates and risk assessments can cover disagreements, wide ranges in point estimates, and systematic errors.
- Concentrate on the costly items such as the repetitive, modular linac systems.
Remaining Systematic Cost Issues

- Treatment of large extrapolations in quantities and manufacturing models.
- Uniform implementation of Learning Curves and Value Engineering.
- R&D, Design and Engineering estimates are under-reviewed.
- Analysis.
- Check dependence of cost on execution model and schedule.
Scheduling Objectives

• Validate the reasonableness of the Warm and Cold cost estimates and plans.

• Create a simple working model as an engaging framework for communicating the schedule and time-phasing the cost estimate.

• Understand the sequence and interrelationship of activities in the different areas of the LC project:
  - Accelerator Systems
  - Control System
  - Commissioning
  - Management Services
  - Conventional Facilities
  - Technical Services
  - Detectors
Scheduling Objectives

• It will be physically and financially impossible to do everything at once. Identify preferences for activity sequencing amenable to:
  - Practical funding and year-to-year funding growth,
  - Efficient resource use,
  - Acceptable completion schedule.

• Understand the schedule consequences of configuration choices.

• Eventually, formulate strategy for the scope and timing of subcontracts, procurements, and opportunities for risk reduction and cost sharing.
Summary of the Working Model Storyboard

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<td>Site-indep. R&amp;D/Design</td>
<td>Approve Baseline</td>
<td>Choose Intl Site</td>
<td>Start of Constr'n</td>
<td>Start of Installation</td>
<td>Start of Preops</td>
<td>Start of Facility Ops</td>
<td>Project Closeout</td>
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R&D / Concept Development

- Engineering Design
- A-E Design

Civil Construction

Sustaining Engineering Support

Fabrication/Production

Installation and QC Checks

Electron Beam Commissioning

Positron Beam Commissioning

Machine Operations


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Observation: Early Injector Completion

- The injectors are complex systems requiring extensive commissioning and operational development before they can be used to commission the downstream systems.

- The electron injector can be the first system operational. It will drive learning for subsequent activities involving:
  - Underground design and construction,
  - Component fabrication/production,
  - Installation and integration,
  - Control System development,
  - System commissioning,
  - Operation and maintenance.
Observation: Main Linac Design Verification

• Shall we seek an early test of the Main Linac’s first 200 m (with housing, utilities, control system and other infrastructure in place at the ILC site)?

   Alternatively . . .

• Shall we build a 1-GeV Engineering Test Facility?
  - Construct at an existing Lab (2005-07) before the ILC host and site are chosen (2008).
  - Operate at first with prototypes during industrialization.
  - Operate later with production articles from inventory.
  - Develop ML installation and maintenance processes.
  - ‘Abandon’ it when ML commissioning starts at the ILC site.
Observation: Partial-Energy Start-Up of HEP

• It would delay project completion. Is there a compelling reason to plan for it?

• Partial-energy start-up would require:
  - Main Linac with partial complement of structures,
  - Beam Delivery to at least one Interaction Region,
  - Injector Systems fully capable.

• Energy for earliest start-up is a strategic choice:
  - How much of the Main Linac energy can be installed by the time the injectors can deliver beams and one I.R. can accept them?
  - Is it enough (2/3) to drive the undulator e+ source?
Observation: Staged Project Completion

- Significant systems may be made operational in stages for the purpose of HEP, Test Beams, and/or Machine Development years before the entire project is completed.

- Some of the resource budgets can migrate from the construction project to Facility Operations.
The Year Ahead

• The Task Force Reports to USLCSG by Sept. ‘03.
  - Cost Analysis of Warm and Cold LC Options.
  - Schedule/Story Development.
  - Time-phased cost analysis.

  - Flexible analysis of trade-offs and opportunities, distinguishing between impact levels of 1%, 5%, 10%.
  - Long-range Budget Planning.
Schedule for task force work

- Jan. 10: Charge to Accelerator Subcommittee from USLCSG Executive Subcommittee
- April 14: Joint task force meeting #1
- April 16, June 11: Status reports to USLCSG ExecComm
- May 22-23 Cost review meeting at DESY
- June 5-6 Design review meeting at DESY
- June 15-16: Joint task force meeting #2
- July 13: report on work at Cornell ALCW meeting
- Late August: Final joint task force meeting
- September: Completion of task force work and submission of report to the USLCSG Executive Committee; presentation to observers from DESY, CERN, KEK