

# National Spherical Torus eXperiment Upgrade

## Overview of Recent NSTX-U Recovery Activities

NSTX-U PAC 40 – September 11, 2019

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Stefan Gerhardt - NSTX-U Recovery Deputy Director

Updated 9/9/2019

# Outline

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- Recent Project History ←
- Scope
- Schedule

# Recovery Has Had a Sequence of Key Project Reviews in the Last 18 Months

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- February 2018 Office of Project Assessment (OPA) Phase 1 & 2
  - Concluded that PPPL should be allowed to continue Recovery (Phase 1)
  - Revalidated mission need (Phase 2).
- September 2018 Director's Review
  - Was envisioned as a prelude to baselining, however issues were identified with basis of estimate.
- March 2019 Basis of Estimate Review
  - Validated the cost estimate for the Recovery Project
- July 2019 Director's Review
  - Validated that the Project was ready to proceed to baselining
- August 2019 CDE-2/3A Independent Project Review
  - Successful CDE-2/3A IPR set the path for ESAAB approval of the baseline and initiation of procurement/fabricated for specified -3A scope
- ESAAB meeting is being scheduled

# September 2018 Director's Review Revealed Key Steps Required Before Baselineing

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- Chaired by John Post (LLNL)
- The technical scope complete at that time (PF1 coils, PFCs, PF1B power loop) was reviewed favorably and ready for CDE-3A approval
- Noted that project risks were properly identified
- Recommended revisiting reuse of existing access control system vs new system

***Project Action:*** Added the PSS WBS element.

- Key areas requiring additional development before CDE-2:
  - The basis of estimate was not yet fully documented
  - Risk mitigation strategies were not well documented

***Project Action:*** Developed new cost books with extensive documentation; held a separate Basis of Estimate review

# The Basis of Estimate Review (March 2019)

## Validated the Revised Cost and Schedule Estimate

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Chaired by Diane Hatton (BNL); R. Boivin and J. Milnes from tokamak community

1. Is there sufficient detailed information available and documented to support the cost estimates? **Met**
2. Are the estimates accurate, credible, comprehensive, and do they follow the GAO 12 Steps for Cost Estimating Best Practices? **Met**
3. Are project risks identified reasonable and included in the project cost? **Substantially Met**
4. Is the schedule resource loaded, identify a critical path, and include sufficient details to successfully achieve CD-4 on time? **Met**
5. Can you positively affirm the NSTX-U Recovery Project cost estimate is well documented, comprehensive, accurate and credible as defined by GAO-09-3SP and DOE Order 413.3B?

***Basis of Estimate Review Committee response: The BOER Team affirms that the NSTX-U Recovery Project cost is well-documented, comprehensive, accurate, and credible.***

# July 2019 Director's Review Provided Confidence that the Project was Ready for Baselineing

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- Chaired by Kem Robinson (LBNL)
- Review was comprehensive - technical, cost and schedule, risk, ES&H, management
- All charge questions answered in the affirmative except that related to Management
  - Identified the need to clarify the timing and requirements for the EVMS surveillance
  - Identified the need to formalize the documentation of project tailoring
- Project Response
  - In consultation with FES and PSO, determined to hold the EVMS surveillance later in CY 2019 (now scheduled for December).
  - Developed a formal tailoring mapping, including expanded PEP discussion

# August 2019 CDE-2/3A was Highly Successful

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- Chaired by Hanley Lee; subcommittee chairs were Cahill, Kellman, Lavelle, Prestemon, Epps
- Answered all questions in the affirmative
  - Validated the baseline, recommended moving forward on the CDE-3A scope.
- Minor corrective actions required; many good suggestions made.
- Link to web site for review:

<https://sites.google.com/pppl.gov/nstx-urecoverycde-23areview/home>

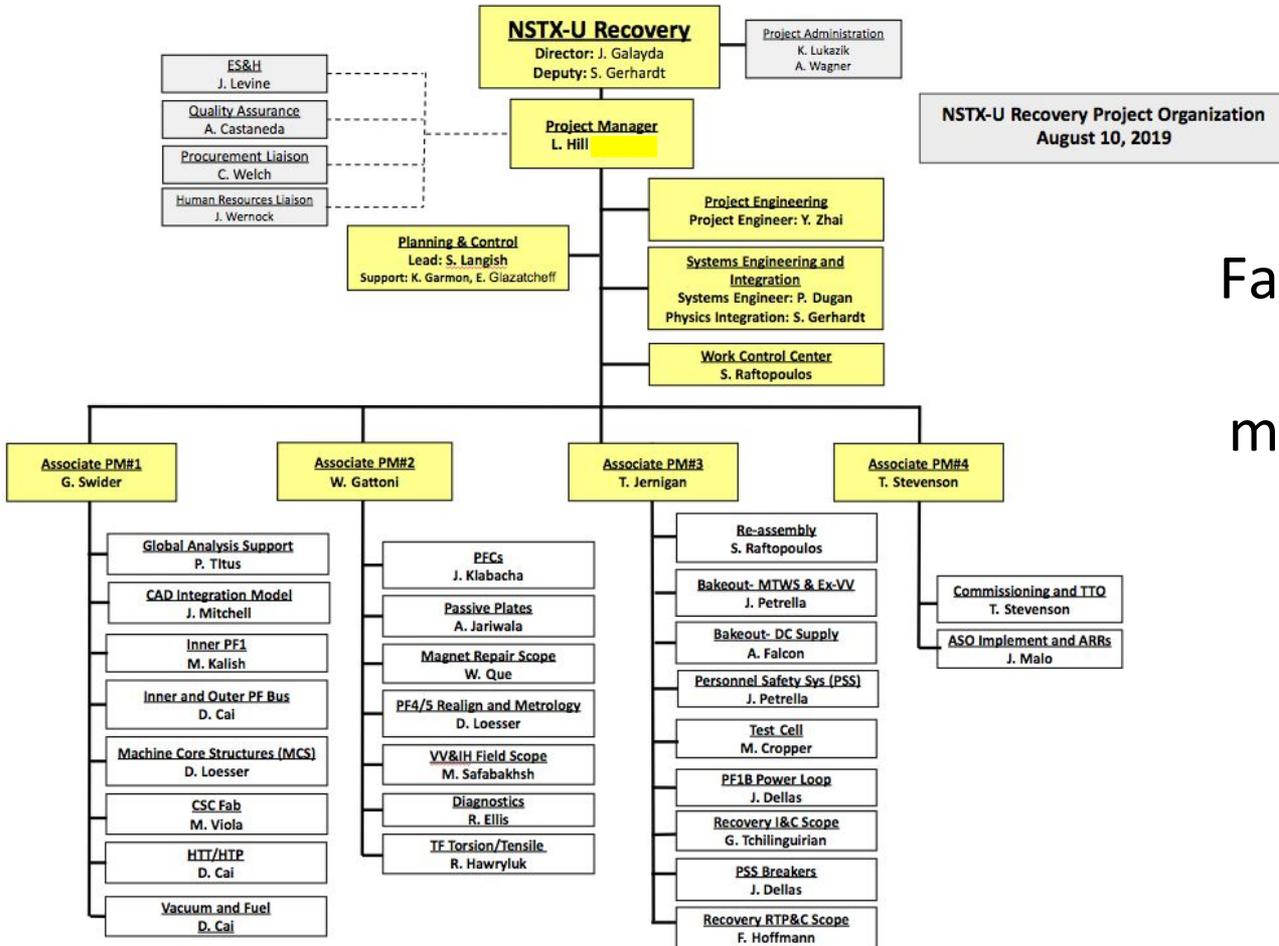
- ESAAB date being finalized - procurements can start following ESAAB

# Other News

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- Jon Menard named PPPL Deputy Director for Research in April 2019
- Rich Hawryluk was interim Recovery Project Director, March - July 2019
- John Galayda named Recovery Project Director since August.
  - Extensive experience in large DOE projects (NSLS, APS, LCLS, LCLS-II)
- Les Hill has been Recovery Project Manager since March 2019
  - Extensive experience in commercial nuclear operations and project management, DOE EM and SC projects (PPPL SLI, BNL NSLS-II)
- A new management tier of Associate Project Managers has been key to recent project success

# Present Recovery Organization



NSTX-U Recovery Project Organization  
August 10, 2019

Facility maintenance and limited targeted modernizations ongoing in parallel with the Recovery Project

# Outline

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- Scope ←
- Schedule

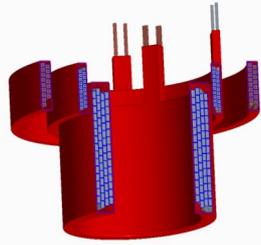
# WBS 1.01 in Machine Core Defined to Ensure High-Reliability Operations - all fully designed and part of CDE-3A

**Six new inner-PF coils**  
(PF-1a, -1b, -1c, upper and lower)

WBS 1.01.02.01

CAM: Swider

*See IPR talk by [M. Kalish](#)*

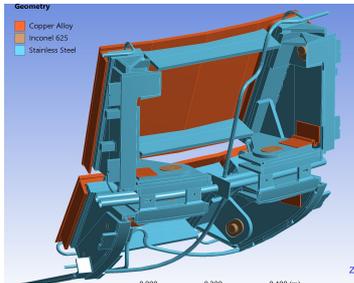


**Repairs to passive plate bracketry** to allow operation at full EM load

WBS 1.01.02.02

CAM: Gattoni

*See IPR talk by [Jariwala](#)*

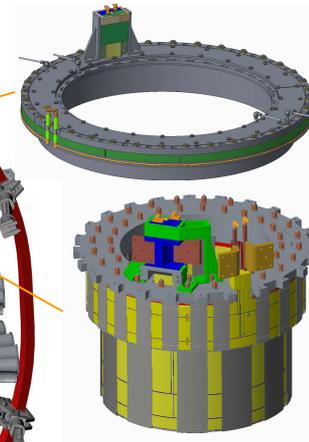
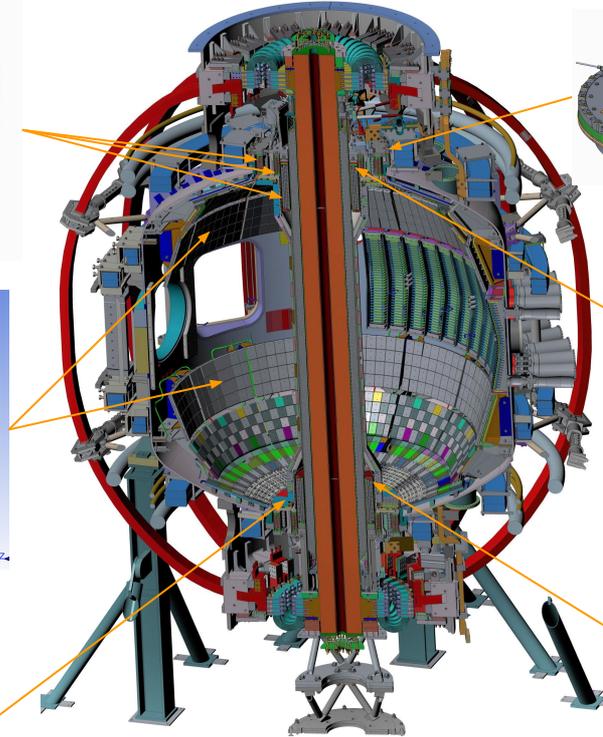
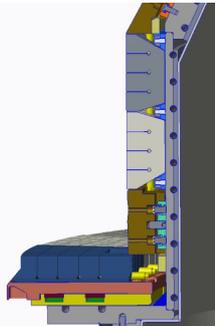


**New graphite tiles** with improved heat flux handling capabilities

WBS 1.01.01

CAM: Gattoni

*See IPR talk by [J. Klabacha](#)*



**PF-1a, -1b, -1c support structures** and double O-ring seals

WBS 1.01.02.01

CAM: Swider

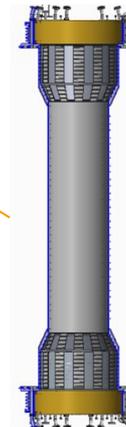
*See IPR talk by [Smith](#)*

**New Center Stack Casing** With Improved Heating/Cooling Features

WBS 1.01.02.06 and 1.01.02.04

CAM: Swider

*See IPR talks by [M. Smith](#), [D. Cai](#), and [M. Viola](#)*



*3A scope in machine core critical for achieving project schedule; tiles define critical path, but other items near*

# Recovery Project Scope includes Systems to Ensure Safe Operations

## Test Cell Shielding

WBS 1.08.01.03

CAM: Jernigan

CDE-3A Scope

Shielding scope includes construction of a labyrinth, addition of a shielding materials in various test cell windows and penetrations.

Final Design is complete

*See IPR talks by [Ascione](#) and [Cropper](#)*

## Radiation Annunciation

WBS 1.08.01.01

CAM: Jernigan

CDE-3A Scope

Install illuminated signs outside test cell indicating when the existing neutron/gamma monitors detect levels exceeding a threshold

Final Design is complete

*See IPR talk by [Cropper](#)*

## Personnel Safety System

WBS 1.09.04.01

CAM: Jernigan

CDE-3B Scope

- Configuration managed safeguards against contact thermal and electrical hazards
- A trapped key system to ensure configuration control
- A safety instrumented system for test cell access control

Preliminary Design is complete

*See IPR talks by [Petrella](#) ([LOPA](#), [PSS-SIS](#))*

## Test Cell Oxygen Deficiency Monitors

WBS 1.08.01.02

CAM: Jernigan

CDE-3B Scope

ODH monitoring system will be installed in the test cell

Preliminary Design is complete

## Medium Temperature Water System Refurbishment

WBS 1.03.01.02

CAM: Jernigan

CDE-3B Scope

Interlocks on 150 °C pressurized water systems consistent with ASHRAE will be installed

Preliminary Design is complete

*See IPR talk by [Gerhardt](#)*

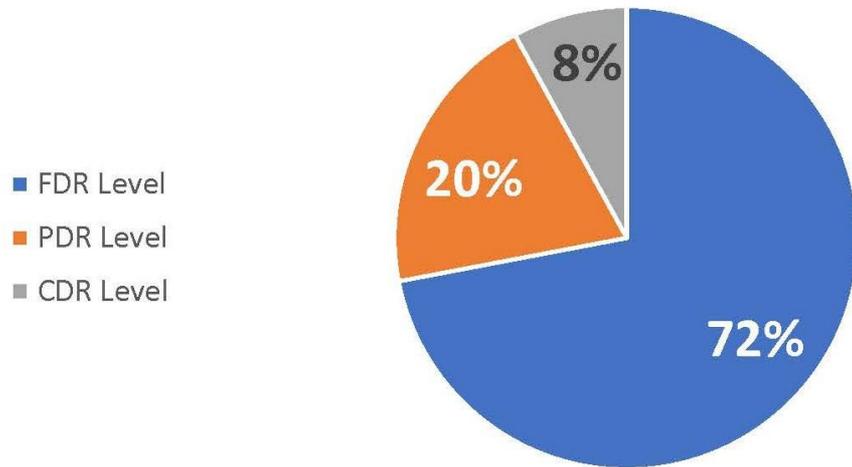
# Project Ends with Reassembly and Commissioning

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- Reassemble the device - WBS 1.09.02.01
  - Sequenced installation of tiles, magnets, buswork, etc.
  - Achieve KPP #1: Alignment of the inner-TF bundle with vertical field coils
- Implement Accelerator Safety Order - WBS 1.09.01.01
  - Write the SAD and ASE, conduct Readiness Assessment and Accelerator Readiness Review
  - See IPR talks by [Stevenson](#) and [Malo](#)
- Commission the device - WBS 1.09.03.01
  - Recommission power, control and protection systems, bakeout, coil operations, first plasma
  - KPP #2: Bakeout all PFCs  $>260\text{ }^{\circ}\text{C}$
  - KPP #3: Vacuum magnet pulse simulating 1.4 MA, 0.85 T, 4 second pulse
  - KPP #4:  $>50\text{ kA}$  First Plasma
  - See IPR talk by [Stevenson](#)

# High level of design maturity supports the NSTX-U baseline approval

## Overall Recovery Project Design Maturity as a Percentage of Cost (Aug-19)



- 72% of work packages at final design
- Project will be at 100% final design in early Calendar Year 2020, prior to the CDE-3B approval

# Large Number of Design Reviews Held Since Previous PAC

## WBS 1.1 TORUS SYSTEMS

### WBS 1.1.1 - PFCs

- [PFC FDR](#) (9/28/2018)
- [CSFW/CSAS Peer Review](#) (5/1/19)

### WBS 1.1.2-Vacuum Vessel and Internal Hardware

- [Polar Region-Inner PF Coil Supports PDR](#) (3/27/18)
- [Passive Plates & He Line Repair CDR](#) (6/8/18)
- [Passive Plates & He Line Repair PDR](#) (7/26/18)
- [Polar Region-Flanges PDR](#) (8/2/18)
- [VVIH Field Scope PDR](#) (2/23/18)
- [TF OH / Casing Trial Fit FDR](#) (4/17/18)
- [CSC Modification PDR](#) (10/16/18)
- [CSC FDR](#) (12/28/18)
- [PF-4/5 Realignment CDR](#) (10/25/18)
- [Metrology Mount FDR](#) (11/26/2018)
- [HTP HTT FDR](#) (11/1/2018)
- [PF-4/5 Realignment Peer Review](#) (5/31/19)
- [PF-4/5 Realignment PDR](#) (7/10/19)
- [Machine Core Structures FDR](#) (8/5/19 & 8/6/19)
- [PF-4/5 Realignment FDR](#) (8/9/19)
- [Passive Plate & He Line Repair FDR](#) (8/21/19)

### WBS 1.1.3 - Magnets

- [Inner PF Coil PDR](#) (12/14/17)
- [Cooling Water System Interlock PDR](#) (2/22/18)
- [Inner PF Coils FDR](#) (3/30/18)
- [Outer PF Coil Inspection / Repair PDR](#) (3/13/18)
- [TF/OH Bundle Reliability PDR](#) (4/3/18)
- [Inner PF Prototype Coil Power Test FDR](#) (5/9/18)
- [Inner PF Water Fitting FDR](#) (1/4/19)
- [PF Bus Work PDR](#) (2/28/19)
- [TF Inner Bundle Review #1](#) (4/9/19)
- [TF Sample Fabrication Peer Review](#) (4/17/19)
- [TF Inner Bundle Review #2](#) (8/7/19 & 8/8/19)

## WBS 1.3 AUXILIARY SYSTEMS

### WBS 1.3.1 Bakeout

- [HTHS Feedthrough PDR](#) ()
- [Gas Piping PDR](#) (1/11/18)
- [Ex-VV Heating System PDR](#) (2/1/18)
- [Bakeout DC Connection PDR](#) (4/5/18)

### WBS 1.3.3 Vacuum and Fueling

- [Interspace Pumping FDR](#) (2/20/19)
- [Private Flux Region Mechanical PDR](#) (04/19/19)

## WBS 1.4 PLASMA DIAGNOSTICS

- [PFC Diagnostics PDR](#) (1/4/18)
- [Machine Instrumentation PDR](#) (3/22/18)
- [PFC Diagnostics FDR](#) (3/29/2019)

## WBS 1.5 POWER SYSTEMS

- [PF1B Power Circuits PDR](#) (2/27/18)
- [PF1B Bipolar Circuit FDR](#) (9/20/18)
- [Breaker Upgrade/Refurbishment FDR](#) (7/12/2019)

## WBS 1.6 CENTRAL I&C

No Recovery Project Design Reviews

## WBS 1.8 SITE PREPARATION / ASSEMBLY

- [NTC Shielding PDR](#) (8/6/18)
- [Machine Reassembly PDR](#) (8/1/18)
- [Test Cell Radiation Annunciator & O2 Monitoring PDR](#) (8/14/18)
- [NTC Shielding FDR](#) (1/14/19)
- [Test Cell Radiation Annunciator FDR](#) (2/12/19)

## WBS 1.9 Site Preparation and Assembly

### WBS 1.09.02 NSTX-U Reassembly

- [Reassembly PDR](#) (8/1/19)

### WBS 1.09.04 NSTX-U Personnel Protection System

- [PSS CDR](#) (12/13/2018)
- [PSS Requirements Peer Review](#) (5/8/19)
- [PSS PDR](#) (6/26/19)

### WBS 1.10

- [Shorted Turn Protection CDR](#) (5/9/2019)

## Maintenance and Run Preparation Reviews

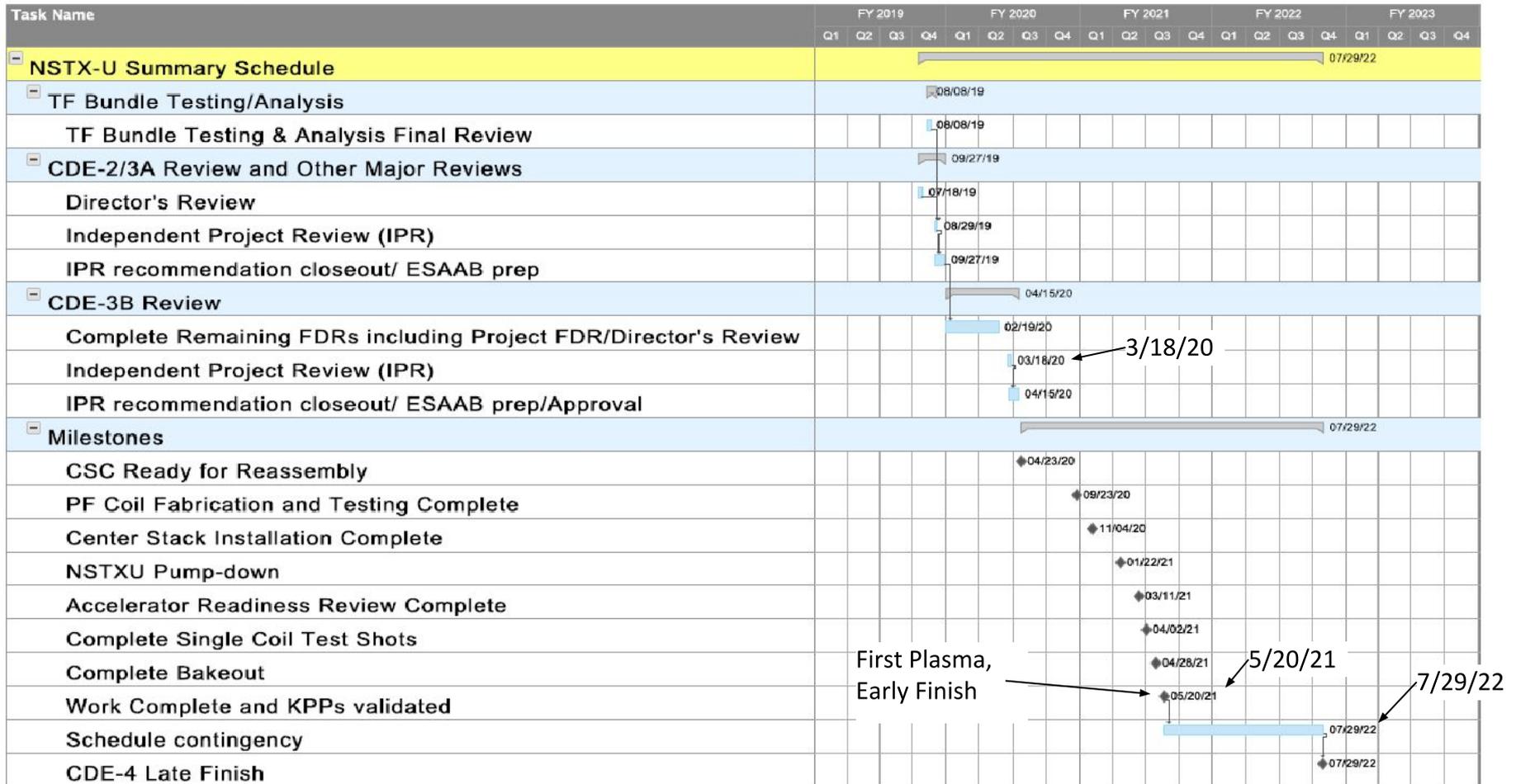
- [CAMAC Phase 1 PDR](#) (2/16/18)
- [GDC Anode PDR](#) (4/19/18)
- [Bakeout PLC Upgrade PDR](#) (5/10/18)
- [GDS Expansion Tank Burst Disc FDR](#) (5/29/18)
- [CAMAC Replacement FDR Phases 1 & 2](#) (6/26/18)
- [CAMAC Replacement Pilot FDR Phase 3](#) (6/6/18)
- [SAD-2 FDR](#) (12/14/2018)
- [TVPS Backing Pump FDR](#) (1/12/19)
- [NTC Network Expansion \(CWDM\) FDR](#) (6/24/2019)

# Outline

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- Recent Project History
- Scope
- Schedule ←

# Schedule Includes all Scope and Results in May 2021 Early Finish Data for Completion of the Work



First Plasma, Early Finish

3/18/20

5/20/21

7/29/22

# Largest, most complex CDE-3A contracts are now in place, balance managed under Critical/Advanced Procurement Plan

PFCs	Plasma Facing Components	Critical/Advanced Procurement Plan
PF Coils	Inner PF Coil Fabrication	Contract awarded
MCS	Machine Core Structures	Critical/Advanced Procurement Plan
CSC	Center Stack Casing Fabrication	Contract awarded
HTT/HTP	Heat Transfer Plate/Heat Transfer Tubes	Contract awarded
PP	Passive Plates	Critical/Advanced Procurement Plan

# Summary

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- Project has have achieved a high level of design maturity
- Project management systems have matured and are functioning well
- Project is attacking the final design activities and moving into the execution phase

*Plan to deliver NSTX-U as a world-class spherical torus user facility in 2021*