CaII: As the evolution of large projects has repeatedly indicated, funding profiles, and their integrals, do not always match expectations. Decisions related to scope, staging, etc., may have to be made to keep the project within an available cost and schedule envelope. The choices might entail re-optimizing the funding routed between the different science/engineering projects, infrastructure capabilities, size/scope of laboratory space and access, etc.
(a) How will the possible decisions alluded to above be made by your collaboration – that is, what is the process that you foresee governing such decisions?
(b) How will the the resulting impact to the scientific/engineering program be assessed and decided?

Design Phase: As a preface to our answer, we note that frequently such problems arise not because of a disappointing funding profile, but because of a design process that proved overly optimistic about costs. On April 19 Chris Laughton's talk will deal extensively with this topic. Some of steps can be taken to protect projects from cost overruns:

- A competent staff at all levels of the Project Office and streamlined management that can make informed, timely decisions.
- A scope definition process that begins with sufficient site investigation so that the geotechnical constraints and uncertainties are quantified.
- Strong design-team expertise in safety, permitting, third-party impacts, and other issues that can delay and escalate project costs, if not properly integrated into the design.
- Careful attention to the needs of the end users, so that costly changes during construction can be avoided. The design process should achieve an early alignment of performance expectations among the stakeholders.
- Careful risk documentation, so that appropriate contingencies are assigned and mitigation procedures developed.
- Excellent documentation of the resulting scope and associated estimates. This should include a schedule based on thoroughly justified productivity assumptions, with supporting risk and sensitivity analyses, which was refined early in the design process through various optimization steps.
- Careful final constructibility checks, to verify proper integration, sequencing, and scheduling.

The goal is a design that, when the bids come in, does not require immediate descoping, redesigns, rebids, rescheduling, or rebaselining.

We assume that such a careful design process has been completed by the Project Office. The resulting design documents would provide, for each project element, the requirements and criteria, a geotechnical assessment of the relevant ground conditions and their implications, a description of the methods and analysis used in the design (including applicable codes), a full risk analysis (risks, impacts on the project and third parties, implications for construction methods and its variations, and appropriate mitigation and contingency measures), and a list of design checks that have been made. The design documents should specify tolerances in materials, workmanship, and geometry; estimated geotechnical variations; mitigation and contingency measures, natural hazards checks, etc. The final constructibility review, in addition to checking overall integration, should include procedures for addressing changes in geotechnical assessments that arise from the construction,

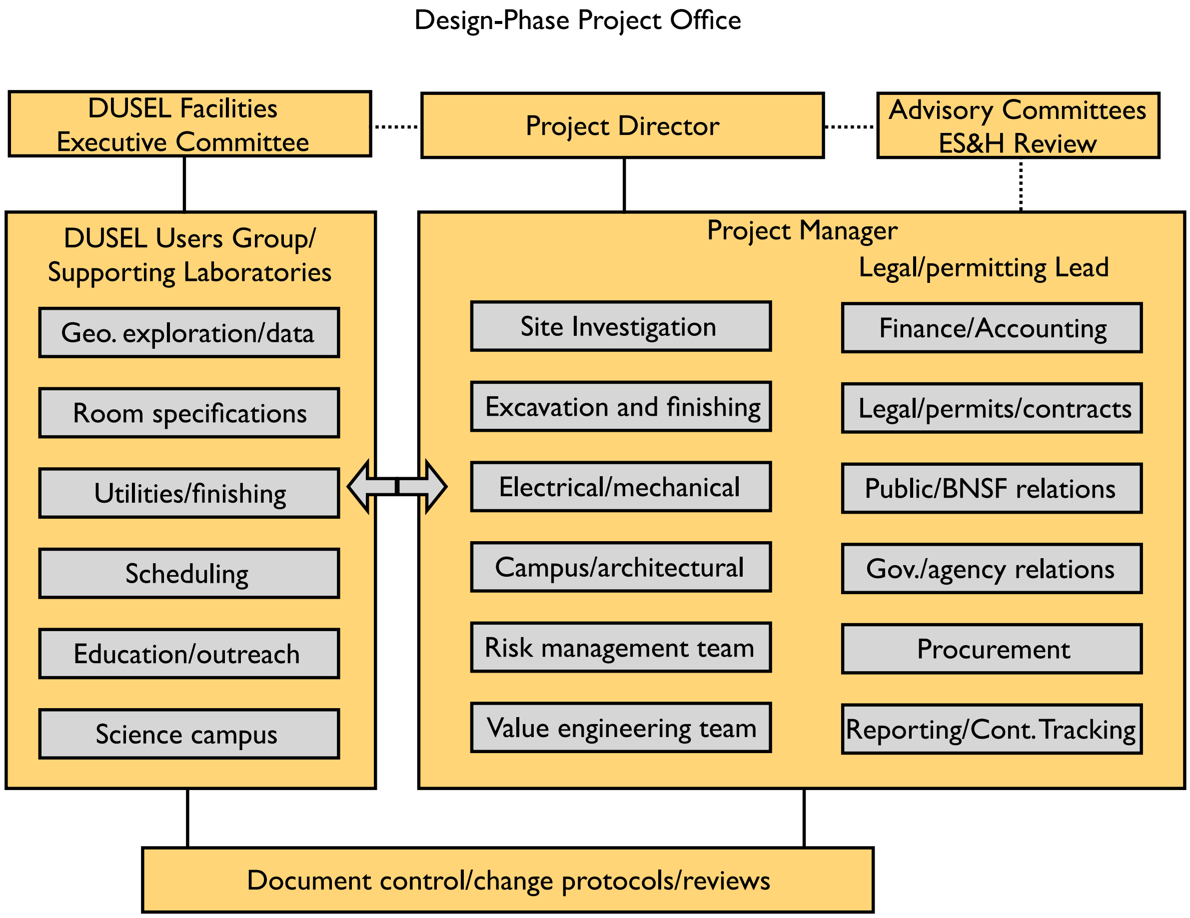

FIG. 1: The proposed Project Office structure for the design phase.

with impacts on methods, schedules, and costs. The review should verify the design's provisions for investigation and site monitoring during construction. That is, the design should be robust in terms of geotechnical variability and workmanship/construction tolerances.

Re-optimizing: Despite all of these efforts, the scenario envisioned in the question can arise in two ways. First, it is possible that unexpected conditions are encountered during construction – the design proves not to be robust. For example, construction could encounter ground conditions significantly outside the envelope of expectations. Because a well-designed project would continue design validation throughout construction, it would then become apparent that the rate of contingency use is not sustainable, or that the risks have grown to the point that the contingencies provided are not adequate to cover possible variations.

Second, the design may be robust, but external conditions might change: funding conditions could require the NSF to stretch out the funding profile, or reduce the overall integral. In either case project management will have to respond to changing conditions.

Our project management scheme, illustrated in Fig. 1, places overall project management in the hands of the Project Director, a person selected for this position because he/she combines excellent physics judgment with extensive large-project management experience. Were the problems to arise from changing construction conditions, the Project Manager, who has day-to-day control of the contingency budget, associated control boards, and configuration management, would be responsible for bringing these problems to the attention of the Project Director. In reaching a decision on re-optimizing the project, the Project Director would have three sources of support:

- The DUSEL Users Group – into which our collaboration and other S2/S3 collaborations would have been absorbed, as explained in our response to question **CaIII** – could provide advice on the cost/benefit analysis influencing decisions on possible scope reductions. The proposal discusses the structure of this group, which includes a leadership team, called the DUSEL Facilities Executive Committee, of respected senior scientists. It would be expected that different subgroups within the Users Group might have different views on descoping. The role of the Executive Committee is to fairly evaluate all of the suggestions, to decide which strategy for descoping is in the best interests of the Laboratory as a whole. The Executive Committee advises the Project Director.

- The Project Office is the engineering arm of this process. They work with the Users Group – the mechanism suggested in our proposal is a series of charettes – to explore the engineering consequences of the suggestions coming from the Users Group, or from the discussions between the Users Group and the Project Office. Just as in the original design process, the Project Office must carefully examine all of the design issues we have discussed previously, to make sure that the full consequences of design changes are understood.

- The Project Director will have the support of external advisory committees that can examine de-scoping/re-optimization suggestions and comment on their advisability – cost and schedule implications, loss of capability, ES&H implications, etc.

But in the end, the Project Director is responsible for the decision: the support apparatus described above is intended to ensure that the Project Director understands the impacts on the science/engineering program, and has a solid engineering basis for design changes he selects.

Some concluding remarks about the process in the context of DUSEL-Cascades: While no project is risk free, the proposal discusses some of the advantages of the Cascades site, in terms of risk analysis and contingencies. This includes relatively low geotechnical uncertainties (especially in Stage I), stable ownership of the site, a relatively uncomplicated permitting map, the absence of legacy issues, and the safety advantages of a low-elevation portal with horizontal access and a mild climate. Thus one would hope that the probability of surprises arising from a less-than-robust design is low.

If adjustments are required because of external funding factors, the DUSEL-Cascades design does have some flexibility. It is a staged project: the proposal notes that stretching out Stage II, so that its construction does not overlap Stage I, is an effective way of coping with year-to-year funding shortfalls. If the finding constraint is on the integral – not just a stretchout – then other adjustments can be made. The least severe would be reductions in the number of rooms provided, and in the sophistication of certain services, like the loading dock/dirty machine room/receiving area. In the case of a severe funding shortfall, Stage II could be delayed: such a decision would lead to significant losses in capabilities, but might be justified if it were clear that the highest priority experiments could manage with just Stage I and SNOLab. For example, if the likely experiments were a large detector for long-baseline physics, nuclear astrophysics, and EXO, a Stage I facility would be adequate for those immediate needs. A Stage I-only facility would be exceeding inexpensive to operate, which might also be a factor if funding were very tight.