The Deep Underground Science and Engineering Laboratory at Homestake
Outline of this Presentation

• **Part 1** (pages 3 - 16)
  Deep Underground Science and Engineering Laboratory (DUSEL): What does it do? What are its Science Goals?

• **Part 2** (pages 17 - 57)
  Laboratory Criteria and Specification
  Homestake’s Approach to Creating DUSEL
  – South Dakota’s Sanford Lab
  – NSF’s MREFC Process

• Project Process

• References, Personnel, Other Documentation
Nomenclature

- Sanford Lab - noun - surface to 4850L, mostly in the Davis Cavity ($65M State-run project)

- Sanford Lab hosts Early Implementation Program ~ 12 experiments in all disciplines between 2007 and 2011 (starting point for DUSEL construction)

- DUSEL - noun, verb - NSF process to establish an MREFC and create a major new user facility ($500M total = $250M facility, $250M expts.)
DUSEL Science

• DUSEL will be a multidisciplinary deep underground science user facility
  – **Physics**: rare searches, exquisite shielding from cosmic rays and other backgrounds
  – **Biology**: examination of the limits and evolution of life in the underground, interactions with geology and hydrology, search for new forms
  – **Earth Science**: geophysics, rock mechanics, geochemistry, hydrology, interactions among...
  – **Engineering**: how to excavate faster, better, safer, cheaper, larger, deeper, ...
  – **Education**: coupling public outreach to science
Deep Science Questions

- What is the universe made of?
- What is dark matter?
- What are neutrinos telling us?
- What happened to the antimatter?
- Are protons unstable?
- How did the universe evolve?

from S-1 Deep Science
Deep Science Questions

- How do biology and geology interact to shape the world underground?
- How does subsurface microbial life evolve in isolation?
- Did life on earth originate beneath the surface?
- Is there life underground as we don’t know it?

from S-1 Deep Science
What are the interactions among subsurface processes?

Are underground resources of drinking water safe and secure?

Can we reliably predict and control earthquakes?

Can we make the earth “transparent” and observe underground processes in action?
Deep Science Questions

- What are the mechanical properties of rock?
- What lies between the boreholes?
- How does rock respond to human activity?
- How does water flow deep underground?
- How can technology lead to a safer underground?
Laboratory Criteria and Specification Inputs

- Bahcall/Lesko Committee 2001 and earlier proposals
- International Facilities (SNOLab, Gran Sasso, Kamioka, other URLs)
- National Academy Reports (principally Science oriented rather than Facility)
- DOE, Multi-agency, APS reports, LRPs,
- NSF’s DUSEL Process
The Vetting of DUSEL

1985  1994

Seattle Neutrino Pre-Town Meeting, Sept 2000

1st S-1 Workshop
Neutrino Matrix 2004
NSF DUSEL Reorganization 2004
DOE Facilities 2003
EarthLab 2003, HEPAP LRP 2003
Neutrino Facilities Report 2003

NuSAG 2005, 2006
Dark Matter SAG 2006
EPP2010
HEPAP 2006
2010

Site-selection
S-1 Complete
CDRs Review
EarthScope 2005
Physics of the Universe 2004
S-2 Awards

1994

11
NSF Process to Create an Underground Laboratory

3-step DUSEL Process

S-1: site-independent science case

Sadoulet leading this effort

S-2: site dependent projection on different sites (Conceptual Design Report)

S-3: Technical Design solicitation competition

Funding in FY11 for DUSEL construction
DUSEL Progress

☑ S-1 Led by
Bernard Sadoulet, UC Berkeley with Hamish Robertson, U.W.; Gene Beier, U. Penn; Charles Fairhurst, U. Minnesota; T.C. Onstott, Princeton; James Tiedje, Michigan State

☑ Conducted extensive workshops, information gathering, discussions with the agencies, foreign laboratories, etc.

☑ S-1 Report Released: www.dusel.org - Deep Science

☑ S-2 8 Candidate sites, 2 awards

☑ July 2006 Henderson and Homestake
DUSEL Progress

- **August 06** non-competitive review of the two CDRs
- **September 06** S-3 solicitation announced, funds to be provided to develop *Preliminary Design*, this Report will be the basis for case for DUSEL in subsequent reviews
- **Fall 06** NSF and DOE announce call for proposals for DUSEL R&D (Jointly reviewed between DOE and NSF)
- **9 January 07** Responses to S-3 Solicitation: 4 proposals
  - Homestake, Henderson, Cascades, Soudan
- **9-13 March 07** Review of 4 proposals, starting with site visits
DUSEL Progress & Remaining Steps

19-22 April 07, panel review of the four proposals

10 July 07 funding for a single proposal to develop advanced plans for DUSEL
  - Next step is to baseline plan: Preliminary Design to be prepare for review by NSF, MREFC Panel, NSB, ...
  - Development of Final Design, 3 year effort
  - Homestake Collaboration Open, additional participation welcomed and encouraged

September 07 Cooperative Agreement completed
  - Winter 07 Call for Initial Suite Experiments (iterative process) S-4 first step, Roll out meeting 2 - 4 November
  - FY11 DUSEL funding, include Experiments and Facility
    • Experiments > 50% of ~$500M MRE
S-1 Findings & Recommendations

๏ Findings:
๏ Deep underground science is an essential component of research at the frontier
 ๏ Disciplines in transformation
๏ Benefits to society
 ๏ Worldwide need for underground space
๏ Need for a U.S. world-class deep multidisciplinary facility

๏ Recommendations:
๏ Strong support for deep underground science
๏ A cross agency Deep Science Initiative
 ๏ A Deep Underground Science and Engineering Laboratory (6000 mwe, 3000 mwe, 30 to 50 years, ASAP)

from S-1 Deep Science
• Part 2

Homestake Near and Far Term - Status and Planning
Letters of Interest: Homestake’s own efforts to define an Experimental Program in Parallel with S-1

- Winter 2005-06 Issued an International Call for Letters of Interest
- Established a Program Advisory Committee
- ~85 LOI responses
  - 25% Physics
  - 10% Education and Public Outreach
  - 65% Earth Science, Biology, Engineering
Initial Suite of Experiments for Homestake DUSEL

• With the Letters of Interest and the Program Advisory Committee’s Recommendations:
  – candidates for the Sanford Lab (early program) were identified (discussed below)
  – a strawman Initial Suite of Experiment was established factoring in depth requirements, approximate timelines, cavity requirements, and other laboratory criteria

• This strawman was then mapped into a conceptual facility layout, plan and schedule

• Good match to S-1 Science Goals
Homestake DUSEL Plans

- 300L R&D, E&O
- 2000L Geo Level
- 3800L Geo Level
- 4850L Major Campus
- 7400L Major Campus
- 8000L Geo Lab
### Homestake Interim Lab and DUSEL

#### Summary of Development of Space and Availability (Underground Space Fully Outfitted and Ready for Detector Installation)

<table>
<thead>
<tr>
<th>Area</th>
<th>Labs, Shops, Offices (Usable Floor Area)</th>
<th>Excavation Volume (including access drifts)</th>
<th>Construction Schedule to be revised</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sq. ft.</td>
<td>sq. m</td>
<td>cu. yd.</td>
</tr>
<tr>
<td><strong>4850 Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ross Shops for Construction Staging</td>
<td>12,469</td>
<td>1,158</td>
<td>5,738</td>
</tr>
<tr>
<td>Davis Lab, Sanford Lab, and Bio-Geo Lab</td>
<td>15,738</td>
<td>1,462</td>
<td>13,543</td>
</tr>
<tr>
<td>Lab Module #1 and Common Facilities</td>
<td>26,464</td>
<td>2,459</td>
<td>25,155</td>
</tr>
<tr>
<td>Lab Module #2</td>
<td>17,560</td>
<td>1,631</td>
<td>21,433</td>
</tr>
<tr>
<td>Lab Module #3</td>
<td>17,560</td>
<td>1,631</td>
<td>23,121</td>
</tr>
<tr>
<td>Lab Module #4 (excavation only, without lab outfitting)</td>
<td>17,560</td>
<td>1,631</td>
<td>22,125</td>
</tr>
<tr>
<td><strong>7400 Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab Module #1 and Common Facilities</td>
<td>28,468</td>
<td>2,645</td>
<td>29,594</td>
</tr>
<tr>
<td>Lab Modules #2 and #3 (excavation only, without lab outfitting)</td>
<td>35,120</td>
<td>3,263</td>
<td>68,883</td>
</tr>
<tr>
<td><strong>300 Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab #1, Shops, and E&amp;O Rooms</td>
<td>8,668</td>
<td>805</td>
<td>14,007</td>
</tr>
<tr>
<td><strong>Surface</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUSEL Offices and User Support Areas, Phase 1</td>
<td>10,000</td>
<td>929</td>
<td></td>
</tr>
<tr>
<td>Sanford Clean Room and Assembly Shop</td>
<td>6,000</td>
<td>557</td>
<td></td>
</tr>
<tr>
<td>DUSEL Offices and User Support Areas, Phase 2</td>
<td>32,000</td>
<td>2,973</td>
<td></td>
</tr>
<tr>
<td>Sanford Center for Science Education</td>
<td>50,000</td>
<td>4,645</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>277,607</td>
<td>25,790</td>
<td>223,599</td>
</tr>
</tbody>
</table>

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### Homestake Footprints

- **300L R&D, E&O**
- **2000L Geo Level**
- **3800L Geo Level**
- **4850L Major Campus**
- **7400L Major Campus**
- **8000L Geo Lab**
Planning to develop four primary campus locations for research:

1. Surface campus at Yates Complex
2. Near-surface campus at 300 Level
3. Mid-level campus at 4850 Level
4. Deep-level campus at 7400 Level

Infrastructure will be maintained for access to additional, selected levels for bio- and geo- sciences and for unique experiments that require specific or isolated sites.
**Yates Complex Surface Facilities:**
- Laboratory Administration Building and Training
- User Support Services: Clean Room Assembly & Fabrication Shops
- R&D Laboratories, User Offices, Meeting Rooms
- Education and Outreach: Sanford Center for Science Education
- Shipping and Receiving, Storage

**Ross Complex Surface Facilities:**
- Construction Materials and Equipment Staging
- Construction Superintendents and Contractor Offices
- Maintenance Shops
- Shipping and Receiving, Storage
- Facility Site Services and Operations

**Experiments and Facilities at 300 Level:**
- Education and Outreach Classroom and Laboratory
- User Support Shops: Assembly, Fabrication and Underground Storage
- Research and Development Laboratories
- Near-surface Experiments
- Low-background Counting and Calibration Facility
Campus Concepts for Mid- and Deep-level Experiments

**Early Implementation Program & Facility Infrastructure Development at 4850L:**
- Low-Background Counting Facility
- Neutrinoless Double Beta Decay
- Dark Matter
- Earth Sciences and Geo-microbiology Lab
- Common Facilities and Clean Room Transition
- Utility Services and Refuge Chamber

**Initial Suite of Experiments at 4850 Level**
- Dark Matter
- Double Beta Decay
- Nuclear Astrophysics
- Solar Neutrinos
- Geoneutrinos

**Design and Excavation concept for future, multiple 100 kTon chambers for Long Baseline Experiment**

**Initial Suite of Experiments at 7400 Level:**
- Large Double Beta Decay
- Solar Neutrinos
- Supernovae Detection
- Large Dark Matter

**Geosciences:**
Large Block Coupled Processes Experiments
To preserve the site for DUSEL, South Dakota initiated a program of rehabilitation and re-entry. Will host a modest Science Program with these efforts.

Motivated by the desire to halt the in-flow of water into the facility.

Financed with State-controlled funds and philanthropic donations.
October 2005, State Legislature approves additional $20M funding for Homestake, **total of $46M** from state controlled sources.
- Rehab plan: $15M
- Indemnification fund: $10M
- Operations: $15M
- Insurance: $2.5M
- Contingency: $3.5M

1 November 2005 - First call: Letters of Interest for Homestake ~ 85 letters responses

Property Donation Agreement Completed 14 April 2006, Property transferred to S.D. May 2006, SDSTA hiring staff to oversee and operate Homestake: ~30 for rehabilitation, ~ 25 to 30 staff members

Banker and philanthropist T. Denny Sanford pledges **$70M** to develop Sanford Lab at Homestake

January 2007 Rehab work initiated

October 2007 SDSTA hires Jose Alonso, Lab Director; active searches for Project Managers, Project Engineers, Safety Director, other Sanford Lab staff

Early Implementation Program at Homestake 2007 - 2012
“**The Sanford Laboratory**”
Approximate boundary of transferred property: 186 acres (surface) 7700 (u/g)
A dedicated science facility without competition or interference from mining, transportation, etc.
Homestake’s Plans & Activities

• Near-Term rehabilitation of Ross and Pumping
  – Φ1 - Surface work, buildings hoists, ventilation equipment: December 06 - April 07
    ✓ Video inspection of Shafts
    ✓ Ross Hoists operational 22 March
    ✓ Ventilation fans installed and operations (100-120 kcfm)
    ✓ First water samples from u/g
  – Φ2 - Underground work, including shaft and pumping, April 07 - December 07
  – Φ3 - Equipment Operation September 07 - May 08
Re-entering Homestake and establishing the Sanford Laboratory

- **Second and Third Phase work**
- Shaft Inspections and Maintenance (Ross then Yates)
- Level Inspections
- Pumping
- Ventilation
- Early Implementation Program at the Sanford Lab
Dewatering Homestake -

**Current Water Levels**

Re-entry Efforts, begun in July, have inspected levels and shafts down to 2100 L.

Focus on turning on pumps at 1250L and 2450L.

5000 level sensor tripped July 2007 (6 weeks earlier than original model).
1250 Level July 2007
First Pump Station ready for Operation

Re-entry Timeline

SDSTA plan for installation of Ross Shaft Pumping System to hold the accumulated water below the 5300 L

Target completion to initiate pumping by in 2007

The first of the Sanford Lab Science Program Initiated: geology, hydrology, biological sampling taking place with re-entry
Early Implementation of the Conversion Plan

• Foremost purpose was to preserve Homestake for DUSEL
• Taking advantage of State funded laboratory: 2007 - 2012
• **300 L, 4850 L**, and other levels, e.g. **2000 L, 3800 L**
• Ross and Yates Shafts refurbished, safe and operating cages
• Basic operations including Safety, Utilities, & Services
• Upgrades and enhancements as budget permits
• Program based on an International Call for Letters of Interest
• Active Program Advisory Committee
  (LOIs and PAC report can be found on [www.lbl.gov/nsd/homestake](http://www.lbl.gov/nsd/homestake))
**Sanford Lab’s Early Program**

**Dark Matter**

**Geo/seismic array**

**Low Background Counting**

**Dark Matter**

**Geo/Bio**

**Neutrinoless $\beta\beta$**

**Large Cavities, LBL vs Carbon Sequestration**

<table>
<thead>
<tr>
<th>Experiment Name</th>
<th>PI(s)</th>
<th>Institution</th>
<th>Letter of Interest</th>
<th>Memorandum of Understanding</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUX: Development of a large liquid xenon dark matter detector</td>
<td>Rick Gaitskell, Brown, Tom Shutt, and collaboration</td>
<td>Brown, Case Western</td>
<td>Yes</td>
<td>Yes</td>
<td>Direct Detection of Dark Matter using cryogenic liquid Xe, detection of signals and separation of signal from background using scintillation light. Detector requires several meters of water shielding to reduce backgrounds. 4850L Davis Cavity is appropriate</td>
</tr>
<tr>
<td>Collaborative Research Towards Transparent Earth</td>
<td>Steven Glaser, UCB, Lane Johnson, UCB, and collaboration</td>
<td>UCB, Case Western</td>
<td>Yes</td>
<td>Yes</td>
<td>This proposal presents a plan to install and operate a permanent seismic observatory illuminating the volume of the Homestake Mine from all six possible directions. We have chosen the Homestake DUSEL site because it offers a unique opportunity - the large volume of mine working of the deepest mine in North America is surrounded and underlain by literally hundreds of open bore holes, which can affordably be instrumented with accelerometers.</td>
</tr>
<tr>
<td>Low Background Counting Facility, DOE BES ESPSoR</td>
<td>Dongming Mei, Bill Roggenthen, and collaboration</td>
<td>USD, SDSMT</td>
<td>Yes</td>
<td>Yes</td>
<td>Develop a state-of-the-art Low Background Assay Facility in the Davis Cavity (4850L)</td>
</tr>
<tr>
<td>minICLEAN</td>
<td>Andrew Hime, LANL, Dan McKinsey, and collaboration</td>
<td>LANL, Yale</td>
<td>Yes</td>
<td>MOU under discussion</td>
<td>Direct Detection of Dark Matter using cryogenic noble gases.</td>
</tr>
<tr>
<td>Liquid Argon Dark Matter</td>
<td>Dongming Mei, Andrew Hime, and collaboration</td>
<td>USD, LANL</td>
<td>Yes</td>
<td>MOU under discussion</td>
<td>Direct Detection of Dark Matter using cryogenic noble gases.</td>
</tr>
<tr>
<td>Homestake: Biological, Chemical and Geological Sampling</td>
<td>Sookie Bang, Mark Conrad, and collaboration</td>
<td>SDSMT, LBNL</td>
<td>Yes</td>
<td>Yes</td>
<td>Site Characterization and baseline establishment for biology, chemistry, hydrology, and geology</td>
</tr>
<tr>
<td>Majorana: Neutrinoless double beta decay R&amp;D</td>
<td>John Wilkerson, Steve Elliott, and collaboration</td>
<td>U.W., LANL</td>
<td>Yes</td>
<td>MOU being developed August 2007</td>
<td>Development of ultrapure materials, low background counting and Ge detector demonstration module</td>
</tr>
<tr>
<td>Large Cavity Development and R&amp;D</td>
<td>Milind Diwan, Ken Lande, and collaboration</td>
<td>Brookhaven, Penn</td>
<td>Yes</td>
<td></td>
<td>Develop plans for large cavities and water-Cerenkov detectors for nucleon decay and long baseline neutrino experiments</td>
</tr>
<tr>
<td>Carbon Sequestration Experimental Design</td>
<td>Joe Wang, and collaboration</td>
<td>LBNL</td>
<td>Yes</td>
<td>MOU being developed November 2007</td>
<td>Development of experimental designs for carbon sequestration facilities and the behavior of super-critical CO2 in the underground</td>
</tr>
</tbody>
</table>
4850L Lab Modules, Shops, and Common Facilities Phased Development Plan

#1 Excavation in FY2008-10
Yates & Davis Labs
Bio- & Geo-sciences Lab
Construction Shops

#2 Excavation in FY2011-13
Common Facilities
Lab Modules #1 and #2

#3 Excavation in FY2012-14
Lab Modules #3 and #4

Total excavated space for labs, shops, and common facilities at 4850L: > 6,000 m² (65,000 SF)
**Existing Cage Dimensions and Capacities**

**Yates Cage Hoist**
- Maximum cage dimensions: 1.4 x 3.7 x 2.2m high (side-by-side)  
  (4’ 8” x 12’ 1.5” x 7’ 2” high)
- Maximum cage payload: 5,450 kg (12,000 lb), nominal  
  5,900 kg (13,000 lb), allowable at 1/2-speed.

**Ross Cage Hoist**
- Maximum cage dimensions: 1.3 x 3.8 x 2.2m high (double deck)  
  (4’ 4-5/8” x 12’ 5” x 7’ 2” high)
- Maximum cage payload: 5,450 kg (12,000 lb), nominal  
  6,100 kg (13,400 lb), allowable at 1/2-speed.

**#6 Winze Cage Hoist**
- Maximum cage dimensions: 1.3 x 3.7 x 2.2m high (double deck)  
  (4’ 4” x 12’ 1-1/2” x 2.2m high)
- Maximum cage payload: 5,450 kg (12,000 lb), nominal  
  6,400 kg (14,000 lb), allowable at 1/2-speed.

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**Yates Shaft Upgrade Plan**

**Improved access to the 4850 Level for personnel, equipment, and utilities**

**South Cage**
- Each Cage Compartment is 5’-3” x 13’-4”
- Service Compartments

**North Cage**
- Each Cage Compartment is 5’-3” x 13’-4”
- Service Compartments

**Super Cage**
- 4m x 4m (~13 ft. x 13 ft.)
- Ducting for Low-Radon Air

**Utilities and Services Compartments**
- Counterweights for Super Cage and Personnel Lift

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**Yates Shaft Existing Plan**
- 8.4 m x 4.6 m
  (27’-8” x 15’)

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**Proposed Yates Shaft Upgrades**

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**Homestake DUSEL**
Homestake DUSEL Project Organization for NSF MREFC Pre-Construction Planning and Development
Research Programs Development, Project Management, and Project Engineering

Principal Investigator
K. Lesko
---------------
Co-Principal Investigator
W. Roggenthen

Program and Safety Advisory Committees

Administrative Support for Science Program Development
D. Jacobs and M. Barclay

Public Information, Liaison, and Communications Office

Project Manager
R. DiGennaro

SUSEL Laboratory Director

Project Safety Officer for Experiments and Research Instrumentation

Deputy Project Manager for Research Instrumentation and Laboratories
R. DiGennaro (Acting)

Deputy Project Manager for Facility Development

Project Manager for Research Programs Development, Project Management, and Project Engineering

Project Staff at UC/LBNL

Project Staff at SDSMT

Project Staff at SDSTA

Outsourced A/E and C/M Services

Abbreviations:
A/E - Architect and Engineering
C/M - Construction Management

Homestake DUSEL

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Homestake Organization through the MREFC

Homestake DUSEL Operations: FY10 to FY15 (Concurrent with DUSEL Construction Project)

Consolidate Organization to Develop DUSEL

Many Trained Staff Transition Directly into MREFC Efforts

Homestake DUSEL

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Homestake DUSEL Operations during DUSEL Operations

Homestake DUSEL Operations: FY16 - Onward (Post-Construction)

DUSEL Experimental Program Coordination Committee

National Science Foundation

Department of Energy & Other Funding Agencies for Experiments

Introduce Laboratory M&O Contractor / Entity

Many Staff Positions Transition into DUSEL
We are moving into the MREFC Readiness Stage to develop a Preliminary Design including:

**Content:**
- Scientific research objectives and priorities
- Site-specific preliminary design
- Resource-loaded Schedule
- Bottoms-up Preliminary Cost Estimate
- Integrated Risk Analysis and Contingency Estimates
- Preliminary Operations Cost Estimate
- Environmental assessments

**Process:**
- Project Execution Plan
- Project Management Control System
- Systems Engineering

Richard DiGennaro
Project Manager
Systems Engineer
Objective: Implement a unified approach to Systems Engineering and Project Management

- Communication
- Requirements Management Database
- Continuous Risk Management
- Work Breakdown Structure, Subsystem Interface Management
- Integrated Safety Management
- Design-Reviews, Integration, and Performance Management
- Value Management
- Configuration Management and Change Control
- Project Controls: Earned Value Management System
1. Environment, Health and Safety and Integrated Safety Management

1.1 Integrated Safety Management Plan

1.2 Environmental Laws, Regulations, and Best Practice
   1.2.1 Regulatory Agencies and Jurisdiction
   1.2.2 Permitting, Codes, Standards and Regulatory Compliance
   1.2.3 Environmental Assessment and Environmental Impact Statement
   1.2.4 Environmental Monitoring Program

1.3 Hazardous Material Management

1.4 Regional communication and public information

1.5 Emergency Management, Response and Communication
   1.5.1 Fire Prevention, Containment, and Monitoring
   1.5.2 Safeguards and Security
   1.5.3 Regional resources and cooperative agreements

(continued)
1. **Environment, Health and Safety and Integrated Safety Management (cont.)**

1.6 Safety Training Programs and Oversight
   1.6.1 Staff/Employees
   1.6.2 Experimenters, Students, Visitors, and Guests
   1.6.3 Contractors, consultants, services

1.7 Safety Review Process, Inspection, Surveillance and Oversight
   1.7.1 Construction
   1.7.2 Experiments
   1.7.3 Maintenance and Operations

1.8 Recycling and Waste Disposal Plans

1.9 Energy Conservation Performance and Energy Management

1.10 Facility Life Cycle Plan, De-integration and Disposal (D&D)
   1.10.1 Laboratory Closure Plan
2. Project Execution Plan

2.1 Research Objectives Summary

2.2 Preliminary Baseline Performance Key Parameters

2.3 Project Governance and Management Organizational Plan
  2.3.1 Sub-awards and Organizational Responsibilities

2.4 Work Breakdown Structure (WBS)
  2.4.1 WBS for MREFC Construction Project
  2.4.2 WBS for Operations
  2.4.3 WBS Dictionary

2.5 Project Resource-Loaded Schedule
  2.5.1 Preconstruction Planning and Development
  2.5.2 MREFC Construction

  (Continued)
2. Project Execution Plan (continued)

2.6 Project R&D Plan
   2.6.1 Preliminary Site Investigation: Coring and Geotechnical Analyses
   2.6.2 Excavation methods and technologies
   2.6.3 Feasibility studies for Large-span Cavities
   2.6.4 Site-specific Safety Standards and Guidelines
   2.6.5 Underground systems and controls for hazardous materials
   2.6.6 Underground Communications, Cyberinfrastructure, IT, and monitoring systems
   2.6.7 Large-scale Reduced-radon Air Supply
   2.6.8 Large-scale underground clean rooms
   2.6.9 Large-scale purified water systems

2.7 Internal and Institutional Project Oversight and Design Review Plan

2.8 Acquisition Plan and Project Delivery Methods

( Continued )
2. Project Execution Plan (continued)

2.9 Systems Engineering Plan
   2.9.1 Requirements Management
   2.9.2 Continuous Risk Management
   2.9.3 Configuration Management
   2.9.4 Quality Assurance and Quality Control
   2.9.5 Value Management
   2.9.6 Interface Control
   2.9.7 Systems Integration, Testing, and Validation
   2.9.8 Information, Communication and Document Management

2.10 Project Management Control System
   2.10.1 Baseline Cost and Schedule Performance Parameters
   2.10.2 Resource-loaded Project Schedule
   2.10.3 Preliminary Risk Analysis and Risk Mitigation
   2.10.4 Preliminary Cost Estimate and Contingency Analysis
   2.10.5 Partnerships and Partnership Funding
   2.10.6 Project Controls and Earned Value Management
   2.10.7 Technical and Financial Oversight, Reporting, and Reviews
   2.10.8 Change Control and Contingency Management
   2.10.9 Project Staffing and Hiring Plan
3. **Summary: Technical Feasibility and Constructability**

4. **Transition to Operations**
   4.1 Operational Readiness Criteria
   4.2 Commissioning
   4.3 Conduct of Operations Plan
   4.4 Operations Management Plan
   4.5 Maintenance and Operations Plan
The resource-loaded schedule for the CDR integrates and links all estimated costs with the sequence of activities for design and construction.
Basis of Estimates for the Conceptual Design

• Re-entry and Rehabilitation for Mining-to-Labs Conversion
  • DYNATEC Feasibility Study (Syd De Vries, mining engineer)

• Lab Module Excavation Estimated Costs, Schedule, and Feasibility
  • Mark Laurenti (consultant, former Homestake mining engineer)
  • Golder Associates (mining engineering consultants)

• Surface and U/G Laboratory Infrastructure: Parametric estimates
  • LBNL Engineering and Facilities staff

• Project Management, Staffing, Engineering and Design, Commissioning
  • LBNL project experience, parametric and level-of-effort estimates

• Facility Staffing, Operating Costs, and Risk Assessment:
  • Homestake and SDSTA experience and derived estimates
  • Golder Associates (mining engineering consultants)

• DUSEL Research Instrumentation and Experimental Equipment
  • Science collaboration budgetary estimates, Scope-dependent (TBD)

• Annual Escalation: 3% per year; Preliminary Contingency Analysis: Range 15% to 30%
Methodology for Risk Management

- Continuous Risk Management process will be integral with Safety Management, Project Management, Systems Engineering, and Operations

- Initial steps have included Risk Identification and Preliminary Risk Analysis, with details presented in CDR and Appendices

- Risk planning has involved consultants and staff having a broad background and perspectives:

  Consultants: Syd De Vries (Risk Identification, Basis of Estimates)
               Mark Laurenti (Basis of Estimates, cost and schedule)
               Mark Nelson, S.D. DENR (Environmental issues)
               Golder Associates (Failure Modes and Effects Analysis)

  Staff and Collaborators: SDSTA Staff, notably Tom Regan (Site Conditions, Safety),
                           Greg King, John Marks, Gary Lillehaug (former HMC engineers)
                           Homestake Science Collaboration members
                           LBNL Management (internal review)
                           LBNL Project Team
Risk Categories for Homestake DUSEL

1. Safety
2. Environmental
3. Performance and Operations
4. Project Management

High Priority and High Visibility Risk Items:
- Personnel Injury
- Water Quality, Environmental Permitting
- Infrastructure Deterioration and Rehabilitation
- Underground Fire Hazards
- Underground Rock Failure, Rock Competency
- Ponded or Stored Water Release
- Availability of Subcontractors and Equipment
- Cost and Schedule Controls, Funding Profiles
Sub-Projects Cost Profile (excluding Experimental Research Equipment)

- Project Management and DUSEL Systems Engineering $K
- (1) Surface Building and Infrastructure TOTAL $K
- (2) Sanford Center for Science Education TOTAL $K
- (3) Mining-To-Labs: Infrastructure Rehabilitation and Re-entry TOTAL $K
- (4) Underground Excavation and Upgrades TOTAL $K
- (5) Underground Labs and Facilities TOTAL $K

Sub-Projects TOTAL (excluding Experimental Research Equipment and Systems) $K
# Institutional Responsibilities and Sub-project Teams

<table>
<thead>
<tr>
<th>Institution</th>
<th>Sub-project Teams</th>
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<tbody>
<tr>
<td>U.C. Berkeley, Lawrence Berkeley National Laboratory, South Dakota School of Mines and Technology and Homestake Scientific Collaboration</td>
<td>Science and Engineering Research Program Development</td>
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<tr>
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<td>Environment, Health and Safety Oversight</td>
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<td></td>
<td>Education and Outreach Program Development</td>
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<tr>
<td>Lawrence Berkeley National Laboratory</td>
<td>Project Management and Project Controls</td>
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<td></td>
<td>Systems Engineering (requirements, risk and value management; interfaces and systems integration; validation)</td>
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<tr>
<td></td>
<td>Underground Labs: Detailed engineering design and coordination with research program requirements</td>
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<tr>
<td></td>
<td>Research Equipment and Experimental Instrumentation: engineering and design support</td>
</tr>
<tr>
<td>South Dakota Science and Technology Authority and South Dakota School of Mines and Technology</td>
<td>Environment, Health and Safety Management</td>
</tr>
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<td></td>
<td>Facility Management, Site Services and Site Operations</td>
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<td></td>
<td>Mining-to-Labs Conversion: Re-entry and infrastructure rehabilitation</td>
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<tr>
<td></td>
<td>Underground Labs: Construction management, commissioning, and installation of research instrumentation</td>
</tr>
<tr>
<td></td>
<td>New excavation, underground facility infrastructure and services construction management, inspection, quality assurance, and commissioning</td>
</tr>
</tbody>
</table>
Homestake DUSEL

• Compelling Arguments for DUSEL at Homestake
  – Physical Characteristics and Key Parameters
    • Depth and Location
    • Rock
      – Well known and researched
      – Demonstrated ability to support large cavities for decades
      – Interesting and varied geology, pristine regions
  – Local, State, Regional & National Support
  – Access and Research Environment
  – Management and Operations
  – Safety Program
  – Science and Education Opportunities
  – Excellent Time and Cost to Science
    • No excavation needed to gain access to 8000
  – Reduced Risks and Uncertainties

• Deepest, Most Expedient, Extremely Cost Effective
• Science begins before the project begins -- gradational approach to the science

• Close interaction and cooperation with a non-academic/non-scientific entity is required

• User groups are truly multidisciplinary
References, Personnel, Other Documentation

- Michael Barnett, LBNL (E+O)
- Yuen-dat Chan, LBNL (Other uses)
- Milind Diwan, BNL (lbl, pdk)
- Reyco Henning, UNC (0vdbd, dm)
- Ken Lande, Penn (lbl, pdk, geo-neutrinos)
- Bob Lanou, Brown (neutrinos, solar neutrinos)
- Chris Laughton, FNAL (engineering)
- Kevin T. Lesko, UCB (physics) PI
- Stu Loken, LBNL (E+O)
- Hitoshi Murayama, UCB (physics theory, neutrinos)
- Tommy Phelps, ORNL (geomicro)
- Bill Roggenthen, SDSM&T (geophysics) coPI
- Ben Sayler, BHSU (E+O)
- Tom Shutt, Case Western (low backgrounds)
- Nikolai Tolich, U.W. (geonus)
- Bruce Vogelaar, Virginia Tech (solar nus)
- Herb Wang, U Wisc. (geology, rock mechanics)
- Joe Wang, LBNL (earth science, geophysics)

Richard DiGennaro, LBNL, Project Manager and Systems Engineer
Dianna Jacobs, LBNL Project Office
Dave Plate, Project Engineering
Mark Laurenti, Mining Engineer
Syd DeVries, Mining Engineer
Dave Snyder, SDSTA Exec. Director
Jose Alonso, SDSTA Lab Director
Trudy Severson, Laurie Gehner SDSTA
SDSTA Engineering and Safety Personnel
Ms. Melissa Barclay & Cathy Thompson

http://www.lbl.gov/nsd/homestake
http://neutrino.lbl.gov/Homestake/LOI
http://neutrino.lbl.gov/Homestake/FebWS
http://homestake.sdsmt.edu/HRB/Refer.htm
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