NSTX CSU Upgrade Overview

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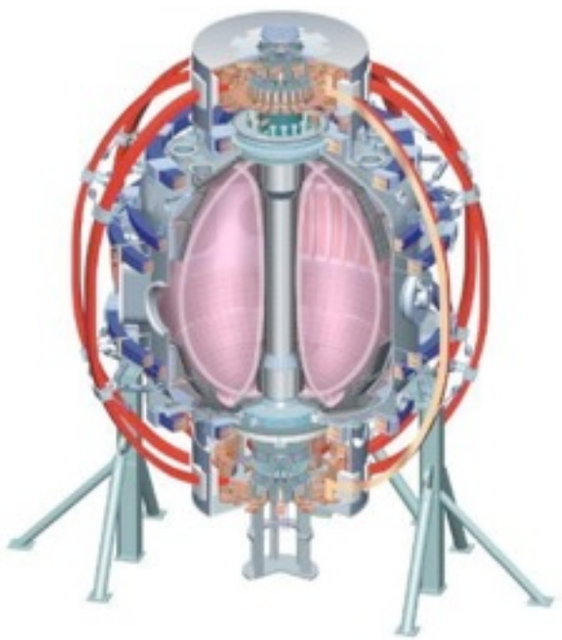
NSTX Upgrade Project Preliminary Design Review LSB, B318 June 23-24, 2010



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Columbia U
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Outline

- Introduction
- Scope
  - Central Core Mods
  - Structural Improvements
  - Electrical System Upgrades & Auxiliary Systems
- Chits
- Major Milestones
- Cost Estimates
- Risk
- Summary

Introduction

- Purpose
  - To expand the NSTX operational space and thereby the physics basis for the next-step ST facilities
  - To achieve higher levels of performance and pulse duration
- Requirements Summary

	NSTX	NSTX-CSU
Plasma Major Radius [m]	0.8540	0.9344
Aspect Ratio	1.266	1.500
Plasma Current, I_P [MA]	1.0	2.0
Toroidal Field B_t [T]	0.55	1.0
Pulse Length, T_{pulse} [s]	1.0	5.0
Rep Rate $T_{repetition}$ [s]	600	2400
Center Stack Radius$R_{centerstack}$ [m]	0.1849	0.3148
Antenna Rad, $R_{antenna}$ [m]	1.5740	1.5740

CS Upgrade Scope
Machine Core / Coils

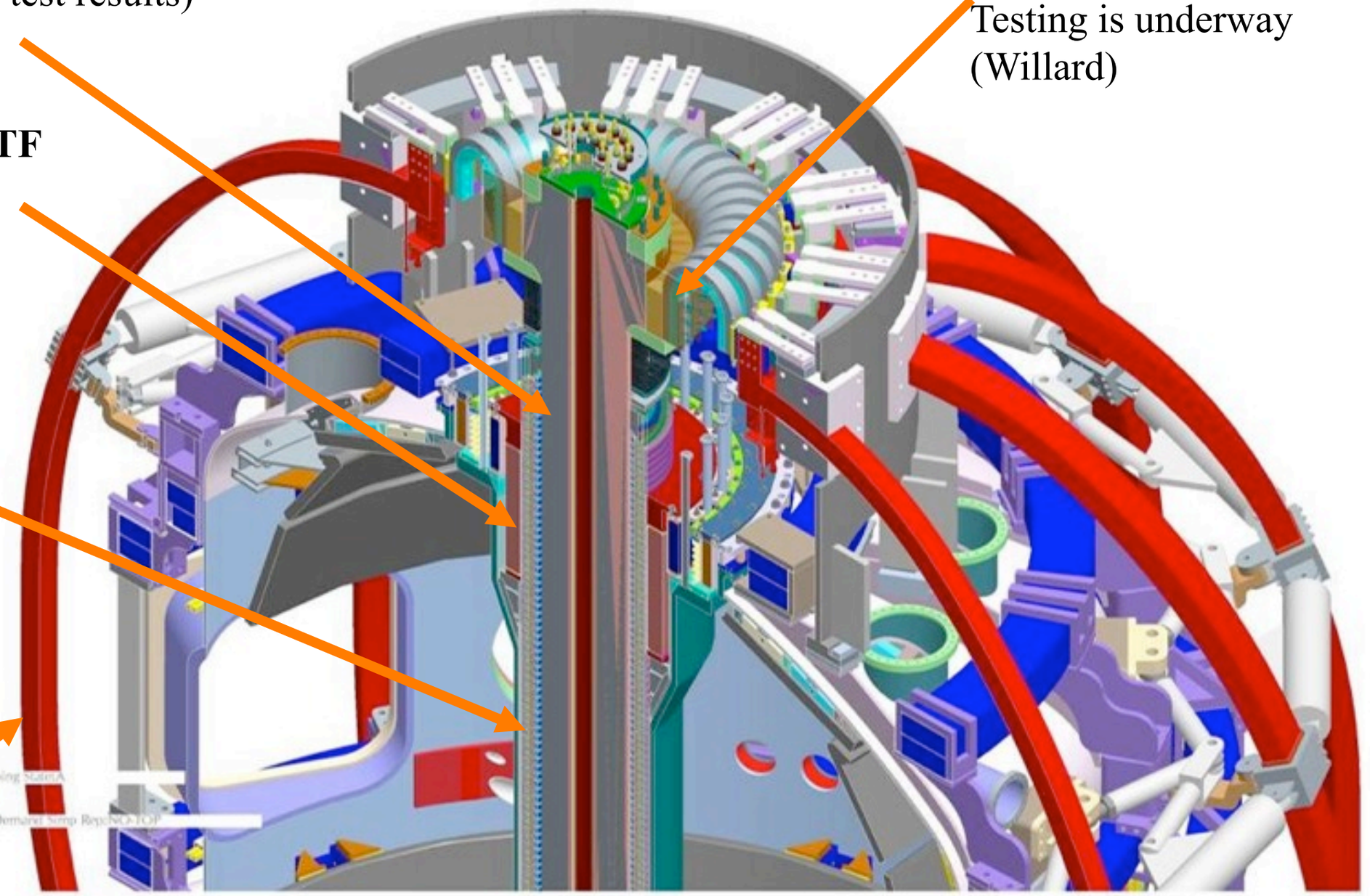
Simpler Inner TF design (Chrzanowski / Titus)
(Friction stir weld test results)

Improved Joint Design
Testing is underway
(Willard)

OH coil wound on TF
Testing Underway

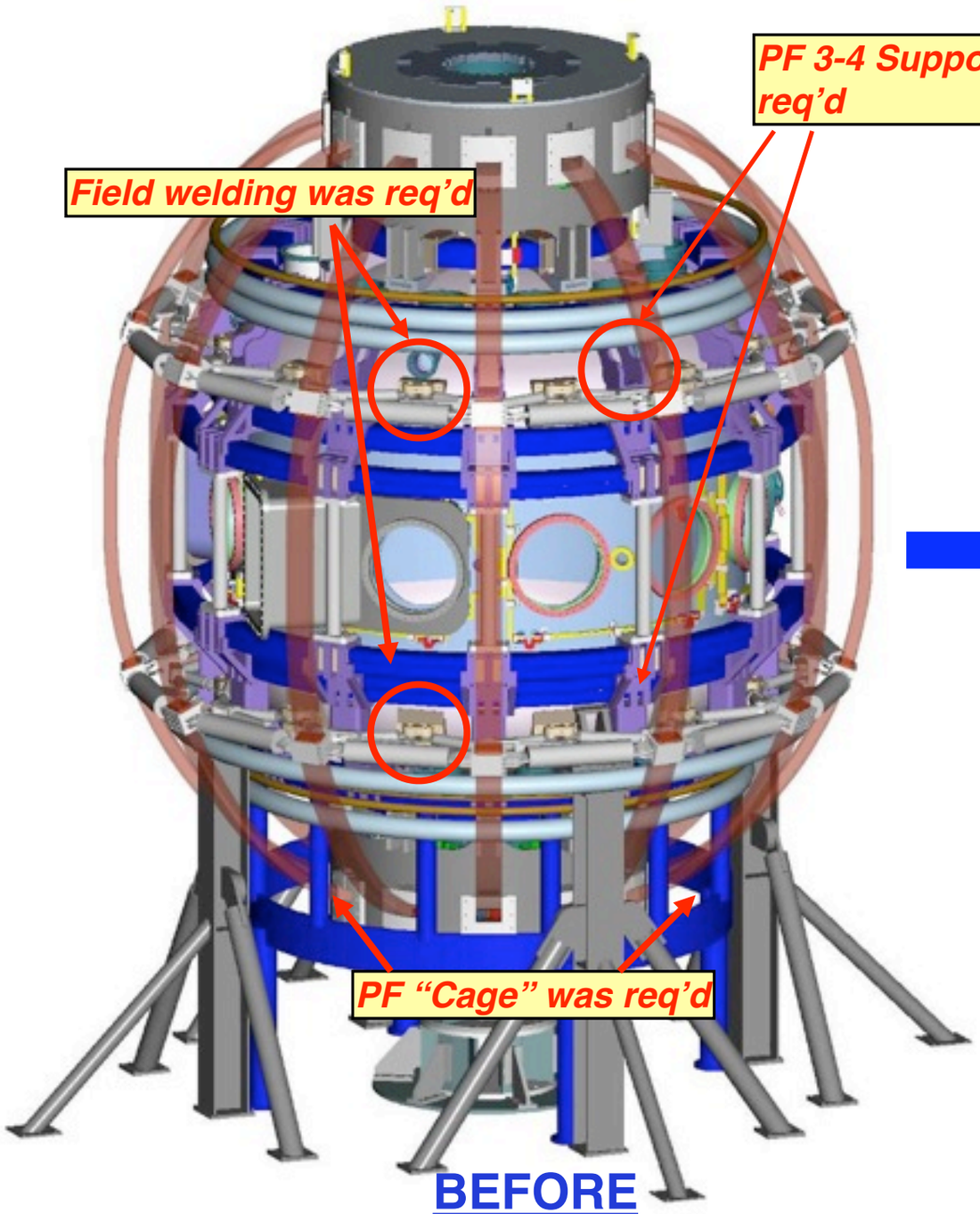
New Centerstack
Casing and Tiles
(Tresemer)

Existing outer
TF WITH water
cooling



CS Upgrade Scope
Mechanical & Support Systems (Smith / Mangra / Titus)

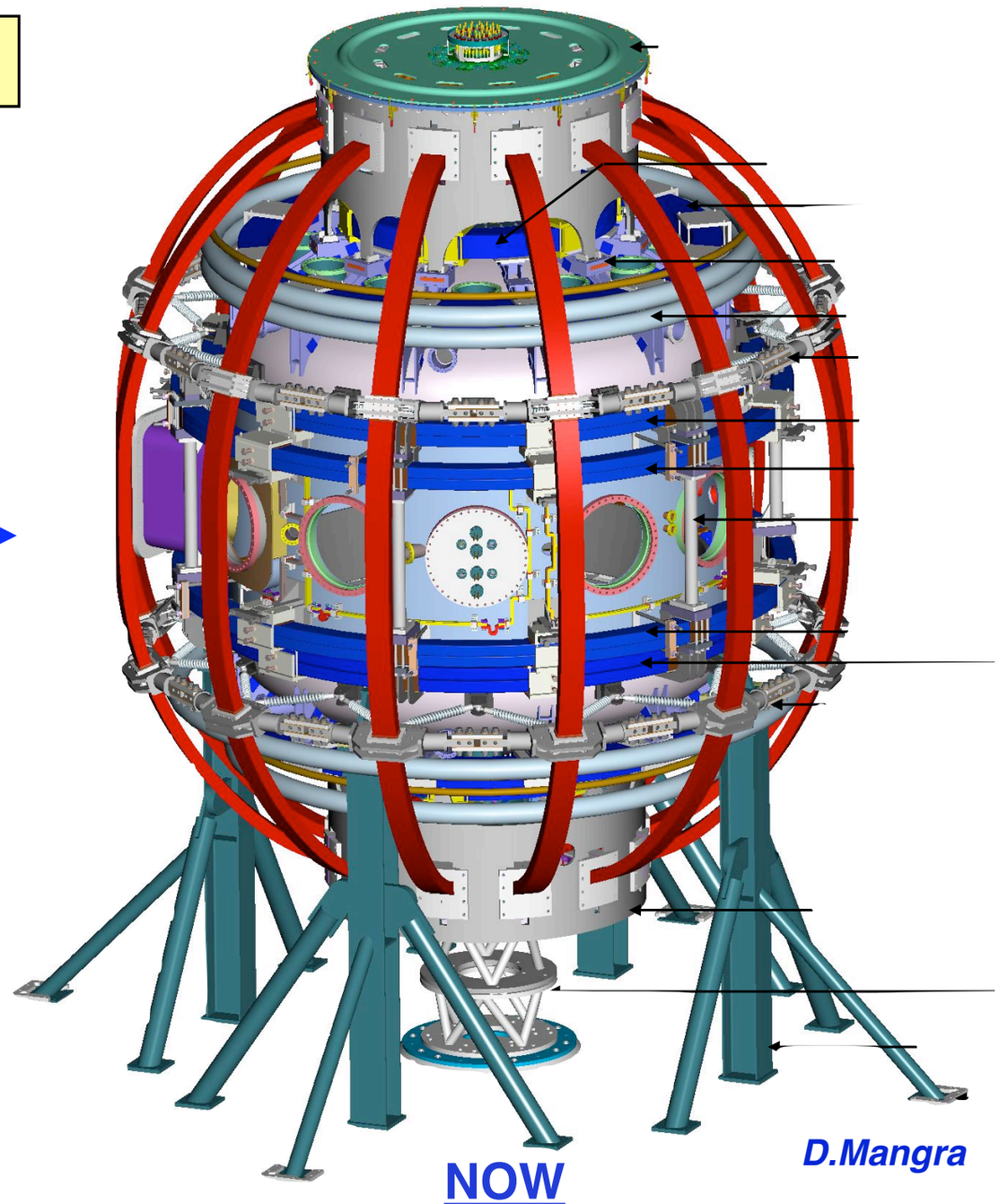
Coil Supports- Design Optimization



BEFORE

(CDR Concept)

- *PF CAGE*
- *Maximum Power Handling*



NOW

(Current Design)

- *DCPS incorporated*
- *Space compatible with existing machine and MPTS*

D.Mangra

Electrical System Upgrades & Diagnostics

- Power Feed Upgrades (Ramakrishnan)
  - Upgrade TF power supply to support full field capability of ~1T. (At ~1T, ~2.5s flattop every 20 min and up to ~5 s every 40 min)
    - Existing cables will be reconnected for TF use. Thus there will be a total of 8 cables per pole for TF.
    - Requires procurement, installation and commissioning of some additional components (CLR's, DCCTs, etc)
  - Digital Coil Protection System (Neumeyer)
    - Provides protection to structures by limiting coil currents to combinations that generate tolerable forces
- Replace Centerstack Diagnostics
  - Utilize existing design of:
    - Rogowski Coils
    - Mirnov Coils
    - Flux Loops
    - Langmuir Probes
    - Thermocouples
  - Basically a repackaging job to fit existing diagnostic designs into new tiles.

Auxiliary Systems

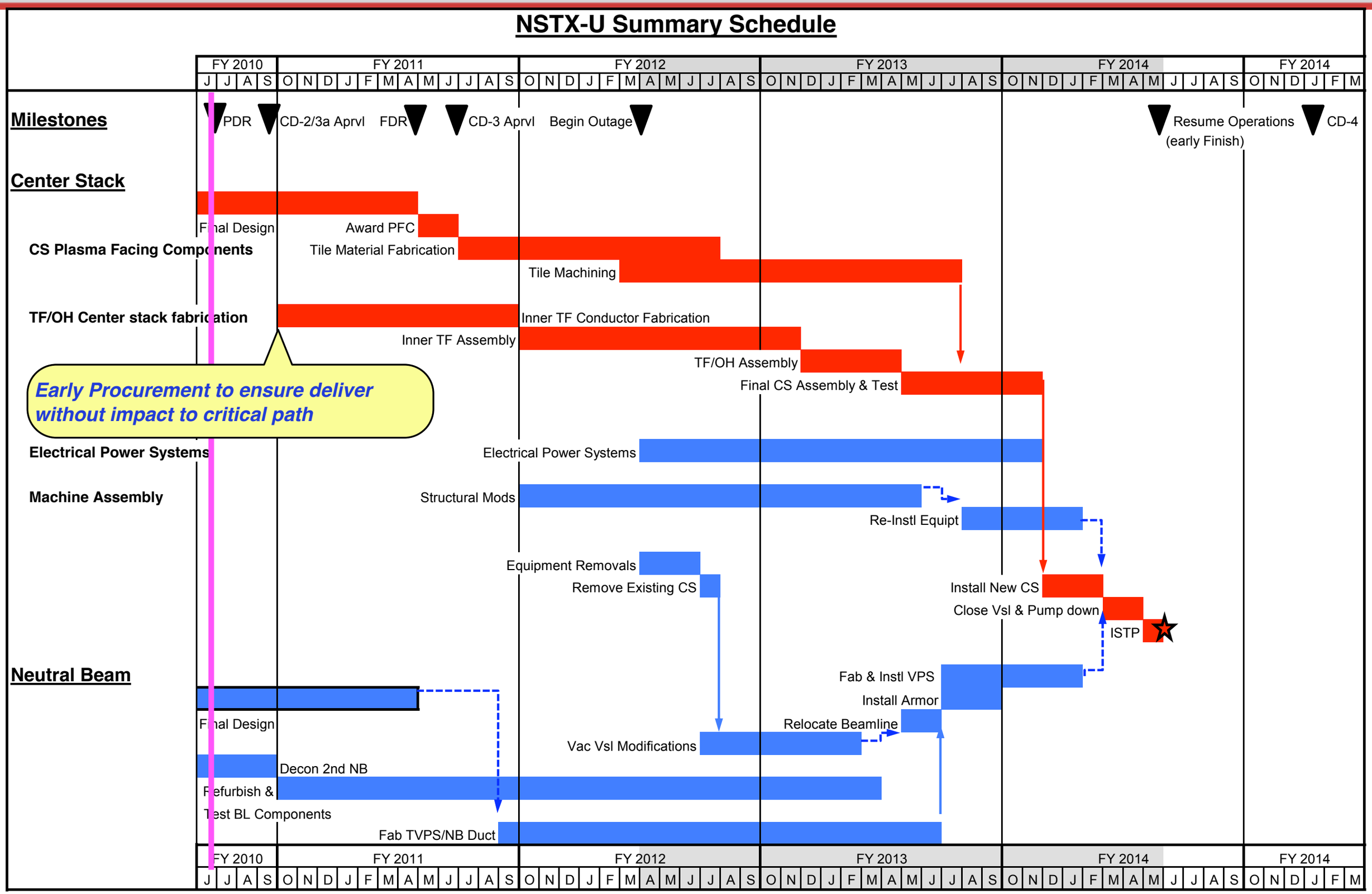
- Gas Injection Systems
  - Relocate existing center stack gas injection system to the new center stack
- Coil Cooling water modifications
  - Restoring of cooling to the outer TF legs for upgraded TF. Conceptual design required 600 psig to the OH, optimization allows operation at 400 psig.

Chits from Previous Reviews

- A second peer review of this design was held in April
- The reviewers included engineers from outside the lab
- Presentations included technical details on the analysis and the preliminary design detail
- Chits / recommendations are being collected and tracked in a log
- Chits will be discussed in detailed presentations

Review	Open	Closed	TOTAL
Aug. 2009 Peer Review	9	31	40
CDR	6	23	29
Lehman CD-1	3	9	12
April 2010 Peer Review	16	4	20

Major Milestones for Center Stack Upgrade



Cost Estimates

- Cost estimates were generated by the Job Managers with input from engineers closest to the work
- Estimates are conservative, “middle of error bars”
- Estimates are reviewed by peers at engineering review meetings
  - Estimates are refined after the meeting as result of the critique
  - Engineers Identify risks
  - Engineers are asked for input to contingency
- Depending on the work estimated, they are based on
  - Previous NSTX construction
  - Quotes from Vendors or suppliers
  - Engineering Judgement
  - Published and actual cost data (eg RS Means)
- Additional detail to be presented by R. Strykowsky

Centerstack Upgrade Risks at CD-1

- Risks are being identified, collected and tracked in a Risk Registry
- The latest Risk Registry now has 36 risks identified
- Retired Risks
  - OTF and PF Support Installation Difficulty
    - Design of the OTF and PF support structure has been greatly simplified to improve installation
      - Modular
      - Utilize space occupied by existing supports
  - The ability to find a cost effective TF Joint that works at higher fields.
    - The selected design has been verified through analysis to be far superior to the existing design for current capacity and liftoff (Willard presentation)
  - Little room to re-enforce outer TF Legs and Umbrella Structure to handle higher loads.
    - The original concept of a diamond brace has evolved to a radius rod and OTF ring
    - Uses space utilized by existing support to transfer the loads back to the VV
  - Flex Joint test stand testing more difficult and costly than planned
    - The joint testing has been simplified due to the elimination of the flag joint used in existing design. The planned tests use convention test methods which are straightforward

PDR Risks

Owner	Number	Affected Job	Job Title	Risk Description	Mitigation Plan (& job where budgeted)	Current Status
Titus	1000a	1000	Centerstack Analytical Support	Analysis indicates a significant component needs upgrade that previously hasn't been identified	Maintain upgrades of the model and keep ahead of the scenario changes	**open - we have identified and addressed all significant components, but still have new scenarios to run, (for example with plasma for the inner PF's) and calculation checking to do. I would reduce the risk to 5-20$K**
Titus	1000b	1000	Centerstack Analytical Support	Analysis indicates a minor component needs upgrade that previously hasn't been identified - weld details, details that are inconsistent with the Pro-E model	Identify these areas early with site surveys and as-builts	**open - Minor components needing work will still probably be found through the FDR and title 3. This risk cannot be retired untill after the FDR**
Titus	1002a	1002	Passive Plate Analysis	New disruption loads are beyond the capacity of the present hardware	Identify areas of concern and address during operations. Modifications to the hardware are not part of the upgrade scope.	**open - we have done a substantial amount of analysis already - sufficient for the PDR but disruptions are an active area of research and experimentation, and these efforts will continue into operation.**
Mangra	1200a	1200	Centerstack Structural Supports	All interferences with existing equipment have not been identified	Field audit of interferences is included in estimate	Retired - audit included in base estimate
Kozub	1303a	1303	TF Joint Test Stand and Testing	Significant change in TF design concept	Perform additional work	Retired - analysis completed for flex
Kozub	1303b	1303	TF Joint Test Stand and Testing	Increased number of redesign/retest cycles	Perform additional work	Retired - no longer planning cyclic testing of completed joint due to robustness of flex
Kozub	1303c	1303	TF Joint Test Stand and Testing	Unexpected technical challenges in implementing testing apparatus and procedures	Perform additional work	Retired - Tests simplified, will use MTS machine instead of test apparatus
Titus	2300a	2300	Miscellaneous small appendage reinforments on vessel	Upgrade mayn increase EM loads to small items on vessel that may need reinforcement, e.g. shutters, ECH, brackets,diagnostic supports.	Reinforce	Retired - we are surveying the diagnostics and instrumentation. There are many that will need upgrade to meet thermal limits, maybe a couple that are limited by disruptions, and some limited by radiation effects on optics. The approach I intend to follow is to identify these deficiencies to those responsible for the diagnostics and have them upgrade them as operations demand
Sichta	6100a	6100	Central Instrumentation and Control	Volume of data from diagnostic camera systems exceed capability of network, storage, and backup systems	Install 10 Gb networks and enhance storage and backup systems	Retired - audit included in base estimate
Sichta	6100b	6100	Central Instrumentation and Control	EPICS data acquisition takes too long	Include in the base job the upgrade of some data acquisition systems (CAMAC)	Retired - included in the base job
Sichta	6100c	6100	Central Instrumentation and Control	Data Acquisition period exceeds GRD requirement	Upgrade additional CAMAC systems	retired - GRD revised to specify the data acquisition period

- ***Eleven (11) risks were identified to be addressed by PDR. Eight (8) of these have been retired. The remaining four have been addressed but it is felt that more work will be required as the design is detailed.***
  - ***Minor component upgrades to weld details, etc - have addressed significant components risk has been reduced***
  - ***Disruptions Loads - a substantial amount of analysis already exists- sufficient for the PDR. Any upgrades beyond changeout of fasteners are not considered part of project scope.***

Summary

- The upgrade requirements are challenging but a conservative preliminary design is being presented
- The design is well defined and is ready to proceed to the final design level
- The upgraded TF joint, which was problematic with the original design, has evolved into a robust design with major improvement in margin
- The PF cage presented as part of the conceptual design as been greatly simplified and modularized
- The cost estimates are based on the conservative design which is being presented