NCSX

CONFIGURATION MANAGEMENT PLAN

NCSX-PLAN-CMP-02
May 16, 2005

Prepared by: Bob Simmons
Digitally signed by Bob Simmons
DN: CN = Bob Simmons, C = US
Reason: I am the author of this document
Date: 2005.05.16 13:29:30 -04'00'

R. Simmons, Systems Engineering Support Manager

Concurrences:

Judith Malsbury
Digitally signed by Judith Malsbury
DN: CN = Judith Malsbury, C = US, O = PPPL, OU = Quality Assurance
Reason: I concur with this document.
Date: 2005.05.16 13:33:04 -04'00'

J. Malsbury, NCSX QA Manager
Project Engineer

Wayne Reiersen
Digitally signed by Wayne Reiersen
DN: CN = Wayne Reiersen, C = US, O = PPPL
Reason: I have reviewed this document
Date: 2005.05.16 13:51:13 -04'00'

W. Reiersen, Engineering Manager

Approved by:

Hutch Neilson
Digitally signed by Hutch Neilson
DN: CN = Hutch Neilson, C = US, O = PPPL
Date: 2005.05.17 09:43:21 -04'00'

G.H Neilson, Project Manager

NCSX Configuration Management Plan

Revision	Date	Description of Changes
Revision 0	February 25, 2003	Initial Issue
Revision 1	February 3, 2004	Made Change Classifications consistent with latest DOE guidance.
Revision 2	May 16, 2005	Rewritten to incorporate recent changes in the configuration control processes, to clarify what constitutes the technical baseline and configuration control of 3D models, and that the decision to develop for as-built drawings lies with the RLM after consideration of technical, cost , and schedule risks.

Table of Contents

NCSX Configuration Management Plan
List of Figures

List of Tables

NCSX Configuration Management Plan

1 BACKGROUND AND INTRODUCTION

1.1 Program Description

The National Compact Stellarator Experiment (NCSX) is an experimental research facility that is to be designed and constructed at the Department of Energy's Princeton Plasma Physics Laboratory (PPPL). Its purpose is to develop the physics of compact stellarators, an innovative fusion confinement concept. The facility will include the stellarator device and ancillary support systems. The design and fabrication project will be led by PPPL, in partnership with the Oak Ridge National Laboratory (ORNL). This partnership approach is being used to effectively take advantage of each laboratory's specific expertise to provide the best possible facility for the fusion research community.

1.2 Overview of the NCSX Configuration Management Program

Configuration Management (CM) is an integrated program that ensures that the configuration is identified and properly documented and that changes to the configuration are controlled during the entire life cycle. *However, this Configuration Management Plan (CMP) focuses on the design and fabrication phases of the NCSX Project, including the integrated systems testing and producing the first plasma.* The Office of Fusion Energy Sciences (OFES) has identified the NCSX Project as a Major Item of Equipment (MIE).

The physical and functional description of the components, systems, and software/firmware comprise the "configuration" of the NCSX MIE Project. The NCSX project and details of its design configuration is progressively described in greater detail as it proceeds through the design process, fabrication, assembly, and installation. The goal of the NCSX Configuration Management Program is to ensure that the configuration design evolution is controlled and that the documentation of the configuration design described in specifications and shown in electronic drawings and models accurately reflects what is installed in the field to the extent practicable. As-built drawings will be developed as appropriate based on considerations of technical, cost, and schedule risks. These risks will be evaluated by the Responsible Line Manager (RLM) and they will make the determination as to whether or not as-built drawings are required.

The NCSX Project is defined and controlled by three baselines: technical, cost, and schedule. At selected points in the NCSX life cycle, the current design configuration, including fabrication and testing define the *technical* baseline. The technical baseline is defined by technical design documents, including specifications, models and drawings, and Interface Control Documents. The cost and schedule estimates to accomplish this technical baseline are developed to form the *cost* baseline and *schedule* baselines. These three baselines are fully integrated since they are derived from the same configuration. The combination of technical, cost, and schedule baselines forms the basis for project work authorization and management. This becomes the basis against which the status of resources and the progress of the NCSX Project are measured. Any proposed change to one baseline must be evaluated from the perspective of its impact on the other two baselines.

The CM program described in this NCSX Configuration Management Plan (CMP) is consistent with higher-level DOE orders and procedures. The CMP is intended to provide the following processes:

- **Configuration Identification** - a process for identifying configuration items and development of the appropriate configuration documentation to define the physical and functional characteristics of each configuration item. A Configuration Item (CI) may be a complete system, a subsystem, a component/assembly, or a subassembly. The decision on the appropriate level of the CI is left to the WBS Manager and may evolve as the design matures. It is anticipated that product specifications will be prepared for every new CI; for existing legacy equipment it is not anticipated that product specifications will be required and hence models, drawings, and ICDs will define the CI.
- **Configuration Change Control** - a process for identifying and managing proposed changes to a configuration item and its characteristics and the impact of the proposed change on the documentation describing the technical, cost, and schedule baselines. This includes evolution of the design of the configuration item over time and tracking of the status of proposed changes to the configuration item until the change is approved or rejected.
- **Configuration Status Accounting** - a process for tracking the status of the implementation of approved changes in detail down to each impacted document.
- **Configuration Verification** - a process for verifying that the latest approved documents are used to fabricate/test configuration items. It is anticipated that most of this effort will occur as part of the final design review process.

While the NCSX Configuration Management Program is implemented immediately when the initial technical, cost, and schedule baselines are established, not all design information will be under formal configuration control at the same time. Rather, progressively more and more detailed information and documentation is placed under formal configuration control as the design matures.

1.3 Relationships to Other DOE and NCSX Plans and Procedures

In accordance with DOE Order 413.3, the NCSX Project is classified in the category of Other Projects (Not Major System Projects). Baseline change control (technical, cost, and schedule) approval thresholds for Level 0 (Secretarial Acquisition Executive) and Level 1 (Program Secretarial Officer) are defined in Attachment 5 to this order. Baseline change control for Level 2 (Federal Project Manager) and Level 3 (Project) are outlined in the *NCSX Project Execution Plan* (NCSX-PLAN-PEP). The PEP provides policy guidance for the overall planning and execution approach being used on the project and invokes this *Configuration Management Plan* (NCSX-PLAN-CMP) as the vehicle for maintaining the technical, cost, and schedule baselines for NCSX. There are 4 levels of change control within DOE Projects. Starting with the Deputy Secretary of Energy for Science and Environment (Level 1), there are technical, cost, and schedule thresholds defined that identify the appropriate approval level. Table 1-1 depicts the Level 1, Level 2, Level 3, and Level 4 NCSX baseline change control approval thresholds for technical, cost, or schedule baselines. In addition, several other NCSX plans, procedures, and documents support and implement other specific details outlined in this CMP.

If deemed necessary as this program is implemented, the NCSX Project may develop project-specific configuration management and control procedures to augment the above documents.

Table 1-1 NCSX Project Change Classification Matrix

Change Level	Approval Level	Technical Scope	Schedule	Cost
0	**Deputy Secretary of Energy**	Any change in scope and/or performance that affects mission need requirements or is not in conformance with the current approved OMB-300.	6 month or greater increase (cumulative) in the orginal project completion date.	Increase in excess of 25% (cumulative) of hte orginal cost baseline.
1	**Associate Director OFES**	Changes to technical requirements and parameters that affect safety basis and operation function, but do not affect mission need objectives**.**	3-6 month increase (cumulative) in the orginal project completion date.	Increase of the original cost baseline.
2	**NCSX Federal Project Manager**	Changes with ES&H impacts significant enough to affect the approved NEPA/EA documentation**.**	<3 month increase (cumulative) in the orginal project completion date **OR** Change in DOE level 2 milestone.	Changes requiring the use of contingency funds
3	**NCSX Project Manager or NCSX Engineering Manager**	Changes to the GRD and all other changes not requiring DOE approval**.**	All other changes to the performance measurement baseline schedules not requiring DOE approval.	All other changes to the performance measurement baseline costs not requiring DOE approval.

2 ORGANIZATION AND RESPONSIBILITY

The NCSX Engineering Manager is responsible for the overall CM Program, including the establishment and monitoring of the technical, cost, and schedule baselines. The Engineering Manager is also responsible for identifying which configuration items will come under configuration control and when. Within his organization, the Systems Engineering Support Manager is responsible for the implementation and administration of the CM process and update of the technical, cost, and schedule baselines as described in this CMP. The NCSX Project Control Manager provides support to the CM process in the area of cost and schedule assessments of proposed changes and implementation of approved changes to the cost and schedule baselines.

The NCSX WBS Managers are responsible for identifying the physical and functional configuration items that comprise their WBS elements and for developing the designs and the associated costs and schedule in their specific areas of responsibility, including

proposing changes to those designs, costs, and schedules. They are also responsible for assessing impacts of other proposed changes on their areas of responsibility.

The NCSX Project Manager is responsible for approving changes to the established technical, cost, and schedule baselines or, for those changes requiring DOE approval, making project recommendations. In some instances where the scope of the change is urgent or a relatively minor nature, the NCSX Project Manager may authorize the NCSX Engineering Manager to disposition and implement the proposed change in an expedited fashion. These processes are described later in Section 3.1.3 of this CMP.

3 CONFIGURATION MANAGEMENT

3.1 Configuration Change Control for Design Basis Documents

3.1.1 Placement of Documents Under Configuration Change Control

The formal DOE design document configuration change control processes described in the applicable DOE guidelines and procedures and this CMP was implemented when the Project received approval of the Critical Decision 2 (CD-2) milestone that established the DOE approved Acquisition Performance Baseline (APB). This milestone was completed in February 2004.

Notwithstanding that CD-2 marked the starting point for the formal DOE configuration control, the Project established the initial technical, cost, and schedule baselines in the late summer of 2002. These baselines formed the basis for the performance measurement baseline in the NCSX Project Control System (PCS). This also marked the start of an internal configuration control process on the NCSX Project where documents are progressively placed under configuration control. The project technical baseline started as a high-level specification and has evolved and will continue to evolve to greater levels of detail as the design progresses. This process is controlled by the manner in which documents are progressively placed under configuration control as the design details mature. Details of the design that are not under formal configuration control are controlled in less formal manner by the Engineering Manager and WBS managers.

In general, project design reviews will determine when specific configuration items come under formal change control. As a guideline, the following types of configuration items will come under configuration control (from a project perspective) at the following design review points:

- Conceptual Design Review (CDR) – The CDR was successfully completed in May, 2002. Following resolution of the major CDR recommendations and comments, including some changes in schedule logic, and revised DOE funding guidance, the Project established its initial set of baselines. This baseline was the source of the baseline cost and schedule information documented in the NCSX Project Execution Plan (PEP) that was approved as part of the CD-1 milestone achievement. For this initial series of baselines, only the General Requirements Document (GRD), the technical data that constitutes the fundamental agreements between engineering and physics (e.g., the coil geometries, coil currents for the reference scenarios, and the first-wall envelope), and the Pro/Engineer (Pro/E) models and drawings will constituted the technical baseline. The cost estimate

and schedules that were consistent with this technical baseline constituted the cost and schedule baselines. These baselines served as a point of departure for implementing the CM process internally.

- Preliminary Design Reviews (PDRs) – At the completion of preliminary design, subsystems or grouping of subsystems will undergo formal PDRs. At the completion of these PDRs, the subsystem requirements expressed in developmental specifications (BSPECs) (flowed down from the GRD), interface control documents (ICDs – representing interface agreements between systems), updated models/drawings, and any other supporting technical data (e.g., tables, sketches, computer files, etc.) will be defined and placed under configuration control. These developmental specifications and constraints let the each WBS manager know what they have to design to and what are the envelope and boundary conditions for final design. Following the completion of the vacuum vessel and modular coil PDR and other prescribed DOE reviews in the fall of 2003, the Project received approval of the CD-2 milestone. It is at this point that the formal DOE configuration control process was implemented.
- Final Design Reviews (FDRs) – At the completion of the final design process, specifications, interfaces, models/drawings, and supporting technical information will have matured to a level of detail sufficient to permit fabrication and assembly. A series of final design reviews or FDRs will be conducted to mark the transition point from design to fabrication. These key fabrication documents that will now come under configuration control include product specifications, fabrication drawings, and any other technical data that is needed to constrain the fabricator or assembler. Assembly procedures, testing procedures will also be developed, but will come under revision control vs. configuration control.
- Project Completion –The goal of the NCSX configuration management program is to ensure that the documentation reflected in electronic drawings and models accurately reflect what is installed in the field to the extent practicable. The DMP summarizes how the Project will make every reasonable effort to achieve this goal.

Once a document is placed under configuration control, an Engineering Change Proposal (ECP) is generally required to modify that document (Section 3.1.3). The one exception to this might be where there are changes to the product specification and/or drawings that, in the opinion of the NCSX Engineering Manager, are minor in scope and extent, that he can waive the need for an ECP on a case-by-case basis, however, the record of revision in the impacted document (or ECN for drawing) will document the change. It also should be noted that baselines might also be established between the times of major project design reviews as the result of an ECP.

3.1.2 Evolution of the Baselines

As above, the initial technical, cost and schedule baselines will be established at the start of preliminary design. During preliminary design or final design the level of detail and understanding of the constraints and envelopes of the design will evolve. Between the time that the initial technical, cost, and schedule baselines are established and the periodic cost and schedule reviews outlined in the PEP and/or the technical design

reviews outlined in this CMP, the technical baseline and its associated cost and schedule details will evolve.

Proposed changes to the internal or DOE controlled technical, cost, or schedule baselines may be identified by several methods:

- Weekly System Integration Team (SIT) meetings may identify technical changes and risk mitigation strategies that need to be accommodated to facilitate successful attainment of mission, physics, or engineering requirements;
- Monthly statusing of the authorized work documented on the Work Authorization Forms (WAFs) or periodic Project and engineering meetings may identify issues that require some changes to the technical, cost, or schedule baseline;
- Suggestions by WBS Managers may identify technical changes that will result in improved performance (technical, cost, or schedule) or are needed to solve technical issues; and
- Preparations for the periodic cost and schedule reviews and/or technical design reviews may identify necessary changes to the project baselines.

3.1.3 Engineering Change Proposal

Once the CD-2 milestone is approved and the DOE APB established, all changes to project baselines (technical, cost, and schedule) will be accomplished by the Engineering Change Proposal (ECP). Figure 3-1 illustrates the change control process. These changes may take the form as individual and very specific changes to those that are more evolutionary.

At one end of the spectrum are discrete and significant changes in which a change of thinking or understanding causes the project to change something that is already under formal configuration change control. These types of changes will be handled by one or more stand-alone ECPs.

At the other end of the spectrum, evolutionary changes to baselines are those in which the design (and the associated cost and schedule impacts) advances in a level of detail, moving beyond but not necessarily changing that which is already under formal change control or adjustments due to actual cost and schedule performance against established baselines, will be handled by periodically updating the reference design to incorporate these developments. For these types of changes, “omnibus” ECPs will be processed to capture multiple small changes.

The decision as to whether a proposed change falls in the “significant” or “omnibus” ECP classification shall be determined by the NCSX Systems Engineering Support Manager in consultation with the proposer, the impacted WBS Managers, the responsible Project Engineer(s), and the Engineering Manager. NCSX Procedure NCSX-PROC-002, NCSX Configuration Management, provides the details of the process for completing and processing an ECP. The ECP will be an electronic form that is available and will be processed on an interactive Configuration Management Web Page that will be accessible from the NCSX Engineering Web Page.

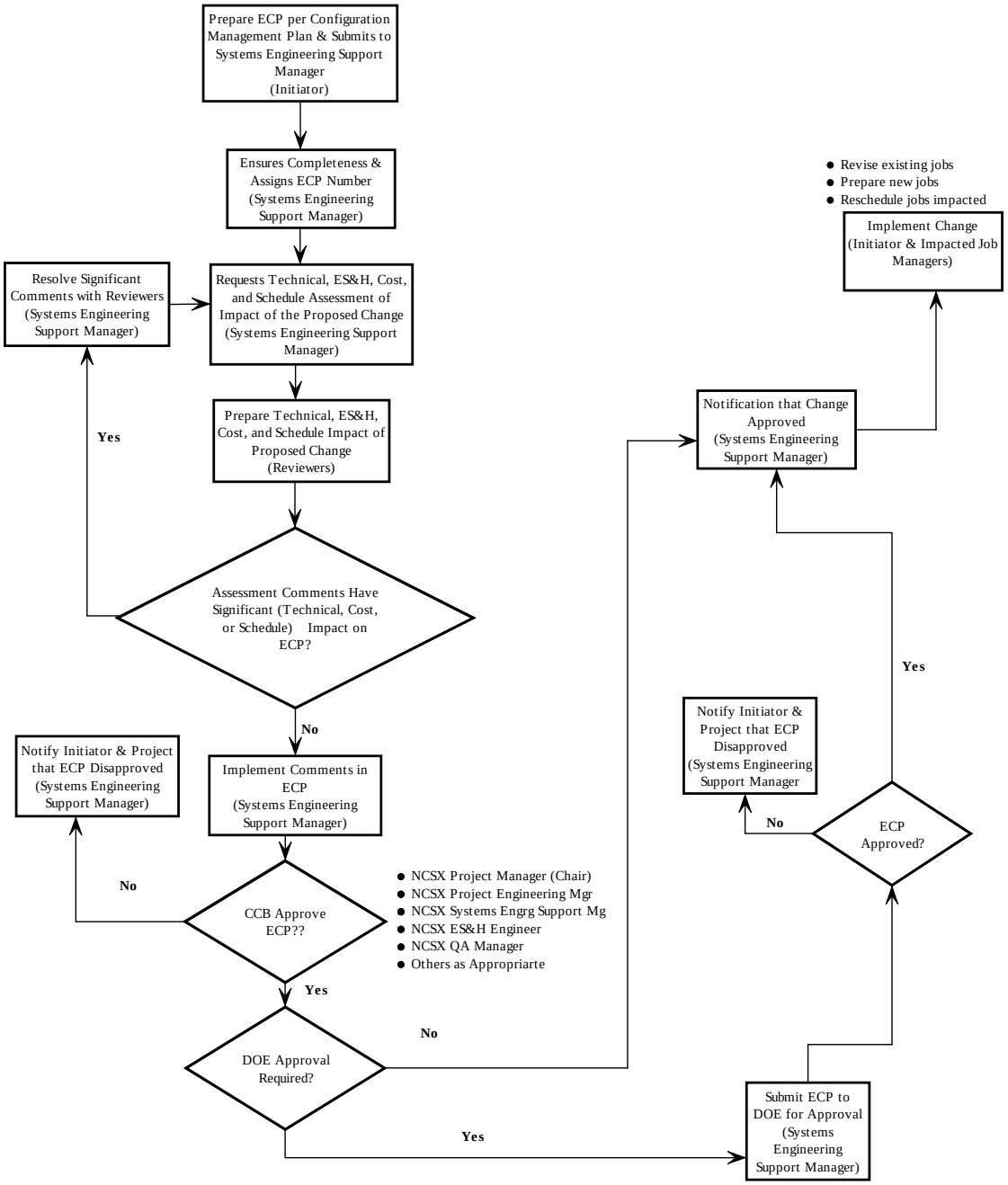
A change request can be initiated by anyone associated with the Project. The initiator identifies the affected documentation, outlines the reasons for the change, quantifies the technical, cost, and schedule impacts, and describes the change in detail. The ECP form allows for review of all changes in a consistent manner. As described below, the normal adjudicating body for each ECP is the Change Control Board (CCB). However, in some instances, a process for "expedited" ECPs may be appropriate. ECPs will be numbered sequentially as follows: ECP- XXX, where XXX the sequential number of the ECP.

Table 1-1 identifies the 4 levels of change control approval. Class 3 changes are reserved for the NCSX Project team for disposition. Class 0, 1, and 2 ECPs require DOE approval. There are two types of ECPs:

- Standard ECPs - involve an orderly project review and a formal meeting of the CCB to discuss and disposition. The NCSX Project Manager will be the chair and deciding official on these ECPs. If the NCSX Project Manager is not available, the NCSX Engineering Manager or a designee named by the Project Manager shall have the authority to approve the ECP for the Project. If a standard ECP requires DOE approval, it will be approved first by the Project and then submitted to the DOE Federal Project Manager for disposition at whatever level of DOE approval is warranted.
- Expedited ECPs - Although any change to established baselines (technical, cost, and schedule) requires an ECP, it may not always be practical to follow the full-blown ECP processing system shown on Figure 3-1. Instances where an "expedited" ECP might be appropriate is when a pending critical procurement needs to reflect the proposed change, if field activities may be delayed by the normal ECP process involving full reviews and the CCB, or if the change is primarily editorial or minor in nature and impact. The NCSX Engineering Manager, in consultation with the NCSX Project Manager, may direct the Systems Engineering Support Manager to implement an "expedited" ECP process in which the NCSX Engineering Manager may review and approve the ECP with only an abbreviated review. If the Engineering Manager is not available, he shall designee a person authorized to sign for him or the NCSX Project Manager may sign. This class of ECPs is a subset of the Level 3 ECP classification. However, any "expedited" ECPs will be reviewed "after-the-fact" by the full CCB to ensure that major errors and/or omissions were not made.

Once the ECP is adjudicated, the Project will be notified as to whether the ECP is approved or not approved. If an ECP is approved, the ECP is then implemented and the affected documentation is revised accordingly in a timely manner The WBS Manager is responsible for implementing approved ECPs, including coordinating the revision of impacted documents. The NCSX Systems Engineering Support Manager shall be responsible to the NCSX Project Engineering Manager following up to ensure that the necessary documentation is revised. The ECP and an updated list of approved, disapproved, and pending changes will be maintained electronically by the Systems Engineering Support Manager on the NCSX Configuration Management Web Page.

Figure 3-1 The Change Control Process



3.1.4 Change Control Board

Once an ECP has been prepared, the determination made that this ECP does not qualify for "expedited" ECP processing, and the impacts fully documented, the ECP will come before a Project Change Control Board (CCB) that is comprised of senior members of the NCSX management team. The NCSX Project Manager or his designee will chair the CCB. Other members of the CCB will be assigned as appropriate, but typically include the following:

- Systems Engineering Support Manager (Secretary of the CCB);
- Project Control Manager;

- Engineering Manager;
- Physics Head;
- Project Engineers impacted by the proposed change
- WBS Managers impacted by the proposed change;
- ES&H Manager;
- QA Manager;
- Other impacted managers; and
- NCSX Project Manager.

The chairperson shall have the ultimate authority to recommend/approve changes for the final approval; other CCB members act solely as advisors. In instances where the ultimate approval authority is DOE, the NCSX Project Manager shall indicate his approval and forward it for DOE disposition with his recommendation to approve.

3.2 Configuration Control for Run Copy Procedures

PPPL Engineering Procedure, ENG-030 addresses technical procedures for experimental facilities. ENG-030 addresses various categories of run copy procedures, including installation, assembly, and manufacturing procedures. Once signed off, the baseline copy of a run procedure is maintained in the PPPL Operations Center. Changes to these procedures will be implemented per ENG-030.

3.3 Baseline Documentation

3.2.1. Technical Baseline

The technical baseline at any stage of the project is defined by any or the entire following configuration defining documents:

- Requirement documents (specifications) that clearly define the performance requirements and constraints that need to be satisfied;
- Interfaces Control Documents (ICDs) that define the interfaces between WBS elements;
- Drawings , models, and technical data that physically define the configuration; and
- Approved Requests for Deviation and approved Non-Conformance Reports. The SEMP defines the purpose and use of these documents.

Documentation (specifications, drawings/models, supporting technical information, etc.) will come under configuration control progressively as the design evolves. A series of "frozen" baselines (from a technical, cost, and schedule perspective) will be established as the documentation package for each design review is finalized. Changes resulting from design review CHITs or other design evolution changes will be addressed as part of the design review closeout and design evolution process. Before the next design review, all CHITs from the previous review must be closed out.

3.3.1.1 Requirements/Specification Documents

Requirements/specifications for the NCSX Project are captured in a hierarchy of requirements, which begin with the system/project (top-level) requirements and flow down in increasing detail into lower level specifications. Different types of specifications will have different functions for NCSX and these will naturally have different formats as appropriate. The NCSX Project shall develop and implement a project-specific approach for developing specifications that meets the requirements set forth in most recent revision to PPPL Engineering Procedure ENG-006, "Review and Approval of Specifications and Work."

As indicated in the Systems Engineering Management Plan (NCSX-PLAN-SEMP) there three type of design and performance related specifications. Theses are the:

- General Requirements Document (GRD) - provides the top-level performance requirements and constraints at the overall system (project) level and the allocation of each requirement to affected subsystems. The GRD is designated by the NCSX Project as the ASPEC. These initial subsystem requirement allocations in the GRD are expanded and developed in subsystem and lower level specifications as described in the following paragraphs.
- Developmental specifications – these documents take the top-level requirements specified in the GRD and provide design requirements by subsystem, envelopes, and boundary conditions that constrain the development of the final design. Developmental specification are generally prepared for the overall subsystem, although the WBS Manager may decide to develop them as needed for lower level components and/or groupings of components. The developmental specifications are designated by the NCSX Project as BSPECs and are sometimes referred to as System Requirements Documents (SRDs). Developmental specifications will be placed under formal configuration control by the completion of preliminary design for that subsystem. Once under configuration control, an ECP will be required to change a developmental specification.
- Product specifications – these documents provide the details to enable a manufacturer to build or assembler to assemble the component, system, or subsystem. The product specifications are designated by the NCSX Project as CSPECs. Product specifications are generally prepared for individual components. Included in this category would be procurement specifications, detailed assembly and fabrication procedures, and detailed testing procedures. Product specifications will be placed under configuration control by the completion of the final design for that component/subsystem. Once under configuration control, an ECP will be required to change a product specification.

As the design progresses into the fabrication stage, the product specifications will give way to installation and assembly procedures. These documents provide the step-by-step processes and material requirements for installation and assembly. Specific requirements for these procedures are outlined in PPPL Engineering Procedure ENG-030, *PPPL Technical Procedures for Experimental Facilities.*

Changes to approved specifications shall require an ECP. If a Request for Deviation (RFD) is approved, the NCSX Engineering Web shall reflect the respective specification revision and the approved RFDs against that specification.

3.3.1.2 Interface Control Documents

Interface requirements are functional, performance, and physical characteristics required to exist at a common boundary. This boundary consists of performance/physical design constraints between systems and subsystems. The interface may define either the physical boundary conditions or the functional or performance boundary conditions.

The ICMP defines the process and format for defining interfaces. Two types of interfaces exist; primary and secondary interfaces. Primary interfaces exist between two separately deliverable items (referred to as Configuration Items/CIs in systems engineering terms) when the mutual boundary area is not controlled by a single developmental specification, when the interface is with systems outside the project (external interfaces identified in the General Requirements Document/GRD), or when, at the discretion of the cognizant Project Engineer, the interface is determined to be critical to the performance of the NCSX program. Configuration Items (CIs) represent the lowest level of control under configuration management and may be a single physical or functional item or collection of items that will satisfy a final end product or deliverable. Physical interfaces are documented in Interface Control documents and functional interfaces will be documented in developmental specifications. Secondary interfaces exist when the interface can be defined by a single developmental specification. Secondary interfaces will remain under local control by the WBS Manager until such time that the design is completed and the CI ready for delivery or the CI interface is elevated to a primary interface status.

As described in the Interface Control Management Plan (NCSX-PLAN-ICMP), the process for defining and documenting primary interfaces involves two steps. The first step is the development of scope sheet interface agreement. These scope sheets, normally in the form of e-mail agreements, will be developed early in the preliminary design phase and document the agreements as to what primary interfaces exist, who will be responsible and a plan for developing either the ICD or developmental performance specifications. Primary interfaces documented in ICDs or developmental specifications will be brought under configuration control by completion of preliminary design and an ECP will be required to change an ICD.

Changes to drawings or models that reflect interfaces must be considered when processing ECPs. While the process of revising ICDs properly reflects updates to drawings or models, the opposite must also be considered – where changes to drawings or models may impact existing ICDs. As part of the impact statement on the ECP, the impact of the change to existing interfaces must be considered as part of the impact identification process.

3.3.1.3 Drawings and Models and Supporting Technical Data

3.3.1.3.1 Drawings and Models

With the exception of legacy equipment drawings, the NCSX Project will utilize electronic Computer Aided Design (CAD) software to prepare, review, approve, and change these electronic models and drawings. For mechanical 2D and 3D models and drawings the PPPL and project standard is Pro/Engineer. For electrical drawings, the PPPL and project standard is AutoCAD. All drawings and models that interface with the stellarator core will be prepared in 3D using Pro/Engineer.

As with hard copy drawings, electronic models and drawings will require the same degree of discipline and review prior to approval. Although primarily done electronically via the respective CAD software programs, the preparer of the model will post the model and drawing and the CAD software will automatically notify the necessary reviewers and approving officials. For the NCSX Project, this will include:

- An independent checker (may be the cognizant engineer);
- A check by the NCSX Design Integration staff;
- A check for welding requirements and symbols by the PPPL Welding Engineer;
- Approval by the cognizant engineer.

The Pro/Engineer models and drawings that first described the technical baseline came under configuration control in the summer of 2002. Since then, the models and number of drawings under configuration control have increased as the project has undergone Preliminary Design Reviews (PDRs) and Final Design Reviews (FDRs). Once CD-2 approval was received, an ECP was required to effect changes to the drawing/model that impact the established technical, cost, and schedule baselines. Each "frozen" baseline is easily identified in the PRO/INTRALINK database via a unique baseline tab within the appropriate PRO/INTRALINK WBS folder. Within the PRO/INTRALINK database, processes are in place to ensure adequate configuration control and the details are included in the PRO/INTRALINK Users Guide. Baselines will be identified not only by a date identifier but also by a unique name; e.g., "0512_CDR_Baseline."

Once a model or drawing has been released for fabrication, the drawing will move from a version number to a revision number (i.e., the initial release for fabrication will receive the *Revision 0* designation and the drawing in pdf format will be signed electronically in accordance with the NCSX procedure on electronic signatures (NCSX-PROC-005). Subsequent changes to drawings will require an ECP and will then reflect updated revision numbers (e.g., 2, 3, 4, etc.) and new electronic sign-off. The official version of that model or drawing will be maintained by the PPPL Drafting Supervisor in a separate Released Drawing folder in the Pro/INTRALINK or AUTOCAD databases. Each product specification (CSPEC) will contain a list of those models and drawings released for fabrication so that casual users might know to go into the Released Drawing folder to obtain the latest version. These specifications are posted on the NCSX Engineering Web page.

3D models will also be reviewed and approved electronically. Since pdf representations of 3D models are not feasible, the protocols and disciplines in the INTRALINK will provide the necessary controls and certifications that the proper checking and review processes occurred. The NCSX procedure on models and drawing control (NCSX-PROC-007) outlines the specifics.

During the MIE Project, changes to drawings released for fabrication will also require that an Engineering Change Notice (ECN) be prepared as an attachment to the ECP. The ECP/ECN connection will be revisited when operations commence. The ECN will be processed in accordance with the latest revision to PPPL Engineering Procedure ENG-010, "Control of Drawings, Software, and Firmware" with one alteration. When an ECN is pending on a particular drawing the Drafting Supervisor will extract the affected drawing from the NCSX Pro/INTRALINK drawing released folder and add an Acrobat stamp records the ECN number and any summary description added to the drop-down note. Once the Acrobat stamp is added, the Drafting supervisor will place the drawing back into the released drawing folder. This process allows all viewers of drawings in the Released Drawing folder to be made aware that an ECN is pending on a particular drawing. After the ECN changes have been completed a PDF file will be made of the revised drawing and placed in the Release Drawing folder and the drawing with the ECN Acrobat stamp removed.

Another special case of models and drawings will be the general arrangement models and drawings of the NCSX facility that show equipment envelops and locations. The current facility model will also be posted on the Engineering Web page in pdf format to facilitate ease in accessing NCSX space allocations information.

The CAD models and drawings are an extension of the systems requirements allocation process. When developed as three-dimensional models and managed within an integrated product data management tool (Pro/INTRALINK) they provide, at the top level, a physical and functional hardware implementation of the design requirements as defined in the GRD. In the Conceptual Design stage, models of the stellarator core and facility were developed and exist in varying degrees of detail, representing the overall design configuration. Some models will have a high level of development while others will provide the allocation of volumetric space of a subsystem.

As described in the DMP and Section 3.1.2 of this CMP, models and drawings will progress though various interim design stages (Conceptual Design, Preliminary Design, Prototype, Final Design) to the fabrication release stage. Each interim stage will be promoted, managed, and stored in accordance with the controlled processes the NCSX procedure on model and drawing control. These processes will support the periodic cost and schedule reviews, technical design reviews, and changes to the technical, cost, and schedule baselines whenever the design evolves to a point that a technical, cost, or schedule baseline change is deemed necessary.

As part of the PPPL Work Planning Process, a decision will be made up front as to whether or not as-built drawings will be required and the PPPL Work Planning (WP) will be annotated accordingly and approved by the RLM. If the decision is made that as-built drawings are not required, the RLM will direct that notations (including red-lining) will

be made on physical drawings. If there are approved Requests for Deviation (RFD) and/or NCR and ECNs impacting that respective model and drawing that have not been reflected on those models or drawings, a notation will be made on the pdf version of the drawing to indicate that there are approved RFDs/NCRs/ECNs not incorporated into the electronic models and drawings. Storage of all release points of the design process will allow models to be checked to assure compliance to earlier space allocations.

3.3.1.3.2 Supporting Technical Data

Technical data (e.g., coil geometries, coil currents for the reference scenarios, first-wall envelopes, tables, computer files, etc.) that support and substantiate the design will placed under formal configuration control on a case-by-case basis and at appropriate stages of the design when needed. Either the responsible Project Engineer or the Engineering Manager makes the decision when supporting technical data will come under configuration control. As the design evolves, it is anticipated that technical data will be controlled, checked, and approved in accordance with the processes set forth in the latest version of PPPL Engineering Procedure ENG-033, "Design Verification." WBS Managers will maintain copies of approved and checked calculations and design confirmatory information.

3.3.1.4 Procurement Support Documents

Procurement support documents include non-technical documents such as Statements of Work (SOWs) and technical documents such as developmental and product specifications and associated drawings and models. SOWs are not considered technical documents and are not part of the technical baseline. In some instances, such as specific and focused R&D efforts that will not become part of the NCSX device, SOWs are used to convey technical information. SOWs will be under revision control, but will not be under configuration control and require an ECP to implement a change. Changes to technical documents such as specifications and associated drawings and models that provide the reference for the basis for the design desired will come under configuration control and will require an ECP to change.

However, note that revised documents (SOWs, specifications, and models and drawings) will not become applicable to the vendor's work scope until such time that the contract is changed.

3.2.2. Design Basis Documents

Another critical set of documentation that supports design reviews will be the Design Basis Documents (DBDs). DBDs are historical documents **NOT** subject to configuration control. Nonetheless, DBDs are important documents in the design evolution process. DBDs are the comprehensive design basis that describes (but not defines) the design of each subsystem and how the design satisfies the requirements specified in the requirements documents. DBDs will be prepared and updated by WBS Managers according to a format appropriate for each major design review (e.g., conceptual design review, preliminary design review, and final design review. The DBDs describe the technical baseline upon which the cost and schedule baselines are predicated at each major design review point. At each major review point, the cost and schedule baselines

are updated and the DBDs are also updated to provide a description of the companion technical baseline at that point in time.

3.3.3 Cost and Schedule Baselines

The cost and schedule baselines are derived from the Project's technical baseline; the scheduled tasks and their estimated costs provide a time scale and cost for completing activities that make up the technical baseline. The cost and schedule detailed baselines reside in a Primavera Project Planner (P3) database that is controlled and maintained by the NCSX Project Control Manager. The Level 2 resource-loaded schedules and associated milestones contained in this database, including year-by-year contingency utilization estimates, constitutes the controlled cost and schedule baseline for completing the NCSX Project.

Level 3 resource-loaded schedules and milestones, expanded in detail from the Level 2 baseline, are incorporated in Work Authorization Forms (WAFs). The WAFs are used to authorized work and measure performance at the task level and those constitute the controlled performance measurement baseline for authorized work.

Adopting changes to the controlled cost and schedule baselines will be done in accordance with approved change control procedures outlined in this CMP. When the project changes the project baselines, the data files that underpin the new cost and schedule baselines will be uniquely identified and locked, preventing further changes under that identifier. Viewable files will be generated for project use in PDF format. The viewable files will include the identifier for the data files from which they were generated.

3.4 Other Management Documents

Project management plans and procedures will not come under the configuration control processes described in this CMP. However, these documents are controlled documents that will be reviewed and approved via a disciplined process. Revisions to these documents will also be carefully controlled by a disciplined change and signature approval process. The DMP indicates the required approval level for each management document.