1.0 purpose

 This procedure provides guidelines and formats for the development of the project work breakdown structure (WBS). The WBS subdivides and logically organizes the entire project scope into its component elements in order to establish a framework for effective management control of the project scope, schedule and budget.

2.0 SCOPE

This procedure describes requirements for creation of a project WBS and associated WBS dictionary.

3.0 REFERENCES

**3.1** DOE Order 413.3B, “Program and Project Management for the Acquisition of Capital Assets”

**3.2** DOE Manual 413.3-1, “Project Management for the Acquisition of Capital Assets”

 **3.3** PPPL Project Management System Description (PMSD)

 **3.4** PM Procedure 1.1, Project Execution Plan

 **3.5** PM Procedure 1.4, Control Accounts, Work Packages & Planning Packages

4.0 RESPONSIBILITIES

The Project Managers are responsible for the creation, coding and maintenance of a WBS for his/her assigned project, with input from other members of the project team. The Project Manager will formally maintain the WBS and the WBS Dictionary as controlled documents.

5.0 PROCEDURES

 **5.1 WBS Structure**

 The project WBS is a product-oriented grouping of project work elements that organizes and defines the total scope of the project. The WBS is a multi-level framework that organizes and graphically displays elements representing work to be accomplished in logical relationships. Each descending level represents an increasingly detailed definition/division of a project component. The WBS is the structure that integrates and relates all project work (technical, schedule, and budget) and is used throughout the life-cycle of a project to identify, assign, and track specific work scopes.

The WBS will consist of a number of levels and be extended to the Control Account level. The WBS will be structured so that each control account is a subdivision of a unique (one) WBS element.

 The WBS will be coded so that cost, schedule summarization and roll-up are possible from the activity level, through the work packages, to the control accounts, and to each higher level WBS element such that the sum of all elements equals the total project. The total project will be referred to as level 1.

The WBS is detailed in the Project Execution Plan (PEP) or attached as an appendix to the PEP.

 **5.2 WBS Guidelines**

The development of PPPL work breakdown structures will include consideration of the following factors:

1. The WBS provides the framework for the scope, schedules, and budgets (see Appendix A for a sample). It includes the entire scope for the project. The WBS will not include scope outside of that authorized as part of the scope baseline.
2. Each WBS element represents an aggregation of all its subordinate elements. Valid WBS elements contain all three of the following characteristics:
* A specific output (i.e., a product or service).
* Discernible beginning and ending dates.
* Resources dedicated to it.
1. A project’s WBS shall not contain Organizational Breakdown Structure or Functional Breakdown Structure elements. The WBS will contain products or services, which are successively subdivided into increasingly detailed and manageable work products or elements.
2. The WBS has elements that can be assigned to individual managers who will be responsible for the planning and control of the scope represented by each of these elements.
3. At its upper levels, the WBS typically has time-phased elements to allow for the closeout of completed work (i.e., initiation, definition, execution, and transition/closeout).
4. At its upper levels, the WBS has elements designated for reporting performance data to the customer.
5. All of the items appearing on the WBS are traceable to items on the project schedule.
6. Costs that are collected and reported are summarized upward directly through the WBS without bypassing lower-level elements or allocating a Control Account (CA) to more than one higher element.
7. All required external reporting elements are included.
8. The WBS includes elements at the CA level for major subcontracted efforts, identifying subcontractors, if known.
9. The WBS does not include contingency or management reserve since it does not represent project work.
10. The WBS will not have upper level elements for operating or capital funds; the accounting of different fund types can be accommodated through base coding.

 **5.3 WBS Dictionary**

 The WBS dictionary is a set of specific definitions that describe the scope of each work element identified in the WBS. It defines each element to at least the control account level in terms of the content of the work to be performed. The WBS dictionary demonstrates that the Scope of Work (SOW) and the WBS are fully reconciled. For EVMS compliant projects, the WBS will be described in a WBS dictionary (see Appendix B), in order to provide an adequate description of the work involved.

6.0 APPENDIX

 6.1 PM-1.2A: Appendix A: Work Breakdown Structure (WBS) - Sample

 6.2 PM-1.2B: Appendix B: WBS Dictionary (Test Format) - Sample

Appendix A

Work Breakdown Structure (WBS) - Sample

**WBS**

**L1 L2 L3 Description**

**1 NSTX UPGRADE PROJECT**

 **1.1 Torus Systems**

1.1.0 Project Integrated Model

1.1.1 Plasma Facing Components

 1.1.2 Vacuum Vessel and Support Structure

 1.1.3 Magnet Systems

 **1.2 Plasma Heating and Current Drive Systems**

 1.2.1 High Harmonic Fast Wave (HHFW)

 1.2.2 Coaxial Helicity Injection (CHI) Current Drive

 1.2.3 Electron Cyclotron Heating (ECH)

 1.2.4 Neutral Beam Injection (NBI)

 **1.3 Auxiliary Systems**

 1.3.1 Vacuum Pumping System

 1.3.2 Coolant Systems

 1.3.3 Bakeout Heating System

 1.3.4 Gas Delivery System

 1.3.5 Glow Discharge Cleaning System

 **1.4 Plasma Diagnostics**

 1.4.1 Plasma Diagnostics

 **1.5 Power Systems**

 1.5.1 AC Power Systems

 1.5.2 AC/DC Converters

 1.5.3 DC Systems

 1.5.4 Control and Protection System

 1.5.5 General Power Systems and Integration

 **1.6 Central Instrumentation and Controls (I&C)**

 1.6.1 Control System

 1.6.2 Data Acquisition System

 **1.7 Project Support & Integration**

 1.7.1 Project Management and Integration

 1.7.2 Project Physics

 1.7.3 Integrated Systems Tests

 **1.8 Site Preparation and Assembly**

 1.8.1 Site Preparation

 1.8.2 Torus Assembly and Construction

Appendix B

WBS Dictionary (Text Format) - Sample

**WBS Element: 1 WBS Level: 1**

**WBS Title: NSTX Upgrade Project**

Definition: The replacement of the entire Center Stack Assembly (CSA) and installation of a second Neutral Beam Injection (NBI) system on NSTX is planned to allow an improved understanding of the Spherical Torus (ST) magnetic confinement configuration which is needed to establish the physics basis for next-step ST facilities, broaden the scientific understanding of plasma confinement for ITER, and maintain U.S. world leadership in ST research capabilities. In particular, operation at higher magnetic field with reduced plasma collisionality is needed to extend the plasma physics understanding of the ST toward next-step ST facilities and ITER. Controllable fully-non-inductive current-drive will also contribute to assessing the ST as a potentially cost-effective path to fusion energy.

**WBS Element: 1.1 WBS Level: 2**

**WBS Title: Torus Systems**

Definition: The torus systems include all the systems and related elements within the boundary of the NSTX support structure. This WBS element includes the Plasma Facing Components (WBS 1.1), Vacuum Vessel & Support Structure (WBS 1.2), and Magnet Systems (WBS 1.3). The scope of the work contains engineering design, R&D, mockups, procurement activities, and component fabrication. Assembly of the Torus System is included in WBS 1.8.

**WBS Element: 1.1.0 WBS Level: 3**

**WBS Title: Project Integrated Model**

Definition: This WBS element includes development of a project integrated model and the associated analysis support of the overall NSTX Upgrade Project.

 As a result of the NSTX Upgrade Project, the NSTX global models and analyses will need to be updated. This WBS element includes analytical support for global models and analysis not presently identified. The global model will provide the basis for updating the analysis to qualify components and identify areas of the tokamak requiring further analysis. Identified plasma scenarios and power supply current limit analyses will be run in the global model and current sets that require further analysis will be identified. These analyses also serve to check the results of more detailed analyses.

**WBS Element: 1.1.1 WBS Level: 3**

**WBS Title: Plasma Facing Components**

Definition: The plasma facing components (PFCs) include all the systems and related elements that serve to protect the vacuum vessel from the charged particles and radiation flux from the plasma. These include the plasma facing tiles and mounting components, passive stabilizers, inner wall protection, divertor area strike plates, and local I&C. This element consists of the engineering design, analysis, procurement activities and component fabrication.

The NSTX Upgrade Project will require new PFCs on the new Center Stack Casing (CSC) and the new Inboard divertor (IBD). This WBS element includes the design and analysis for both the CS and IBD PFCs, design modifications to the PFC tiles to accommodate surface diagnostics, including design of the tile mounting schemes and routing plans for diagnostic wires, generation of required documentation such as checked calculations, specifications and procedures, the procurement and installation of all PFC tiles and hardware on the CSC and IBD.

In addition the NSTX Upgrade will require analysis of the passive plates for disruption and thermal loads. CDR level calculations were performed that addressed one of five disruptions. The remaining identified disruptions are to be completed during Preliminary Design. During Final design, analysis updates are expected as a result of preliminary design evolution. Modest hardware upgrades are anticipated are anticipated as part of this task. Additions of accelerometers or other diagnostics to benchmark calculations with actual performance in NSTX are also anticipated. This analysis effort is included in this WBS element.

With the exception of the modifications identified above, no additional modifications to the PFCs are anticipated.

**WBS Element: 1.1.2 WBS Level: 3**

**WBS Title: Vacuum Vessel and Support Structure**

Definition: The vacuum vessel & support structure (VVSS) consists of the vacuum chamber, not including the PFCs, all ports and vacuum boundary closures and the torus support structure which provides the overall supporting mechanism for the torus components to the test cell floor. This WBS element includes the engineering design, analysis, procurement activities and component fabrication.

The NSTX Upgrade Project will require that the existing VVSS be modified to accommodate the new center stack structure, including the umbrella structure and the new center stack support structure. This WBS element includes the analytical and CAD design of the support structures associated with the Magnet upgrade activities. The scope includes; the Vacuum Vessel & Structural Support, the Outer TF Structures, the Outer PF Coil Structures, the Umbrella Structural Reinforcement, the CS Support Pedestal and miscellaneous Vacuum Vessel Structural Supports. It also includes the procurement and fabrication of these structures, but does not include installation costs. Installations costs are included in WBS 1.8.

**WBS Element: 1.1.3 WBS Level: 3**

**WBS Title: Magnet Systems**

Definition: The magnet system consists of the outer Poloidal Field (PF) coils (PF#2-5), the outer Toroidal Field (TF) coil legs, and the Center Stack Assembly (CSA). The CSA contains the inner TF coil legs, the TF coil joint (flex bus assembly), the OH solenoid, the shaping coils, and the center stack casing. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication of the magnet systems up to and including the magnet system coil buswork, but does not include installation costs. Installations costs are included in WBS 1.8

The NSTX Upgrade Project will require engineering, analysis, design procurement and fabrication of a new CSA, replacement of two outer TF coil legs, and a fabrication of a new TF coil joint

This WBS element provides CAD design support for the overall assembly drawings associated with the CSA upgrade. It also includes some time for space allocation studies associated with the magnet upgrades. CAD design support for individual components is included in the specific component jobs.

**WBS Element: 1.1.3.1 WBS Level: 4**

**WBS Title: Outer Poloidal Field Coils (PF #3-5)**

Definition: The outer Poloidal Field coils (PF 3-5) consist of 5 poloidal field coils PF 3 upper and lower, PF 4 upper and lower and PF 5. There are no changes to the outer PF coils as part of the NSTX Upgrade Project scope.

**WBS Element: 1.1.3.2 WBS Level: 4**

**WBS Title: Outer Toroidal Field Coils**

Definition: The outer Toroidal Field coils subsystem consists of the coil sections that make up the 12 TF outer legs. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication. For the NSTX Upgrade Project two (2) new Outer TF coils will be fabricated to replace existing ones. This WBS element includes the fabrication of (2) new Outer TF coils to replace the existing leaking OTF#7 and OTF#11 in NSTX. The scope includes the procurement of conductor, insulation material, aluminum castings and supports necessary to fabricate a new OTF coils. Coil fabrication will be performed in-house. This scope does not include costs associated with installation. Installations costs are included in WBS 1.8