NCSX Progress

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NCSX partners:

Princeton Plasma Physics Laboratory
Oak Ridge National Laboratory

Briefing for Don Erbschloe
Princeton Plasma Physics Laboratory
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NCSX Progress in Fabrication and Risk Reduction

NCSX

Topics

- **Project Objectives**
- **Component Fabrication**
  - Progress
  - Schedule issues, resolution, and recovery plans.
- **Project Management highlights:**
  - Safety management
  - Risk management

Key points

- **Component deliveries are late but vendor issues are getting resolved.**
- **Project has a sound plan to get back on schedule and meet baseline objectives.**
- **We support DOE safety and project management improvement priorities.**

NCSX Benefits to the Fusion Program

Stellarators solve critical problems for magnetic fusion.

- Steady state without current drive.
- Stable without feedback control or rotation drive. No disruptions.
- Unique flexibility to resolve 3D plasma physics issues for magnetic confinement.

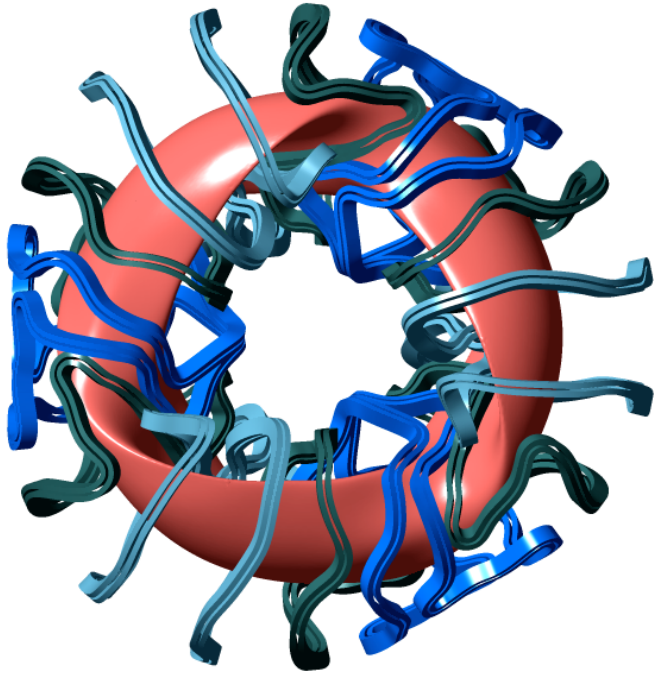
U.S. focuses on *Compact* Stellarators.

- Lower aspect ratio than other stellarators.
- Magnetic quasi-symmetry:
  - overlap with tokamak physics- makes full use of tokamak advances, including ITER's.
  - tokamak-like confinement.

3D geometry produces benefits and costs. We will quantify both.

NCSX Mission

- Attractiveness of compact stellarator for MFE.
- 3D physics for fusion and basic science.



Plasma and Coil Design for the National Compact Stellarator Experiment (NCSX)

NCSX Project is More Than 1/3 Complete

Scope

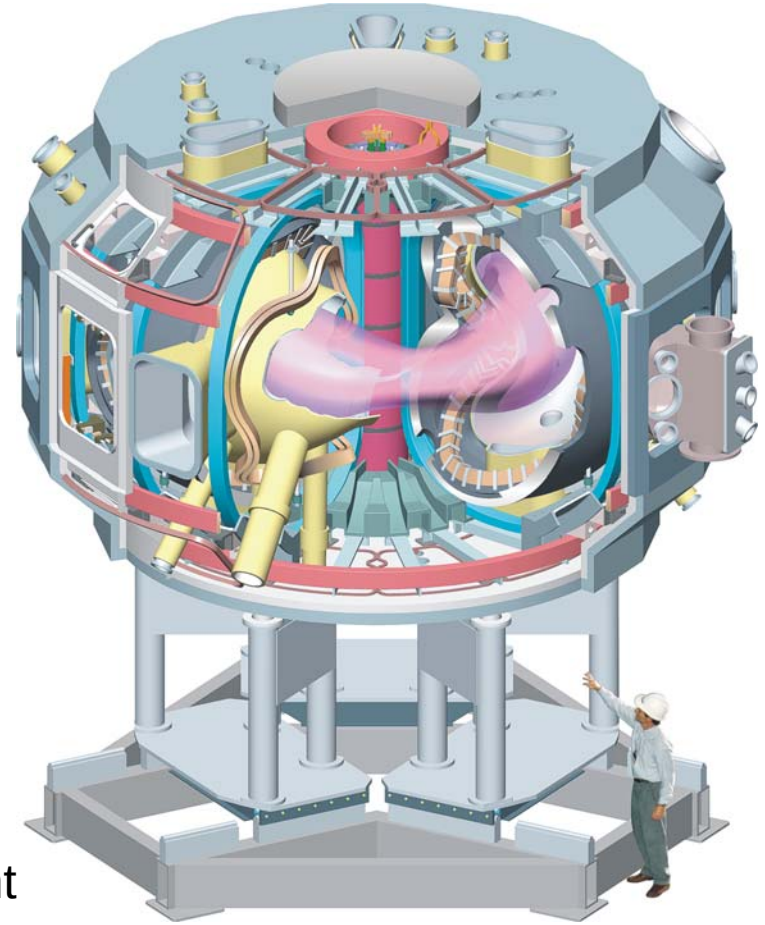
- Fabricate & install stellarator.
- Adapt existing operational infrastructure to NCSX needs.
- Test system and make first plasma.

Schedule and cost

- April, 2003 - July, 2009 (76 months)
- TEC $92.4M

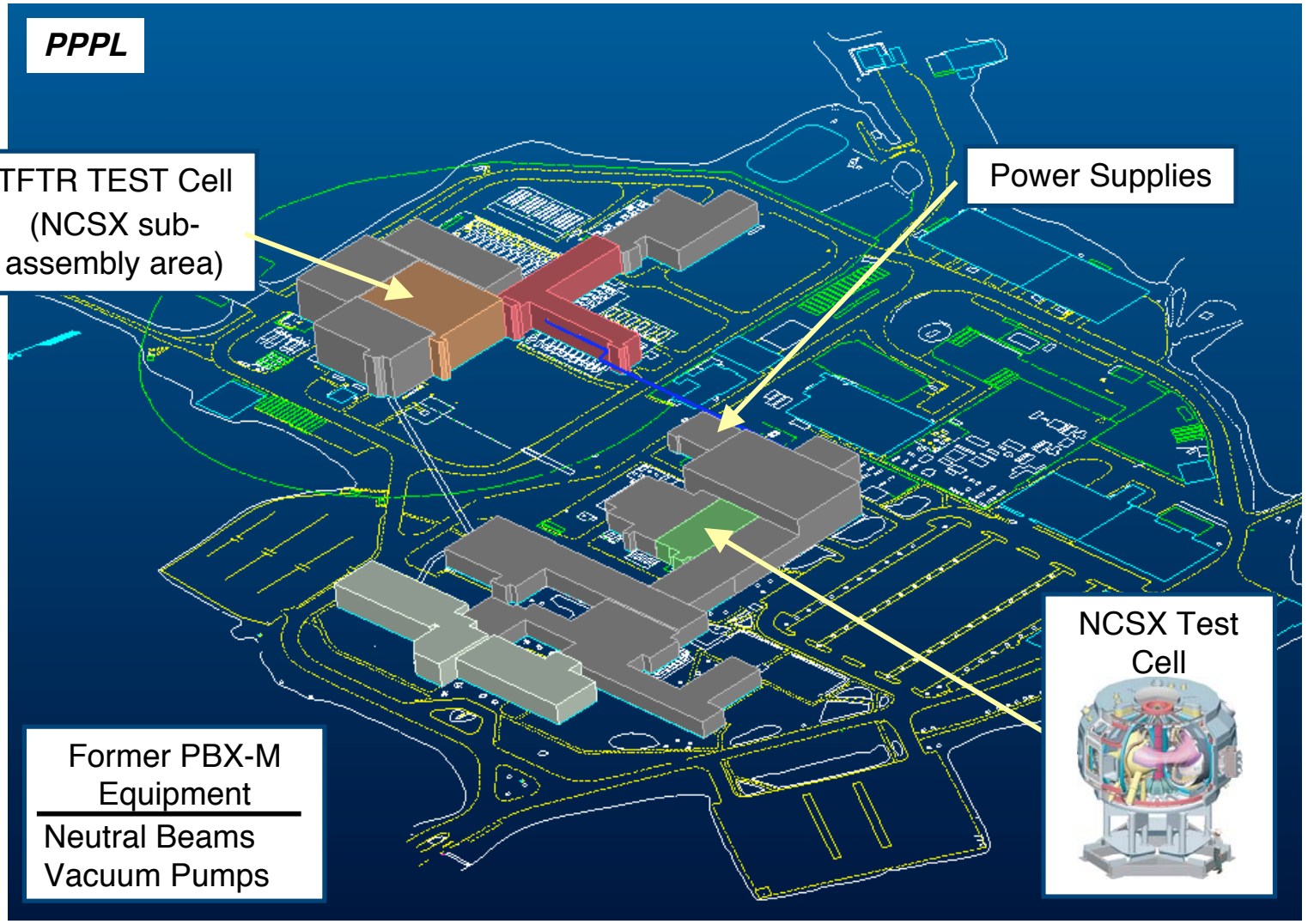
Status

- CD-3 was approved and both major component fabrication contracts were placed Sept., 2004.
  - First delivery expected this month.
- Work performed to date $35.0M (38% of TEC)

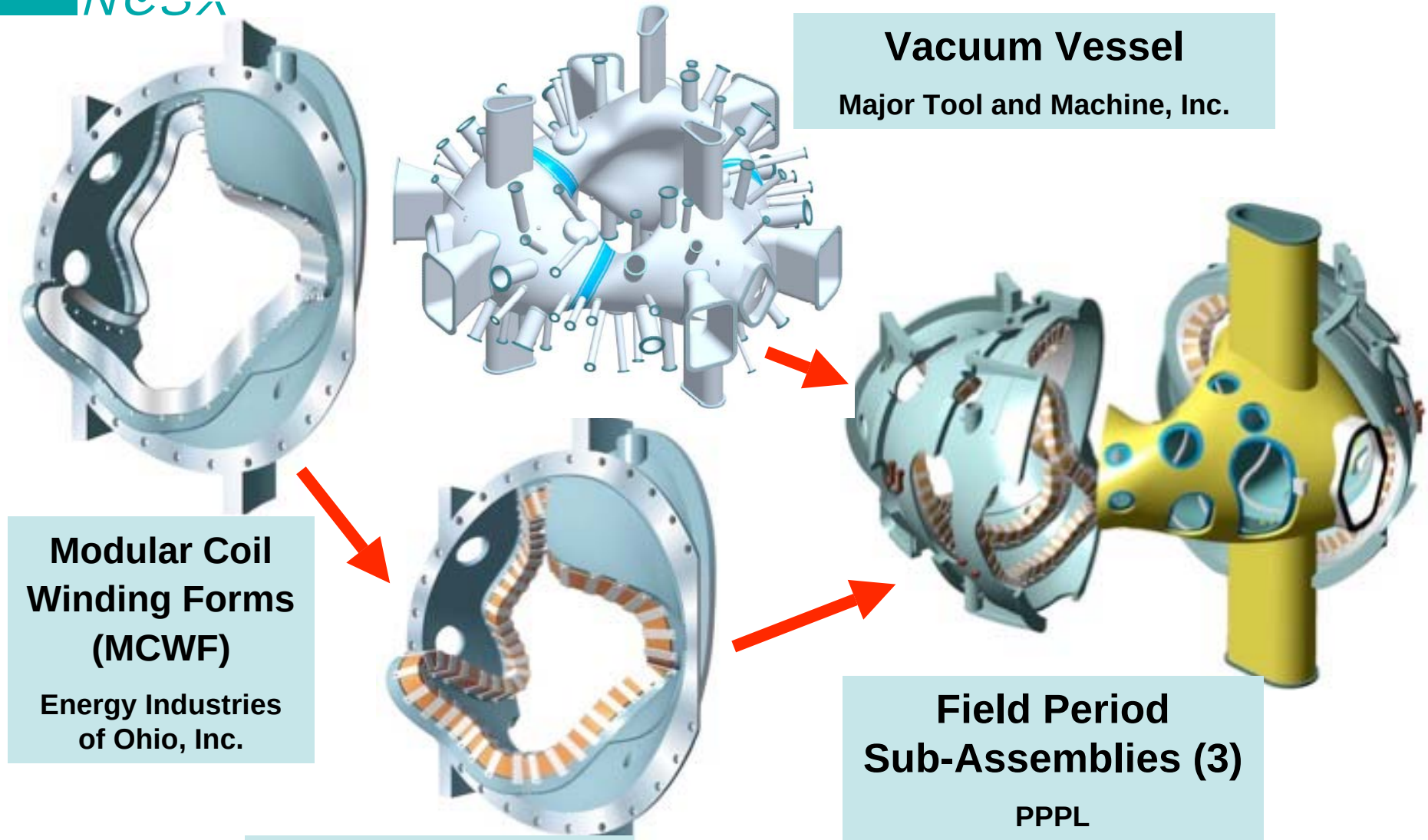


NCSX Stellarator
Major Radius 1.4 m
Magnetic Field 2.0 T
Pulse length ~1 s

NCSX Uses Existing Fusion Program Infrastructure to Reduce Costs



NCSX Engineering is Based on a Robust Concept



Vacuum Vessel

Major Tool and Machine, Inc.

Modular Coil Winding Forms (MCWF)

Energy Industries of Ohio, Inc.

Modular Coils (18)

PPPL

Field Period Sub-Assemblies (3)

PPPL

Winding form stays with the coil as part of the machine structure.

MCWF Deliveries Are 4 Months Late, But First-Unit Fabrication Issues are Being Resolved.

18 forms (3 shapes- A, B, C). Status:

- 3rd pattern (the last) ships to foundry this week.
- 7 castings have been poured (all 6 C's, 1 A).
- 3 are in machining.
- Forecast #1 delivery Sept. 23 (19 weeks late).
- Forecast #2 delivery Oct. 14 (13 weeks late).

MCWF casting ready for machining

Vendor's initial plans had to be modified to overcome issues which delayed #1 at each manufacturing step.

- Pattern-making (2 week delay)
  - now well off critical path and nearly complete.
- Casting (4 weeks delay)
  - pattern was re-worked to optimize alloy feed, reduce post-processing requirements.
- Machining (13 weeks delay)
  - hundreds of machine programs were revised to improve contour machining efficiency.

MCWF being machined

High quality is being maintained.

Some MCWF Manufacturing Challenges Remain, but Vendor Schedule Performance is Recovering

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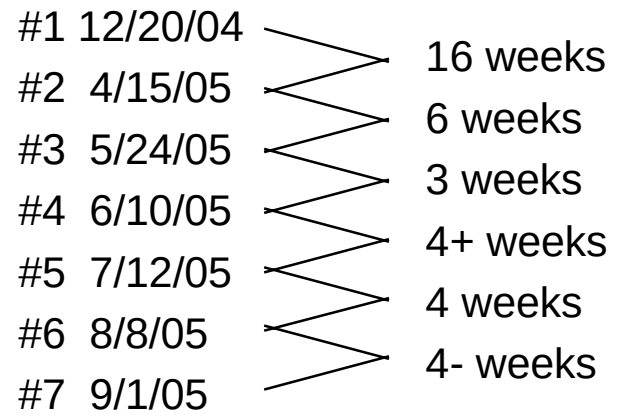
Progress…

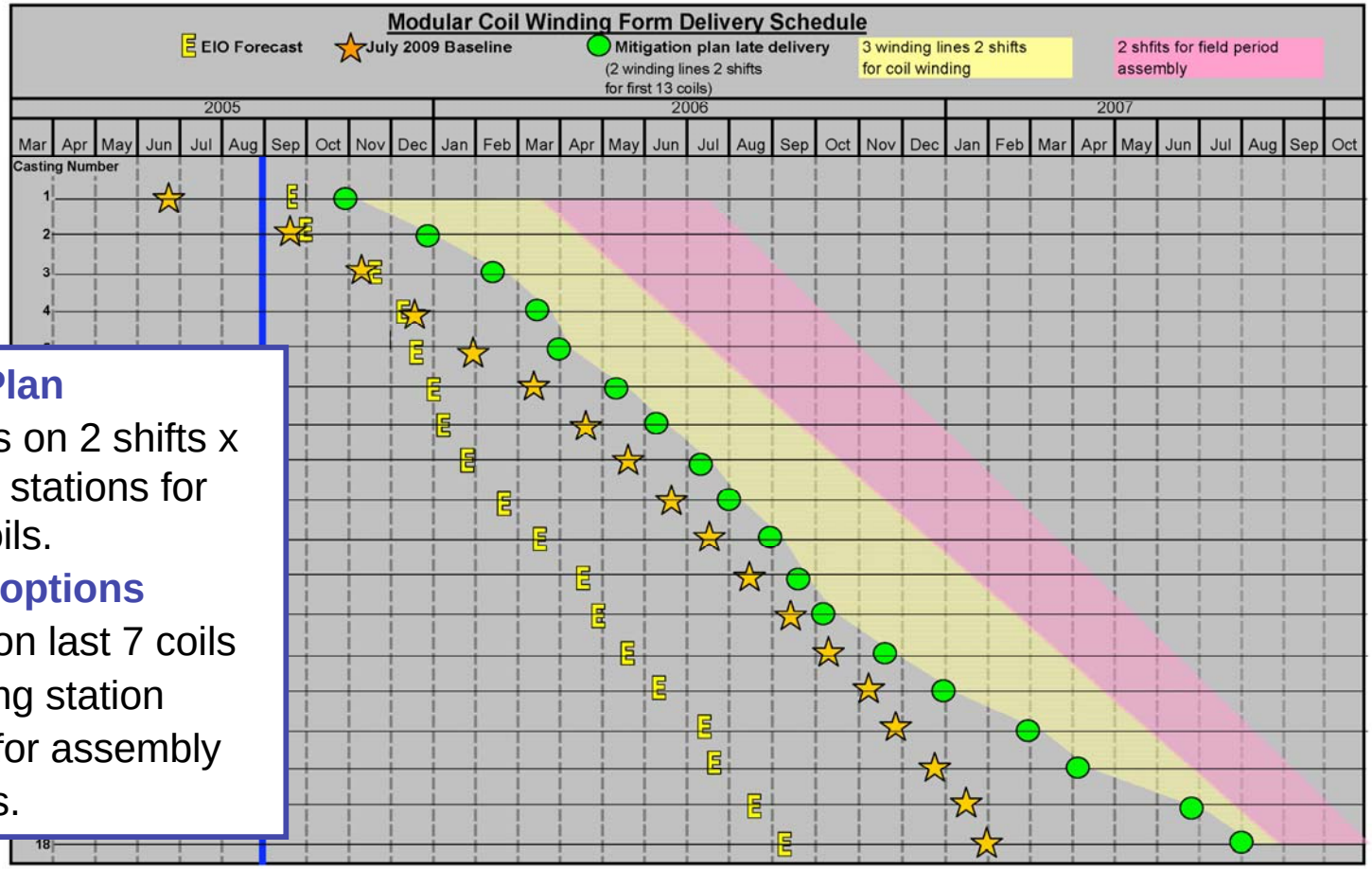
- Patterns are nearly complete.
  - First two have been successfully used. Last is in final inspection.
- Castings are being poured at a rate consistent with EIO's baseline delivery schedule.
- Casting post-processing times still need improvement.
  - Issues are now production schedule-related, not technical. Receiving plant production manager's attention and priority.
- Machining times have improved dramatically.
  - #1 is through machining, in final inspection and testing.
  - #2 is progressing with no recurrence of #1 problems. Developed solutions are working.
  - Forecast 15 weeks to machine #2 *vs.* 25 weeks for #1.
  - Expect first of each type will require some extra development time, with learning-curve improvements thereafter.

EIO Casting Pour Dates



MCWF Delivery Delays Are Accommodated within the Project Baseline

- EIO is working to get back to their original schedule (E), but project baseline (★) does not count on it. Current plan* can even absorb further delay (●).
- We will miss our FY-05 Joule target (wind 1st coil) by no more than 3 months.
- We maintain our CD-4 schedule (July, 2009) with 5 mos. contingency.



***Current Plan**

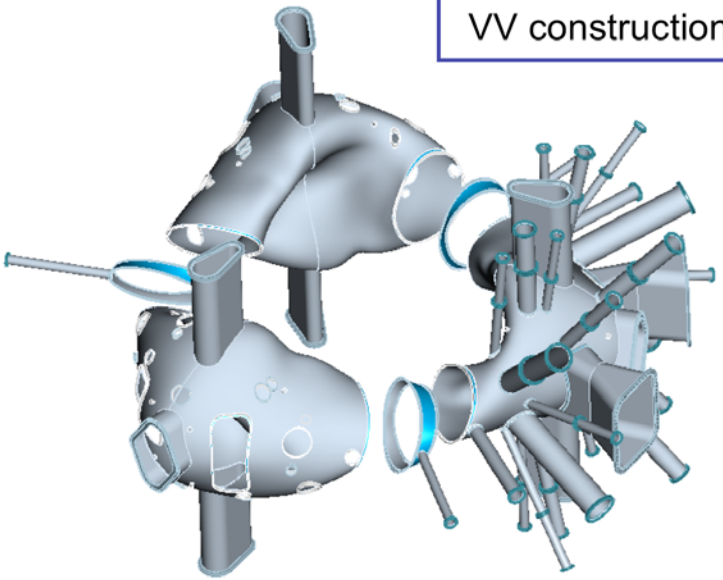
- Wind coils on 2 shifts x 2 winding stations for first 13 coils.

Reserved options

- 2nd shift on last 7 coils
- 3rd winding station
- 2nd shift for assembly
- weekends.

Vacuum Vessel Fabrication

- Shell geometry similar to plasma's.
- Panels are press-formed, welded together into sectors.
- First 120-degree sector has been welded.
- Port fabrication is in progress.



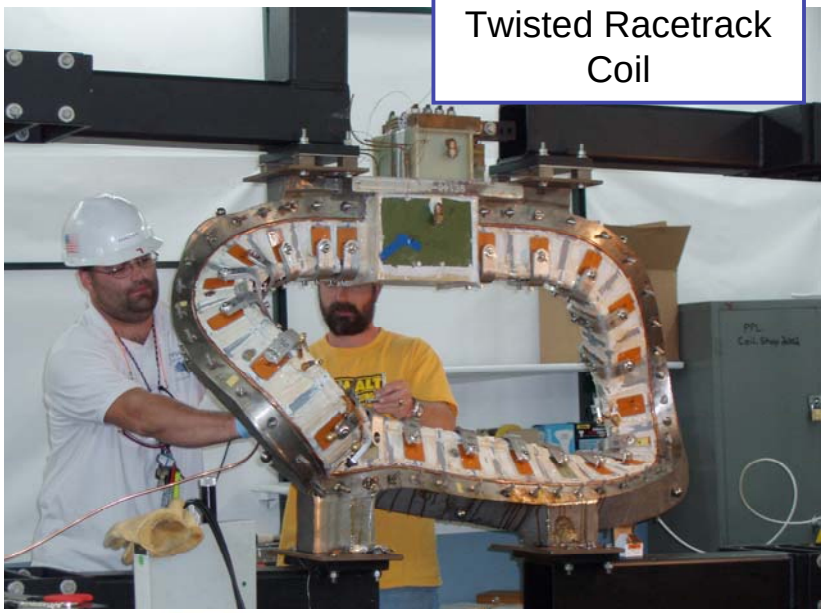
VV construction

Panel being formed

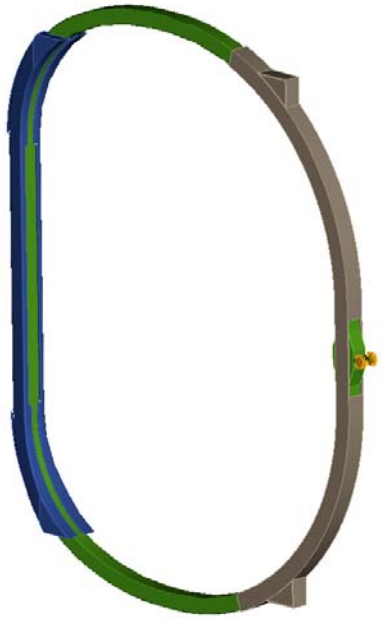
Sector fabrication

Coil Winding Preparations

- "Twisted racetrack" R&D coil was successfully fabricated.
  - Demonstrated all critical manufacturing operations.
  - Trained the staff.
  - Made changes in design details that improve manufacturability.
    - Resulting Title II design delays are accommodated by our plans.
- We are ready to wind modular coils as soon as MCWF#1 arrives.
- TF coils will also be wound at PPPL.
  - Minimizes quality risks.
  - Conductor ordered, winding table installed.

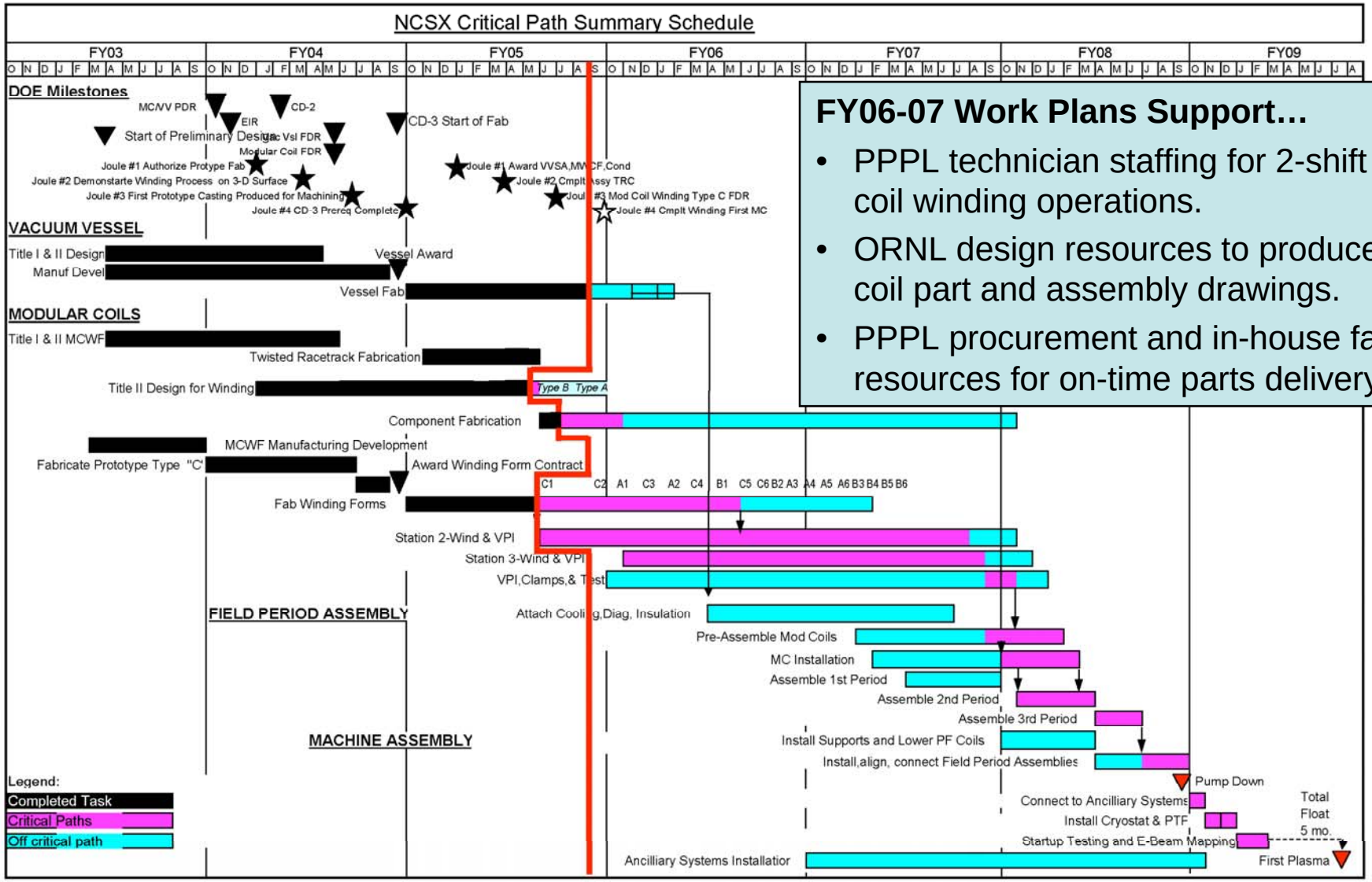


Twisted Racetrack Coil



The TF coils are relatively simple.

Coil Winding is Off to a Late Start But We Have a Sound Plan to Get Back on Schedule



FY06-07 Work Plans Support…

- PPPL technician staffing for 2-shift coil winding operations.
- ORNL design resources to produce coil part and assembly drawings.
- PPPL procurement and in-house fab. resources for on-time parts delivery.

Safety is Integrated into NCSX Work at All Levels

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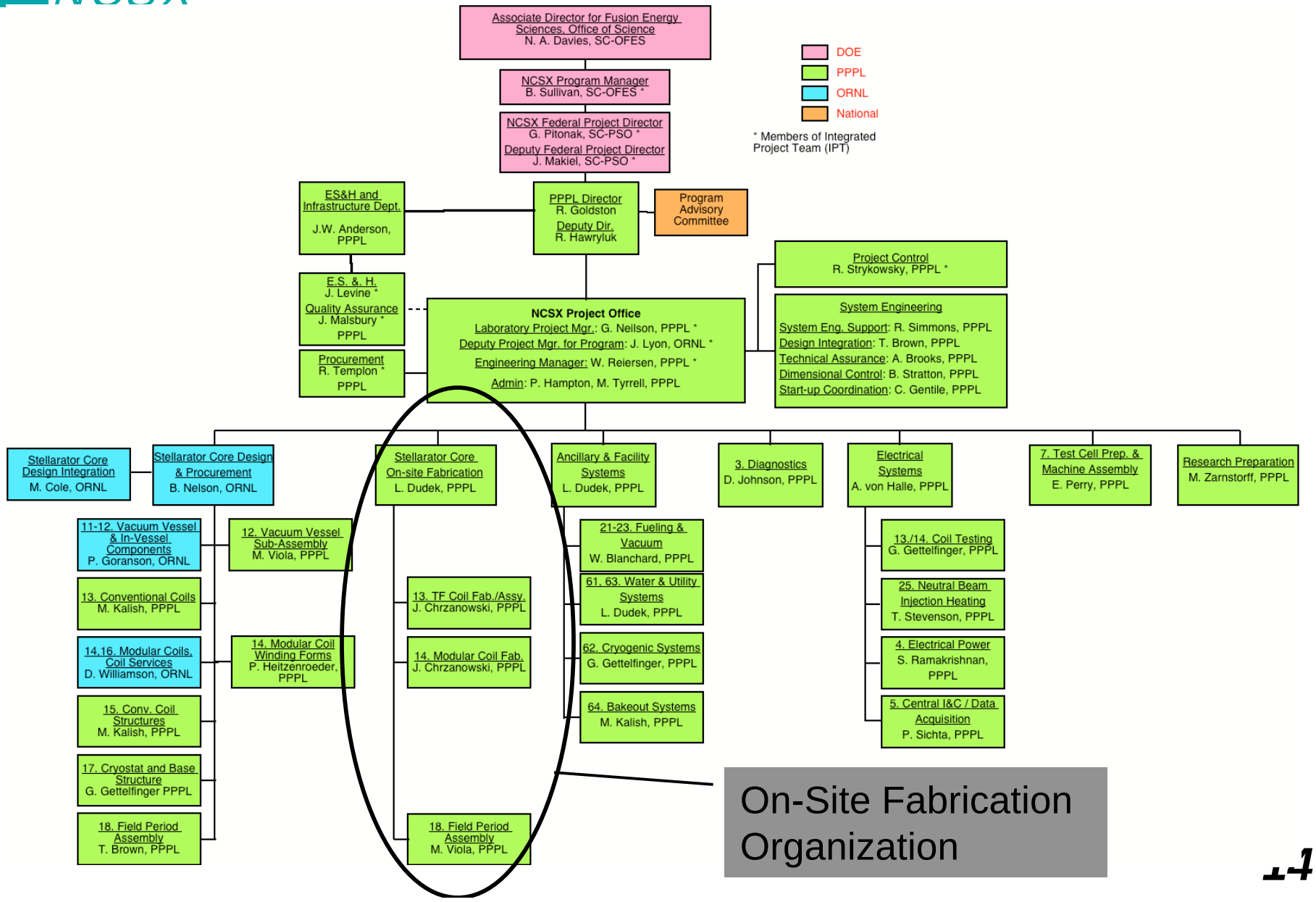
- Job Hazard Analysis checklist used for all field tasks.
- All staff taking Hazard Awareness Training (JHA-based) to improve understanding of NCSX hazards.
- Lab Activity Certification Committee (ACC) reviews NCSX manufacturing and test facilities and associated procedures prior to operation.
- Safety is addressed in design reviews and influences choices (e.g., hazards of thermal insulation options; hoisting & rigging hazards in assembly operations).
- IPT reviews or participates in safety activities as part of its management duties.
- Project organization is structured to promote safety management.
  - New NCSX on-site fabrication organization is led by a PPPL fabrication division head.
- Safety, cost, and schedule objectives are mutually supportive, not in conflict.
  - Work is done according to documented plans and procedures.
  - Project organization keeps safety, cost, and schedule responsibilities in alignment.

NCSX Project Organization



Project Risk Management Follows 413.3

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- Key technical risks (challenging geometries and tolerances) were identified during the planning stage.
  - No new risks of comparable significance have emerged.
- Risk mitigation plans, included in the baseline from the beginning, are succeeding.
  - Manufacturing processes have been developed through R&D.
  - System engineering program has maintained good control of requirements and configuration design.
    - Have avoided performance compromises and costly re-engineering.
- IPT's risk management approach is working well.
  - Continually identify, assess, and track risks using dynamic Critical Issues List.
  - Continually mitigate cost/schedule risks through value engineering and planning improvements.
  - Apply contingency when risks are retired.

Progress in NCSX Design, R&D, and Production has steadily improved plans and reduced risks.