Executive Summary of Major NuMI Lessons Learned

Fermilab's DUSEL Beamline Working Group

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Introduction

- Tremendous experience with the NuMI Project, which, at the time, had a new level of neutrino beams from a higher-power proton source.
- The experience is fairly directly applicable to the next project (e.g., similar civil construction issues including: tunneling, service buildings, outfitting, and potential claims/legal issues).
- Some things might be done very differently (e.g., decay pipe, windows, target, beam dump, and precision of power supply control/monitoring).

Seven Categories of Lessons Learned

1. Differences Between the NuMI Project and Any Next Project
2. The Process of Starting Up the Project
3. Decision and Review Processes
4. Environment, Safety, and Health
5. Local Community Buy-In
6. Transition from Project Status to Operation
7. Some Lessons on Technical Elements

First, Two Items

- NuMI had top-down imposition of an unrealistic combination of scope, cost, and schedule -- partially corrected by a re-baselining. However, the full, desirable scope was never achievable.

- Crippling shortage of resources, especially early in the project. Critical early design work could not be done in a timely fashion, leading to schedule delays, inefficiencies, and corrective actions.

Differences Between the NuMI Project and Any Next Project

- ✓ Flagship-program priority, and risk mitigation - more robust designs and quality assurance procedures will require increased engineering effort and increased other costs.

- ✓ Planning for decommissioning, with unknown future standards.

- ✓ An order of magnitude more beam power on the target

- Radiation damage to component materials will exceed current experience. Reliability levels will be learned only in full operation.
- Different strategies should be employed (e.g., making the most robust component possible and making it a permanent installation may be less desirable than making a more fragile, but easily replaced component).
- Build more spares. Also, design in remote handling capability. Higher activation levels may preclude repairs.

- ✓ Special circumstances of low-cost and/or reused elements

The Process of Starting Up the Project

- Have a more nearly complete design team in place at the beginning of the project than was the case for NuMI - given the interrelation of so many design elements; e.g., technical and civil-construction components

- Have the beam specification early. If the possibility of change is significant, the range of changes possible should be part of the initial specification.

- Do risk management project-wide and from the start.

- Identify critical technologies early and start R&D early. Front-end loading the R&D (especially on targeting, tunneling, and radiological mitigation) will reduce risks and costs.

- Make radiation exposure and environmental release limits a part of the specification before designs are begun. Similarly, specify maximum down times allowable during scheduled operations. More generally, understand (at design time) the operational modes including recovery from failures.

- Exploitation of facilities beyond original plans is traditional. The DOE even recognizes and rewards re-using facilities in its reviews and awards programs. [For example, cathodic protection for piping may be a good idea.]

Decision and Review Processes

- Major decisions benefit from internal and/or external reviews.
- DOE reviews tend to be focused on compliance with DOE procedures, a different function.
- Technical problems are not the focus of management reviews, and the DOE has begun to ask that technical reviews be held independent of their reviews.
- In any case, people with strong technical backgrounds must be in positions to impact decisions. Cost alone should not drive decisions.

ES&H

- The Laboratory Integrated Safety Management System does reduce injury rates and costs.

  The NuMI experience helped improve it a lot.
- Laboratory management liaison with all levels of the subcontractor team is needed early and continuously to ensure that our ES&H culture is understood and accepted. It's not enough to be in paperwork (e.g., the subcontract).
- Build relationships with subcontractor employees - avoids mistakes, and improves morale on the project.

Local Community Buy-In

- Beam line and near detector hall will extend to the site boundary, close to the Woodland Hills subdivision.
- Important to work with that community and others affected by the anticipated construction.
- The Laboratory's community outreach activities have developed since the NuMI project, and the main point is to start outreach communications well before the project is approved.

Transition from Project Status to Operation

- Staff and funding tied to a project tend to evaporate even before the formal completion of the project. It's critical to plan for the transition from project to operations.
- Inadequate allowance for the transition is an issue for debugging and commissioning, having the necessary training and documentation.
- First real operation does not resolve all the issues.
- Spares which take extended time to build need to be available at the start of operations.

Lessons on Technical Elements

- R&D on radiation effects; e.g., corrosion.
- Inspection and maintenance plan for drains
- Shotcrete, if not concrete, of all exposed rock
- Avoiding use of high strength steels in high radiation, humid environments
- Reuse of (40 yr old) Main Ring B2's
- Beam commissioning and tuning
- Tails of beam: 10x beam needs 10x better understanding
- Handling of radioactive components, including having enough working and storage space, etc.

Finally, …

A great deal of detail beyond what is in the executive summary is available from the presentations and discussion summaries of the 28 DUSEL Beamline Working Group meetings. These are available on the web from

https://beamdocs.fnal.gov/SNuMI-public/DocDB/ListTopics

- Management
- ES&H
- Civil Construction
- Primary Proton Beam
- Neutrino Beam
- Beam Monitoring
- Near Detector and Physics
- Visit to J-PARC Neutrino Beam Facility