

## **Closeout Notes for NCSX System Analysis & Technical Assurance WBS 82, Job #8204**

The NCSX System Analysis and Technical Assurance Job provided supporting analyses for a number of activities including:

- Analyzing field errors and managing field error budgets for as-designed conditions, out-of-tolerance conditions, eddy currents, and magnetic materials. Includes the disposition of nonconformance reports (NCRs).
- Providing analysis support to the metrology and dimensional control efforts for troubleshooting problems as well as production and assembly activities.
- Analyzing options for optimally aligning modular coils based on physical and magnetic measurements.
- Performing global analyses which are outside the scope of individual subsystems. Analyses include electromagnetic analyses to determine coil inductances, fields, forces; global structural modeling to determine overall structural behavior, mechanical interface loads, and operating limits. (Global seismic analyses was performed as part of the base support structure design in WBS 15.)
- Providing independent assessments of the design adequacy and risks for critical systems and design features. Facilitate resolution of critical issues.

Specific activities that were in progress at the time of project termination that would need to be resumed if the project goes forward at a future date are given below. At each link is a README.txt file that gives additional information specific to the task.

Support for Metrology and Machine Assembly:

Station 1 – Modular Coil Winding

All Modular Coils have been wound and the current centers have been calculated and archived for future physics needs.

[http://ncsx.pppl.gov/NCSX\\_Construction/Dimensional\\_Control\\_Metrology/Dimensional\\_Control/Module\\_Coil\\_Windings/Final\\_Current\\_Centers/](http://ncsx.pppl.gov/NCSX_Construction/Dimensional_Control_Metrology/Dimensional_Control/Module_Coil_Windings/Final_Current_Centers/)

The as-wound current centers have been used in the determination of the Coil Realignment Matrices which are also archived.

[http://ncsx.pppl.gov/NCSX\\_Construction/Dimensional\\_Control\\_Metrology/Dimensional\\_Control/Module\\_Coil\\_Windings/Final\\_Current\\_Centers/](http://ncsx.pppl.gov/NCSX_Construction/Dimensional_Control_Metrology/Dimensional_Control/Module_Coil_Windings/Final_Current_Centers/)

Station 2 – Half Period Assembly

Coil Alignment Calculator tailoring/support for subsequent HP Modules

[http://ncsx.pppl.gov/NCSX\\_Engineering/FieldPeriodAssy/Station%20%20-%20HP%20Asembly/](http://ncsx.pppl.gov/NCSX_Engineering/FieldPeriodAssy/Station%20%20-%20HP%20Asembly/)

Shim Sizing Calculations including application of Coil Realignment Matrices

[http://ncsx.pppl.gov/NCSX\\_Engineering/FieldPeriodAssy/Shim%20Sizing/](http://ncsx.pppl.gov/NCSX_Engineering/FieldPeriodAssy/Shim%20Sizing/)

Station 3 – Assembly of Half Period over VV

HP Alignment Calculator Support

[http://ncsx.pppl.gov/NCSX\\_Engineering/FieldPeriodAssy/Station%20%20-%20HP%20Asembly/](http://ncsx.pppl.gov/NCSX_Engineering/FieldPeriodAssy/Station%20%20-%20HP%20Asembly/)

Development of Laser Traces based on as-built Laser Screens and Laser Alignment

[http://ncsx.pppl.gov/NCSX\\_Engineering/FieldPeriodAssy/Station%20%20-%20Assembly%20of%20HP%20over%20VV/](http://ncsx.pppl.gov/NCSX_Engineering/FieldPeriodAssy/Station%20%20-%20Assembly%20of%20HP%20over%20VV/)

Station 5 – Field Period Assembly - and Station 6 – Final Machine Assembly

Assembly activities were not started but it was anticipated that some of the Alignment Calculators developed to aid in Station 2 and 3 would be modified as needed here.

Field Error management:

The reintroduction of trim coils into the project baseline help assure we had the ability to deal with anticipated field errors and also provide ample margin for dealing with additional field errors arising from coil out of tolerance conditions (on fabrication and assembly) and other non-conformances (ie magnetic permeability issues). It is expected that further numerical evaluation of these conditions would be necessary should they arise. Tools are in place (ie VACISLD Code) to support this.

It is possible that the coil realignment strategy may be expanded as Half Period Assemblies are completed and as-built metrology becomes available to try to recover from field errors introduced by HP or even FP realignment. This has not yet been started or proven to be effective. The approach taken would be similar to what was done for Coil Realignment.

# System Analysis and Technical Assurance

A. W. Brooks

*NCSX WBS 824*

*System Analysis and Technical Assurance*

# System Analysis Overview



- Responsibilities
- Job Status
- Staffing Requirements – Manpower Loading

# Responsibilities



- Analyzing field errors and managing field error budgets for as-designed conditions, out-of-tolerance conditions, eddy currents, and magnetic materials with Trim Coil correction. Includes disposition nonconformance reports (NCRs).
- “Back Office Support” - Providing analysis support to the metrology and dimensional control efforts for troubleshooting problems as well as production activities
- Analyzing options for optimally aligning modular coils based on as-built measurements to mitigate resultant field errors
- Performing global analyses which are outside the scope of individual subsystems. Analyses include electromagnetic analyses to determine coil inductances, fields, forces; global structural modeling to determine overall structural behavior, mechanical interface loads, and operating limits. (Global seismic analyses will be performed as part of the base support structure design in WBS 15.)
- Technical Assurance - Providing independent assessments of the design adequacy and risks for *critical* systems and design features. Facilitate resolution of critical issues. (Does not include general calculation checking which is handled within each WBS)

**WBS provides System Analysis LOE As Needed  
To Support Project Integration and Systems Engineering**



# Status



Task	Personnel	Status
Field error analysis and management	Brooks Zhang	Ongoing in support of machine assembly. Computational tools have been developed to aid analyses and evaluations.
Analysis and troubleshooting support for metrology and dimensional control	Brooks Zhang	Ongoing in support of machine assembly. Initial computational tools to aid assembly and alignment have been developed but need to be tailored for each assembly. Some uncertainties exist for future demands as dimensional control plans and metrology procedures have not been fully exercised.
Modular coil alignment calculations and implementation	Brooks Zhang	Initial Phase based on Winding 16 of 18 coils Completed. Will be revisited following completion of 18 coils and as HP and FP subassemblies are completed.
Global modeling and analysis	Fan	Much of this work has already been completed. Global structural models need to be updated as the design of the coil structures (WBS 15) and base support structure (WBS 17) and Trim Coils are completed. This effort is expected to continue until the completion of the design of stellarator core components.
Technical assurance	Fan	Future tasks authorized by the Engineering Manager to resolve critical issues when they arise. Past tasks included MCWF bolted joint and shim evaluations.

**Han Zhang recently joined PPPL and NCSX to provide needed backup for personnel to mitigate schedule risk as recommended in prior reviews**



# Manpower Loading



Task	Manpower Loading, FTE					TOTALS
	FY2008	FY2009	FY2010	FY2011	FY2012	
Field error analysis and management	0.28	0.23	0.23	0.10	0.05	0.875
Analysis and troubleshooting support for metrology and dimensional control	0.55	0.45	0.45	0.20	0.10	1.75
Modular coil alignment calculations and implementation	0.28	0.23	0.23	0.10	0.05	0.875
Global modeling and analysis	0.55					0.55
Technical assurance		0.31	0.31	0.10	0.10	0.82
<b>All</b>	<b>1.65</b>	<b>1.21</b>	<b>1.21</b>	<b>0.50</b>	<b>0.30</b>	<b>4.87</b>

**LOE activities provide Ongoing Project Support which is expected to be front loaded and tail off as machine assembly matures. A bottoms up estimate was done to support these LOE's**





# Summary

- System Analysis a key part of Project Integration and System Engineering
- We have responded to past recommendations to mitigate schedule risk by adding personnel to provide backup in critical areas
- LOE tasks anticipated to provide support for project at a diminishing level until project completion.
  - Job estimate risk tied to project schedule performance