ACORN and IOTA/FAST Collaboration

Christian Roehrig
IOTA/FAST Collaboration Meeting 2024
14-March-2024

In partnership with:

Outline

- Project overview

- Research and development plans

Accelerator Controls Operations Research Network (ACORN)

- The ACORN Project is a DOE O413 project that will modernize the laboratory's **accelerator control system** and replace end-of-life **accelerator power supplies**.

- Approve Mission Need (CD-0) was approved August 28, 2020.

- Approve Alternate Selection and Cost Range (CD-1) is projected to occur Q3 FY24 (June 2024).

- Total Project Cost (TPC) range: 100 – 142M$

- Project Completion (CD-4): 2028 – 2030

Project Motivation

- "ACNET was developed four decades ago and uses hardware that is no longer available and software that is no longer maintainable. It cannot provide the large data rates that are necessary to enable the use of AI/ML applications for more efficient and reliable operations."[1]

- "Many of the accelerator power supplies that drive the accelerator complex have exceeded their useful life, are not designed to modern safety standards, and cannot be controlled with the speed and precision needed for future accelerator operations. "[1]

- "Modernized control and power systems for the complex will provide for more efficient, cost effective, and reliable operations while significantly reducing the risk associated with the failure of end-of-life accelerator components. Modernized systems will address the requirements for greater spatial and temporal granularity needed to operate the complex at the higher beam intensities that are provided by PIP-II."[2]
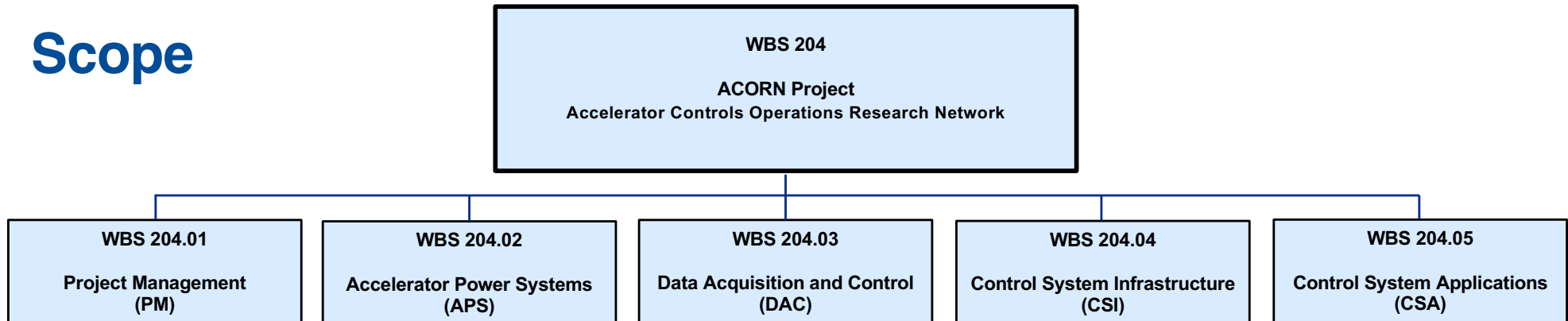
[1]Mission Need Statement for the Accelerator Operations Research Network
[2]ACORN Conceptual Design Report

Project Key Performance Parameters

- Replace end of life power supplies in the 5 to 500 kW output range.
  - Mostly used for ramping magnets
  - Includes regulation electronics and control system interfaces
- Replace Computer Automated Measurement and Control (CAMAC) field systems.
  - Power supply control, ramping and non-ramping
  - Timing and Clock generation
  - Digital I/O
  - Analog-to-digital signal conversion
- Deliver hybrid ACNET/EPICS accelerator control system infrastructure that satisfies DOE cybersecurity requirements and AI/ML requirements (stretch goal).
  - Computing resources
  - Storage
  - Networking
- Deliver core and critical control system user applications.
  - Core -> Essential for day-to-day operations, e.g. live plotting, alarms, and downtime log
  - Critical -> Essential for mission-critical needs, e.g. historical plotting and alarm configuration

Scope

WBS	Scope
204.01 Project Management	Labor, materials, travel, and fixed costs associated with work performed for project definition, prototyping, project integration, and for developing documentation and standards.
204.02 Accelerator Power Systems	Deliver modernized accelerator power systems by providing labor, materials, and services associated with the management, design, procurement, fabrication, and testing of power supplies and power supply regulation systems.
204.03 Data Acquisition and Control	Deliver modernized data acquisition and control for the accelerator control system by providing labor, materials, and services associated with the management, design, procurement, fabrication, and testing of field devices and field device infrastructure.
204.04 Control System Infrastructure	Deliver modernized control system infrastructure for the accelerator control system by providing labor, materials, and services associated with the management, design, procurement, fabrication, and testing of central services systems, the control system network, and integration and testing systems.
204.05 Control System Applications	Deliver modernized control system applications for the accelerator control system by providing labor, materials, and services associated with the management, design, procurement, implementation, and testing of the application framework, user applications, and the user interface.

Project Effort

- The team effort has risen from 4.3 FTEs to 25.5 FTEs in two years.

ACORN
FNAL Effort in FTE's

Legend: ■ FY 2022 ■ FY 2023 ■ FY 2024
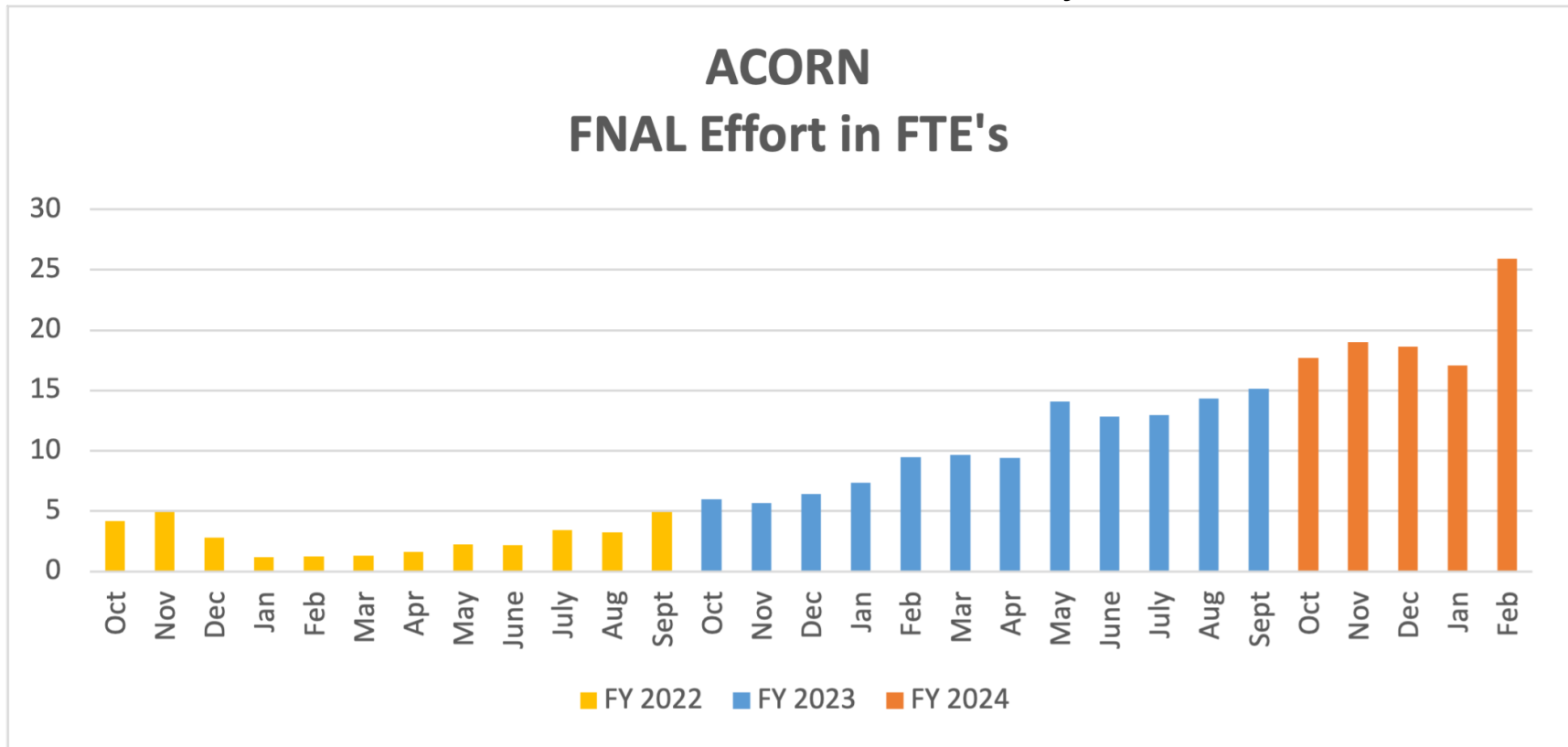
🌀 ACORN

Important Dates

- Director's Cost and Schedule Review: March 26th – 28th

- ACORN Technical Advisory Board CDR Final Report and Endorsement : April 26th

- Director's CD-1 Review: May 21st – 23rd

- DOE Independent Cost Review: To be scheduled

- DOE CD-1 Review: September 10th – 12th

ACORN R&D

Accelerator Power Systems

- Power System Testing
  - A candidate for replacement has been identified.
  - SCR vs Switchmode
    - Historically Fermilab doesn't use switchmode supplies above 60 kW.
    - Vendors supply systems that can output up to 500 kW.
  - Commercial regulation systems
    - Fermilab designs its own voltage and current regulation systems.
    - Vendors now market solutions to research labs like Fermilab.

Data Acquisition and Control

- MicroTCA Advanced Mezzanine Card design
- MicroTCA Rear Transition Modules design
  - How much data can be pushed over the zone 3 connector?
  - How many functions can be placed in one RTM?
- White Rabbit
  - Event stream generation.
  - Integration into the ACLK (accelerator clock) timing system.
- Front-End software
  - EPICS
  - Elixir / Nerves
- MicroTCA crate links
  - Inter-crate
  - Board to board
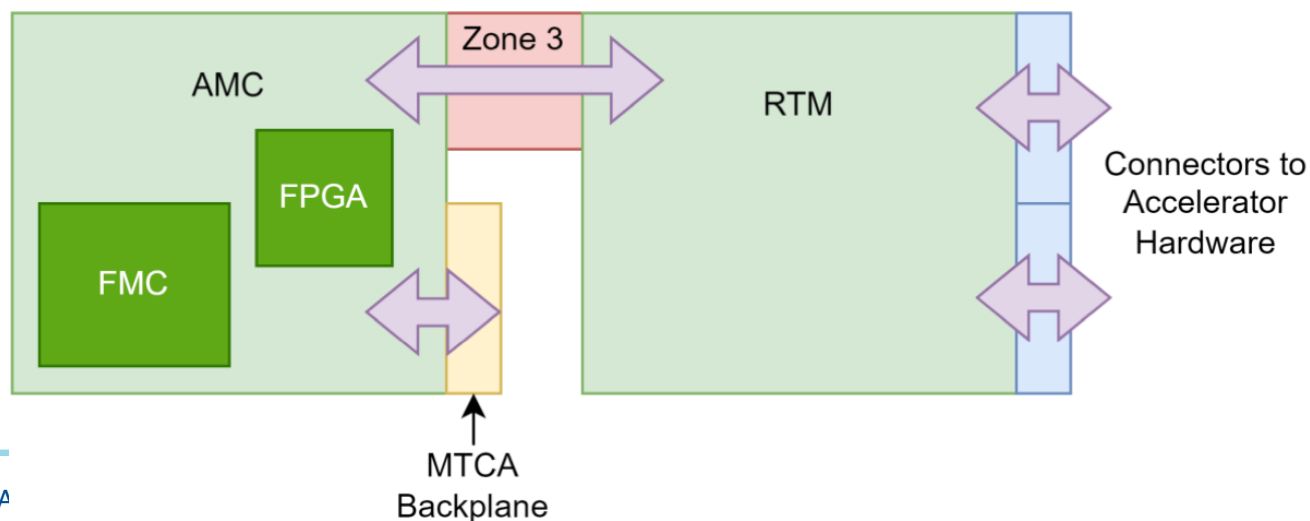
Control System Infrastructure

- Turn-by-Turn BPM data streamed to the proposed Data Lake
  - Test ACORN network switches
  - IOTA/FAST, Instrumentation Department, ACORN

Control System Applications

- Plotting application options.
  - Features for customization of plots
  - Options for exporting plots
- Move from Synoptic displays to Phoebus.
- Batch setting changes with transactional validation.
  - Could be a joint R&D task with Control System Infrastructure.
  - All or nothing, reports on success or failure.
- Python replacement for ACL.
  - Is this of benefit to Fermilab?
  - What is the best way to implement?
- ACSYS-Python synchronous API.

Summary

- Project scope is well defined

- The team has experienced a considerable amount of growth in the last two years, and in the last year in particular.

- Research and development plans are in their initial phase of development.

- We are excited by the potential of working with IOTA/FAST.