NCSX Fabrication Project

Work Breakdown Structure (WBS) Dictionary

Electrical Power Systems (WBS 4)

-Revision 0-

August 27, 2003

Prepared by:

R. Simmons, Systems Engineering Support Manager

Reviewed by:

R. Ramakrishnan, WBS 4 Manager

Larry Dudek, Ancillary Systems Project Engineer

R. Strykowsky, Project Control Manager

W. Reiersen, Engineering Manager

Approved by:

G.H. Neilson, Project Manager

WBS Element: 4	WBS Level: 2
WBS Title:	**Electrical Power Systems**
Description:	The NCSX MIE (Major Item of Equipment) Project includes all Electrical Power System capabilities required for initial operation as defined in the GRD. All equipment in the MIE Project will be installed prior to first plasma. All upgrades will be implemented after the first plasma. Included in the MIE Project are all the engineering and physics design efforts starting with the preliminary design phase (Title I) and ending with completion of the MIE Project, all the necessary Research and Development (R&D) to support the design effort, all component fabrication, assembly, and installation activities, and all system level commissioning and testing. Integrated systems testing of the entire NCSX device is covered in Pre-Operational and Integrated Systems Testing (WBS 92). Suitable provisions will be made for transition to the upgrades defined in the GRD. This summary-level WBS element consists of the electrical power systems needed by the NCSX device and facility. Electrical Power Systems (WBS 4) includes the following elements: • AC Power Systems (WBS 41); • AC/DC Convertors (WBS 42); • DC Systems (WBS 43); • Control and Protection Systems (WBS 44); • Power System Design and Integration (WBS 45); and • FCPC Building Modifications (WBS 46) Electrical Power Systems (WBS 4) includes bus up to the interface with the subsystems, typically at the stellarator core outside the cryostat boundary. Power supplies for plasma heating systems are not included in Electrical Power Systems (WBS 4), but rather in Auxiliary Systems (WBS 2).

WBS Element: 41	WBS Level: 3
WBS Title:	**AC Power Systems**
Description:	This WBS element consists of the following subsystems: • Auxiliary AC Power Systems (WBS 411); and • Experimental AC Power Systems (WBS 412).
WBS Element: 411	**WBS Level: 4**
WBS Title:	**Auxiliary AC Power Systems**
Description:	This WBS element consists of the effort to design and reconfigure existing auxiliary AC power systems. The existing AC power infrastructure at C-site will be re-used to the maximum practical extent, except for that in the Test Cell that will be stripped. A new AC distribution system, up to and including power panels, is provided in the Test Cell. Activities associated with the reactivation of AC power systems at C-site are included. UPS systems are provided for the controllers of the cryogenic systems associated with NBI and the main NCSX coils. Grounding in the NCSX test cell is provided. This WBS element includes cabling to the racks of Diagnostics equipment. Appropriate measures shall be taken by other WBS elements to isolate the a) Vessel and b) PFCs from one another and ground. Isolation shall be tested at 5kv DC. All diagnostics components mounted on the vessel/PFC shall also be isolated at 5kV DC or float with vessel/PFC.

WBS Element: 412	WBS Level: 4
WBS Title:	**Experimental AC Power Systems**
Description:	This WBS element consists of the effort to design and reconfigure existing experimental AC power systems. This WBS element covers the work associated with the use of the D-site Pulsed AC Power 13.8kV distribution systems for NCSX, including reactivation of feeders not in use since TFTR along with minor changes to the lockout and E-stop interlocks which must now interface with the NCSX interlock system. The D-site Pulsed AC Power System, including the MG sets, and 13.8kV SV1/SV2 buses will be shared by NCSX and NSTX. In addition, some of the SV1/SV2 switchgear, feeders, and transformers will be shared. Other SV1/SV2 switchgear, feeders, and transformers not presently in use by NSTX and not used since TFTR operations might need to be reactivated. WBS 5 to provide interface for Lockout and E-Stop features.

WBS Element: 42	WBS Level: 3
WBS Title:	**AC/DC Convertors**
Description:	This WBS element consists of the following subsystems: • C-Site AC/DC Convertors (WBS 421); and • D-Site AC/DC Convertors (WBS 422).
WBS Element: 421	**WBS Level: 4**
WBS Title:	**C-Site AC/DC Convertors**
Description:	*No work in this area is required for the MIE project.*
WBS Element: 422	**WBS Level: 4**
WBS Title:	**D-Site AC/DC Convertors**
Description:	This WBS element consists of the effort to design and reconfigure existing experimental D-Site AC/DC power convertors. Existing Transrex rectifiers in the FCPC building at D-site will be used to power the NCSX Modular, Poloidal Field, and Toroidal Field coils. Rectifier units not in current use for NSTX need to be reactivated and brought to an operating condition. This includes various preliminary tests such as hipot, controls check out, water system check out, trip settings, and dummy load test. Some modifications to the controls may be required to interface with the NCSX real time control system.

WBS Element: 43	WBS Level: 3
WBS Title:	**DC Systems**
Description:	This WBS element consists of the following subsystems: • C-Site DC Systems (WBS 431); • D-to-C- Site DC Systems (WBS 432); and • D-Site DC Systems (WBS 433).
WBS Element: 431	**WBS Level: 4**
WBS Title:	**C-Site DC Systems**
Description:	This WBS element consists of the effort to design and reconfigure existing experimental C-Site DC systems. For the main coils (Modular, PF, TF), 1000MCM power cables coming across from D-site will be received in the existing PLT OH/EF building, and spliced to existing 1000MCM cables which connect to the Disconnect/Link area in the C-site MG basement. The existing switches and bus bar carry the current into the Test Cell. From the stubs penetrating the floor, new 1000MCM cables will be connected to the coil circuit terminals. All the components to be used for NCSX Power system which includes a) 1000 MCM cable runs b) DC Bus c) Bus stubs coming into the Test Cell shall be retained for use by WBS 4.

WBS Element: 432	WBS Level: 4
WBS Title:	**D-to-C-Site DC Systems**
Description:	This WBS element consists of the effort to design, fabricate, and install experimental D-to-C-Site DC Systems. A new cable run, approximately 600 feet long, will be installed from the East-West wing of the FCPC building at D-site, 2nd floor, to the C-site PLT OH/EF building. This will include 1000MCM cables, cable trays, and support system mounted above ground level.
WBS Element: 433	**WBS Level: 4**
WBS Title:	**D-Site DC Systems**
Description:	This WBS element consists of the effort to design and reconfigure (as needed) existing experimental D-Site DC systems. Reconfiguration (as needed) of the outputs of the NCSX- dedicated Transrex power supplies via new power cabling and new DC current limiting reactors. Modification of existing cabling and provision of a common tie points for the shared systems via 1000 MCM cable. Dummy load testing of NSTX systems after reconnection. Provision of isolating switches provided for opening the circuit for troubleshooting purposes at the FCPC.

WBS Element: 44	WBS Level: 3
WBS Title:	**Control and Protection Systems**
Description:	This WBS element consists of the following subsystems: • Electrical Interlocks (WBS 441); • Kirk Key Interlocks (WBS 442); • Real Time Control Systems (WBS 443); • Instrumentation Systems (WBS 444); • Coil Protection Systems (WBS 445); and • Ground Fault Monitoring System (WBS 446).
WBS Element: 441	**WBS Level: 4**
WBS Title:	**Electrical Interlock System**
Description:	This WBS element consists of the effort to design, fabricate, and install an electrical interlock system for NCSX. An electrical interlock system is designed and installed which ensures the proper configuration of the power system in accordance with the commanded state from the NCSX control room and access control systems, and which provides coordinated fast fault response of the power supplies when faults are detected. The system is implemented by Programmable Logic Controllers (PLCs) at various C-site and D-site locations interconnected through a fiber optic network. The system must be compatible with both NCSX and NSTX operations.
WBS Element: 442	**WBS Level: 4**
WBS Title:	**Kirk Key Interlocks**
Description:	This WBS element consists of the effort to design, procure, fabricate, and install kirk key interlocks for NCSX. Mechanical kirk key interlocks are used throughout the D-site power supply system to ensure the proper sequence of manual switching operations and that equipment is in the safe state prior to accessing hazardous areas. This system must be modified (as needed) to reflect the modified power supply configuration, and must include appropriate elements from the C-site elements of the power system.
WBS Element: 443	**WBS Level: 4**
WBS Title:	**Real Time Control Systems**
Description:	This WBS element consists of the effort to develop the specification of the hardware requirements and software algorithms to be provided by WBS 5 (Central I&C) for the real time digital feedback control of the power supply system, including the high-speed digital input and output links.

WBS Element: 444		WBS Level: 4
WBS Title:	**Instrumentation Systems**	
Description:	This WBS element consists of the effort to design, specify, procure, install, and implement current and voltage measurements for the Modular, PF, and TF coils. Current measurements are made at D-site using one precision DC Current Transducer and one optically isolated shunt per circuit. Voltage measurements are at C-site using voltage transducers from line to ground, one from each pole of each circuit to ground. Also included are signal conditioners that receive the current measurements and buffer, filter, and fan out each signal to multiple destinations.	
WBS Element: 445		**WBS Level: 4**
WBS Title:	**Coil Protection Systems**	
Description:	This WBS element consists of the effort to design, specify, procure, program, and implement hardware and software as required to provide 1) Coil protection system and 2) Ground fault detection system for the Modular, PF, and TF coil systems. The coil protection system uses the coil current measurements as input and declares a fault if electrical, thermal, or mechanical limits are exceeded. The ground fault detection system declares a fault if excessive ground current flow is detected.	
WBS Element: 446		**WBS Level: 4**
WBS Title:	**Ground Fault Monitoring System**	
Description:	This WBS element consists of the effort to design, specify, procure, implement a ground fault monitoring system that serves to detect the integrity of machine grounds and generate alarms in case of spurious grounds.	

WBS Element: 45		WBS Level: 3
WBS Title:	**Power System Design and Integration**	
Description:	This WBS element consists of the following subsystems: • System Design and Interfaces (WBS 451); • Electrical Systems Support (WBS 452); and • System Testing/PTPs (WBS 453).	
WBS Element: 451		**WBS Level: 4**
WBS Title:	**System Design and Interfaces**	
Description:	This WBS element consists of the electrical system engineering and design/drafting, which includes the design and analysis of the overall electrical system, its documentation, and the conduct of design reviews.	
WBS Element: 452		**WBS Level: 4**
WBS Title:	**Electrical Systems Support**	
Description:	This WBS element consists of the effort to ensure overall project coordination of electrical systems by providing electrical systems support to other systems, including diagnostics, which provides the engineering, design/drafting, and installation of diagnostic cabling.	

WBS Element: 453	WBS Level: 4
WBS Title:	**Systems Testing (PTPs)**
Description:	This WBS element consists of the effort to conduct all systems-related preoperational testing, including: • DC circuit hipots and impedance measurements • Electrical interlocks • Overall systems testing, including: o kirk key interlock testing, o instrumentation test & calibration, o real time control system testing, o coil protection system testing, o ground fault monitor testing, coil power supply dummy load testing, and o trim coil power supply dummy load testing.

WBS Element: 46	WBS Level: 3
WBS Title:	**FCPC Building Modifications**
Description:	This WBS element includes the modification of 2nd floor of the FCPC Building. This includes installation of required penetrations through the FCPC floor and installation of weatherproofed penetration through the 2nd. Floor wall of FCPC for cables running from FCPC to the NCSX Test Cell. This may also require relocation of some of the existing offices and laboratories on the 2nd floor of the FCPC Building to accommodate the NCSX requirements.