Fermilab | U.S. DEPARTMENT OF ENERGY | Office of Science

ACORN GUI Strategy at Fermilab

Madelyn Polzin
UX Engineer

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In partnership with:

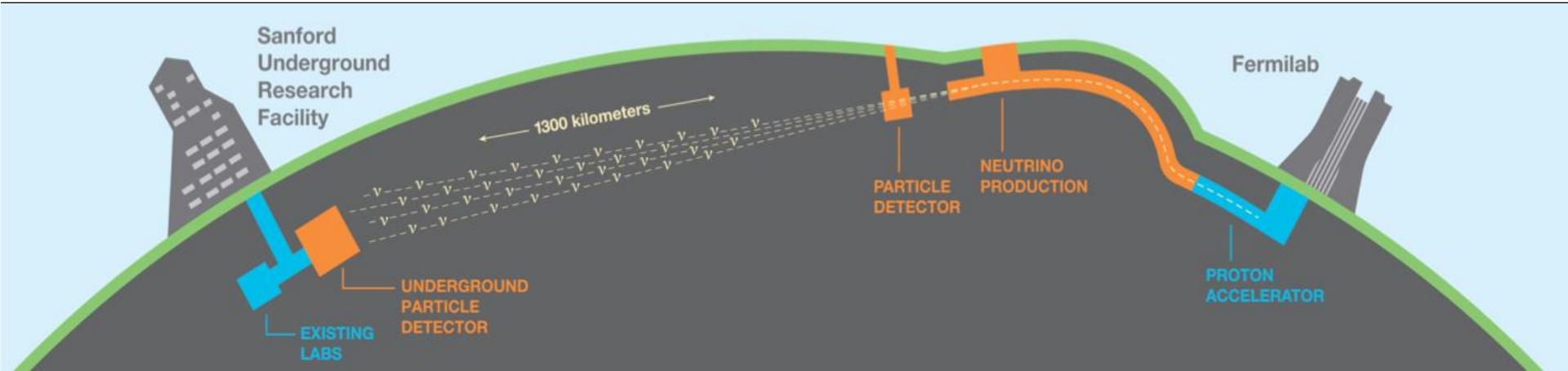
Argonne NATIONAL LABORATORY | INL Idaho National Laboratory | OAK RIDGE National Laboratory

Outline

- ACORN overview
- Current control system - ACNET
- Modernization strategy for ACORN
- Next steps

Accelerator Controls Operations Research Network (ACORN)

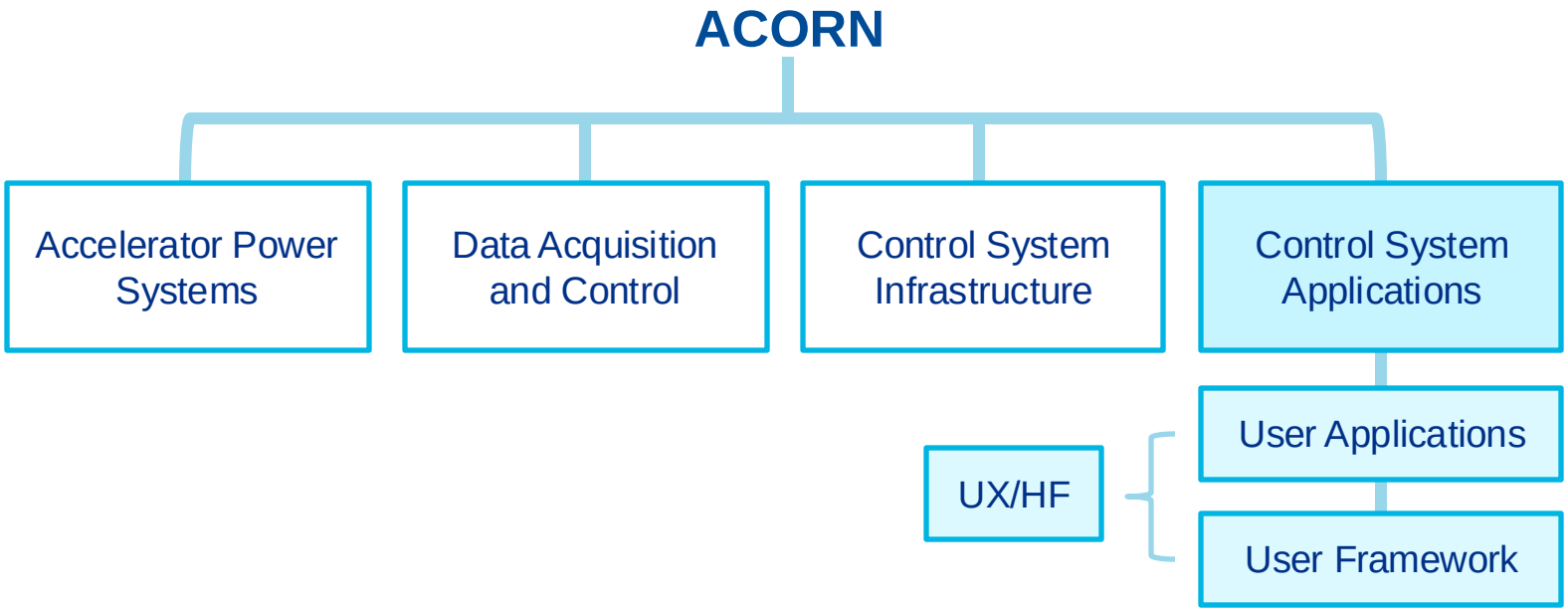
- The ACORN Project will modernize Fermilab's accelerator control system and replace end-of-life accelerator power supplies
- ACORN Mission Need (CD-0) was approved August 28, 2020
  - Fermilab's power systems and ACNET control system need to be modernized or replaced to **meet the future needs of LBNF/DUNE and PIP-II**
- Project Completion (CD-4): 2031
- $211M total project cost



ACORN Project Goals

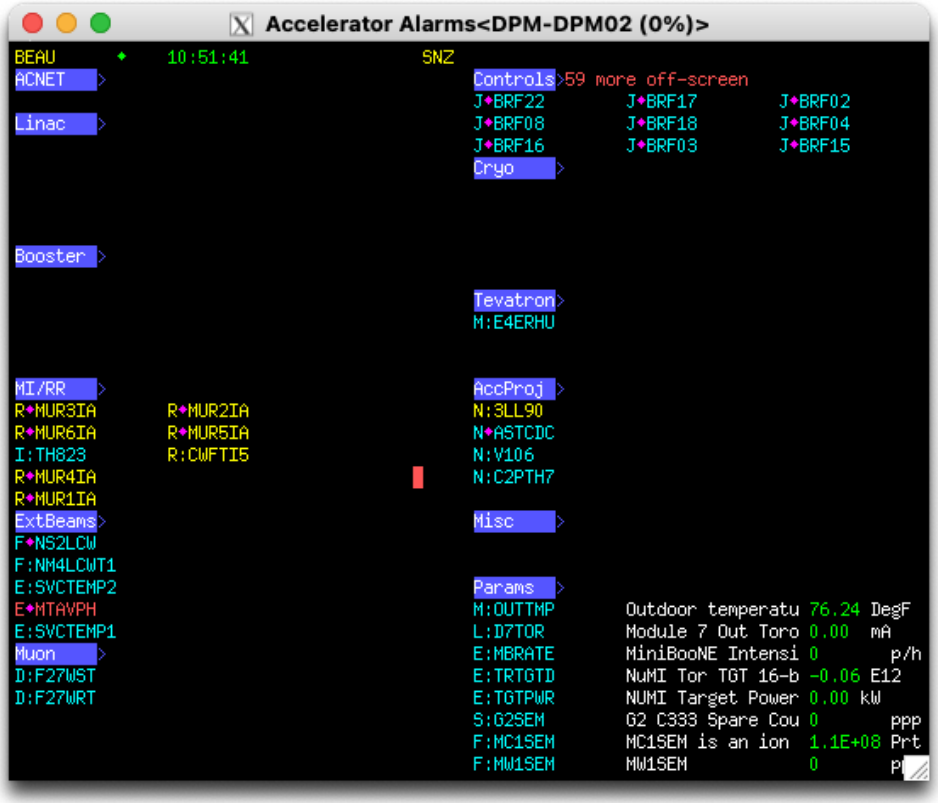
- Replace end-of-life Booster, Main Injector, and Muon Campus accelerator power systems
- Replace the antiquated ACNET control system with EPICS for the accelerator complex
  - Improve the human-system interfaces & software development applications of the accelerator control system
- Implement an architecture that promotes a highly reliable and resilient control system
- Support the development and deployment of AI/ML capabilities for accelerator operations

Accelerator Controls Operations Research Network (ACORN)



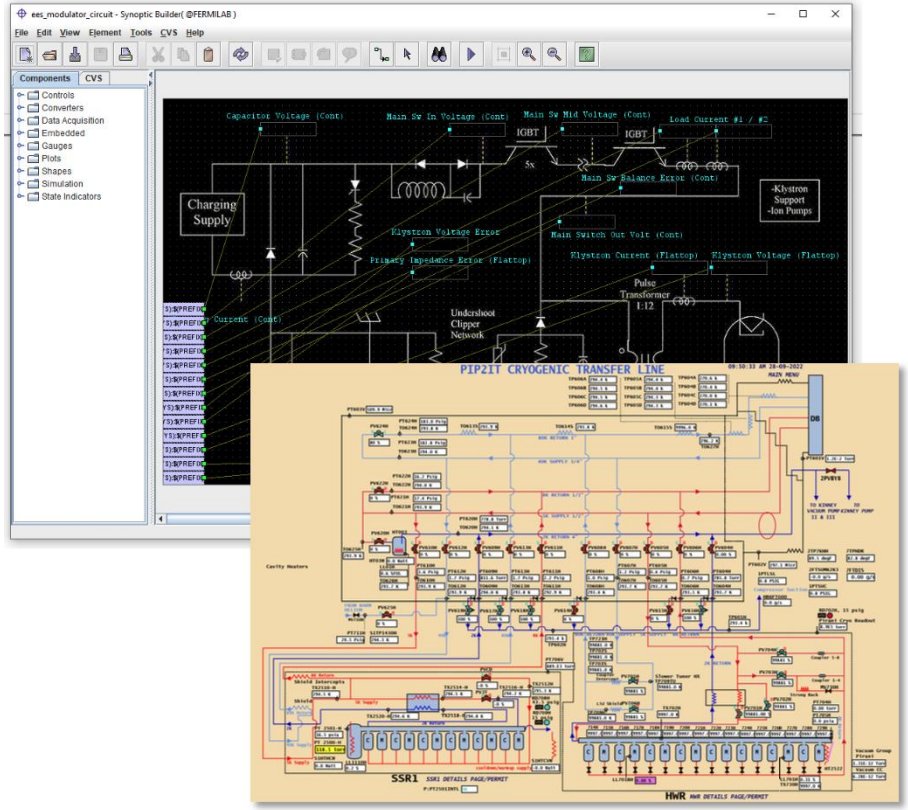
Fermilab's Control System

- ACNET
  - 40+ year history at Fermilab
  - Unified system for the entire complex
    - All accelerators, all machine and technical equipment
    - Common console manager can launch any application
      - Users connect to a LinuxVM via SSH
      - Applications are served to desktop via X11
  - Most applications written in C/C++
    - FORTRAN still exists
  - Handful of applications written in Java



Fermilab's Control System - Synoptic

- Built with Java APIs
- "No-code" Display Builder
- SVG for rendering displays
- Displays can be launched in a dedicated viewer or browser
- Still supported but development has stalled
- 1,600 Synoptic displays
- Synoptic → Phoebus



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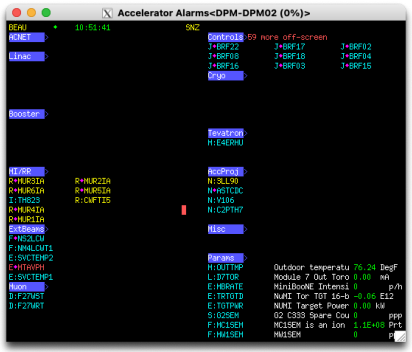
ACORN Applications Modernization

- Our GUI strategy is to embrace web and cloud computing technologies as the future for control system applications and services
  - Move from mostly text-based applications to modern graphical web applications
- Currently in the alternatives analysis phase that will develop the next generation platform for control system GUIs at Fermilab
- Incorporating User Experience and Human Factors into the development of our applications from the beginning



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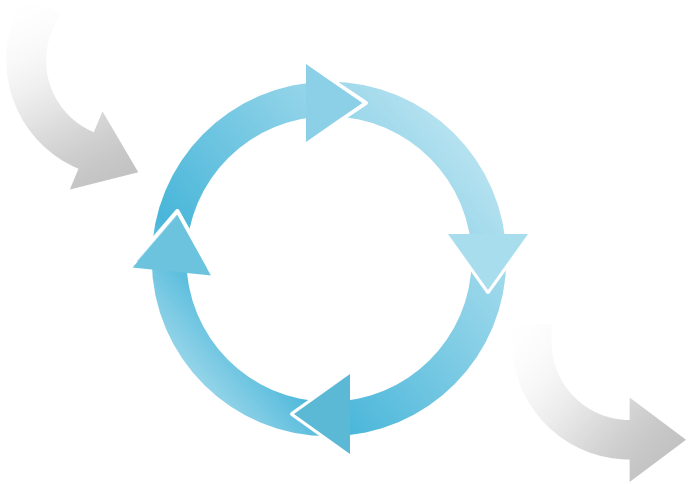
ACORN Applications Modernization

- Currently 629 active applications
- ACORN's Scope
  - Core Applications (13)
    - Essential for day-to-day Main Control Room Operations
    - Discussions with Operations Department
  - Critical Applications (58)
    - Essential for mission-critical operations
    - Discussions with the Accelerator Directorate on how they use the control system to accomplish their responsibilities

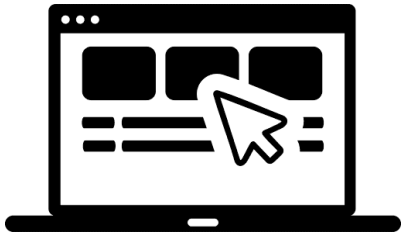
ACORN Applications Modernization

- Process (iterative)
  - Design
  - Test
  - Implement
  - Deploy
- User inclusion throughout

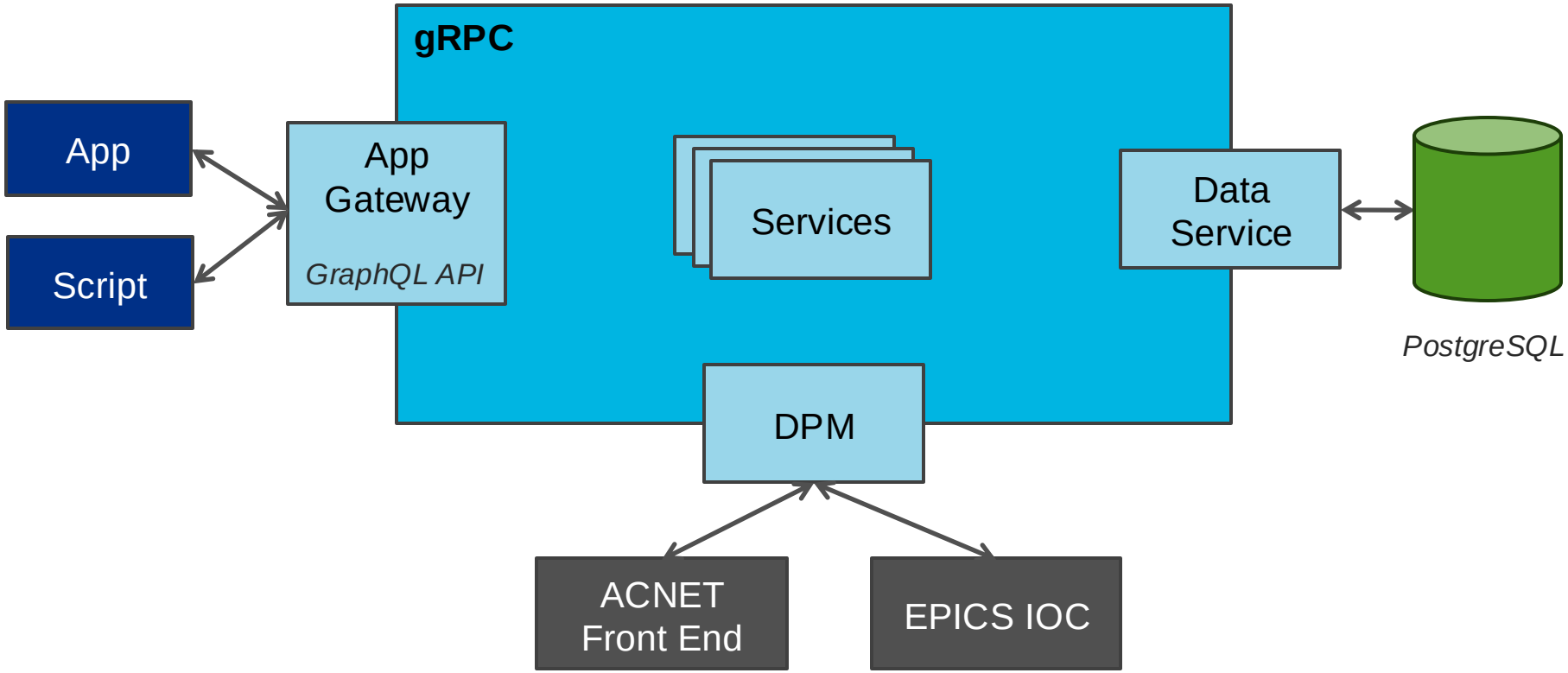


ACORN Applications Modernization

- Applications to work with ACNET and EPICS while giving the user the same experience
- Web Applications
  - Widely available and understood
  - Cross-platform
  - Accessible
  - Widget oriented
- Moving business logic from applications
  - Using existing APIs gives us flexibility for our GUI framework
  - Decoupling and moving into backend services tier
  - Web applications become thin clients that interact with the service tier

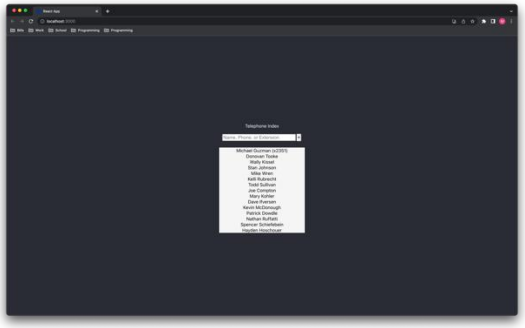


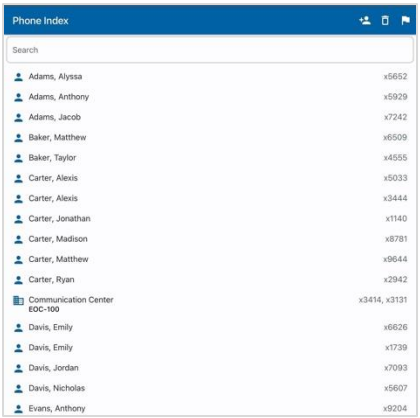
Architecture (Simplified)

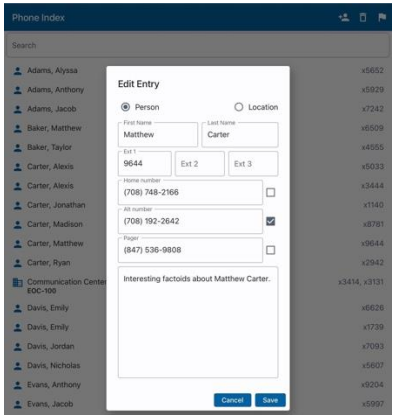


Application Framework

- Flutter for framework (Dart)
  - Investigated various popular application frameworks – Flutter was preferred
  - Flutter allows for progressive web applications that can be adaptive to screen sizes
  - Uses Material (Google) so there is no need to create components from scratch



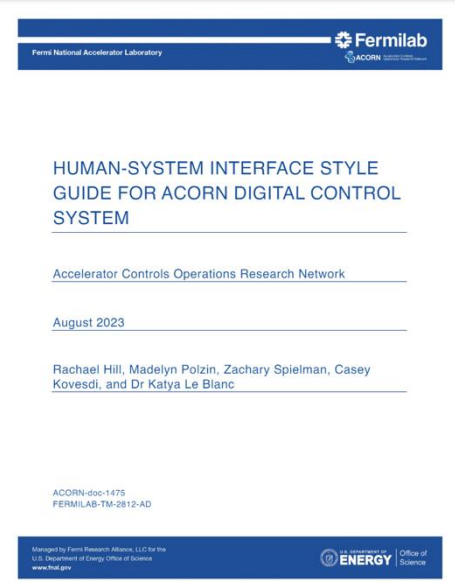




Telephone Index Application using React and Flutter

ACORN User Experience and Human Factors

- Identifying end-user tasks and objectives
- Identify functional objectives of the system
- User research and usability testing
- UX design
  - Design philosophy - UX/HF principles and standards
  - Design style guide
  - Application GUI design
- Lab tour
  - Valuable to learn from others as we modernize our control system
  - Collaborative efforts & fostering an exchange of knowledge

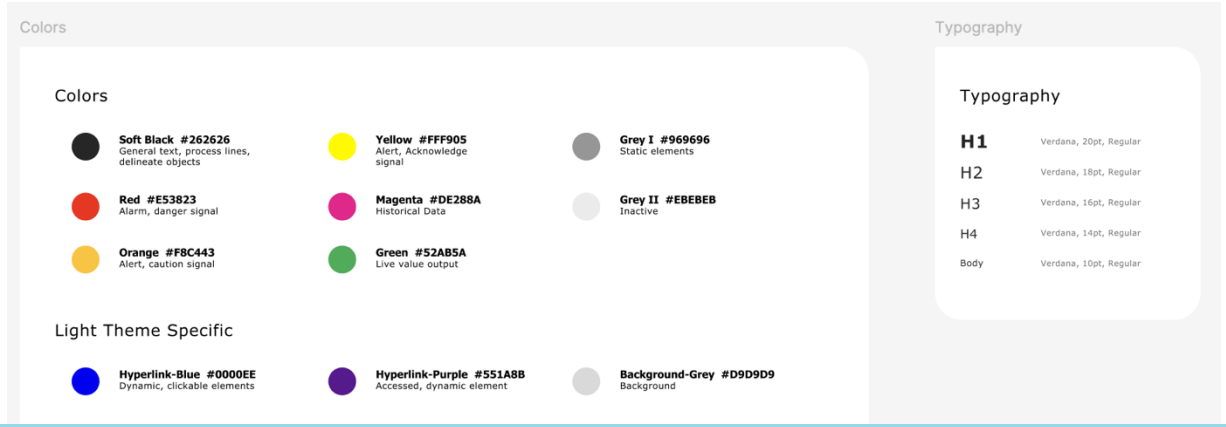


Prototyping and Design

- Figma
  - Design tool used to create, share, and test designs for websites, mobile apps, and other digital products and experiences
  - Rapid prototyping to workshop designs
    - Not heavy UI design upfront
    - Iterative process
    - Opportunity for user input
  - Widget and style library
  - Ability to generate code in Figma

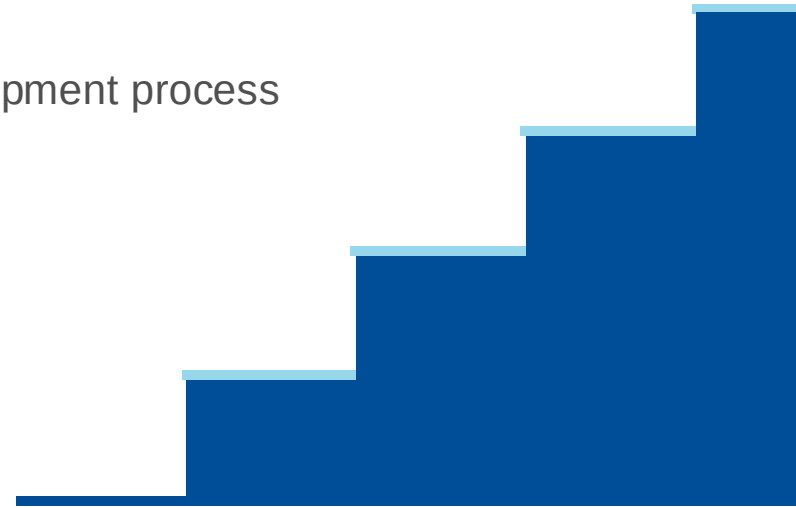
Widget and Style Library

- Library of common components to streamline the development process
  - Cards, fonts, colors, etc. styles
- Material Design 3 (Google) as a starting point
  - Application “scaffolds” (title bars, navigation bars, etc.)
  - Graphing and chart elements



Next Steps

- Requirements for core and critical applications
- Prototyping and GUI design development
  - Templates
  - Widget & style library
- Continued user input/interaction throughout our development process
- Synoptic to Phoebus conversion



Thank you!

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acorn.fnal.gov

Madelyn Polzin | UX Engineer

mpolzin@fnal.gov