ACORN Project

Erik Gottschalk

EPICS Collaboration Meeting

25-April-2023

In partnership with:

About Me

- Senior Scientist in Accelerator Directorate, Controls Department
  - Project Manager for the ACORN Project
  - Deputy Department Head for the Controls Department
- Head of the Office of Integrated Planning and Performance Management (IPPM) in the Fermilab Directorate (**previous assignment**)
  - IPPM functions included laboratory strategic planning, enterprise risk management, performance oversight, and lab-wide workforce planning
  - Science Liaison for the Integrated Engineering Research Center (IERC) adjacent to Wilson Hall, responsible for leading the effort to define science requirements
- Deputy Head of the Particle Physics Division (**previous assignment**)
  - Project Director for Liquid Argon Test Facility, Muon g-2 building, and the Remote Operations Center (ROC-West)
- Level 2 Manager for the BTeV trigger system (B physics experiment at the Tevatron)

Overview

- Laboratory Director's vision for accelerator complex modernization

- Why modernize the accelerator control system?

- ACORN Project

- Project timeline

- Current status

- Presentations at this EPICS Collaboration Meeting

Fermilab Accelerator Complex User Facility Modernization

Vision/Goals

- Highly effective, efficient accelerator operations with a modernized control system, work and lab spaces and integration of emerging technologies like robotics and AI/ML for accelerators

Key Initiatives

- **ACORN**: DOE O413 project to modernize the accelerator control system and replace end-of-life power supplies; partnership with INL for user interface and human factors expertise

- **Robotics Initiative**: Motivated by need to increase worker safety and efficiency for accelerator and target operations

- **CAST**: Proposed building to potentially include updated Main Control Room, co-located controls and instrumentation staff and space for USPAS, visiting scientists and engineers

Recent Achievements

- Completed Accelerator Operations Requirements Workshops – broad labwide participation; documented requirements for AI/ML for accelerator operations, cybersecurity, ES&H, software development, etc.

- Completed Robotics Strategic Plan and initiated partnership with National Robotics Engineering Center (NREC) at Carnegie Mellon

Fermilab visitors Tia Miceli, Adam Watts, and Mayling Wong-Squires with CHIMP (CMU Highly Intelligent Mobile Platform) at NREC

ACORN is the key to enabling future accelerator operations capabilities

Why Modernize the Accelerator Control System?

Why modernize when the accelerator complex is operating at peak performance?

Why Modernize the Accelerator Control System?

Why modernize when the accelerator complex is operating at peak performance?

Fermilab Accelerator Advisory Committee (Dec. 2018):

The existing lab-wide accelerator control system has aging and heterogeneous front-end hardware, multiple different frameworks and network protocols, 1980s era network services and a collection of generic functionalities. The top level is a mix of high-level software some of which is using obsolete frameworks. Recent targeted modernization has included rather specific, targeted initiatives. Major issues include: lots of old hardware; lots of old software, and an aging and declining in strength work force (no software development related hires since 2001 for instance).

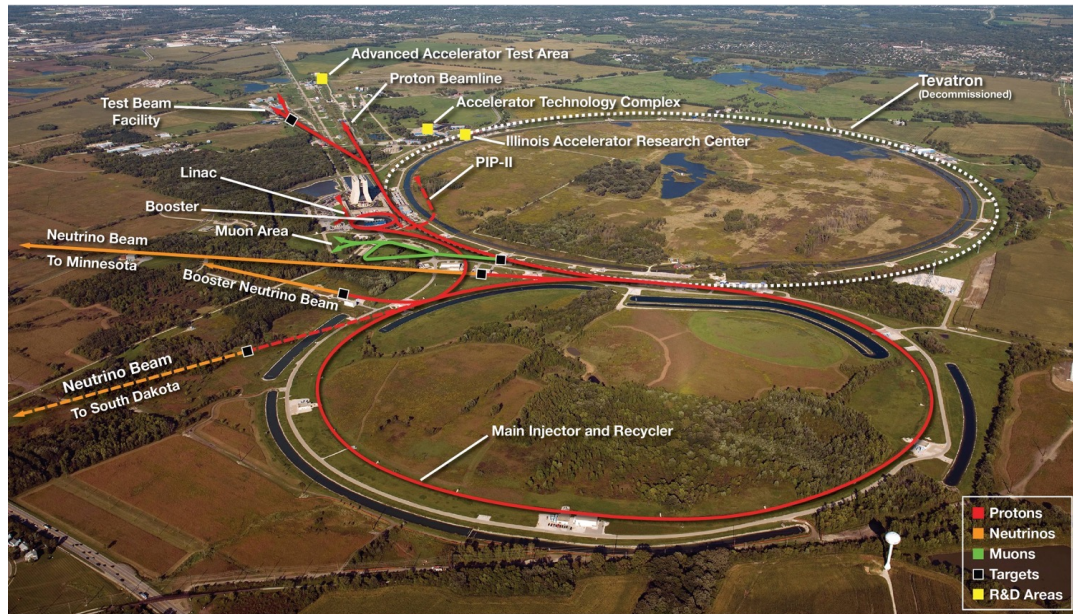# Fermilab Control System (ACNET) History of Upgrades

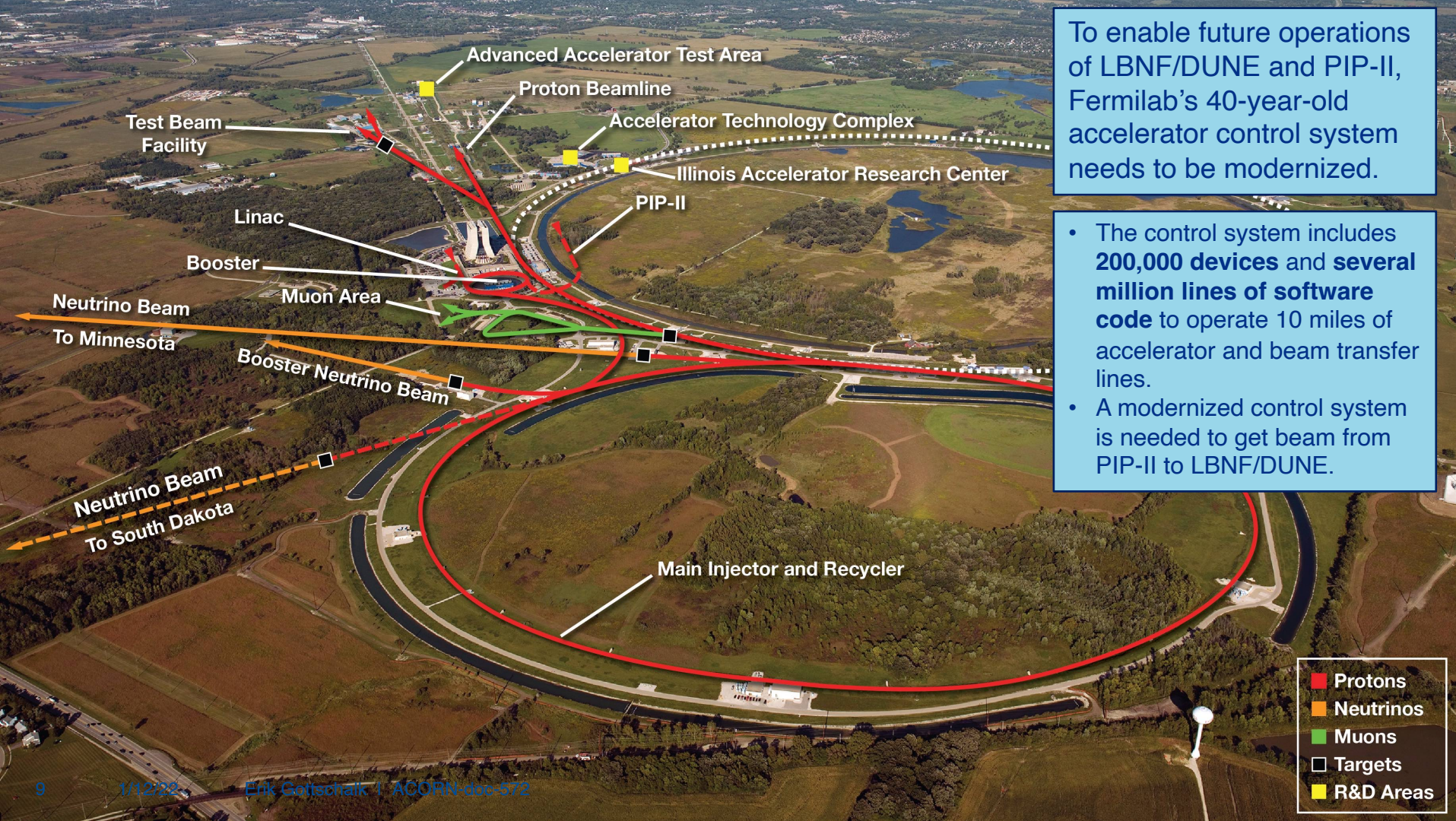Upgrades of ACNET have occurred throughout its history.

- Upgrading from PDP-11 to VAX
- Moving from VAX to Linux servers
- Transitioning from a proprietary database to a commercial database
- Moving from a commercial database to an open-source database
- Introducing Java controls for central services, applications, and data acquisition
- Developing and expanding the Data Pool Manager central service
- Numerous fieldbus hardware upgrades (CAMAC module development, IRM/HRM, BSSB/MFTU…)

The ACORN Project represents the first major overhaul of the accelerator control system in the past 40 years.
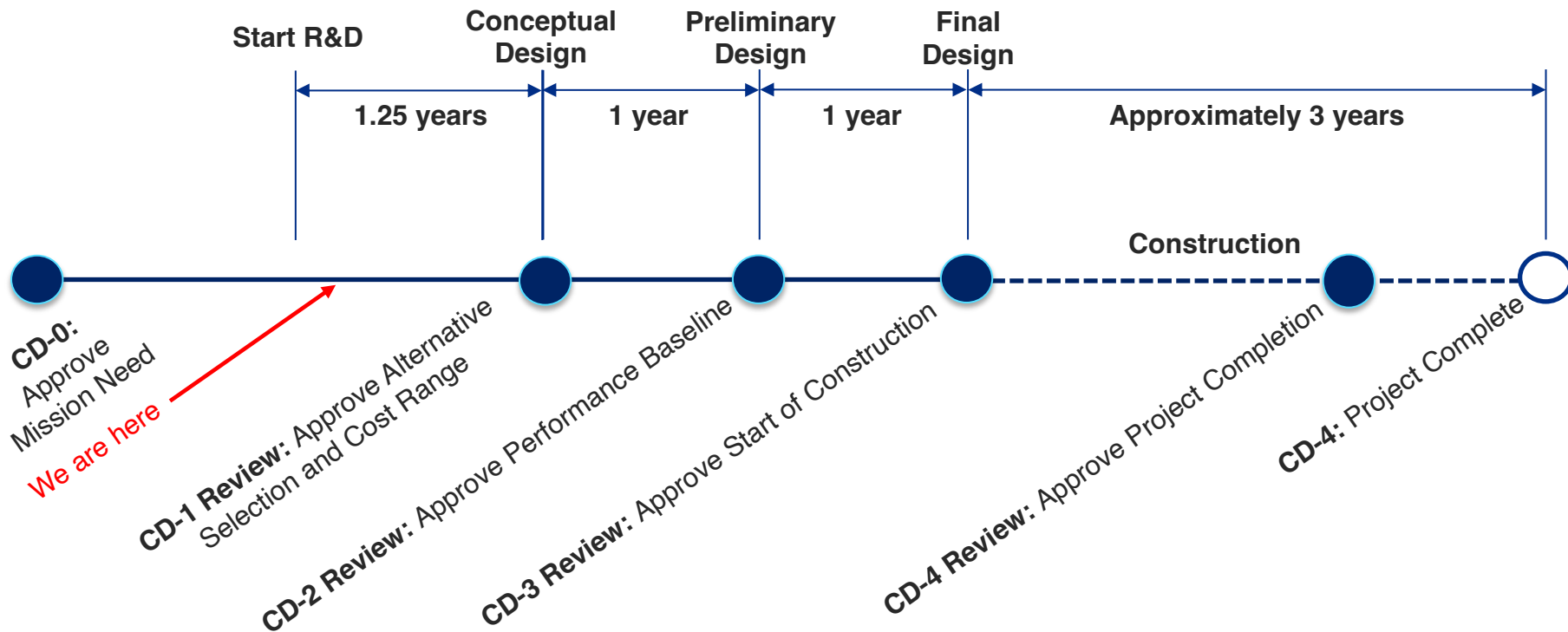
Accelerator Controls Operations Research Network (ACORN)

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

- "Approve Mission Need," referred to as Critical Decision 0 (CD-0), was approved August 28, 2020.

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

- Total Project Cost (TPC) range: 100 – 142M$
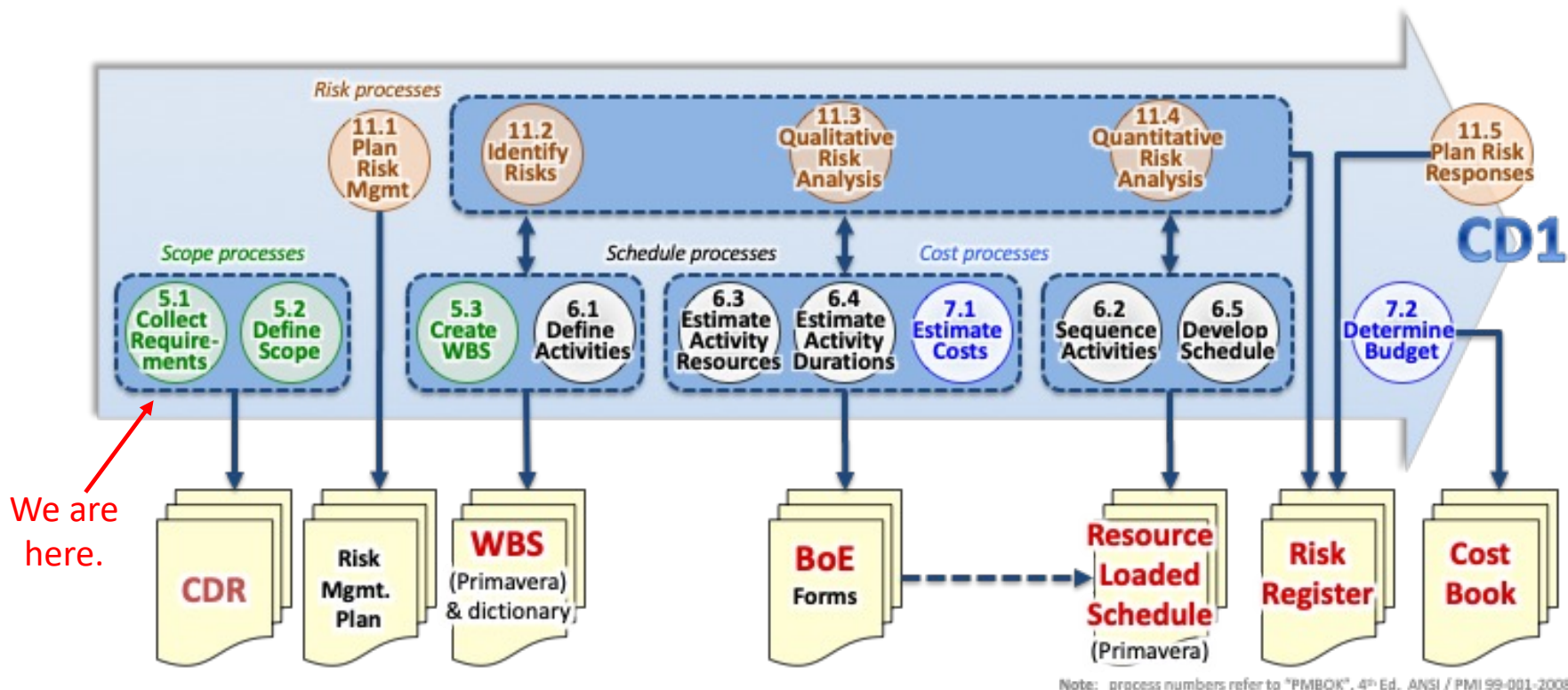
- Project Completion (CD-4): 2028 – 2030

To enable future operations of LBNF/DUNE and PIP-II, Fermilab's 40-year-old accelerator control system needs to be modernized.

- The control system includes **200,000 devices** and **several million lines of software code** to operate 10 miles of accelerator and beam transfer lines.
- A modernized control system is needed to get beam from PIP-II to LBNF/DUNE.

Advanced Accelerator Test Area

Proton Beamline

Accelerator Technology Complex

Test Beam Facility

Illinois Accelerator Research Center

PIP-II

Linac

Booster

Muon Area

Neutrino Beam To Minnesota

Booster Neutrino Beam

Neutrino Beam To South Dakota

Main Injector and Recycler

- Protons
- Neutrinos
- Muons
- Targets
- R&D Areas

Project Timeline

Project Tasks and Deliverables for CD-1

We are here.

Risk processes

11.1 Plan Risk Mgmt

11.2 Identify Risks

11.3 Qualitative Risk Analysis

11.4 Quantitative Risk Analysis

11.5 Plan Risk Responses

CD1

Scope processes

5.1 Collect Require-ments

5.2 Define Scope

Schedule processes

5.3 Create WBS

6.1 Define Activities

Cost processes

6.3 Estimate Activity Resources

6.4 Estimate Activity Durations

7.1 Estimate Costs

6.2 Sequence Activities

6.5 Develop Schedule

7.2 Determine Budget

CDR

Risk Mgmt. Plan

WBS (Primavera) & dictionary

BoE Forms

Resource Loaded Schedule (Primavera)

Risk Register

Cost Book

Note: process numbers refer to "PMBOK", 4ᵗʰ Ed, ANSI / PMI 99-001-2008.

ACORN

Collect Requirements

- We interviewed stakeholders to identify use cases for the **existing** control system.
- Conducted a review of requirements for the **existing** control system.
- Reviewers included:

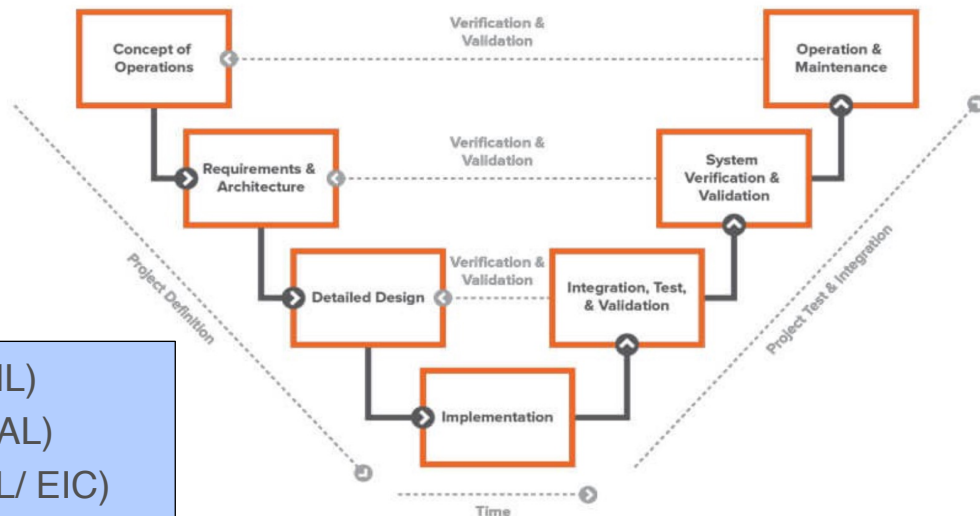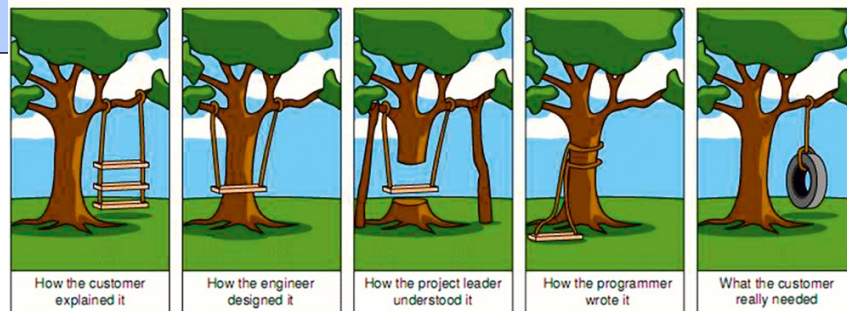|	
Guobao Shen (ANL)	Andrew Johnson (ANL)
Chris Roderick (CERN)	Denise Finstrom (FNAL)
Elvin Harms (FNAL/ PIP-II)	Jim Jamilkowski (BNL/ EIC)
Kyle Hazelwood (FNAL)	Lidija Kokoska (FNAL/ PIP-II)
Timo Korhonen (ESS)	

Looking ahead:

- Interview stakeholders to identify use cases and requirements for **future** capabilities (e.g. AI/ML, robotics)

Current Status

- The ACORN project team recently received the funding that was requested to prepare for CD-1.

- This is enabling the project to:
  - Build the team
  - Prepare for CD-1
  - Perform R&D needed to develop conceptual design
  - Complete the required Analysis of Alternatives
  - Work with the PIP-II project to align accelerator control system requirements

ACORN Effort in FTE's
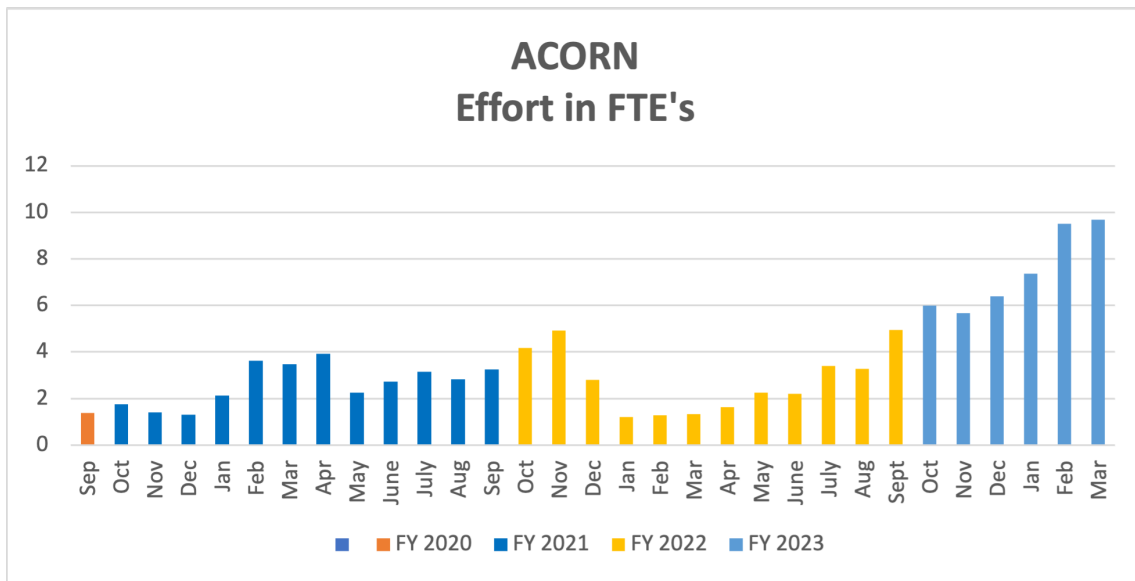
Presentations at this EPICS Collaboration Meeting

The following presentations are associated with the ACORN Project:

- **Tuesday 2:40pm** – *Ethernet as a Fieldbus: Scaling Distributed Systems Interfacing with EPICS and ACNET* (Robert Santucci)

- **Tuesday 4:10pm** – *ACORN Human Factors* (Rachael Hill)

- **Wednesday 9:20am** – *Introduction to Machine Learning* (Gopika Bhardwaj)

- **Wednesday 11:00am** – *Machine Learning Operations for Accelerator Control* (Tia Miceli)

- **Wednesday 3:00pm** – *Fermilab Accelerator Directorate Robotics Initiative* (Brian Hartsell)

- **Wednesday 4:12pm** – *Fermilab Web-Based Controls Application Framework R&D* (John Diamond)

- **Wednesday 4:18pm** – *Data Pool Management Across Multiple Front-End Architectures* (Charles King)

Summary

The Department of Energy recognized the need to modernize the Fermilab accelerator control system in 2020.

- Critical Decision 0 (CD-0) was approved on August 28, 2020.

- The project team recently received the funding that was requested to prepare for CD-1 (Alternative Selection and Cost Range).

- The team has developed functional requirements for the **existing** accelerator control system based on stakeholder interviews, benefited from a requirements review, and is developing requirements for future capabilities such as Machine Learning and Robotics.

- ACORN is exploring opportunities to partner with people at other laboratories and institutions.