NCSX Value Engineering Taskforce

1. Introduction

A value engineering task force was formed on 27 May 2003 to specifically focus on Value Engineering of the NCSX Fabrication Project. The task force members are Dr. Michael Zarnstorff (Chair, head of NCSX Physics), Larry Dudek (manager of NCSX WBS 6), and Charles Neumeyer (head of PPPL Electrical Engineering). Michael Williams (head of PPPL Engineering Dept.) also participated in some task force activities.

The task force was charged to "identify possible changes in the NCSX project plans that could reduce estimated costs without significantly impacting or delaying performance." The task force analyzed and reviewed major systems in the NCSX project for the purpose of achieving the required functions with both the lowest TEC of the fabrication project and the lowest life-cycle costs, consistent with laboratory procedures and requirements for quality, reliability, and safety. Changes to reduce risk were also investigated and proposed.

The task force members had various levels of familiarity with the NCSX design and problems. All had extensive previous experience with the design and operation of fusion experiments. Most of the members had extensive recent experience with the design, construction and operation of the NSTX experiment, which is similar in size to NCSX.

2. Approach

The VE task force participated in a series of brainstorming meetings with each top-level WBS manager and project management, including Hutch Neilson, Wayne Reiersen, and Ron Strykowsky. During each meeting, the scope, design, and estimated cost of each lower-level WBS element was reviewed and discussed. Alternative methods for achieving the necessary functionality were proposed and explored. Many of the ideas discussed were quickly shown to not be advantageous and were quickly discarded. Changes that appeared viable and promising were identified for further investigation and analysis, either by the WBS manager and his team or by VE task force members.

Follow up meetings were held with the WBS managers to discuss the results of the investigations, modify and iterate the proposed changes, and clarify whether they were advantageous or not. In some cases, as many as four subsequent meetings were held, developing and understanding a proposed change.

3. VE Investigations

The specific major changes proposed during the VE task force activities are briefly summarized below, including the motivation for the change, and the current status including any savings achieved.

3.1 Local Control (WBS 5) Status: Accepted

Since the NCSX control room will be adjacent to the NCSX torus hall, I&C systems can make use of local control of equipment, where practical. This reduces costs relative to equivalent systems on NSTX by minimizing the need to make mimic displays and software. In addition, some equipment can be controlled by direct access to the torus hall. *Expected Savings: $1.5M*

3.2 Avoid use of TFTR test cell (WBS 1) Status: Rejected

It was proposed to shift the coil winding and period assembly tasks out of the TFTR test cell, in order to eliminate health-physics monitoring costs due to residual tritium surface contamination. Acceptable usable space was identified (the Rad-Waste building and the D-site MG hall). However, these spaces are not currently air conditioned and do not have enough AC power available. Initial informal estimates of the costs to upgrade these spaces to the needed capabilities appeared promising. However, detailed estimates indicated the costs were approximately double the expected savings.

3.3 Use C-site power systems to energize coils (WBS 4) Status: Under study

The C-site motor-generators, power supplies, and some buswork are adjacent to the NSX torus hall, and were used to power PLT and PBX-M. Some of these systems have not been used since the last operation of PBX-M (1992?), but were being maintained until approximately 2 years ago. The rest of the power supplies are in active use by CDX-U. Using these supplies would save the costs of re-configuring the TFTR supplies at D-site (in use by NSTX), constructing transmission lines to the NCSX torus hall, purchasing new D-site components, and integrating the NCSX and NSTX control and safety systems. Using C-site supplies would also allow both machines to operate independently, but would eliminate some projected operational cost sharing (guessed at $0.5M/year total). Some operational cost sharing between NCSX and CDX-U may be available. The upgrade path for achieving full NCSX capability (during the operations phase) using C-site power systems, particularly for rapid changes in modular coil currents, will be investigated. *Expected Savings: $2.0M*

3.4 Use 4-in hand winding of coils (WBS 1) Status: Accepted

A change in the method of winding and insulating the coils was proposed to reduce the winding time, increase the copper fraction of the coils, and better match the coil impedance to the power supplies. The winding method was changed from winding one copper rope at a time to winding four parallel ropes (four-in-hand), and from 14 turns per coil-pack (consisting of 14 ropes) to 10 turn (consisting of 40 ropes). This reduced the maximum turn-to-turn insulation, allowing an insulation scheme similar to that used on Wendelstein-7AS. The smaller rope size reduced keystoning at the coil bends. These combined to increase the copper cross-section of the coil by approximately 32%, decreasing required voltages, coil heating and required cooling, and risk for high-field operation. *Expected Savings: $??M*

3.5 Use wireless networking (WBS 5) Status: Under study
Wireless networking is proposed for use in the control room and test cell. This would greatly reduce the infrastructure costs for connecting data acquisition and analysis equipment to the data network. Possible interference from other systems in the test cell must be tested to determine suitability for data acquisition equipment. Hopefully, this will be explored on NSTX.

3.6 Simplified RGA and gas handling (WBS 2) Status: Accepted
Simplified residual gas analyzer (RGA) and gas handling systems were proposed, making use of NCSX's local access and control capabilities.

Expected Savings: $0.13M

4 Other VE activities

In addition to the activities discussed above, during this time-period value engineering improvements were developed and proposed within the project. Some of these improvements interacted with the VE task force ideas and activities above. Here we discuss briefly some that evolved independently:

4.1 Initial operation at room temperature. Status: Accepted
By conducting first plasma and initial field mapping at room temperature, the accuracy of the device assembly can be verified while adjustments are still possible. After cryogenic operation has begun, modification of coil positions would require disassembly and re-fabrication of the cryostat at significant expense. Thus, initial operation at room temperature will significantly reduce the risk of mis-positioned coils. The proposed room temperature operation will not increase the lifecycle equipment costs, but will delay the start of cryogenic operation until after the end of the MIE project.

TPC Savings: $1.8M

4.2 Adjusted coil shapes to improve manufacturability Status: Accepted
The coils shapes were locally adjusted to improve manufacturability, following final physics design. Oscillations in the coil shape were reduced and the minimum coil separation increased. The proposed changes were analyzed to ensure that physics characteristics were preserved and requirements met. Several proposed modifications that did not preserve physics properties were rejected.

4.3 Simplified GDC system Status: Under study
A simplified glow discharge system (GDC), re-using the components from the initial NSTX GDC is being designed. This will rely on fixed anodes and manually controlled power supplies.

5 Summary

Six substantial changes were investigated and developed by the Value Engineering task force process, and an additional three changes outside the task force. One proposal was rejected and three are still under study. The total expected savings from the accepted changes is approximately $3.43M. In addition, an additional $2M of proposed savings are being studied by the project. If they are accepted, the total savings of $5.4M is about 7.3% of the projected construction budget $73.5M (including contingency). Further savings may be possible from ideas being studied and designed, but have not yet had savings quantified.

In addition, several of the accepted changes reduced risk or increased confidence in achieving the design goals, as discussed above.