Leading Edge Flow Meter (LEFM) Fleet Wide System Replacement and Standardization

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Goals & Outline

Goal: Provide an overview of a recent multi-site LEFM replacement project

Outline:

- Exelon's pre-project LEFM Systems
- Existing system basic design
- Existing system failures and parts obsolescence
- Replacement options
- Chosen replacement basic design
- Project progress to date
- Enhancements from old system
- Lesson's learned

Pre-Project Exelon LEFM CheckPlus Systems

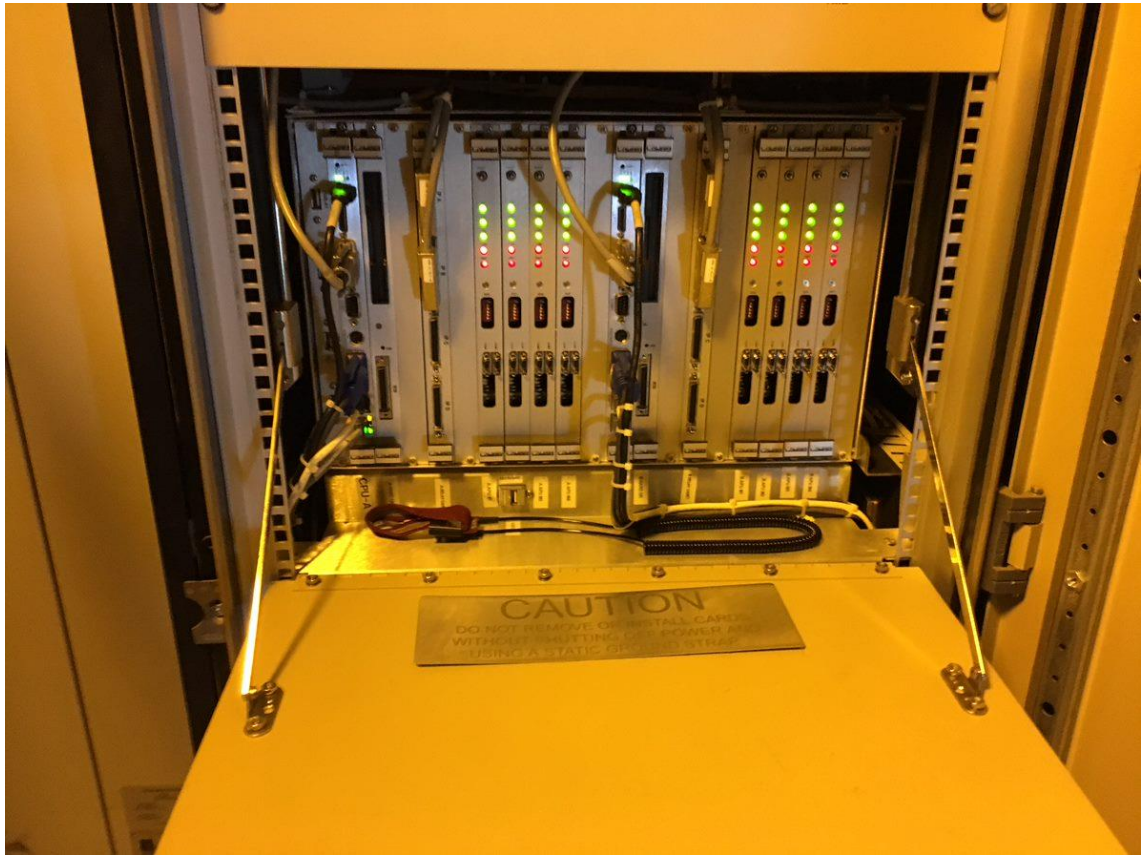
Exelon Plant	System Commissioned	# Loops	Equipment
Peach Bottom 2	Oct-02	3	CheckPlus 2000
Peach Bottom 3	Oct-03	3	CheckPlus 2000
La Salle 1	Mar-08	2	CheckPlus 2000
La Salle 2	Mar-11	2	CheckPlus 2000
Limerick 1	Apr-10	3	CheckPlus 2000
Limerick 2	Apr-11	3	CheckPlus 2000
Byron 1	May-11	4	CheckPlus 2000
Byron 2	Oct-11	4	CheckPlus 2000
Braidwood 1	Apr-12	4	CheckPlus 2000
Braidwood 2	May-11	4	CheckPlus 2000
Quad Cities 1*	Jun-11	3	CheckPlus 2000
Quad Cities 2*	Apr-10	3	CheckPlus 2000
Dresden 2*	Nov-11	3	CheckPlus 2000
Dresden 3*	Dec-10	3	CheckPlus 2000
Calvert Cliffs 1	Feb-10	2	CheckPlus 2000
Calvert Cliffs 2	May09	2	CheckPlus 2000

* Quad Cities and Dresden never performed an MUR, thus LEFM not required for full power operations and were not in the scope of this project

LEFM CheckPlus system components

- System consists of A and B Windows CPUs
- The A CPU processes data from Plane A data received by the transmitters
- The B CPU processes data from Plane B data received by the transmitters
- CPUs A and B communicate internally so that both A and B CPUs can obtain Plane A and B data
- Both CPUs have to be running and functional for fully accurate data to be available
- Each CPU can provide data back to the PPC system for use in the calculated heat balance

LEFM CheckPlus VME Chassis Windows computers



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Problem Statement in 2017

LEFM control system components are obsolete. Failure of the LEFM system without the ability to restore to OPERABLE status within 72 hours requires a power reduction of approximately 1.6% at Byron, Braidwood, LaSalle, Limerick, Peach Bottom and Calvert Cliffs (TRM Requirement).

Existing spare parts for certain components (CPU, APU, hard drive, and relay board) are obsolete and no longer available from the OEM (Cameron)

- Cameron has zero available 9A-201B037G02 CPUs in stock
- Cameron has zero available 9A-202B166G01 APUs in stock
- Cameron has zero available Hard Drives (9A-201B457G01) in stock
- Cameron has 6 available Relay Cards (9A-201B084G02) in stock
- LEFM manufacturer, Cameron, issued a “Last Buy” opportunity in 2010 when certain components, manufactured by a third party sub-vendor, would become obsolete

Exelon inventory of spare parts to maintain current system was being depleted

Replacement options – LEFM CheckPlus-M or M3P

- In 2008 a replacement for the CheckPlus systems was introduced it is the CheckPlus-M (2010 platform)
- Late in 2016 Cameron introduced a PLC based design called the CheckPlus-M3P system
- The CheckPlus-M was based on COT CPUs and other components which would allow for easier form, fit and function replacement in the future
- CheckPlus-M still used Windows operating system on the CPUs that were needed for operation
- The CheckPlus-M3P system uses standard PLCs as the primary CPU engine
- For both versions both CPUs run independently of each other which provides for higher redundancy
- Both solutions can be installed as direct cabinet replacements with wiring terminations that match between the old and new systems to simplify installation

Replacement options – LEFM CheckPlus-M or M3P

- Advantages of the CheckPlus-M3P system over CheckPlus-M
  - A Windows computer is utilized with the CheckPlus-M3P system but *only* for diagnostics it is not required for the system to provide accurate data
  - Increased operating temperature range since Windows computers not required for system operation. Only one HVAC unit per cabinet required not two
- Disadvantages of CheckPlus-M3P system over CheckPlus-M
  - Was still in late 'concept' stage
  - No installations in the field, our first installation would be the first nuclear production use
  - CheckPlus-M installed at several nuclear sites already

LEFM CheckPlus-M3P PLC based

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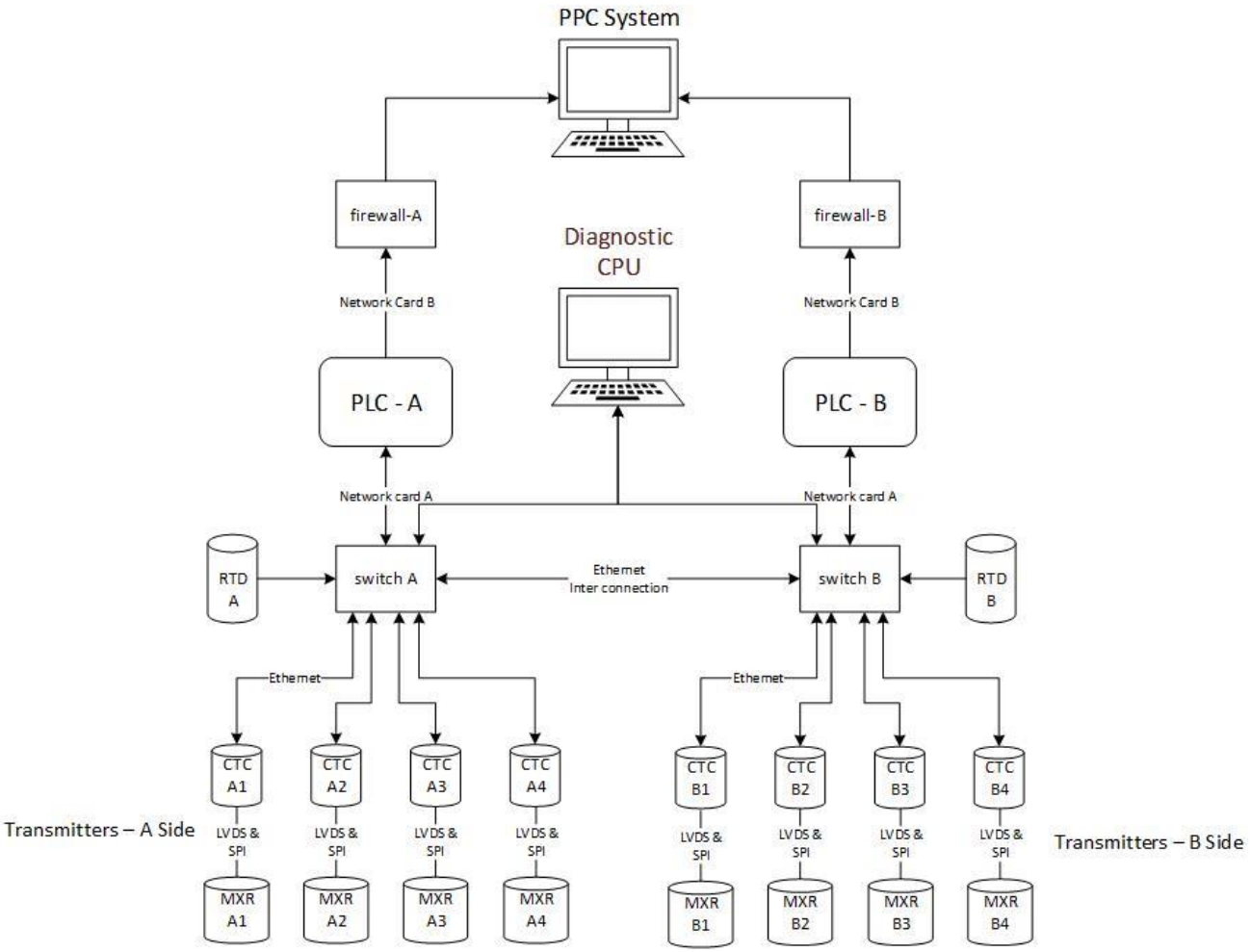
LEFM CheckPlus-M3P High Level Architecture



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Project Objectives

Eliminate risk of lost generation by replacing the LEFM's obsolete control system with the CheckPlus-M3P control system

- Existing cabinet will be replaced with a new cabinet that houses the CheckPlus-M3P system
- Maintain use of existing feedwater piping spool pieces, transducers, and cabling
- Core thermal power uncertainty that establishes the licensed thermal power is NOT impacted; The uncertainty of the new system is bounded by the existing uncertainty
- Design engineering being performed in-house
- Maintain MUR status at Byron, Braidwood, LaSalle, Limerick, Peach Bottom and Calvert Cliffs

High level installation plan

- Pre-outage after the nuclear unit falls below the pre-MUR operating limit, shutdown, determ, and install the new LEFM system
  - It is also possible to start 72 hours early by utilizing the allowed time period when the unit can run at MUR level with LEFM unavailable
- Get new system powered up pre-outage
  - Perform calibrations
  - Tune system as best as possible depending on power level
  - Perform some modification acceptance testing
  - Ensure PPC is communicating with the new LEFM system
  - If power level is still above 95% full system commissioning can be performed pre-outage (only Calvert Cliffs U2 has done that so far)
- During the outage
  - Perform any tuning/setup that is possible
  - Replace any faulty hardware or instruments found
- Post outage after the nuclear unit is above 95% power
  - Perform final tuning as needed (prior to commissioning)
  - Perform full commissioning of system before ramping unit to original MUR power level

Progress to date

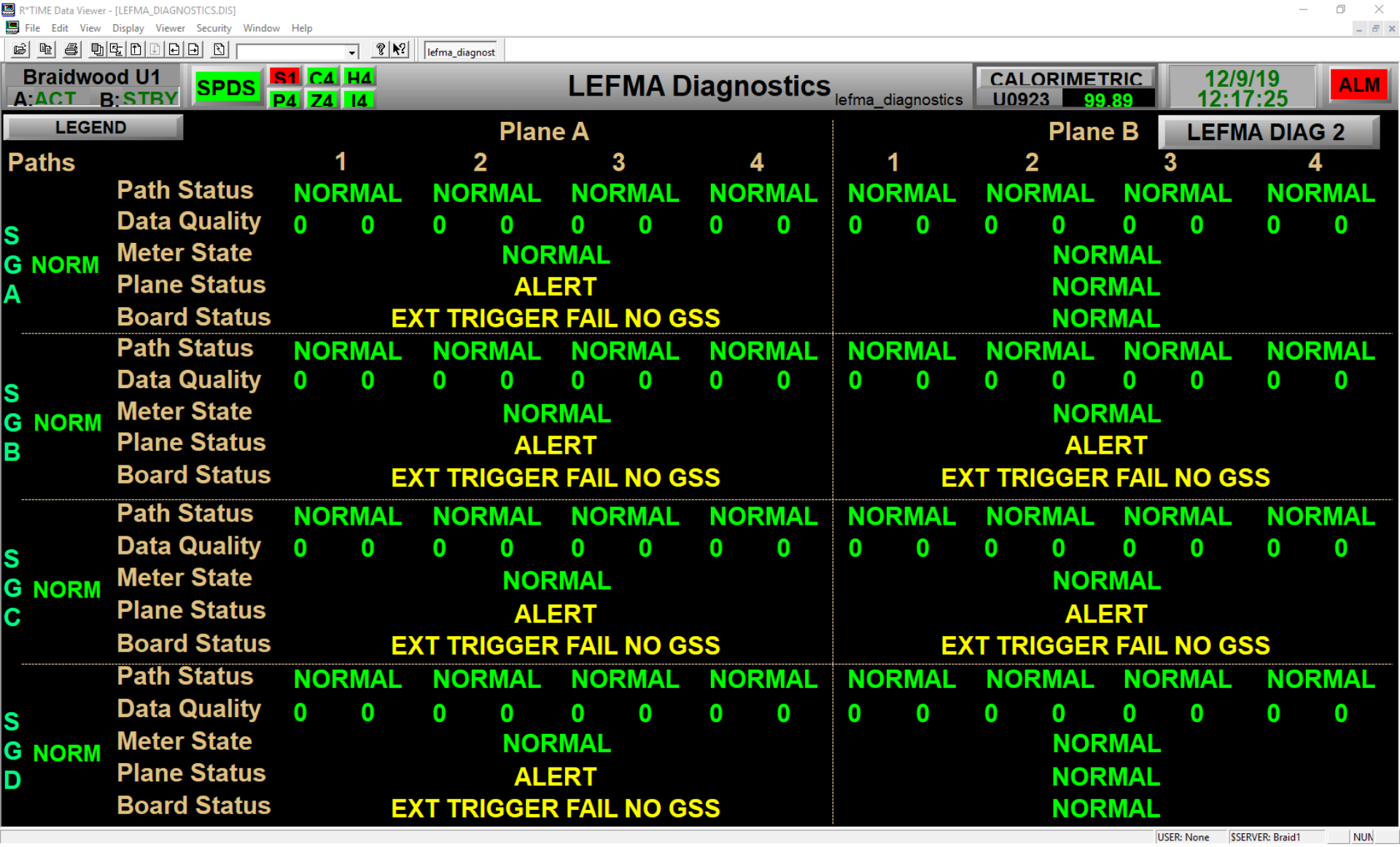
- The following systems have been installed already
  - Byron U1 in fall 2018
  - Braidwood U2 in fall 2018
  - Calvert Cliffs U2 in winter 2019
  - LaSalle U2 in winter 2019
  - Limerick U2 in spring 2019
  - Byron U2 in spring 2019
  - Braidwood U1 in fall 2019
  - Peach Bottom U3 in fall 2019

- Remainder in 2020
  - LaSalle U1
  - Calvert Cliffs U1
  - Limerick U1
  - Peach Bottom U2

Enhancements to collected data

- The vendor provided for the ability to retrieve a significant amount of internal data from the new LEFM system, that was not strictly needed for the heat balance
- This data consisted of SNR, gain, velocity, detailed statuses, rejects and more.
- At two of our sites system engineering expressed interest in transferring this data to the PPC
- Approximately 500 data points per LEFM CPU where obtained
- Data was available in the original LEFM systems, but not transferable to the PPC, had to obtain manually from LEFM itself
- All sites now use Modbus interface for their PPC to the LEFM system, some previously used other transfer methods

Diagnostic Screen #1



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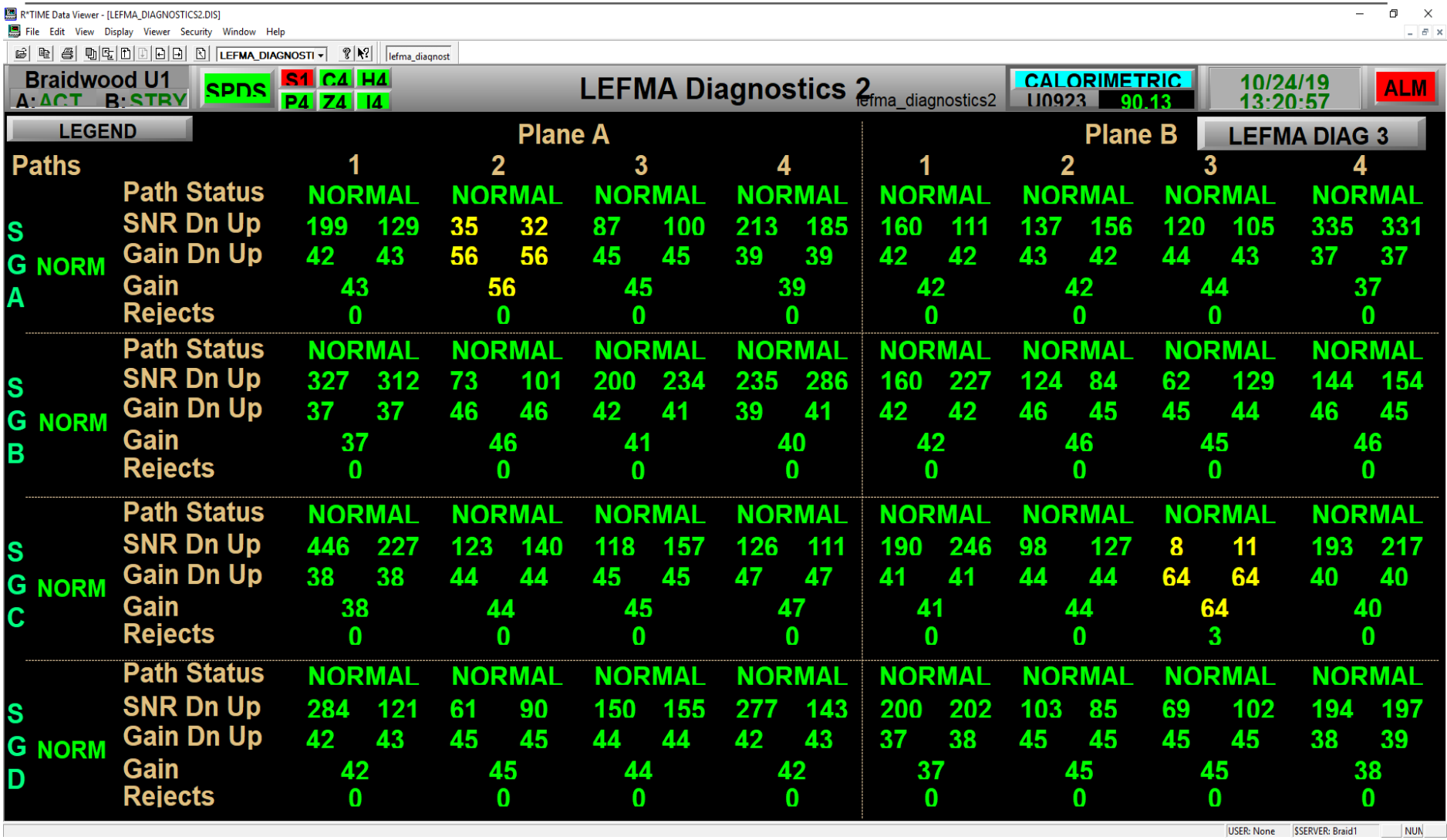
Diagnostic Screen #2



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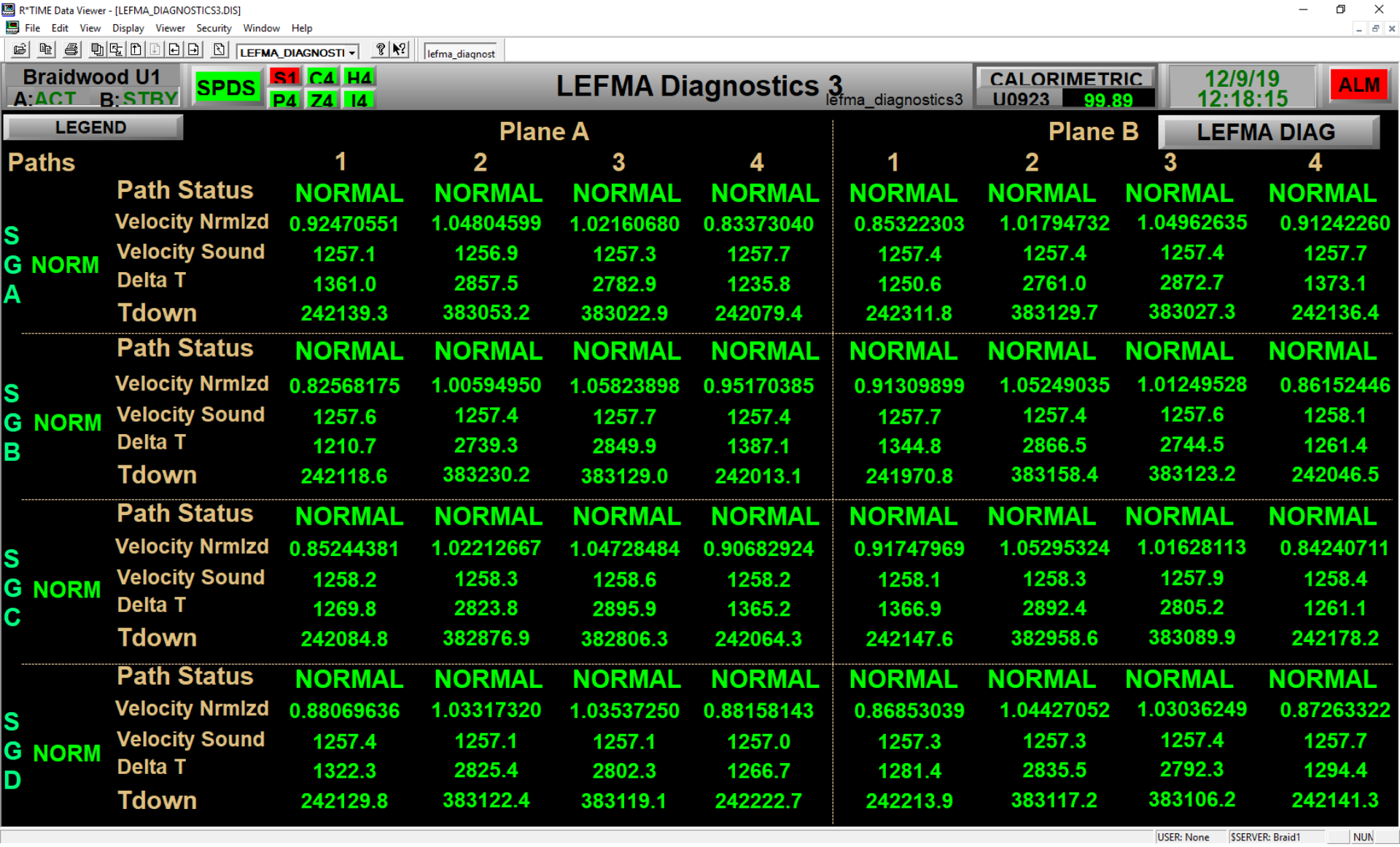
Diagnostic Screen #3



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Lesson's Learned

Issue

- Site specific project managers or task managers were not assigned to the project, this function was to be done by the system engineers which is not their skill set and they don't have the time to 'herd the cats'. This occurred due to the relatively low cost of the project and has caused challenges at some sites particularly when it came time for the actual installation to take place.

Recommendation

- Evaluate and plan from the beginning and allocate resources to coordinate installation activities among the various departments

Issue

- Some component issues were not discovered until installation and MAT, should have been found during FAT, including terminal blocks not ordered physically as expected

Recommendation

- Include in FAT physical inspection of the component layouts to ensure they are as designed

Lesson's Learned

Issue

- Some site specific setup was not in place on the new systems prior to shipment, the settings weren't testable at FAT, but systems should have been configured with site specific parameters. It is exponentially harder to make the changes once the system is at the plant and installed than when it is sitting at the vendor's location still

Recommendation

- Site specific configuration to be loaded before FAT and reviewed as part of FAT

Issue

- Cabinet internal wiring inadvertently reversed the polarity of the pressure transmitter inputs and was not discovered until the first new cabinet was wired to the field. The decision was made to reverse the field inputs because it was much harder to 'fix' the internal wiring

Recommendation

- Careful review of the vendor internal drawings may have caught this, enhance FAT to include signal injection using polarity on site specific drawings

Lesson's Learned

Issue

- Original field wiring did not have ferrules on them, removing the wiring and reattaching to the new system caused several loose connections.

Recommendation

- Ferrules were added to all wiring and job step was added to future installations

Issue

- At the first site issues were encountered performing some of the calibrations which almost caused a delay in unit startup.

Recommendation

- These checks and calibrations need to be done pre-outage or even during the outage if possible

Issue

- High number of existing transmitters at one site were found to not be in tolerance with the new system and required replacement

Recommendation

- Review signal to noise ratio reported by existing system prior to replacement to plan for needed transducer replacement

Lesson's Learned

Issue

- Being that the system was new and had never been installed in the field, numerous issues and errors were discovered in the vendor documentation, unfortunately many of these weren't discovered until the installation during the unit outage

Recommendation

- Review by highly experienced personnel may have caught these issue, but some would have slipped through because it was the first of its kind

Issue

- A parameter entry error caused the system to enter maintenance mode during unit down power. Tied back to site specific parameters not entered and checked on the system prior to being installed at the plant.
- A averaging setting was found to be lower on one feedwater loop than the other three, this caused oscillations in core thermal power output
- Engineering units were not set correctly for some installations to match those expected at the plant

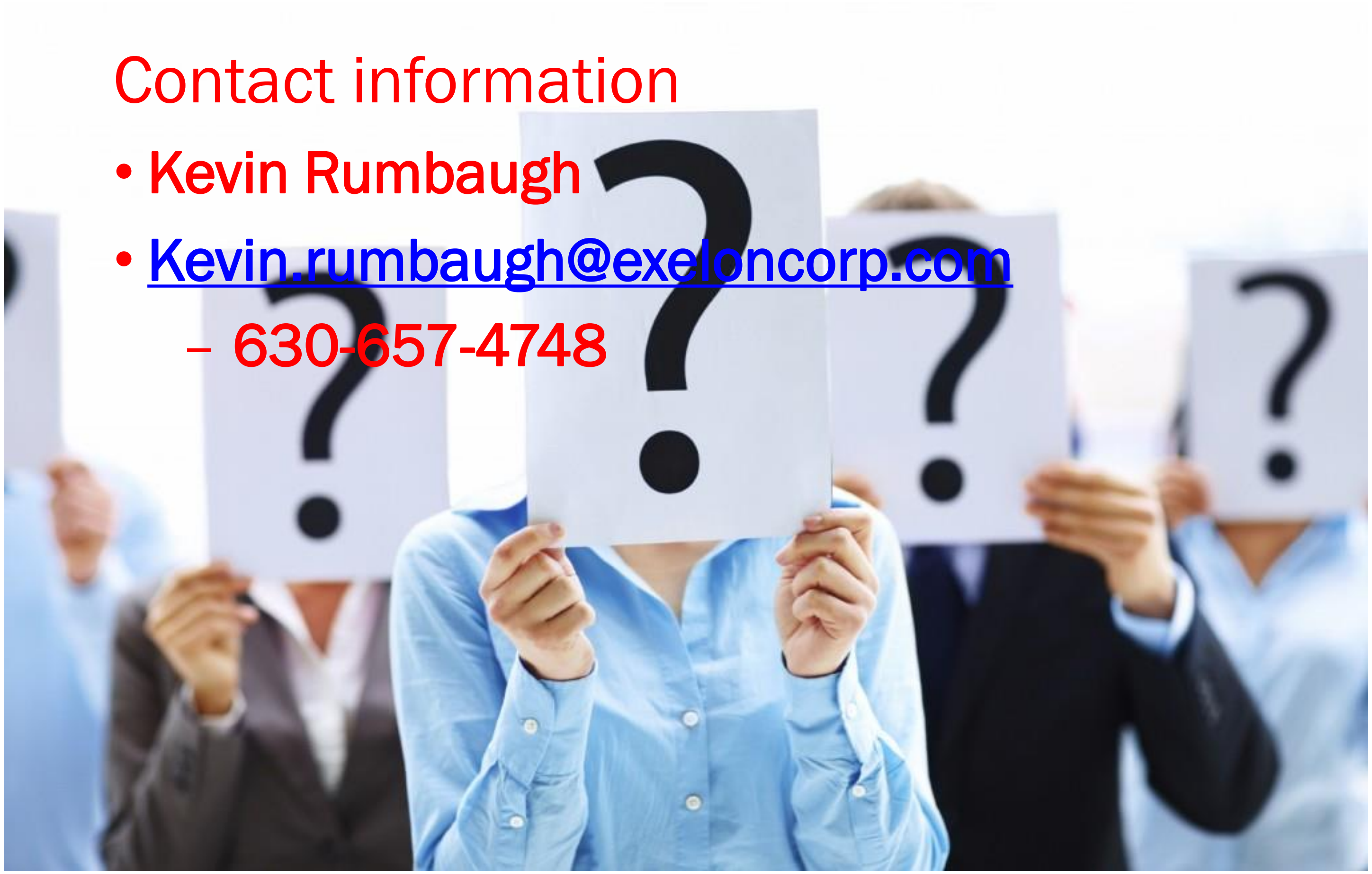
Recommendation

- Stronger use of peer check and challenge/review of planned changes could avert these errors
- Ensure consistency between feedwater loop settings are the same, or known to be intentionally different

In Summary

- Multi site projects can be like herding cats sometimes
- Standardization from site to site helps everyone in the long run
- Having one overall technical lead helps to ensure consistency throughout the projects lifecycle
- Need site project or task managers to coordinate installation amongst multiple site disciplines, engineers aren't always the best choice for this role

Contact information



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