Los Alamos NATIONAL LABORATORY

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Ongoing Improvements to the Instrumentation and Controls System at Los Alamos Neutron Science Center (LANSCE)

Martin Pieck

Group Leader *presenting on behalf of*
Instrumentation and Controls System Group
Accelerator Operations & Technology Division

Talk only a “teaser” – talk to me

Outline

1. Los Alamos National Laboratory
2. 51-year History of LANSCE
3. LANSCE Control System
4. Instrumentation & Control System Group
5. Ongoing Challenges
6. Vision & Risk Based Strategy
7. Approach to Maintenance & Project Execution
8. Major Accomplishments & Summary

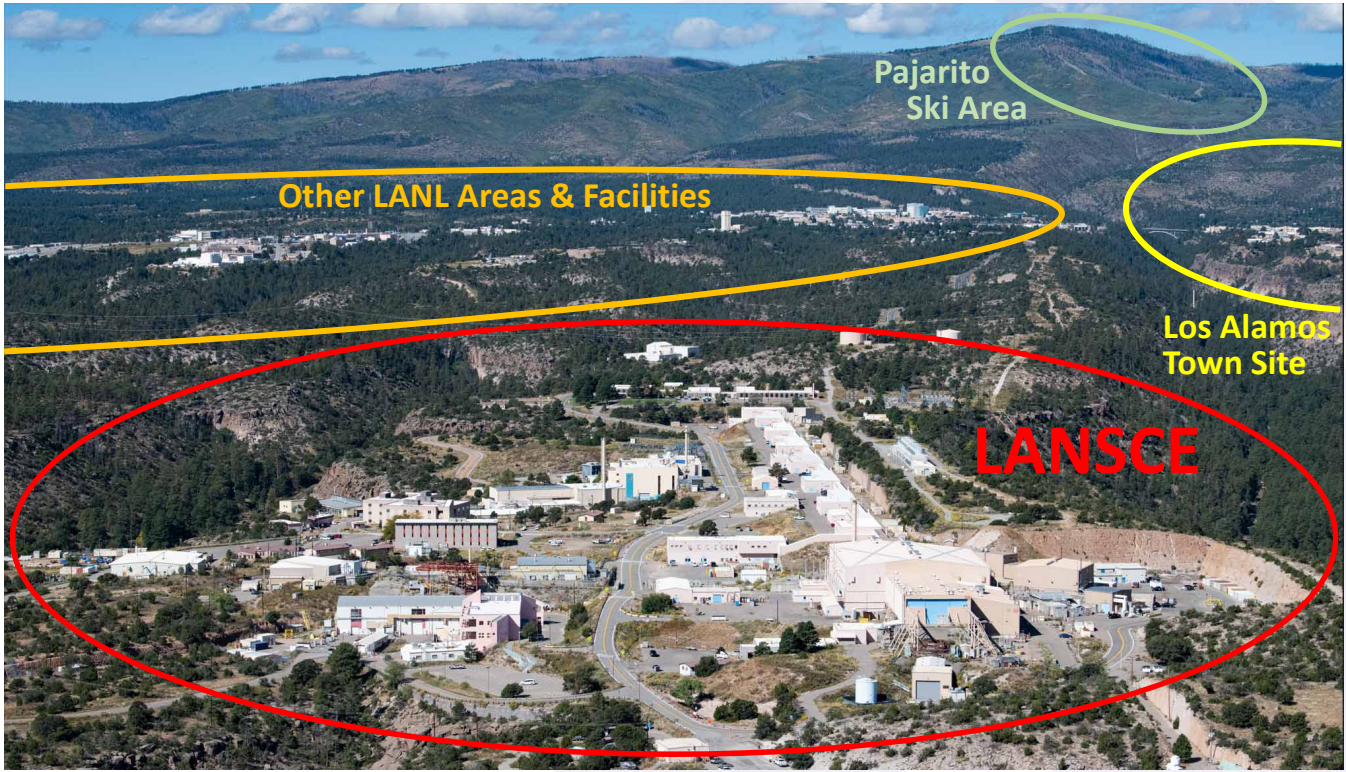
LANSCE is part of Los Alamos National Laboratory which is located in Los Alamos, New Mexico, USA

Credit: https://www.nationsonline.org/oneworld/map/usa_map.htm

Los Alamos National Laboratory (LANL) - Area

- ~40 square miles (~104 square km)
- Workforce ~14,150
- Annual Budget $4.03B

2022 Data
https://about.lanl.gov/



LANSCE's 51-year History

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Dr. Louis Rosen was a nuclear physicist, and the "father" of the Los Alamos Neutron Science Center (LANSCE) accelerator. Shown here with a model in 1962.

LANSCE's five Experimental Facilities support research in **Nuclear Physics** & **Materials Science**, as well as **Fundamental Science** and **Medical Isotopes**.

LANSCE
Los Alamos Neutron Science Center

Until 1995 known as Los Alamos Meson Facility

- 1960's – design & construction started
- 1972 – LINAC achieved 800 MeV
- 1977 – Weapons Neutron Research (1)
- 1985 – Lujan Center (Neutron Scattering) (2)
- 1997 – pRAD (Proton Radiography) (3)
- 2004 – Isotope Production Facility (4)
- 2005 – Ultra Cold Neutron (UCN) Facility (5)
- AREA - A orig. Facility not used (6)

- 2022 - 50th Anniversary

Instrumentation & Controls System Description

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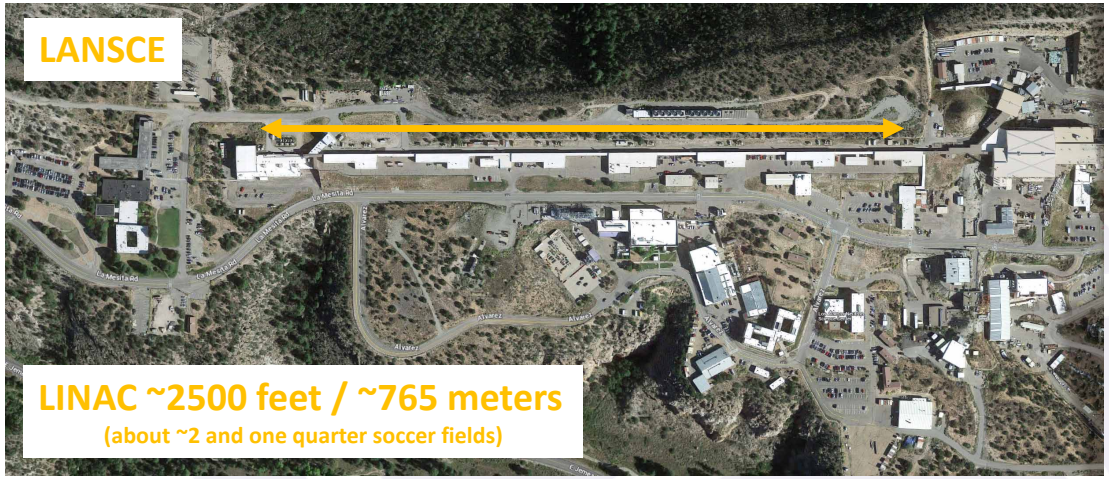
LANSCE's Instrumentation and Control System by #s



- We are an EPICS - 3.15 Facility with over ~171.000 Process Variables
  - 233 NI cRIO IOCs
  - 184 Altera FPGA IOCs
  - 79 cPCI Timing IOCs
  - 19 VME IOCs – some interface to CAMAC
  - 23 Allen Bradley PLCs

- Our controls network consists of redundant core switches with 110 leaf switches running 4 virtual networks

- We have about 1,500 network addressable device (equipment with its own IP Address)
- ~110 Workstations provide easy access to the LANSCE Control System.
- 20 Servers and 44 **Virtual** Servers
- ~930 Graphical User Interfaces
- ~880 Scripts

Instrumentation & Controls System Group

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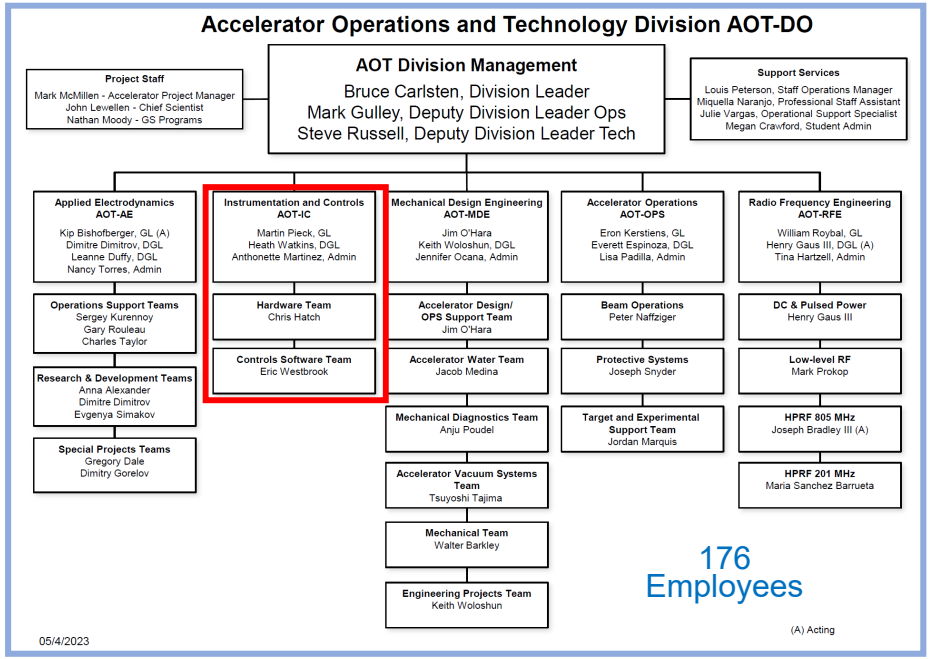
Instrumentation & Controls Group is part of an Accelerator Operations and Technology (AOT)



AOT Division provides leadership in the Laboratory's core capability of Accelerators & Electrodynamics.

and operates the LANSCE Accelerator

but not the 5 Experimental Facilities

Instrumentation & Controls Group (AOT-IC) – count & background

Group Management (2) – Group & Deputy Group Leader

- Electrical Engineering, Computer Science, Business Administration, Management of Technology, Project Management

Controls Hardware Team (14)

- 3 Technicians
- 1 Designer/Drafter (ECAD)
- 1 Technologist (ECAD)
- 2 Technologist (Electrical)
- 1 Mechanical Engineer
- 6 Electrical Engineers

Controls Software Team (12)

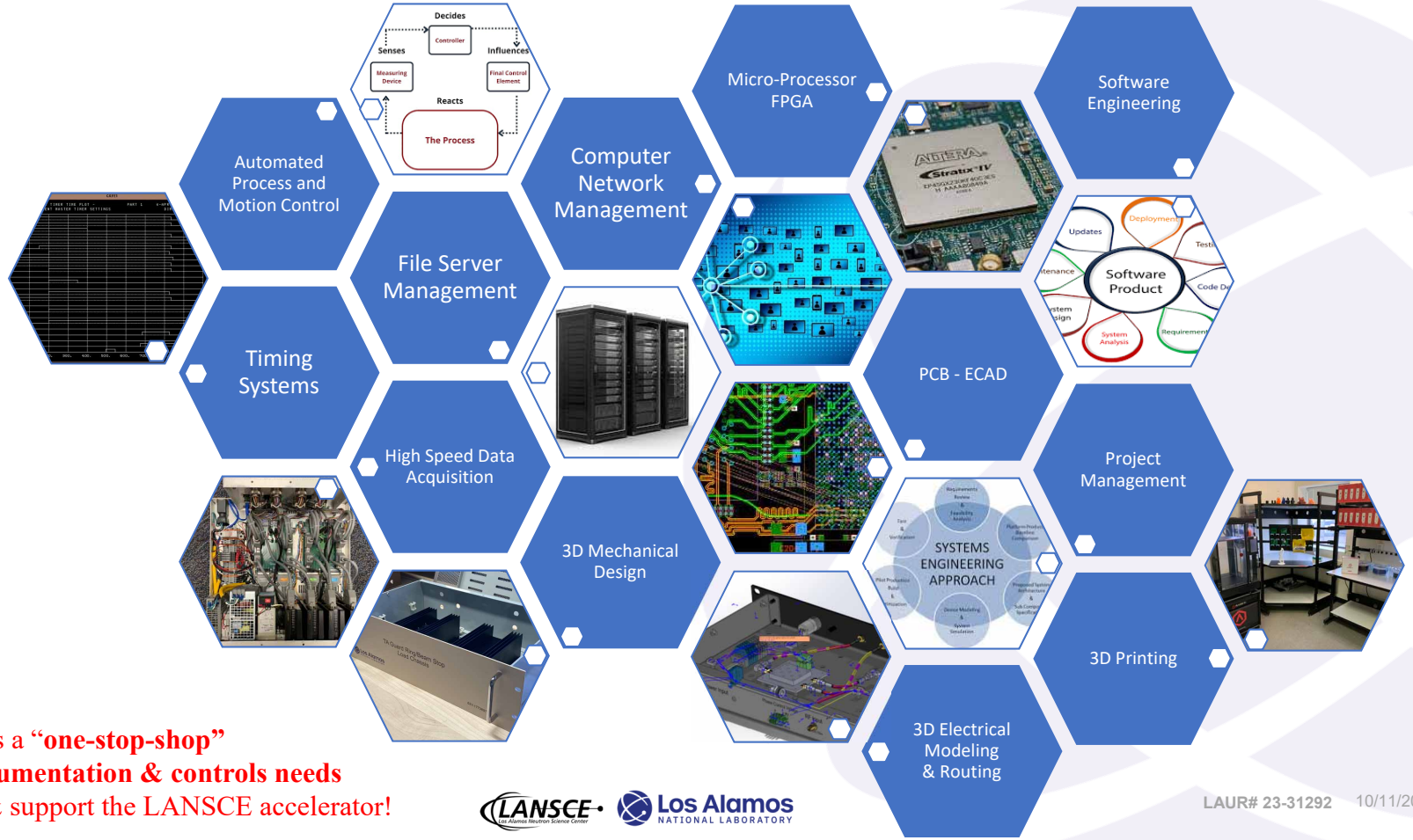
- 5 Computer Scientists
- 1 Computer/ Systems Engineer
- 3 Electrical Engineers
- 2 Mechanical Engineers
- 1 Physicist

28 Controls Group Members

Among other assignments, our group's most important responsibility is the LANSCE Control System

=> however **only 18.5 of the 28 group members** are funded to do so <=

Instrumentation & Control Group Capabilities



Our group is a "**one-stop-shop**"
for **all instrumentation & controls needs**
to operate & support the LANSCE accelerator!

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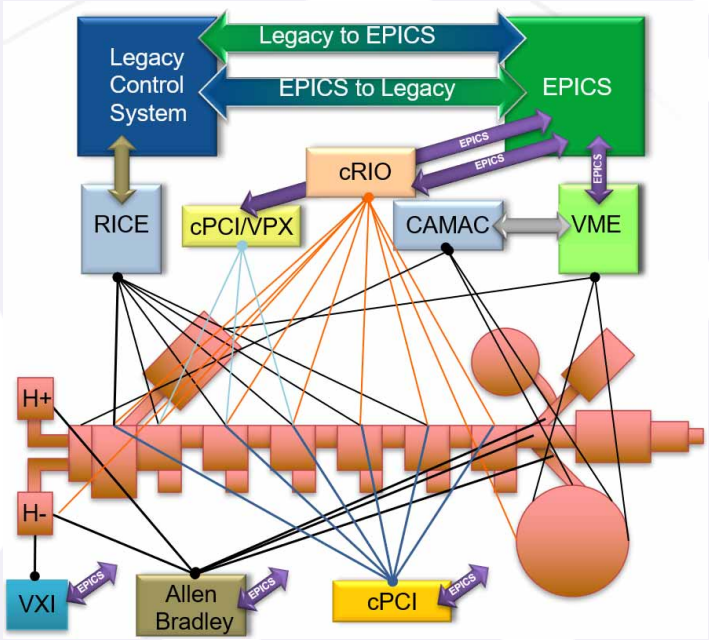
Ongoing Challenges

Some Issues that challenge the LANSCE Control System maintainability & longevity

- Accumulated 50-years worth of Software & Equipment
  - employee training, spares, life cycle, …
- Insufficient Annual Maintenance & Operations funding
  - relatively flat for the last ~8-10 years
  - only ~$1M (~0.95M EURO) for Material & Services
  - “One-Time’ funds ($0.8M–$2M/year mostly material)
- Only 4 month/year (beam outage) to upgrade systems
- Modern equipment has much shorter life span
  - i.e., VME vs FPGA
  - Life cycle management challenges
- etc.



LANSCE Control System Status 2021 – Hardware Form Factor View

In Summary: Limited resources, large amount of obsolete equipment, backlog of maintenance activities, etc. … left us overwhelmed & questioning our priorities & long-term plans.

Vision & Strategy

A renewed Vision & Strategy is helping us to overcome our Challenges

Our Vision (for LANSCE)

6 Principal Values/Criteria:

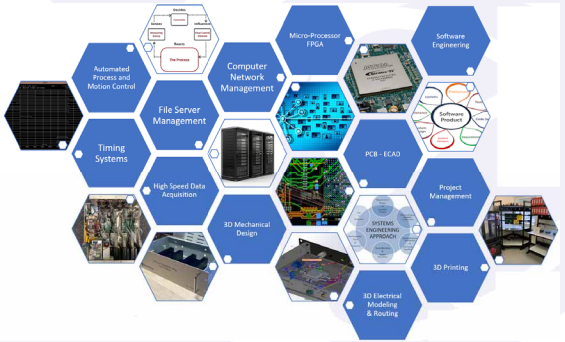
1. **Continue** to develop a most qualified workforce
2. **Conform** to safety & regulatory requirements

3. **Reduce** equipment failures & unplanned downtime
4. **Optimize** operational efficiency & performance
5. **Decrease** operational & maintenance cost
6. **Extend** software & equipment lifespan

Our Strategy (for LANSCE)

addressing 3-6 through
standardization of software & equipment

Under this objective we regularly access the current state & deficiencies of our Subject Domains (Capabilities)

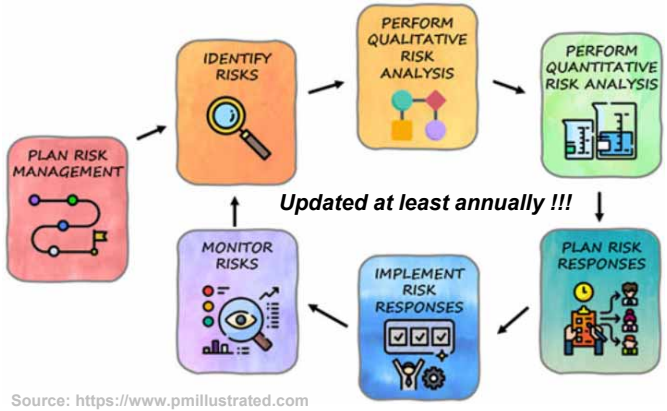


=> System "Well-Being" Assessment

System "Well-Being" Assessment input to Risk Management Plan

(which addresses current deficiencies and those relative to our Vision)

Risk Management Plan helps us to document the foreseeable risks, estimates their impacts on LANSCE, and defines the responses to the risks.



Source: https://www.pmillustrated.com

Output is a Risk Register that is an equivalent of risk based prioritized list of maintenance activities/outage projects and resources (days/$) needed to complete them.

Benefit: Process Formality & Documentation adds Credibility and aligns with our Program Manager's thinking ($$$) !

Selection, Planning, Execution, Monitoring & Control

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HOWEVER, Maintenance/Outage Project Selection is still a challenging process because of several competing objectives & constrains …

- besides Project Risk Level
- Alignment with our Vision
- Technology Maturity Level
- Preparation Time needed
- Installation/Testing Time needed
- Scalability of Maint./Project
- Labor Resource Availability
  - Right Skill Levels
  - Right Person to Lead (PIC)
  - Career Development Opportunity
  - Work for Others vs LANSCE
- Material Resource Availability
  - Funding
  - Lead Time
- Facility Services Availability
- etc.

after an iterative process we select

Maintenance/ Outage Projects

and

Project Teams

FY24 Outage Project Assignments

Hardware Team driven - Software Team driven

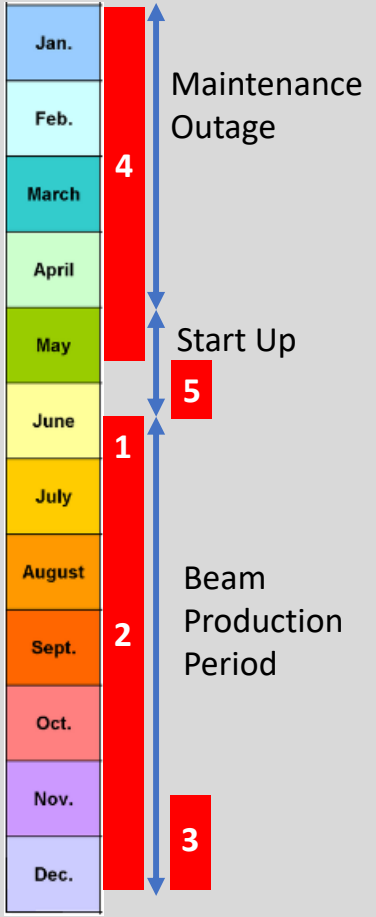
Outage Task	PIC	HW Team Support	SW Team Support	Outage Talk Scheduled?
Emittance (TBEM02,03,04, TREM01,02) / Harp TDHP01 + associated Dual Harp Mode (6)*	Montoya	Johnson	Zimmermann/Fratantonio	
Old CCPG (CAMAC/VME)	Braido	Buck	Ramakrishnan	
PSR BPPM Instrumentation	Vince (HW)/ Heath(SW)	Valdez	Zimmermann/Baily	
LEBT dLLRF – Bunchers Interface (IIO cRIO, network, timing, FCM, etc.)	Duran	Martinez	Leffler	
CCR Logic Patch Panel (and/or with the next)	L. Walker	-	-	
MT Distribution / New Timing IOCs* (see above)	L. Walker	Atencio	Ramakrishnan/Fratantonio	
CAMAC Crate 6 / REB1 VME Retirement (dLLRF H.B. – Moxa Serial migration)	Rai	-	Leffler	
Network Addressable Devices*	Valdez	-	Quemuel	
QAC/DAC Wire Scanner J00 Re-Wiring* (and/or with the next)	Martinez	Atencio	-	
L-RM 46WS02 + Prep Work for 41WS001, 42WS001, 44WS001, 45WS001* (see above)	Martinez	Atencio	Leffler	
IPF Control System upgrade PLC 4 to cRIO (funding dependent)	Johnson	L Walker	Leffler	
ICR (5=>3) & linac (~30) Switch replacement	Elliser	Valdez	A. Walker/Martin	
Core Switch replacement*	Elliser	Valdez	A. Walker/Martin	
vIOCs (migration to Linux VMs/containers)*	Fratantonio	-	Zimmermann/Westbrook	
Rocky 8 Services (migrate rem. Service from RHEL & Gentoo)*	New Hire	-	Westbrook	
Archiver (Deploy EPICS Archiver – convert CAFlux DSRP, Alarms)	Quemuel	-	Fratantonio	
Object –Oriented IIO (update all IIO to object-oriented IIO)	Martin	Hatch	-	
Tcl/Tk to EDM/Python Operator Screen upgrade*	A. Walker	-	SW Team	
EPICS 3.15 (consolidate remaining IOCs on EPICS 3.15)*	Baily	Hatch	-	
Outage Progress Reporting / ERCs (Diagnostics / Industrial Controls / Software)	Watkins	HW Team	SW Team	

* Project Scope can be adjusted based on progress/resource availability

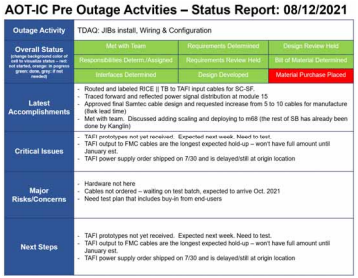
Outage Maintenance/Project List with assigned Leads (PICs) & Support Team

Advantage: The projectized approach creates an environment of people empowerment with the necessary responsibility & accountability to deliver!

Project Execution during Annual Accelerator Operating Cycle

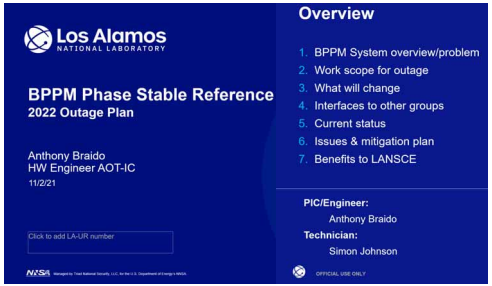


We believe that our Repeatable Formality & Projectized Approach has increased our Productivity & Success Rate



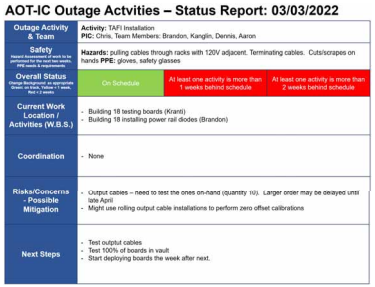
2) Pre-Outage Preparation Period

monthly Status Updates Meetings using standard slide



3) Pre-Outage Talk to Stakeholders

outage schedule is also being delivered

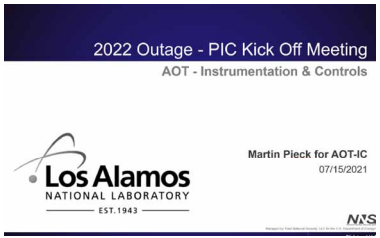


4) Maint. Outage Period

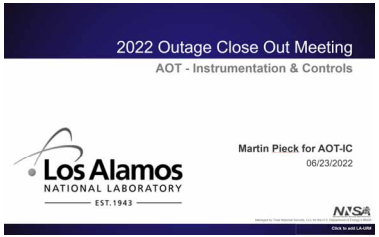
focus on Monitoring/Control

bi-weekly Meetings using standard slide

Outage Project Process Flow!



1) Project Kick-Off



5) Project Close Out & Lesson Learned

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Results & Summary

In 2022 & after 50-Years of Continuous Service we retired LANSCE's original Control System

It took **11 years** to replace it due to

- its integral architecture,
- number of channels >10,000 hardware I/O points
- unique data taking characteristics which needed to be preserved
- funding level to develop new systems & to 4-month/annual outage
- etc.

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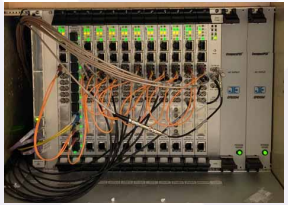
1 of 60 original Control System Modules

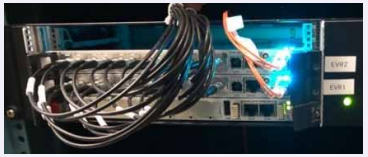
To replace these 60 Modules we deployed ~300 pieces of well standardized equipment

40 network switches

~300 Total



2 Redundant Master Timer Systems



79 cPCI Timing IOCs

41 NI cRIO Chassis for Diagnostics Data Acquisition & Motion Control

108 NI cRIO Chassis for Industrial Controls

61 Custom VPX/cPCI Systems for Fast Data Acquisition

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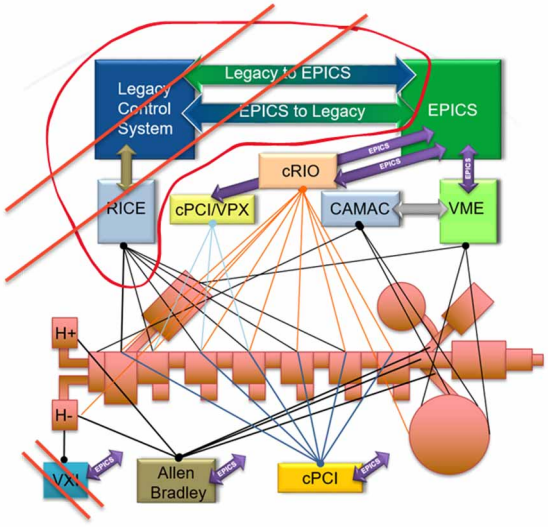
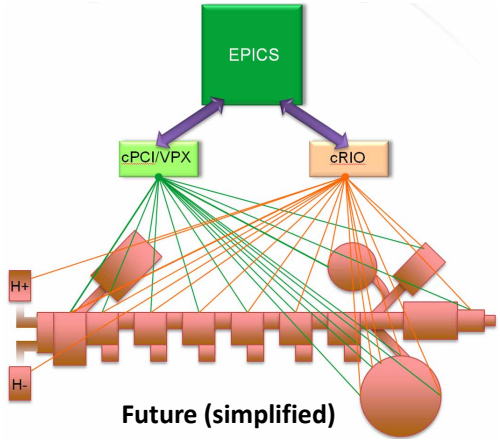
SUMMARY: Improvements to our Vision, Strategy, and Processes have produced Positive and Measurable Results

- Developed a Risk-Based Approach to identify Priorities
- Energized our people through our Vision, and Strategy
- Developed Formal & Productive Project Environment
- Retired our 50-year-old/original Control System
- Replaced with a Modern, High-Performing Standardized System



2023 LANSCE Control System Status



Future (simplified)

Other LANL / LANSCE Contributions:

Chuck Taylor ID: 1679 - TU1BCO05 Model Driven Reconfiguration of LANSCE Tuning Methods

Laura Walker ID: 1618 - THPDP085 LANSCE's Timing System Status and Future Plans

Thank You!

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