
Lunch and Learn
Digital Modernization Strategies
Thursday, April 1
ANS Events
INL

Digital Transformation Of Limerick Station

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Exelon Generation.

Problem Statement:

- Original construction safety systems are reaching the end of their practical service life - performance issues are becoming more common and costs to maintain these systems is rapidly increasing
- Historical regulatory barriers have largely precluded modernization of safety systems
- The industry is facing unprecedented economic challenges and must find innovative ways to reduce labor and material costs

In 2019, a public / private partnership was formed between Idaho National Labs and Exelon to deconstruct daily activities to the determine the real cost of maintaining the I&C status quo and identify opportunities to reduce cost and further improve performance

Transformation Framework

- Both the research and execution of the Limerick Transformation Project is founded on multiple technical and regulatory initiatives including:
  - EPRI Digital Engineering Guide (3002011816) and subordinate processes
  - EPRI Nuclear Plant Modernization Strategy (3002018428)
  - DNP Standard Digital Engineering Process (NISP-EN-04)
  - NRC integrated action plan for digital modernization (SECY-15-01062)

This strategy was deliberately structured to maximize efficiency, bring advanced analytical tools to bear and make the public facing research transportable to any utility that seeks to pursue similar initiatives

Key Takeaways

- Four safety-related systems at Limerick Station will be upgraded:
    - Reactor Protection System (RPS)
    - Redundant Reactivity Control System (RRCS)
    - Nuclear Steam Supply Shutoff System (NSSSS)
    - Emergency Core Cooling System (ECCS)
- Approximately 80% of physical components are displaced by software which does not degrade over time and requires minimal ongoing maintenance
- Significant changes will be made to the control room to improve situational awareness and maximize information available to operators
- All four systems will be upgraded in a single, standard duration refueling outage

Project Scope

- Upgrade analog, Safety-Related, protection systems to Westinghouse Common Q^{TM} digital platform integrated into PPS:
  - Reactor Protection System (RPS)
  - Nuclear Steam Supply Shutoff System (NSSSS)
  - Emergency Core Cooling System (ECCS)
- Upgrade analog Redundant Reactivity Control System (RRCS) to Ovation^{TM} DCS platform and reclassify to non-safety in accordance with the ATWS Rule (10 CFR 50.62)
- Install Data Display System (DDS) to display sources of information in an environment that improves the ability to synthesize plant data

Current Control Room Configuration

Potential Arrangement with Monitor Visuals

Exelon Generation.

Potential Arrangement with View from SRO Station

Exelon Generation.

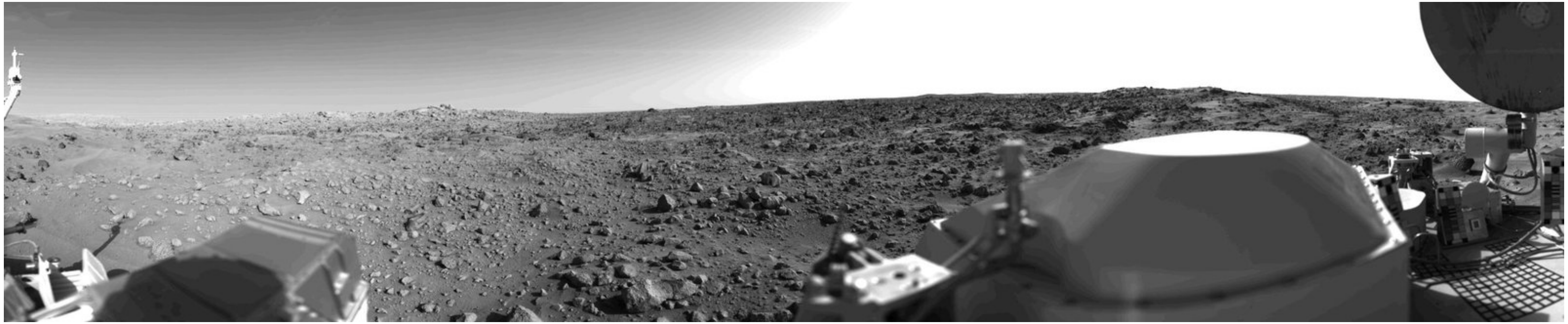
Southern Nuclear

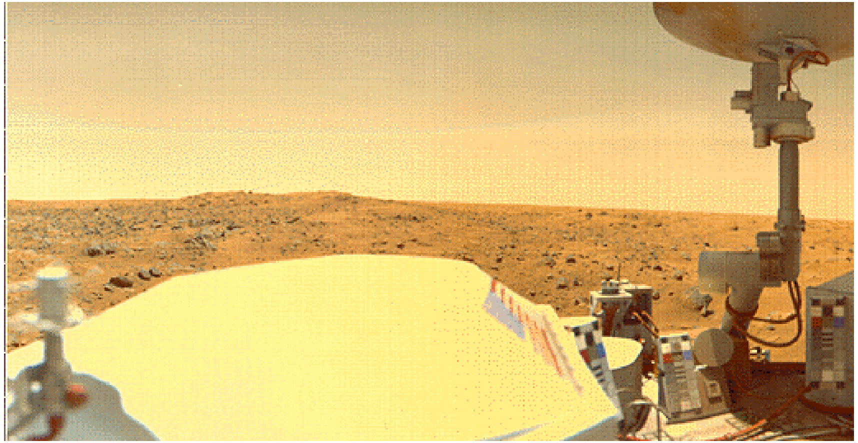
Strategic Digital Modernization

Raymond Herb
Fleet Digital Principal
April 1, 2021

ANS Human Factors and I&C Division
Digital Modernization Strategies
Lunch and Learn

1976 Mars Viking Lander **Mission: Explore Mars**





Credit NASA/JPL

2021 Perseverance Rover **Mission: Explore Mars**

Credit NASA/JPL

Nuclear Power Plant Control Room **Mission: Control the Power Plant**

Farley Unit 1 MCR

Vogtle Unit 3 MCR

EPRIs Four Basic Modernization Strategies

Table 1-1
Four Basic I&C Strategies

Option	Productivity Improvement	Initial Investment	Long Term Maintenance	Plant Risks	Project Risks
Full Scope Modernization Strategy	High	High	Low	Medium	High
Limited Scope Modernization Strategy	Medium	Medium	Medium	Low	Medium
Tactical Upgrades	Low	Low	High	Medium	Medium
Maintain or Replace Legacy Components	None	None	Very High	Very High	Very Low

Source: EPRI 3002015797 Digital Systems Engineering: Modernization Guide for Practitioners, 03/20

SNC's Digital Modernization Strategy Enablers

Increased Reliability & Operational Flexibility

- Increases system reliability
- Reduce mechanical & thermal stress
- Reducing HU Issues
- Increased access to data

Reducing Plantwide Operating Costs

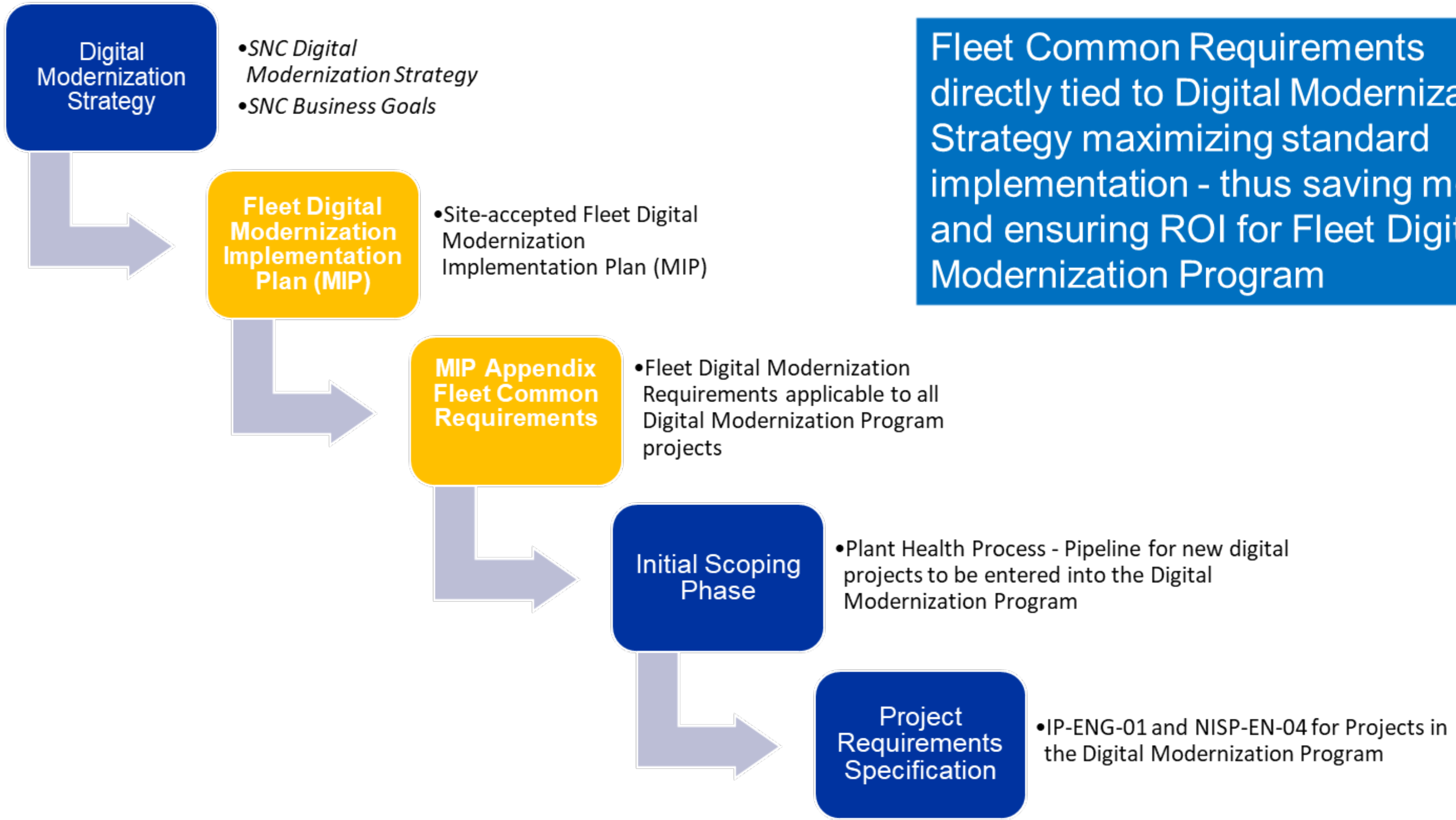
- Maintenance & surveillance tasks
- Smart instrumentation
- Common architecture
- Inventory reductions

Workforce Planning

- Resource sharing
- Common platform
- Aligns with emerging workforce

Modernization Implementation Plan (MIP) Process

Fleet Common Requirements directly tied to Digital Modernization Strategy maximizing standard implementation - thus saving money and ensuring ROI for Fleet Digital Modernization Program



MIP Based on Systems Engineering Principles and EPRI 3002015797

- Start with Fleet Strategy and Goals
- Operations and Support Focus
- Top-down Stakeholder Needs Assessment (Corp and Sites)
  - Executive Leadership
  - Functional Area Management
  - Individual Contributors
- Distillation of Common Requirements related to the I&C Components and Architecture
- Gain Alignment across Fleet
- Integration into the Plant Health and Design Change process.

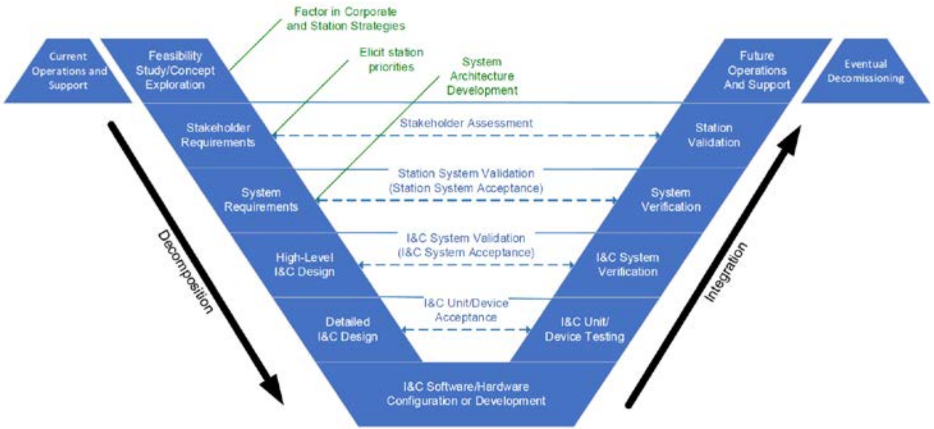


Figure 1-3
Systems Engineering V-Model
Source: EPRI 3002015797

Value of the MIP

- Provides set of common requirements that address the needs of Operations, Maintenance, and support organizations
- Ensures requirements reflect site/corporate consensus decisions tied to strategic goals
- Leverages existing infrastructure and technology investments (e.g., wireless networks, M&D center software - OSIsoft PI Historian)
- Ensures requirements are tied to economic benefits/O&M savings
- Provides fleet-accepted requirements that will ensure an integrated end vision is realized versus series of independent digital upgrade projects
- Provides a standard set of quality requirements to efficiently define digital projects' common scope through end of plant life

Vogtle Unit 3 Containment and Turbine Building

February 2021

Xcel Energy®

Data Analytics and Remote Monitoring

April 1, 2021

Monitoring & Diagnostics (M&D)

Utilizing advanced analytics to proactively identify equipment risk, leading to reduced maintenance expense and unplanned outage impact, while enabling condition based maintenance practices and operational excellence.

Advanced Pattern Recognition (APR) predictive analytics identify statistical deviations of modeled operating parameters.

Xcel Energy Monitoring & Diagnostics (M&D)

2014: Inception - 7 plant pilot program

2016: Major thermal units included:14 plants, 35 units

2017: Expansion to wind, 3 nuclear units

2020: 13,135 MW thermal generation

- 846 MW Wind generation, 2000 MW Wind EOY 2020

Predictive Analytics - Mechanical condition monitoring

- Failure modes limited by plant instrumentation

$29M avoided and hard savings through Q1 2020

- >4000 actionable advisories

M&D Success & Results

Operational Excellence

- Excessive desuperheat spray leading to HRSG tube damage
- Feedwater regulator closed resulting in low fuel gas temp – damage prevented to comb. cans
- Excessive feedwater heater draining – low levels, erratic levels
- Poor condenser performance, efficiency impact

Avoided Cost Examples

- Wind turbine gearbox – numerous early gear defects avoiding gearbox replacement ~ $350k per event
- Air heater guide bearing temperature increase, lube oil supply problem corrected
- Steam turbine vibration changes, balancing prior to forced event
- Fan bearing temperature increase, cooler operation corrected preventing failure
- Boiler acoustic leak indication, operation mitigation until scheduled outage

Direct Savings Examples

- Major maintenance deferrals, known good condition and performance, i.e. BFP overhaul elimination ~ $250k
- Capital budget reduction for wind turbine gearbox replacements, early fault identification and known condition
- Condition based maintenance – known good condition allows for delay or elimination of scheduled or calendar based maintenance – expansion priority

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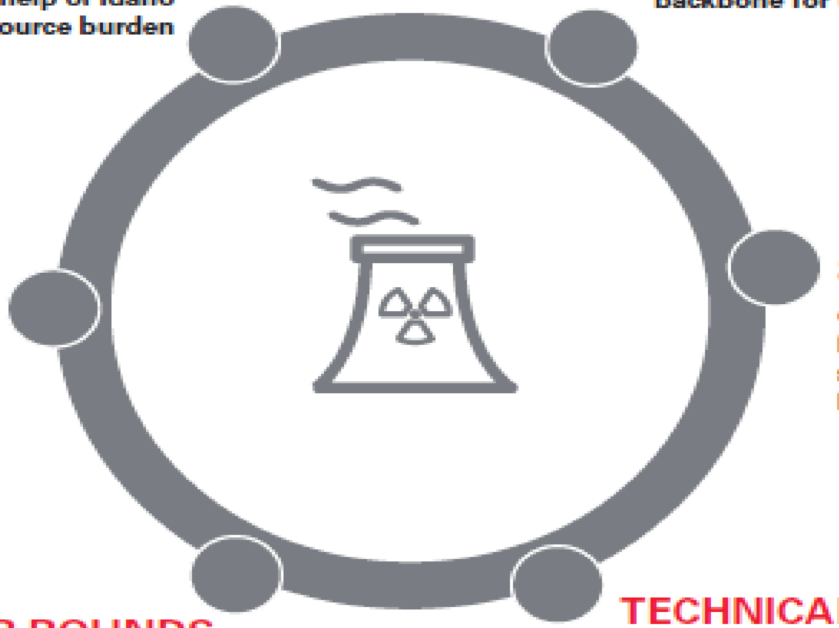
Nuclear Focus

VERIFYING COMPLIANCE THROUGH TECHNOLOGY



CORRECTIVE ACTION PROGRAM
Improved CAP screening tools with the help of Idaho National Laboratory reduces the resource burden

INFRASTRUCTURE
Permanent Wi-Fi in plants serves as backbone for technological improvements

PREVENTIVE MAINTENANCE
Maintain equipment at the optimal time using data trends from new wireless sensors and advances in machine learning

STAKEHOLDER AUDITS & INSPECTIONS
New process for automated data sharing supports inspections and key performance indicators

OPERATOR ROUNDS
Critical data for trending plant performance with wireless sensors and machine learning application developed with USA

TECHNICAL SPECIFICATION SURVEILLANCES
Increased public safety by monitoring plant equipment with wireless sensors ensures continual compliance with technical specifications

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Xcel Energy Nuclear Innovation: Sensor Infrastructure

Mechanical Sensors

- Vibration Sensors
- Wireless Gauge Readers
- Void Monitoring
- Remote Radiation Mapping
- Valve Position Indication

Electrical Sensors

- EPRI Acoustic Monitors for Transformers
- EPRI Disconnect Switch Monitor
- Continuous Thermal Imaging

Wi-Fi Devices

- RealWear / iPhones / Tablets

Xcel Energy Nuclear Innovation: USA Advanced Remote Monitoring

- Xcel is working with INL to begin development of a method to streamline current pain points in the M&D architecture
- Part of a larger initiative with collaboration with USA plants, as well as Idaho National Lab
  - Standardized Monitoring and Diagnostics (M&D) Software Platform
  - Automatic thermal performance and fire detection using image/video recognition tied into cyber compliant systems
  - Beginning to automate operator round data collection
  - Transformer and cycle isolation monitoring
  - Begins to apply machine learning to monitoring limits (Xcel collaboratively with INL)

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Palo Verde Innovation Team

What is the Maker Movement?

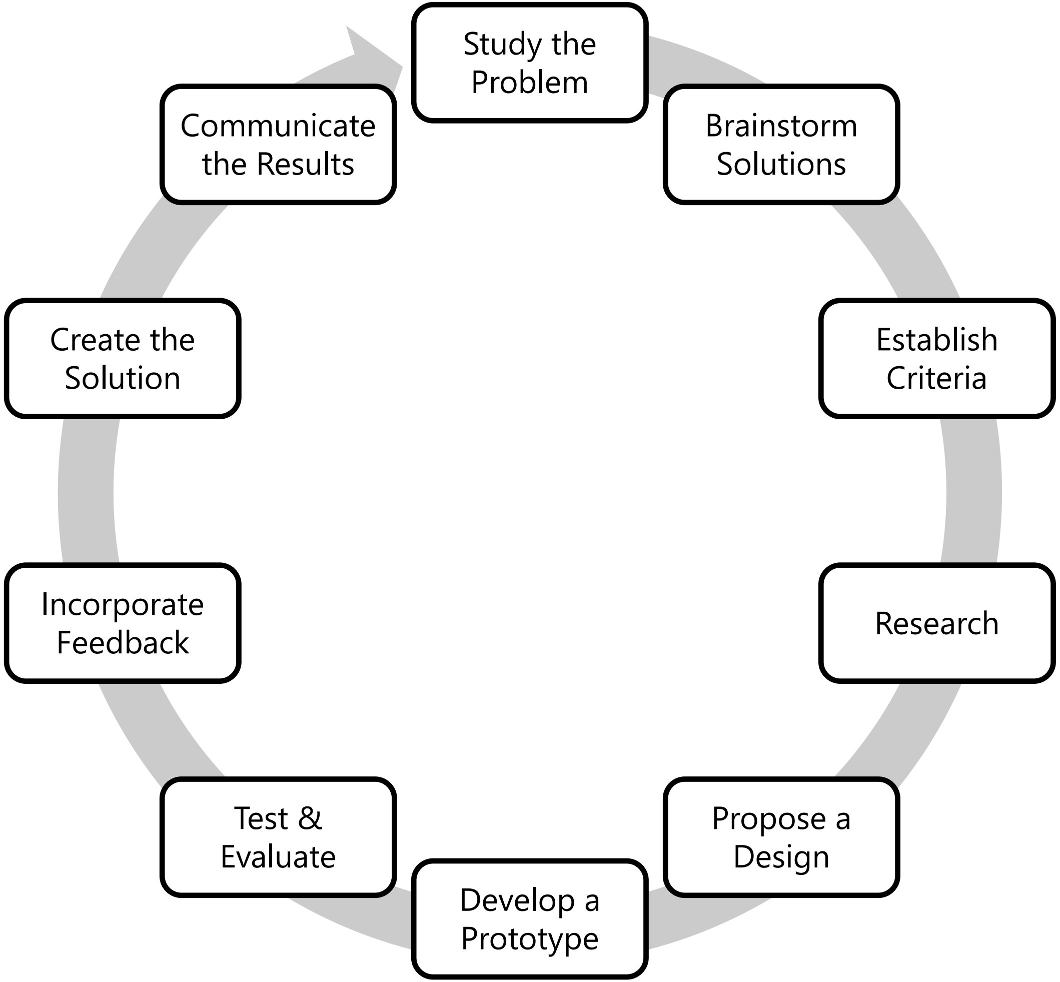
The maker culture is a contemporary culture or subculture representing a technology-based extension of DIY culture that intersects with hacker culture (which is less concerned with physical objects as it focuses on software) and revels in the creation of new devices as well as tinkering with existing ones.

-Wikipedia

Innovation Team at Palo Verde

- Reverse engineering to support station overall cost reduction efforts
- Dedicated resources to focus on opportunities in I&C
- Adds agility and responsiveness to implementing identified solutions
- Focus on technology to solve equipment-related problems and cost challenges

Innovation Design Process



Major Success

Background

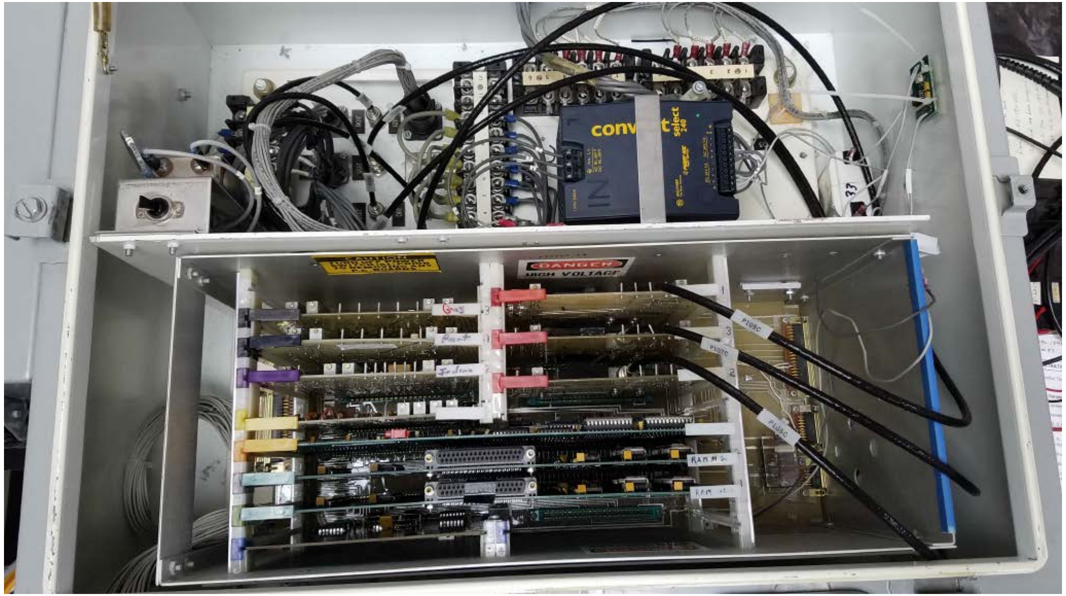
- There are 157 radiation monitors.
  - Safety Related Radiation Monitoring System (SRMS) (42 monitors total)
  - Post-Accident Radiation Monitoring System (PAMS) (39 monitors total)
  - Digital Radiation Monitoring System (DRMS) (67 monitors total plus 9 portables)
- The vendor, Kaman Sciences (OEM), went out of business in 1988.

Replacement Micro Mod

- System is an in-house designed microprocessor replacement
- Beginning in 2015, 72 monitors have been replaced so every day, > 1500 hours of service time is accrued
- Monitors use modern technology
    - 36 process monitors
    - 36 area monitors
- Electronics are made to fit current enclosure

Old Monitors

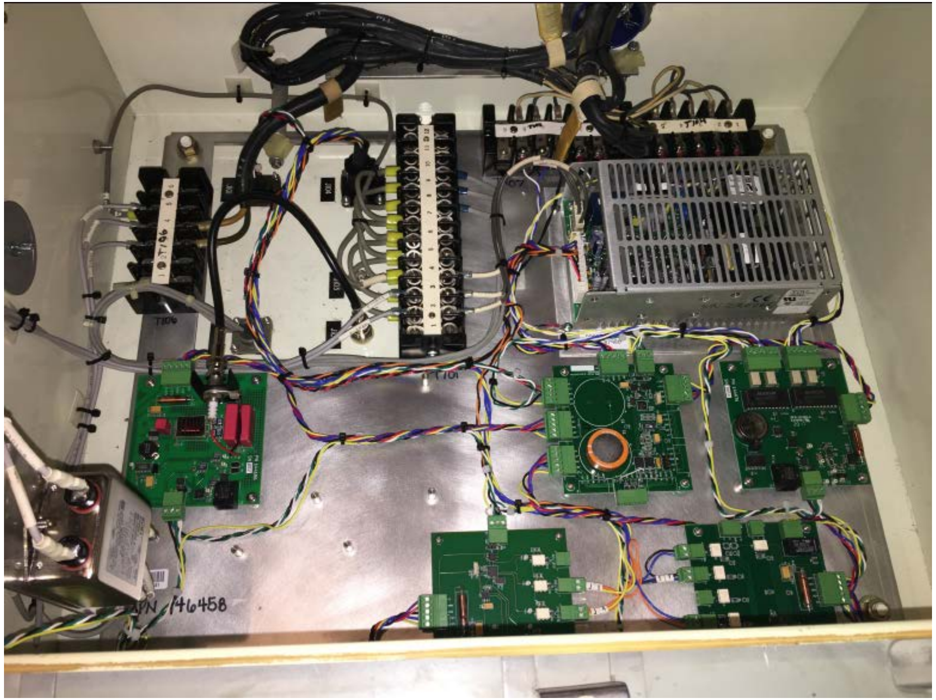
Process Monitor



Area Monitor

New Monitors

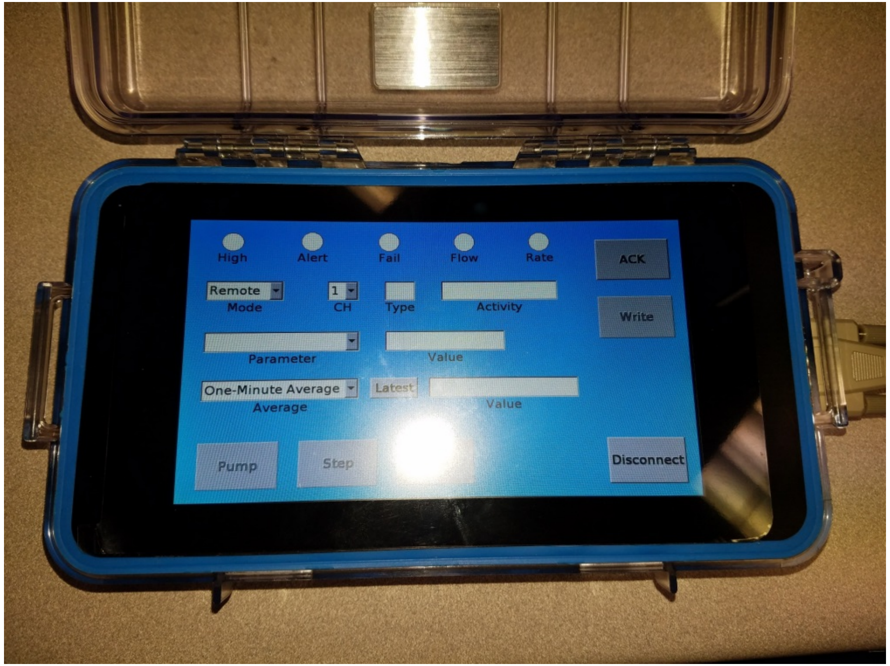
Process Monitor



Area Monitor

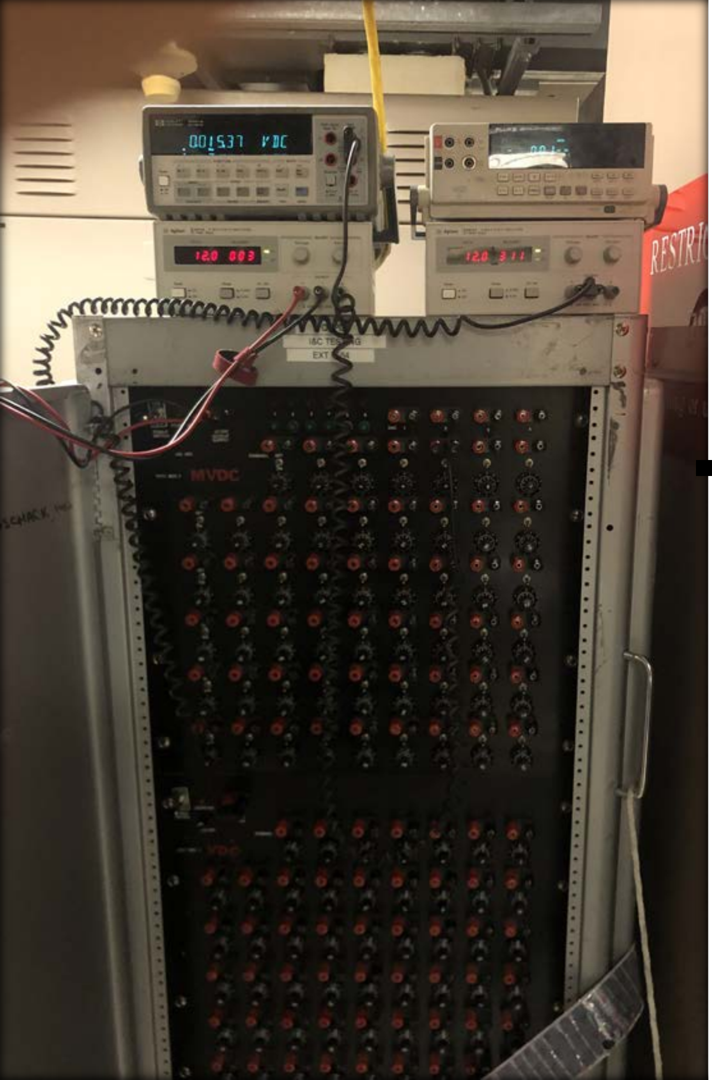
PIC vs EPIC

Portable Indication & Control



Electronic Portable Indication & Control

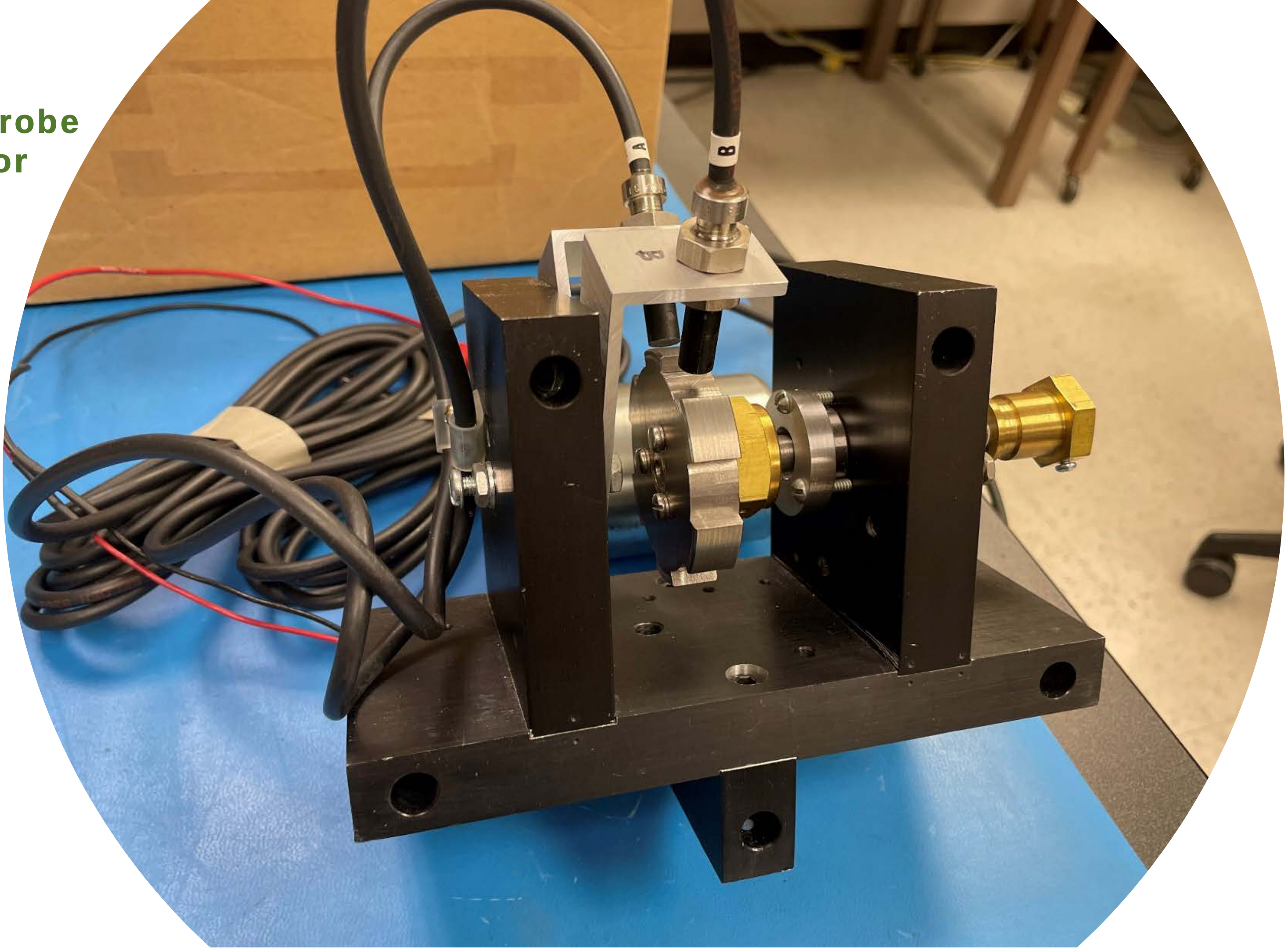
Designs in Flight



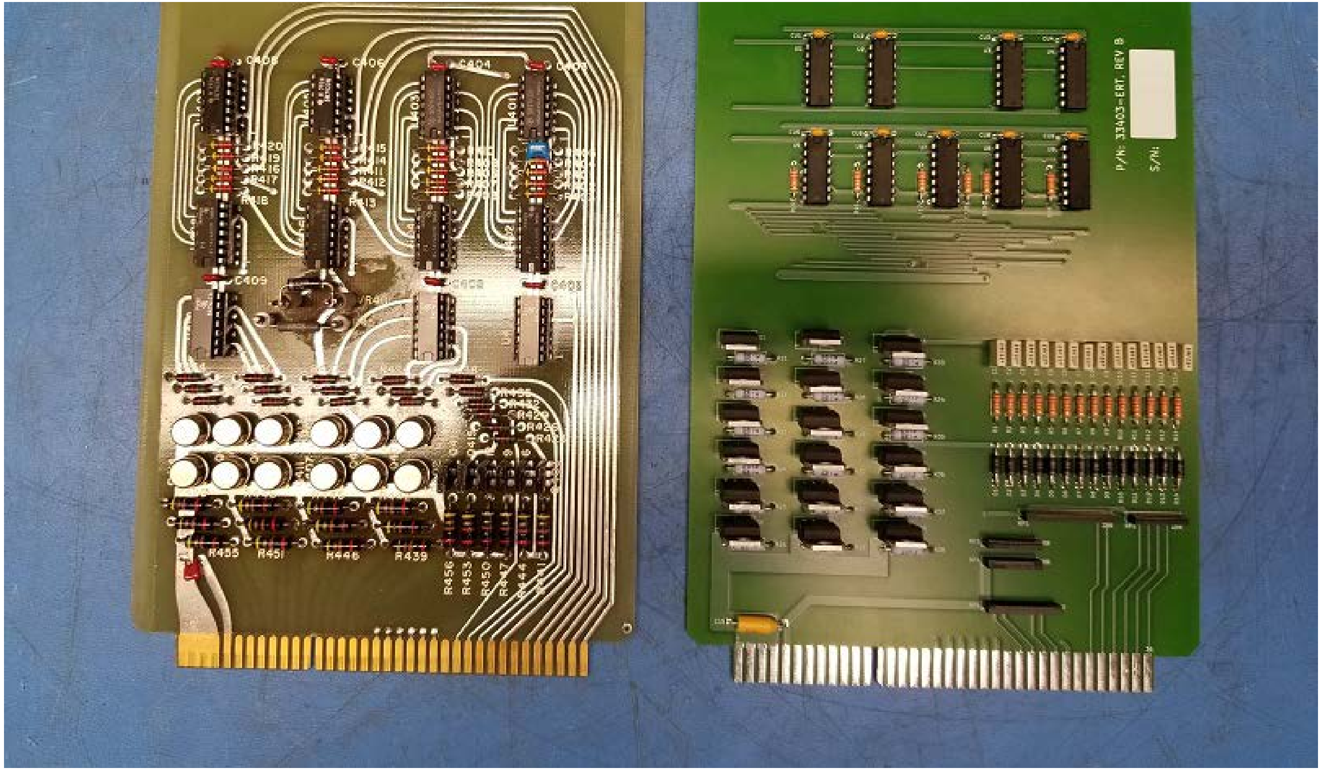
QSPDS Decade Box

Building a new tool to facilitate and add automation to the performance of a Surveillance Test. Projected to cut the task duration from two weeks (2-3 I&C technicians) down to two shifts.

RCP Speed Probe Simulator



Redesign of Plant Protection System Logic Indicator Driver Circuit Card



What are the possibilities

- Power Supplies
- Control Logic
- Analog/Digital Circuit Boards
- Virtualization of Computers
- Mechanical Parts/Valves
- 3D Printing