Fermilab

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To: Steve Webster
From: Greg Bock
Subject: NuMI Lessons Learned

In this brief report I will summarize the lessons learned from the NuMI Project. As you know the project achieved CD1 in 1997, CD2/3 in 1999, was rebaselined in 2001 and then finished comfortably within cost and schedule early in 2005. In its first year of operation, NuMI/MINOS achieved all performance expectations and has already produced its first public scientific results. Along the way we learned things we did well as well as things we could have done better. This final memo from the project is intended to briefly summarize those most significant lessons learned. The lessons are drawn from both our successes and difficulties. While one might argue about whether all these lessons derived exclusively from experience on NuMI, to one extent or another they certainly apply.

NuMI was baselined before the project was fully engineered. In our initial estimates we relied on our prior experience with above ground and low-medium intensity beams and planned to re-use existing equipment for much of the beam. Ultimately we were able to do less of that than planned. The extreme high power of the proton beam required more adjustments to our normal design practices than we had initially allowed for as well. Timely engineering resources are vital.

Frequent internal technical reviews commissioned by the NuMI Level 2 managers themselves to advise on issues and plans were very successfully used across the project. Knowledgeable reviewers were drawn from other organizations at Fermilab as well as other institutions, both nationally and internationally. Their advice usually affirmed our plans, but in some cases pointed to improved alternate approaches that reduced risks and led to better performance. One example was a review of our primary beam design which led to a significant re-design and a very easy-to-operate high-performance system.

Professional procurement personnel were not always participants in the earliest stages of our planning. This lead to some inefficiencies in both contract award and performance. Closer ties with the laboratory's procurement offices from the earliest stages of project planning are now routine practice among projects being planned at Fermilab. Now professionall procurement personnel are identified members of project teams, even before CD1.

In conventional construction contracts we learned several valuable lessons. First, that we had underestimated the amount of oversight needed to assure adequate contract performance, especially in the assurance of safe work practices. We were too slow to establish an adequately sized and properly staffed construction office to manage the large underground excavation contract. Proper staffing

ultimately included consultants who were key in overseeing both the physical contract work as well as negotiating differences of opinion with the contractor. This contributed to the difficulties in both cost and schedule. We learned that both liquidated damages and safety incentives can be valuable additions to our plans and we employed each in later construction contracts on NuMI. Insufficient contingency was budgeted for underground work. Coupled with an especially unfavorable (to NuMI) economic construction climate led to schedule and cost contingency problems.

Wide collaboration on a scientific project of the scale of NuMI is essential, and it worked very well throughout the project's lifetime. Our mutual agreements and understandings with collaborators and agencies in the United Kingdom and the University of Minnesota were key in the project's success. Similarly our collaboration with universities proved, as envisioned, effective and essential for the construction of the project. It is difficult to overstate the importance of this.

Finally I note that the Fermilab Director's Office has significantly increased its oversight of projects. As an example it has established a dedicated Office of Project Management Oversight which focuses both training and detailed oversight by the Laboratory's line organizations.