Central Instrumentation and Controls - WBS6

P. Sichta
and the NSTX Upgrade Team

Princeton Plasma Physics Laboratory
NSTX Upgrade Project
Final Design Review
LSB, B318
June 22-24, 2011

College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
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LANL
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Nova Photonics
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IPP, Garching
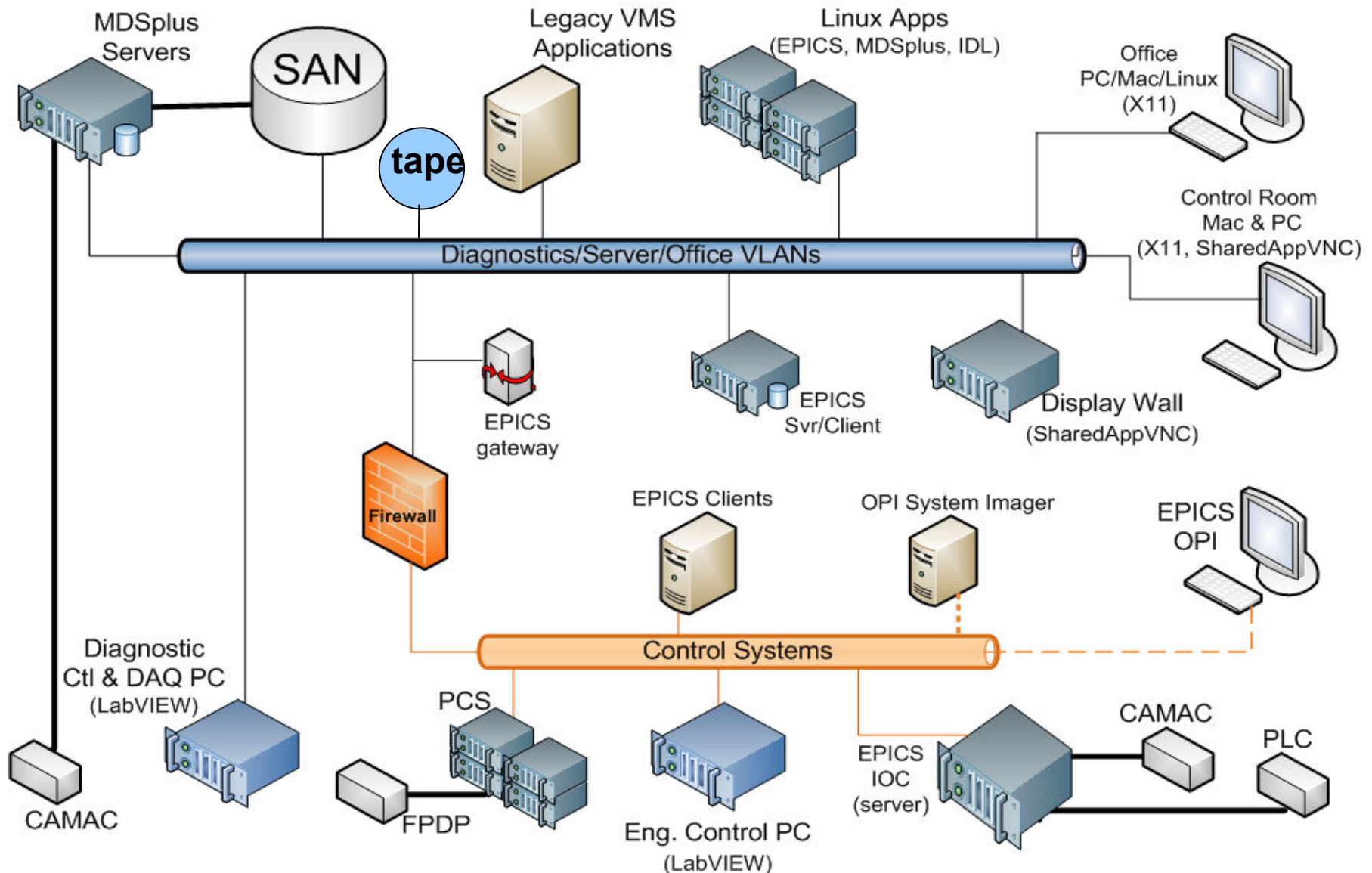*ASCR, Czech Rep*
U Quebec
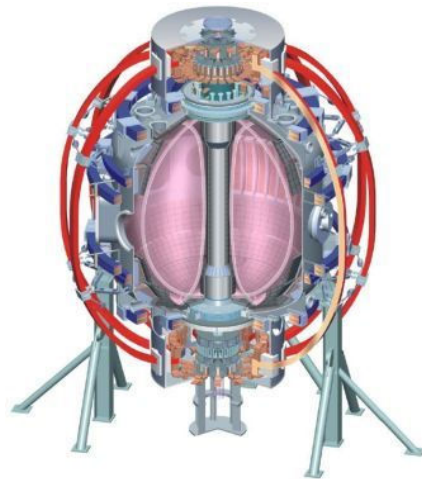
Agenda

Requirements

Scope of Work

Update since PDR

Cost & Schedule

* Supplemental material available

NSTX Computing, Controls, and Data Acquisition

Overarching Requirements

- Pulse Length: The pulse length drives real-time control, data acquisition, analysis, networking, and storage.
    - Currently, a 'long' plasma lasts ~1.8 seconds.
    - GRD Design Requirement: **6.5 second plasma**.

- Quality of Service: The *timeliness* of data acquisition, analysis, and visualization should not degrade from the pre-upgrade experience.

Central I&C (WBS6) Work Breakdown

- Real-Time power supply and plasma control.

- Data acquisition.

- Networking & data management.

- Re-commission relocated racks.

  - Communications, Controls, Timing

Real-time Controls

- The current 8-core real-time system (circa 2006) is at-capacity for processing.
    - The longer pulse length, new algorithms, and additional I/O will overwhelm the current system.

- Tasks:
    - Procure RT computers
    - Migrate software to 64-bit operating system
    - Implement new control algorithms for NSTX-U
    - Support additional Input/Output points
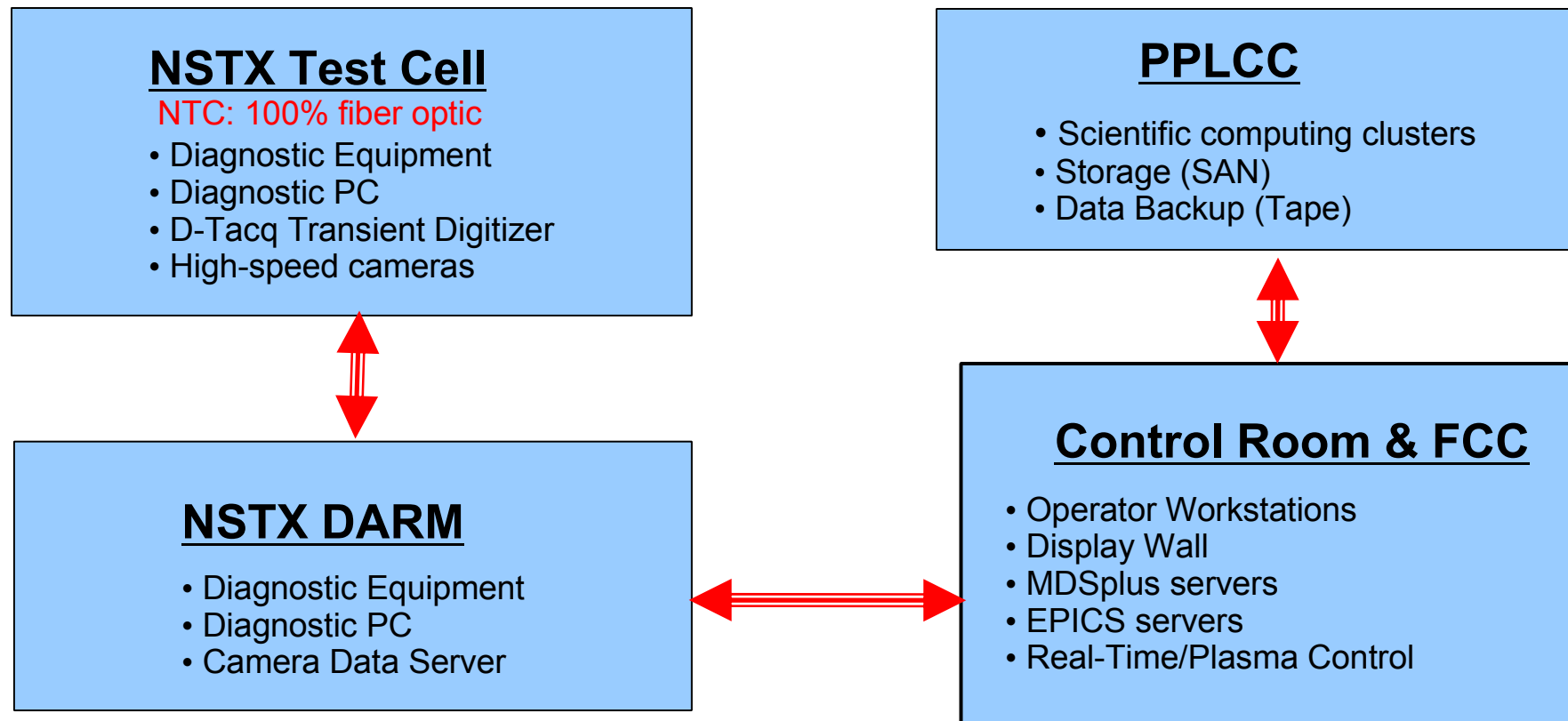
Data Acquisition: Reduce Role of CAMAC

Pre-upgrade (Oct. 2010)	Post-Upgrade (Sept. 2014)
(**100**) 908/3232, (**43**) 907, (9)6810, (9) TR612	(**34**) 908/3232, (**25**) 907, (9) 6810, (9) TR612
1500 channels, 77 MB	**860** channels, 70 MB
•MDSplus ACQ: 2.5 minutes •EPICS ACQ: 7.5 minutes	•MDSplus ACQ: 2.5 minutes •EPICS ACQ: 5 minutes
	•(11) D-Tacq Networked Digitizers. •(3) PXI-based systems • (24) One Mega-sample memory boards (CAMAC)

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CAMAC Transient Digitizer Replacement

- ## CAMAC digitizer migrations

  - (11) D-Tacq @ ~$16K each

  - (3) PXI (for NB) @ ~$20K each

  - (12) FCPC Fault Detector solution - free

- ## Systems designated for CAMAC upgrade

  - FCPC at Junction Area (1)

  - Magnetics (7)

  - TF Joint data (2)

  - EIES (Edge Impurity Emission Spect.) (1)

  - NBI (existing beamline) (3)

Network & Data Storage

- October 2010 baseline: 1 Gbit/sec "uplinks"; *presently saturated.*

- NSTX-U will need 10 Gbit to support 5-10x data/shot

- SAN Storage and data backup infrastructure adequate.

  - 4x fewer shots/day (full power shots).

NSTX Test Cell

NTC: 100% fiber optic
- Diagnostic Equipment
- Diagnostic PC
- D-Tacq Transient Digitizer
- High-speed cameras

PPLCC

- Scientific computing clusters
- Storage (SAN)
- Data Backup (Tape)

NSTX DARM

- Diagnostic Equipment
- Diagnostic PC
- Camera Data Server

Control Room & FCC

- Operator Workstations
- Display Wall
- MDSplus servers
- EPICS servers
- Real-Time/Plasma Control

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- WAF: Labor and M&S revised; cost unchanged.

- Test Cell rack-relocation effort for *drafting* was over-estimated. This work is covered by WBS2 (2490).

- CAMAC data acquisition upgrade more extensive than preliminary design.

  - More aggressive in response to recommendations/chits.

  - Retired risk 6100c, "Data acquisition takes too long".

  - Design based on *in-depth analysis* of CAMAC data acquisition considering: free slots in CAMAC Crate, amount of data, time to acquire, importance of data.

  - The final design choice (from numerous candidate systems) fell towards the more expensive end (technically superior).

  - (25) one mega-sample CAMAC memory boards are required (prelim count was 10).

WBS6 Cost & Schedule

- ## Cost: ~$900K

  – An additional $400K for *required workscope* will be funded by 'Operations' (detail in *Supplemental* section). This work would be required regardless of the NSTX-U project.

- ## Schedule

  – Final Design Review June 2011

  – Work on-hold until Summer 2013

    • WBS6 post-hold *Peer Review* May 2013

  – WBS6 ready to support ISTP in Aug. 2014

    • ISTP sched for Sept. 2014

    • Only ~1 month sched. contingency. See Risk Registry 6100d.

Risk Registry

Updated	Number	Risk Description	Mitigation Plan/Impact	Deadline to retire risk	Cost incurred plan	Status	likely hood	Cost impact ($K)
12/08/09	6100a	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	FY10 PDR	FY13	RETIRED	U	30 to 200
12/08/09	6100b	EPICS data acquisition takes too long	Include in the base job the upgrade of some data acquisition systems (CAMAC)	FY10 PDR	FY13	RETIRED	VL	10 to 100
12/08/09	6100c	Data acquisition takes too long	Upgrade additional data acq systems and/or networks, revise software	FY11 FDR	FY11	RETIRED – *pending 5/17/2011*	VU	5 to 25
07/25/10	6100d	Loss of key personnel	**Assure project schedule has free float to absorb potential schedule impact**. Hire replacement and assess schedule impact	CD-4	FY14	**Open-** *Sichta to recommend rescheduling some tasks (real-time controls)*	U	10 to 50
07/25/10	6100e	NSTX operations does not fund the work scope as listed in WBS6100 PDR and FDR	Continued diligence to assure the program office provides funding for the required infrastructure improvements. Otherwise, there will be additional work scope for upgrade.	CD-4	FY14	**Open**	U	50 to 300

Recommendation Log
(all have been *Closed*)

Date Ref	Item/Concern	Comment/Action	Status
200908-02	NSTX-U pulse length will increase 5x. Increasing memory of CAMAC likely does not increase speed of data read-out and archiving. Should consider options that can return data as fast as we presently archive instead of 5x longer.	Additional CAMAC replacements have been included in baseline estimate	*CLOSED*
200908-24	Evaluate eliminating CICADA with state of the art equipment	Eliminating all CAMAC is out of scope for the NSTXU work-scope describe in the GRD. Some CAMAC systems will be converted to modern technology in order to maintain present data acquisition performance.	*CLOSED*
200911-24	Consider alternate solutions to the I&C system other than CAMAC. It is old and frought with problems and difficult to debug failures. Now may be the time to replace	The GRD has been revised to specify that the post-shot data acquisition and analysis time should be the same as before the upgrade. The design presented at the PDR will consider this.	*CLOSED*
200911-32	Consider replacing data acquisition and I&C CAMAC systems with something more modern and reliable.	See 200911-24	*CLOSED*
201004-10	Is the 10Gbit/sec network required as part of the GRD?	Yes. The 10 Gbit is an implementation to satisfy the requirement that data acquisition, analysis, and visualization should not be degraded (in light of 4x data load).	*CLOSED*
201004-15	Resolve I&C requirements. Paul should estimate scope as presented and resolve during a WAF review meeting.	WAF updated and reviewed prior to PDR.	*CLOSED*

Summary

- Work organized in a CAM-developed WAF. Cost and schedule integrated into the project's Resource Loaded Schedule and regularly reviewed.

- Contributions to the estimate were provided by an experienced engineering staff with specialized knowledge in distributed control systems, Plasma Control, EPICS, and MDSplus software, as well as NSTX operations.

- Ongoing, operations-based computing and control upgrades that will support NSTX-U have been identified and estimated. These are required to fulfill the GRD but are not included in the NSTX-U scope of work.

Supplemental

GRD Excerpt

3.6 Central Instrumentation & Control (I&C) System (WBS 6)

a. The Central I&C system shall provide the same functionality as existing except for the change in pulse length and repetition period. To accommodate the full interval of coil current rise and fall the time interval of real time control of the plasma and power suppliesshall be extended to 10s. Nominal repetition period in this mode of operation shall be 2400s, upgradeable to 1200s as described in section 2.4.

b. The baseline set of individually controlled power supply circuits is the same as the existing NSTX device. However, feedback control of individual branches of the TF converter will be necessary, adding to the number of measurements and feedback loops to be managed by the real time control. The details of this requirement will be determined during the design process.

c. With the future addition of the PF1BU, PF1CU, and PF1CL circuits, the real time power supply control shall be expandable to include these three additional measurement and feedback loops.

d. Other control, monitoring, and data recording-analysis-management services provided by Central I&C, which includes some diagnostics, shall be upgraded to accommodate a 5 second plasma.

e. The time required for post-shot data acquisition and the presentation of between-shots analysis shall be comparable to the pre-upgrade time.

Basis of Estimate

- Follow established NSTX-U project methods

  - Detailed Work Approval Form (WAF) developed including task descriptions, labor estimate by demographic, M&S detail, key risks and uncertainty.

  - WAF incorporated into project Resource Loaded Schedule (RLS).

- Catalog prices and prior purchases

- Similar tasks previously executed

- Engineering judgment

Central Computing *Attribute* and *Plan* for longer plasma pulse

Real time plasma control	• Longer control period. • Additional algorithms and I/O (2nd NB).
CAMAC data acquisition	• Migrate selected systems to newer technology. • Develop 1 MegaSample Memory board. • Improve CAMAC data acquisition performance. • Deploy UNT Clock Receivers.
Data acquisition and management (currently <10 GB/shot)	• Data load up 5-10x • Buy more disks • Improve networking • Upgrade nstxpool & MDSplus services
NSTX networking	• Deploy 10 Gbit/sec networks
NTC Rack Moves	• Rack moves covered in WBS2 "No engineering required". • Support designers.
Center Stack Thermocouples	16 additional Class 3 TC's

Data Acquisition, Data Storage and Management

Issue	Approach
CAMAC Memory - The CAMAC crates do not have room for more memory modules.	Develop a (high-density) 1 megasample CAMAC memory module
CAMAC serial Highway - The throughput is too low.	Reduce the amount of CAMAC data by migrating selected CAMAC-based systems to current technology-based data acquisition systems.
Camera-based diagnostics' data acquisition and file transfer timeliness exceeds the present capability.	Upgrade the networking and computing capability of the present systems.
Post-shot data analysis and visualization timeliness exceeds the present capability.	Upgrade the networking and computing capability of the present systems.
EPICS CAMAC acquisition slow	Reduce CAMAC data load, improve software, upgrade IOC servers.
5-10x data per shot will place additional burden on IT Division infrastructure for data storage (SAN) and data backup systems	•Issue somewhat mitigated because of 4-5x fewer shots (45 min. between full power shots). •For operations: consider adding intteligence to data acquisition to acquire limited data for shorter shots.

Required NSTX-U Workscope funded by Operations

These would likely occur regardless of NSTX-U. Total ~$400 K

- PCS real-time computer upgrade (more CPU/cores)

- PCS real-time software port to 64-bit OS (memory > 4 GB)

- FPDP_IO support for digital (Transrex) Firing Generator

- Diagnostic CAMAC replacements

- EPICS CAMAC acquisition speedup

- 10 Gbit networking

- Upgrade nstxpool computers

Drawing Summary

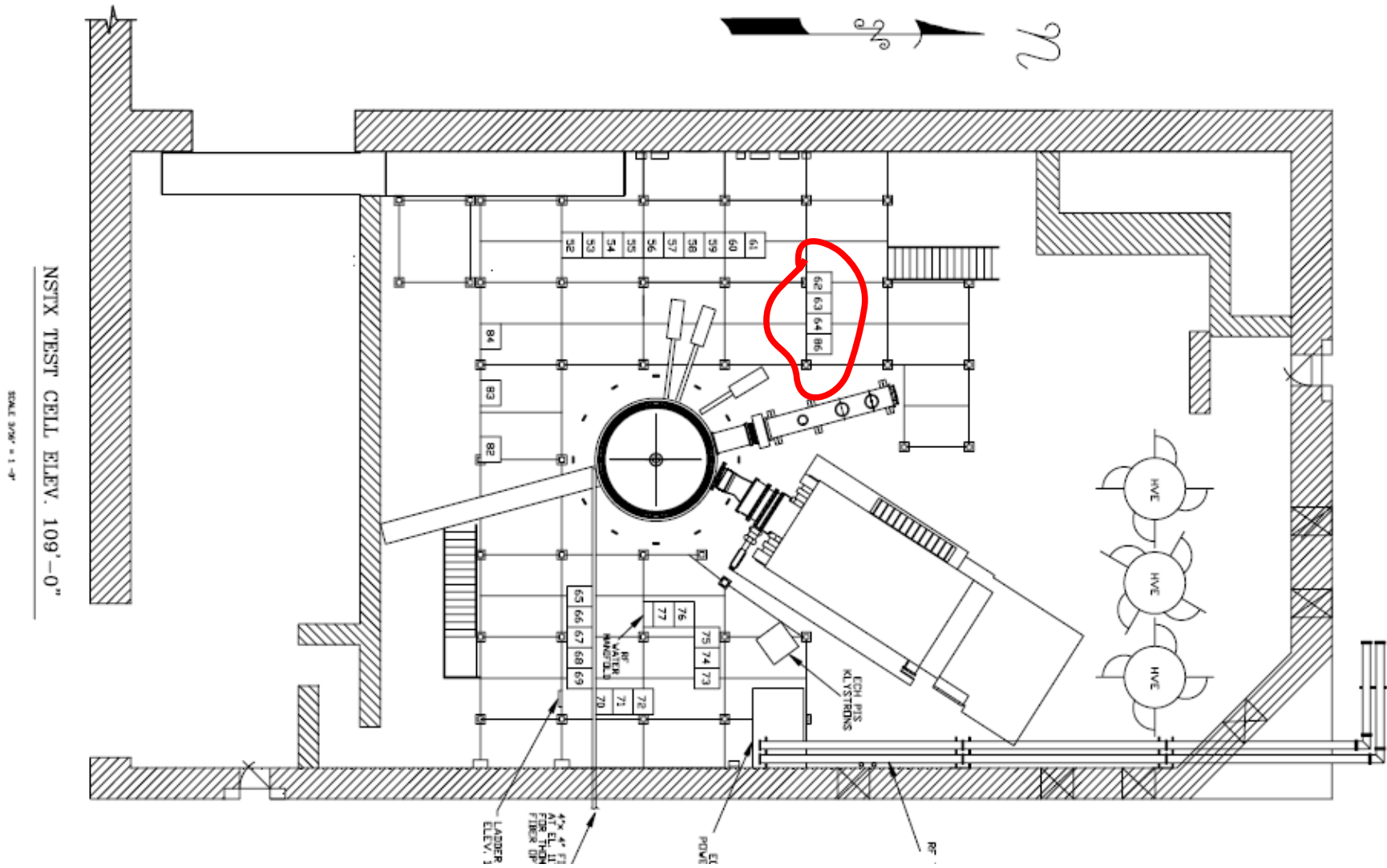| Description	#dwgs	#prepared	#approved
CAMAC 1 MS Memory Board	15 new	15	15
CAMAC to D-Tacq	7 new	0	0
CAMAC to PXI	4 new	0	0
Rack relocations	7 rev.	0	0
Thermocouples	2 rev.	0	0

CAMAC One mega-sample Memory Board
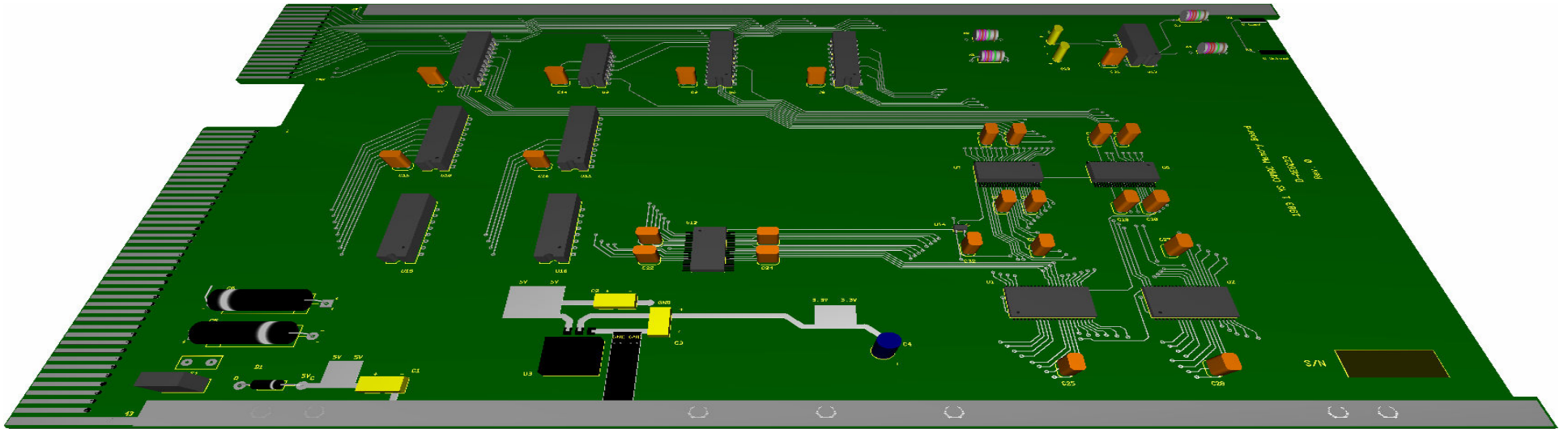
Center Stack Thermocouples

- In addition to the former CS thermocouples (TC)

  - (16) new Type "E" TC

  - CWD's forthcoming from Kaita/Tresemer

- I&C workscope:

  - Add H359 Instr. Ampl. module to class3 TC CAMAC crate

  - Revise CAMAC dwg A-AE1026

  - Revise EPICS databases, displays, SNC program, trending/archiving.