NLC Technical Systems Overview
Organization-Methodology-Status

Lehman Review
May 25, 1999
Technical Systems Overview
Definitions

• Technical Systems include generic systems and activities (eg. Installation) which are not specific to one area of the NLC, but apply over many areas. Systems include:

  • **Sources:** Electron and positron source systems
  • **RF:** Klystrons, modulators, low level rf, rf structures and waveguide delivery systems
  • **Magnet Systems:** Magnets, power supplies, cable plants, cooling
  • **Movers, Supports, Optical Anchor:** Motors and controls for magnets and structures, structures, optical anchor
  • **Vacuum:** Manifolds, pumps, electronics and cabling
  • **Collimators, Beam Dumps:** Mechanics, instruments
Technical Systems Overview
Definitions - Continued

- **Instrumentation:** Source lasers, laser wire scanners, synchrotron light monitors, profile monitors, toroid current monitors, etc.

- **Global Timing:** Master oscillators, stabilization, fiducial distribution, imbedded timing control chips

- **Global Controls & Protection:** Controls architecture, networks, distributed controls, feedback, software systems, machine protection, beam containment, personnel protection, racks

- **Systems Installation:** Installing beamline devices & systems

- **Manufacturing facilities:** Factories, shops, preassembly, testing

- **Conventional Facilities:** Sites, buildings, tunnels, utilities, environmental, etc.)

- **Project Planning & Management:** Tools, methods, costs, schedules, engineering standards, etc.
Engineering Organization
Technical Systems Engineering Teams (TSETs)

• TSETs responsibilities include:
  – Planning, cost analysis and scheduling for WBS1 (design and construction) and WBS2 (conceptual design and R&D)
  – Reliability engineering and risk analysis applied to design, manufacturing, installation, checkout phases
  – Optimization and standardization of system designs across all areas of the machine
  – Design reviews, vendor development, documentation standards

• TSETs combine Mechanical, Electrical and Facilities engineering disciplines as appropriate to each system. Each TSET is led by 1-2 Team Coordinators.
# Technical Systems Engineering Teams (TSETs)

<table>
<thead>
<tr>
<th>System</th>
<th>Coordinator(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coordinator: J. Weinberg, L. Eriksson, E. Hamner, B. McKee, K. Millage, T. Porter</td>
</tr>
<tr>
<td>Supports &amp; Movers</td>
<td>Coordinator: A. Ringwall &amp; N. Yu, G. Bowden, M. Browne, D. Brown, B. McKee, M. Munro, B. Roster</td>
</tr>
<tr>
<td>Low Level RF</td>
<td>Coordinator: H. Schwarz, P. Corredoura, G. Dalit, J. Frisch, J. Judkins, M. Munro, W. Ross, R. Tighe, K. Underwood</td>
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<tr>
<td>Modulators Induction</td>
<td>Coordinator: R. Cassel &amp; B. Merritt, K. Fant, M. Ross, D. Schultz, R. Ruland</td>
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<tr>
<td>Conventional Facilities</td>
<td>Coordinator: J. Weinberg, C. Rago, M. Munro, M. Neubauer, E. Doyle, L. Eriksson, E. Leung, T. Porter, K. Fant, M. Ross, D. Schultz, R. Ruland, Area Mgrs, Area Coords</td>
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<td>Systems: Structures</td>
<td>Coordinator: C. Spencer, S. Smith, R. Johnson, E. Medvedko, M. Munro, V. Smith, J. Weinberg</td>
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<td>Collimators &amp; Dumps</td>
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<td>Area Installation</td>
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<td>Manufacturing</td>
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<tr>
<td>BPMs</td>
<td>Coordinator: J. Weinberg, C. Rago, M. Munro, M. Neubauer</td>
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</tbody>
</table>

*LLNL #Bechtel NV

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**NLC - The Next Linear Collider Project**

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**R S Larsen**

5/25/99

Page 6
Global Systems & Planning

Global Controls
Coordinator: R. Humphrey
              R. Fuller
              S. Clark
              M. Crane
              L. Hendrickson
              M. Ortega
              J. Rock
              R. Sass
              H. Shoae
              E. Siskind*

Global Timing
Coordinator: E. Cisneros
             M. Browne
             D. Brown
             D. Bernstein
             J. Frisch
             D. Thompson

Global Protection
Coordinator: R. Humphrey
             B. Bennett
             P. Bong
             M. Crane
             J. Dimaggio
             K. Joe
             W. Kroutil
             A. Tilghman
             R. Zdarko

Special Instrumentation
Coordinator: M. Ross
             J. Frisch
             E. Cisneros
             E. Doyle
             K. Joe
             D. McCormick
             T. Slaton
             A. Tilghman
             D. Bernstein
             D. Thompson

Project Planning & Coordination
Coordinator: T. Lavine
             T. Knight
             A. Larsen
             Z. Wilson

Project Management
Coordinator: D. Burke
             C. Adolphsen
             J. Cornuelle
             J. Ives
             R. Larsen
             T. Lavine
             T. Markiewicz
             T. Raubenheimer
             J. Sheppard

* NYCB Real Time Computing
TSET Reporting Responsibilities

- *Area Managers and Coordinators* are responsible for major machine areas: Injection, Main Linacs, Beam Delivery. TSETs are responsible to Area Managers.

- **TSETs:**
  - Receive *system requirements* from and generate *responses* to each Area Manager. Area Coordinators are liaisons and members of the TSET.
  - Work with Area Managers & Coordinators to achieve integrated, optimal, cost effective system solutions.
  - Collaborate with Area Managers & Coordinators to define appropriate Conceptual Design and R&D goals for the CDR project.
TSET Responsibilities
NLC Design & Construction (WBS1) Cost Modeling

• TSET Functions (typical)
  – Choose model for basis of estimate
  – Develop Definitions, Descriptions, Specifications
  – Perform scaling, parametric or bottoms up estimates
  – Follow *standard checklist* to estimate activities, materials, labor, equipment
  – Evaluate risk factors for contingency calculation
  – Produce top level cost summaries in Excel
  – Coordinate data transfer to Planning Group for WBS
  – Collect documentation into a *NLC Cost Book*
TSET Cost Estimating (WBS1) Guidelines & Standards

- Detailed guidelines for cost estimating posted on Website
- *Subsystem/Component Top Level Cost Summaries* - 2/99
  - Abbreviated Checklist:
    - Design
    - Reliability engineering
    - Design reviews
    - Prototyping
    - Developing multiple vendors
    - Contracting test quantities and QC
    - Testing early designs and QA
    - Preparing bid packages
    - Awarding contracts
    - Manufacturing and QC
    - Acceptance testing and QA
    - System assembly
    - Installation, systems integration
    - System testing
    - Commissioning
## TSET Cost Estimating (WBS1) Standard Checklist - Sample

### Table 1: Subsystem/Component Top Level Cost Summary

<table>
<thead>
<tr>
<th>Activity</th>
<th>Detailed Activities</th>
<th>ED &amp; I</th>
<th>M &amp; S</th>
<th>Labor</th>
<th>Equipment</th>
<th>Space</th>
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<td>Design</td>
<td>Conceptual design, reliability design, simulations, modeling, planning, estimating, scheduling, reports, design reviews</td>
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<tr>
<td>Laboratory design &amp; setup</td>
<td>Design laboratory, procure furniture and specialized/standard test equipment, coordinate with builders and crafts, plan and fulfill staffing, calculate floor space requirements for use by Conventional Facilities. Note special definition of Equipment in Dictionary.</td>
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<td>Design &amp; Fabricate Prototype</td>
<td>Detailed design of prototype hardware, firmware/software, control panels and interface, built-in diagnostics, parts procurement, fabrication, test, design reviews, rework, test reports, Design for Manufacture, reliability engineering</td>
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<tr>
<td>Factory design &amp; setup</td>
<td>Design factory, procure special fabrication and test equipment, coordinate with builders and crafts, plan and fulfill staffing, develop work methods and procedures, develop training plans, calculate floor space requirements for use by Conventional Facilities. Note special definition of Equipment in Dictionary.</td>
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<tr>
<td>Manufacturing-Pre-Production</td>
<td>Develop manufacturing plan, quality plan, contracts for pre-production, design &amp; develop jigs and testers, factory tests for pre-production, design reviews, reports.</td>
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</table>
WBS1 Summary Example
Global Systems (230 $M)
TSET CDR Project (WBS2)
CD & R&D Planning

• Conceptual Design includes:
  – Iteration/finalization of Requirements, Specifications, Descriptions
  – Design, modeling, simulations, reliability studies, cost and risk analysis, documentation, CDR preparation

• R&D Programs include:
  – Reducing technical risk- proof of principle of new designs
  – Improving reliability and efficiency, reducing operations costs
  – Reducing cost risk- back cost estimates with industry proposals, prototype designs or quotations.

• Task: Develop WBS2 Cost & Schedule
  – Identify critical tasks CD-1 to CD-2, generate costs & manpower loaded schedule, integrate with Primavera WBS2
## CDR Project
### Conceptual Design Key Goals

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<td>NLC CD-1 Model</td>
<td>DOE “Lehman” Review</td>
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<td>CDR 0.4 Progress</td>
<td>CDR Outline</td>
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<td>Functional Requirements</td>
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<td>2000</td>
<td>May CDR 0.4 Design Review</td>
<td>Technical Specifications</td>
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<td>Designs/Component Lists</td>
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<td>Risk/FMEAAnalyses</td>
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<td>Costs/Schedules</td>
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<td>Priorities for NLC CDR 0.8</td>
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<td>CDR 0.8 Progress</td>
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<td>CDR 1.0 Progress</td>
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<td>May CDR 1.0 Design Review</td>
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<td>Final Risk Analysis</td>
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<td>Continuing R&amp;D Plans Complete</td>
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<td>Draft CDR Complete</td>
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<tr>
<td>July</td>
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</table>

Supporting R&D is mapped, costed, and loaded into Primavera.
Conceptual Design Key Goals
Engineering Configuration Control

• Key Goals
  – Complete iteration of functional requirements & technical specifications within one year

• Machine Configuration will be defined and formalized as goals are completed.

• Configuration Control (CC) must begin during CD phase prior to approval to start Engineering Design.

• CC implementation a significant milestone demonstrating Design Phase readiness by formal handoff of firm specs from Physics to Engineering.
## Conceptual Design Phase
### R&D Plans

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Baseline Model</th>
<th>Basis of Estimate</th>
<th>Key R&amp;D Issues &amp; Plan</th>
</tr>
</thead>
</table>
| Magnets            | PEP & SLC designs                  | Scaling & Bottoms up | Reliability of magnets & power supplies  
Prototyping n/n+1 supplies via SBIR. Prototyping magnet designed for reliability.  
Prototyping PEP magnets design.  
Prototyping magnet designed for reliability. |
| Vacuum             | PEP Electronics using new switchers | Bottoms up SLC     | PEP uses HV distribution powering multiple pumps. Cable plant costs 50% of system (high).  
R&D supports SBIR to investigate small supplies in linac tunnel on 25-75 l/s pumps.  
R&D supports SBIR to investigate small supplies in linac tunnel on 25-75 l/s pumps.  
Must be radiation hardened for 7 R/hr at 1 m from beamline. Not feasible for DRs. |
| Supports & Movers  | FFTB Movers model                  | FFTB & SLC         | Movers must be state of art mechanically & electrically. Test setup has achieved resolution of 200 nm.  
R&D continues testing motors & transducers. R&D to develop noncontact transducer. |
| Low Level RF       | PEP with advanced digital design   | PEP plus Bottoms up | New design requires accurate measurement of phase to 1 deg. at X-band, low noise, high bits resolution.  
R&D to test power switching via precise phase control of klystrons driving DLDS.  
R&D to prove principle w/COTS parts. R&D to advance digital design w/ custom ASIC (chip).  
R&D to support full power rf tests on NLCTA. |
| Modulators         | SLAC Linac Line Modulator          | Bottoms up learning | Baseline model (2-pack) has low efficiency & high cost. R&D to investigate solid state induction design. Prototype 2-pack for early klystron testing and possible use on S&L band linacs. Induction 8-pack prototype aims to support full power NLCTA tests. R&D to commercialize first 8-packs. |
| RF Sources         | SLAC 50 MW and 75 MW klystrons, structures, DLDS | New prototypes | Major R&D issue to commercialize tube fabrication. Bids let for early 50 MW units to qualify vendors, to be followed by commercial DFM 75 MW tubes. Early delivery critical to full power tests. Early fabrication and testing of structures, DLDS and all power components. |
## Conceptual Design Phase
### R&D Plans-2

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Baseline Model</th>
<th>Basis of Estimate</th>
<th>Key R&amp;D Issues &amp; Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPMs</td>
<td>PEP</td>
<td>PEP with scaling</td>
<td>New design is more demanding resolution than PEP, which was state of the art. R&amp;D aims to test critical features of new design. Cost risks reduction follows through ASIC design, then rad hard design.</td>
</tr>
<tr>
<td>Global Controls Hardware &amp; Software</td>
<td>New concept using COTS fiber networks plus custom local real time network/control, EPICS based software</td>
<td>Commercial quotes plus bottoms up custom hardware &amp; software</td>
<td>New redundant concept needs extensive architectural development, plus testing of critical sections. Database development needed early to support other R&amp;D phase work. EPICS needs to be qualified through advances in design to assure capability of managing bandwidth and throughput of a very large system in 120 Hz pulsed mode. Design needs to be refined for better cost estimates at CDR time. Software development plan must involve maximum institutional collaboration. Plan for phased availability needed to support early testing of key components, full sectors, etc.</td>
</tr>
<tr>
<td>Global Timing</td>
<td>New concept using redundant fibers to distribute both master rf clock and timing fiducials</td>
<td>Bottoms up from preliminary designs</td>
<td>Preservation of timing precision of about 10 picoseconds at each linac sector is required for LLRF and BPM operation. Redundant design needed for reliability. R&amp;D needed to test basic stabilization principle of using reflected laser light in feedback system. R&amp;D to investigate backup systems if lasers are limited in noise performance or tunable range. R&amp;D to demonstrate a complete closed loop system with 15 km of test fiber. R&amp;D to investigate various compensation and temperature control schemes.</td>
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<tr>
<td>Global Protection</td>
<td>SLC, PEP, TJNAL</td>
<td>Scaling from SLC/PEP/ Tjnal</td>
<td>PPS concepts extrapolated from TJNAL Programmable Logic design. MPS poses main R&amp;D issues. R&amp;D needed to develop basic protection strategies, logic and control algorithms. R&amp;D needed for proof of basic hardware/software principles. R&amp;D for architectural design and modeling to refine cost models and specifications for related protection devices. New high performance high cost devices needed for driving sources and for laser wire scanners. R&amp;D primarily for developing strategies for build versus buy, for estimating industry availability and qualifying vendors, and eventually for purchasing prototypes.</td>
</tr>
<tr>
<td>Special Instrumentation</td>
<td>New lasers for sources &amp; scanners</td>
<td>Scaling from nearest industry models</td>
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Potential Cost Reduction
Rad- Hard Electronics in Tunnels

• Goals: Improve reliability with custom ships & lower costs by cable plant reductions. Cost benefits~ 30-40%.

• Radiation Physics(*) calculates 7 R/hr at 1 m from linac beamlines. Sensitive (non-rad hard) electronics shieldable w/ 4 in. lead. But many problems.

• Radiation hardened electronics w/o shielding tolerates 500 Krad total dose, >10 yr. lifetime. Newer <0.35 μm processes tolerate ~ 10 MRad (ref. Heijne et al @CERN).

• Potential advantages must be studied vs. access for repair implications. Candidates: BPMs, Movers, Vacuum.

(*): Preliminary estimates of the radiation levels inside the Next Linear Collider Linac Tunnel, S. Rokni, J.C.Liu, S.Mao, SLAC Radiation Physics Note, September 25, 1998
CDR Project (WBS2) Schedules

- Detailed schedules for each TSET CDR Project in development, using MS Project, for ultimate integration into the Primavera Project master schedule.
- Resource loaded FY99- FY02 for CD and R&D activities.
- Schedules completed for:
- Others are in process.
- All schedules will migrate to Primavera when completed.
CDR Project Schedule

Example: Mover Electronics

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# Task Usage Cost Report

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Total Work: 79.2h
CDR Project Budgets and Headcount

• Budget Plan for each TSET CD/R&D program developed and integrated into Primavera for:
  – Conceptual Design
  – R&D
  – Labor and M&S categories

• Budgets profiled by Quarters (FY99-02)

• Budget breakdowns for Technical Systems shown in the following graphs.

*Note: Costs for RF, Modulators and LLRF not included. Refer to Main Linacs section.*
CDR Project (WBS2) Budgets
Global Systems $5.5M
CDR Project (WBS2)
TSET Engineering Headcount

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R S Larsen
5/25/99
Page 25
TSET CD Phase All Budgets
$12.5M
Manpower Planning

- CD Phase plans show strong rampup in FY01 and 02
- Additional Engineering manpower from Collaborating Institutions indicated
- Current plan in operation with LBNL, and LLNL & Bechtel-Nevada (the latter for Modulator R&D).
- Future collaboration with LBNL planned in chip design and Controls.
- Future collaboration with Fermilab desired in Controls, Software and other areas of need.
Summary

CDR Project Readiness 1,2

1. Are Technical Status, Planning and Management Tools ready?
   • Baseline Models are defined, R&D plans are in place
   • Management tools to guide Engineering teams through Conceptual Design are in place. See Planning Web Page.

2. Are R&D Phase cost, schedule and resources adequate?
   • R&D plans are adequately defined through resource loaded schedules.
   • Extra manpower required in FY01-02 is planned primarily from collaborating institutions, and alternately from new hires or contractors.
Summary

CDR Project Readiness 3

3. *Is the Management Structure adequate?*

- Management model is based on successful PEPII model of cooperation with Department line managers and strong collaborations from sister Laboratories.
- Induction Modulator R&D collaboration with LLNL and Bechtel-Nevada a highly successful example already in place.
- Management strong and eager to further strengthen laboratory and industry collaborations to meet full demands of CDR.
Summary
CD Phase Readiness 4

4. Is the NLC CD-1 description complete? Are preliminary (WBS1) costs and schedules adequate starting points?

- CD-1 description complete
- Cost models & tasks defined in detail to ~ 90% cost level.
- Cost estimating procedures and tools promulgated and uniformly applied across all Technical Systems.
- Lessons applied from successful PEPII and ongoing ATLAS and SNS programs: Need for early development of collaboration, management & engineering tools & personnel.
- Preliminary schedules indicate feasible timeline for all Technical Systems.
Conclusion

Technical Systems Engineering is fully prepared to produce the NLC Conceptual Design.