Technology Innovation

October 4, 2018

Technology and Operations

The Case for Innovation

The Case for Innovation

- **IT as a Budget Opportunity**
  - How do we leverage technology to gain efficiency and reduce business costs?
- **Balancing People and Technology**
  - How do we automate and incorporate machine learning to reduce costs?
- **Technology and Performance**
  - How do we leverage technology and data to be more analytical and predictive?

Technology and Operations

Sensors | Mobility | Monitoring

Industrial Internet of Things

Edge

1. Read sensor data
2. Edge Processing
3. Format and transmit data via radio

Communication

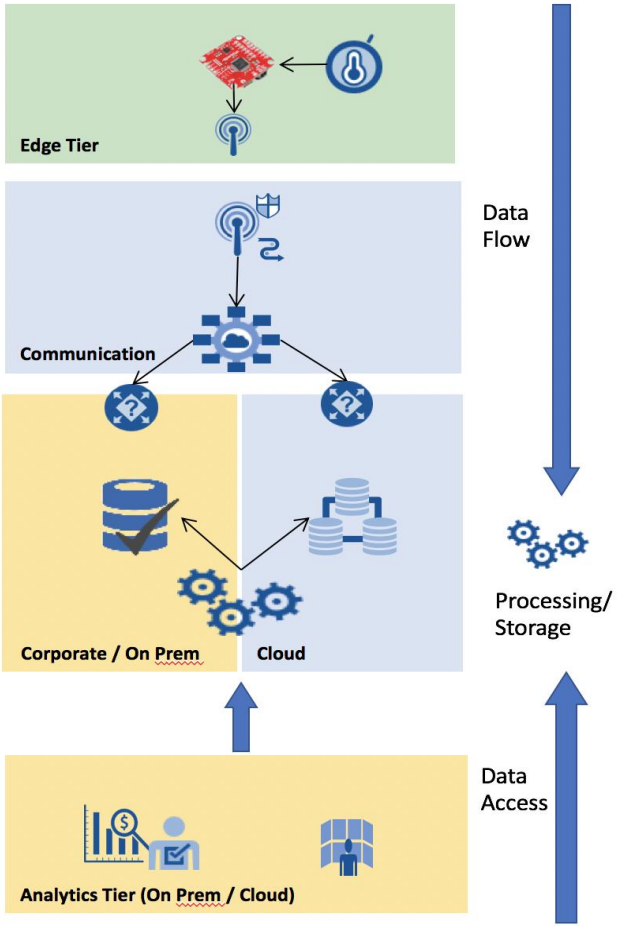
1. 900Mhz / Wifi / Bluetooth / LTE
2. Authentication / Authorization of devices
3. Gateways between networks and radio technologies
4. Connectivity to cloud
5. Connectivity to Corporate

Processing

1. Event hub processing
2. Mapping sensor data to Data Historian points
3. Writing sensor data to Data Historian

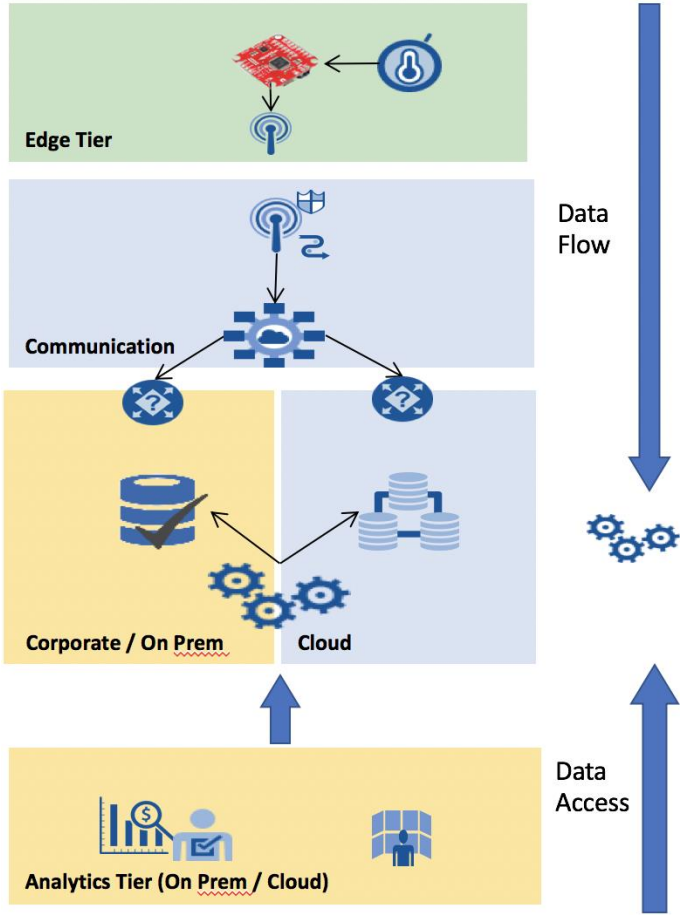
Analytics / Enterprise

1. Streaming Analytics
2. Monitoring Thresholds
3. AI / Reporting

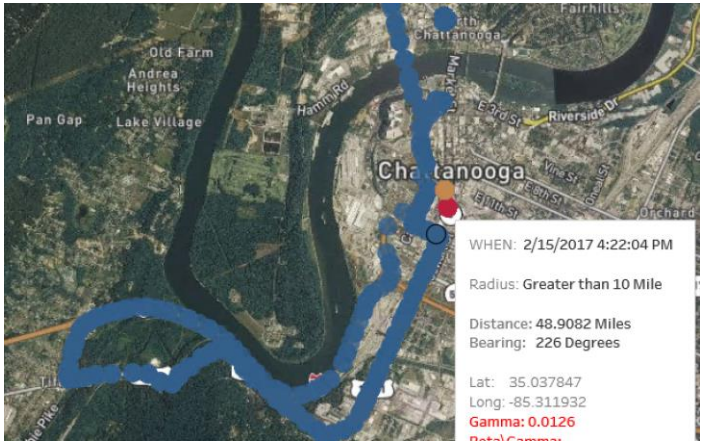


IIoT Challenges

- Remote sensor data collection:
  - Data Lake on Azure Cloud
  - Data Historian on Premise
- Realtime and historical analytics needed
- Pervasive Wi-Fi not available inside plants
- 2.4 Ghz does not penetrate plant equipment
- Crossover between IT, Electro Engineering and 3D Design



Wireless Sensors – In-House Developed



Wireless Vibration Sensors Deployed

Features

- Industrial Grade 3-axis Vibration Sensor with RMS, MAX and MIN g vibration
- Vibration Range ±16g
- Noise Removal using Low pass filter
- Frequency Range(Bandwidth) up to 408 Hz
- Sample Rate up to 952Hz
- 900Mhz - 2 Mile Range with On-Board Antenna
- Operating Temperature Range -40 to +85 °C
- IP65 Rated Enclosure
- Up to 500,000 Transmissions from 4 AA Batteries

https://store.ncd.io/product/industrial-wireless-vibration-and-temperature-sensor/

Wireless Vibrations Project

Awards:

- 2018 Nuclear Energy Institute (NEI): Top Innovation Practice (TIP) Award

NCD wireless vibration and temperature sensor:

- 900 MHz Digi Key Mesh network
- 950Hz sampling rate
- Up to 255 sensors per mesh network

Deployments:

- SQN: 96 sensors deployed
- WBN: 96 sensors deployed
- BFN: 108 sensors in the process of being deployed

Nuclear and IT Employees Recognized with TIP Award for Original Wireless Vibration Sensor

May 24, 2018

Nuclear News

NEI Awards

Technology and Operations

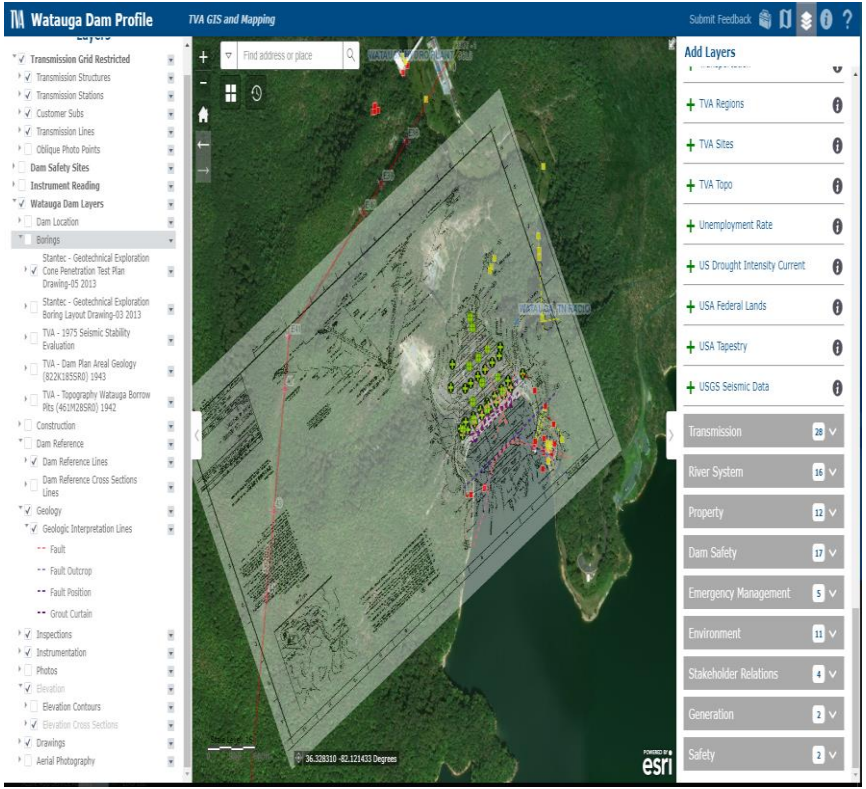
Sensors | **Mobility** | Monitoring

Dam Records And GIS ONline (DRAGON)

- Consolidates instrumentation readings into one central system
- Eliminates the use of spreadsheets
- Mobile application eliminates travel time for error rechecks
- Automates reporting

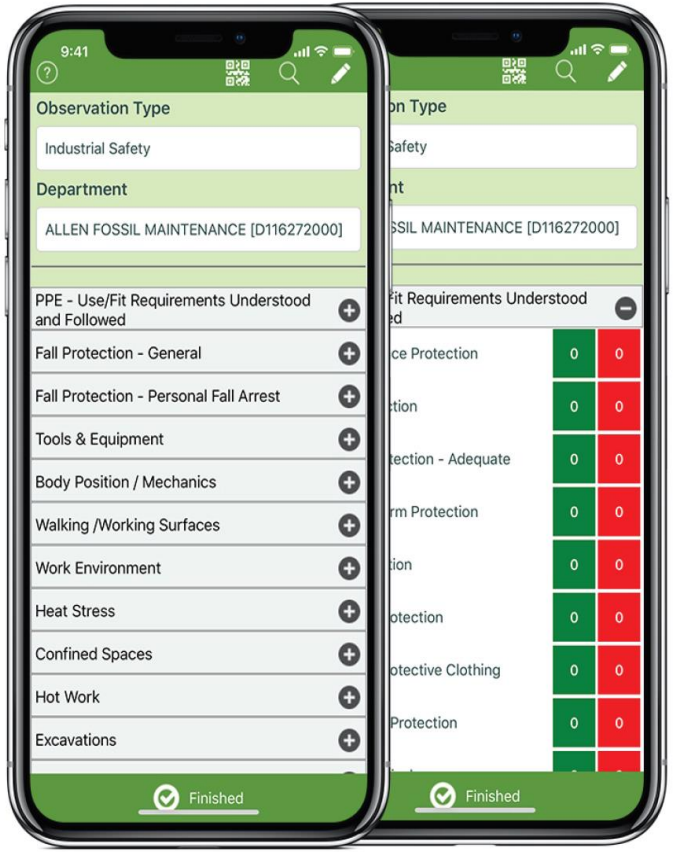
Benefits:

- Providing a mobile solution for 193 inspections scheduled for 2019
- Estimated hours saved for 2019 is over 1000 man-hours

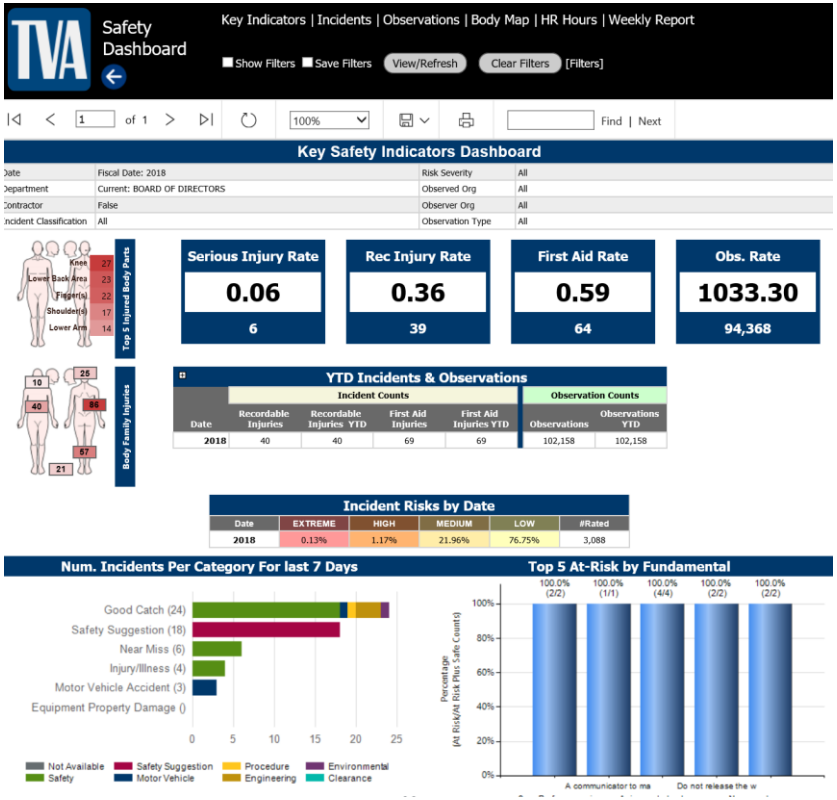


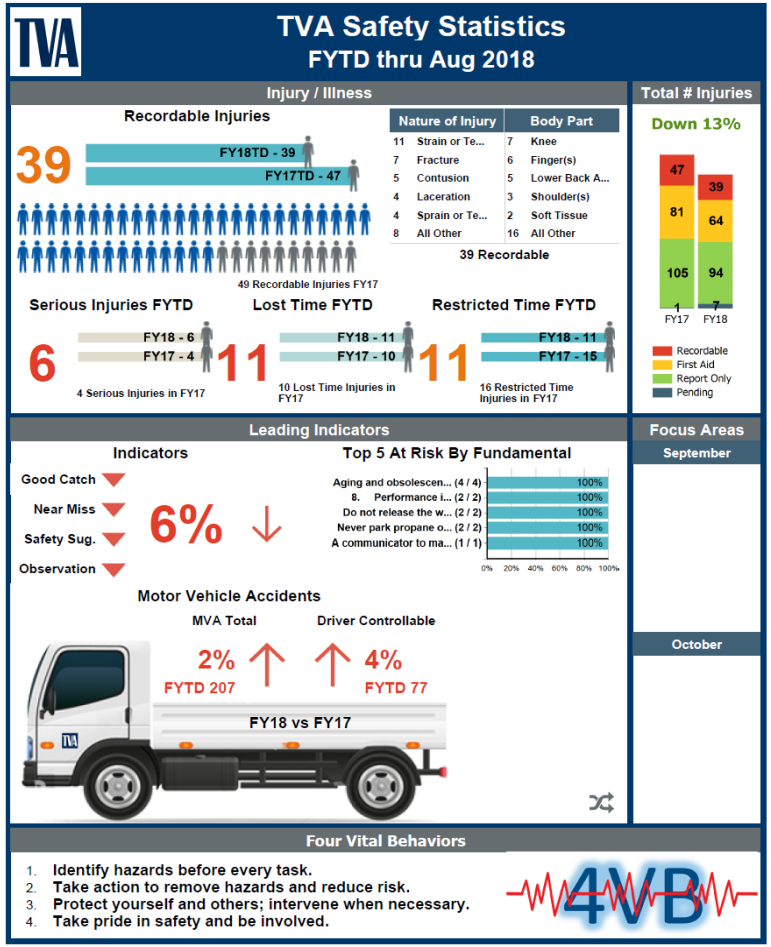
SafetyNet

- Improves efficiency and accuracy of TVA's safety observation program by allowing personnel to submit observations in real time
- Provides a user friendly interface for assigning safe vs. at-risk conditions and behaviors
- Includes ability to submit photographs
- Enables trending
- Leading indicators based on behaviors and conditions
- Red Flag predictive modeling / analytics
- Externally linked to Union leadership
- TVA hosted demonstrations for over 20 peer companies and presented at 2 industry conferences

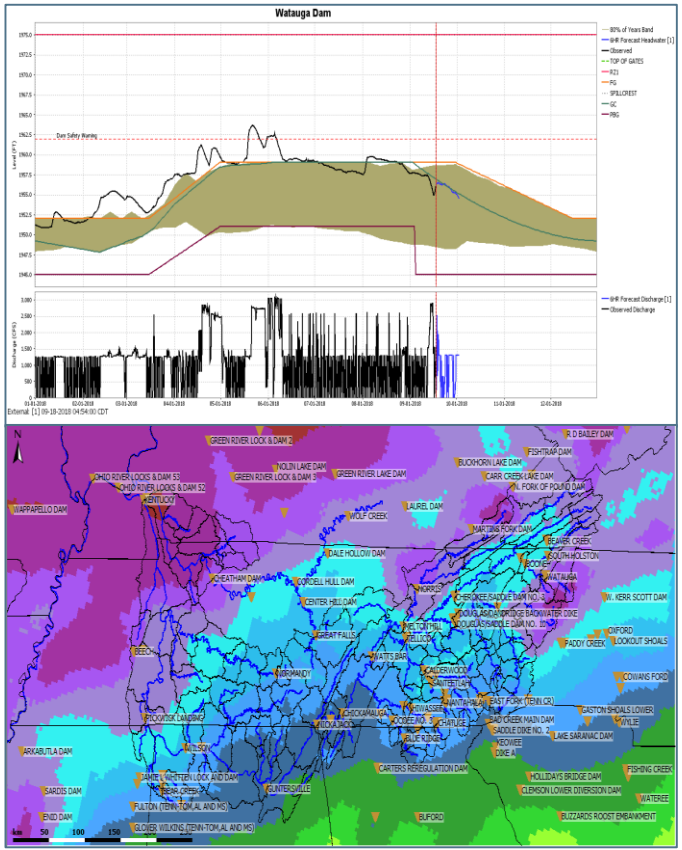


Safety Dashboard





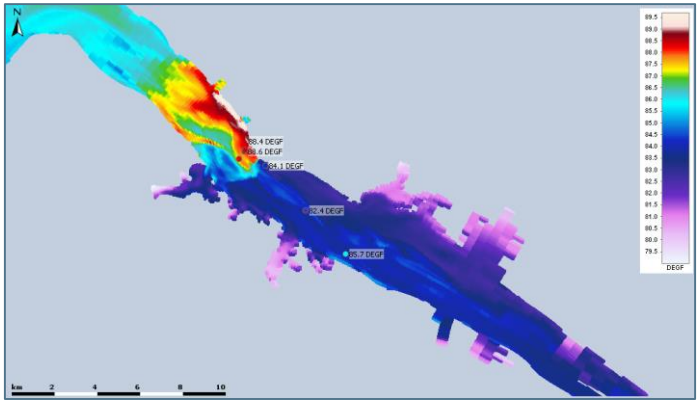
River Forecast Verification System



- River Forecast Center forecasts water supply, flooding, navigation, lake levels, generation, etc.
- Improved forecasting leads to optimized river operations at lower cost
- Determines where error exists and how to address it
- Supports future enhancements and hydro projects through data-driven inquires
- Provide training opportunities
- National and International benchmarking has occurred against TVA's river systems
- Will be highlighted at International FEWS User Conference in the Netherlands this November

Hydrothermal System

- Reduction in forecast uncertainty will save an estimated $1M/Year
- Better data allows for less conservative steady-state river operations
- Solutions provided:
  - Created 3D thermal modeling for more fine-tuned optimizations
  - Upgraded Browns Ferry and Sequoyah Nuclear Plant models
  - Developed Wheeler, Chickamauga, and Melton Hill Reservoir models
  - Upgraded Kingston, Gallatin, and Cumberland Fossil models



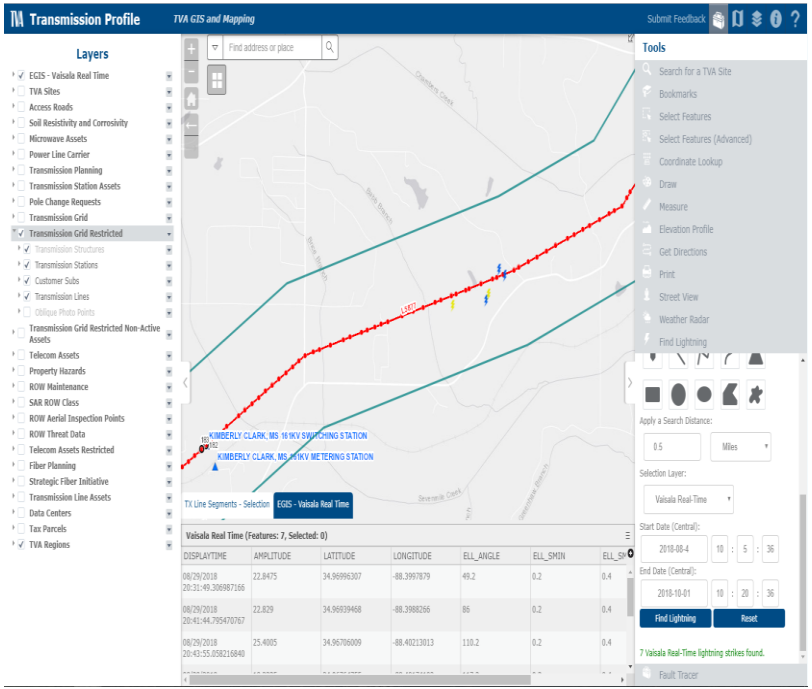
Example of enhanced 3D river modeling near Nuclear intake

River and Reservoir Compliance Monitoring

- TVA aquatic biologists track the health of rivers and reservoirs by counting fish and benthic populations on a periodic basis for environmental and compliance purposes
- More efficient and accurate field surveys
- Consolidation of data sets
- Moved historical data from spreadsheets to database
- Enhanced reporting capabilities

GIS Situational Awareness

- Modernized Enterprise GIS platform services at TVA and consolidated disparate data sources while allowing for greater system scalability and system integration
- Some business problems solved through use of the platform:
  - Transmission Line Maintenance
  - Transmission Line Planning
  - Load Coordination Planning
  - Power Quality Lighting Strike Insurance Management
  - Disaster Response Management
  - Dam Safety Analysis



Continuous Emissions Monitoring System

- Meeting EPA requirements to capture emissions data via continuous emissions monitoring systems
- Upgrades to data loggers
- Virtualization of all physical servers
- Single points of failure removed
- Server storage and network uplifts
- Software uplifted to latest versions at all sites
- Greatly reduces travel time, speed to problem resolution, and support costs through virtualization

Technology and Operations

Sensors | Mobility | **Monitoring**

Monitoring in an Operational Environment

Challenges faced:

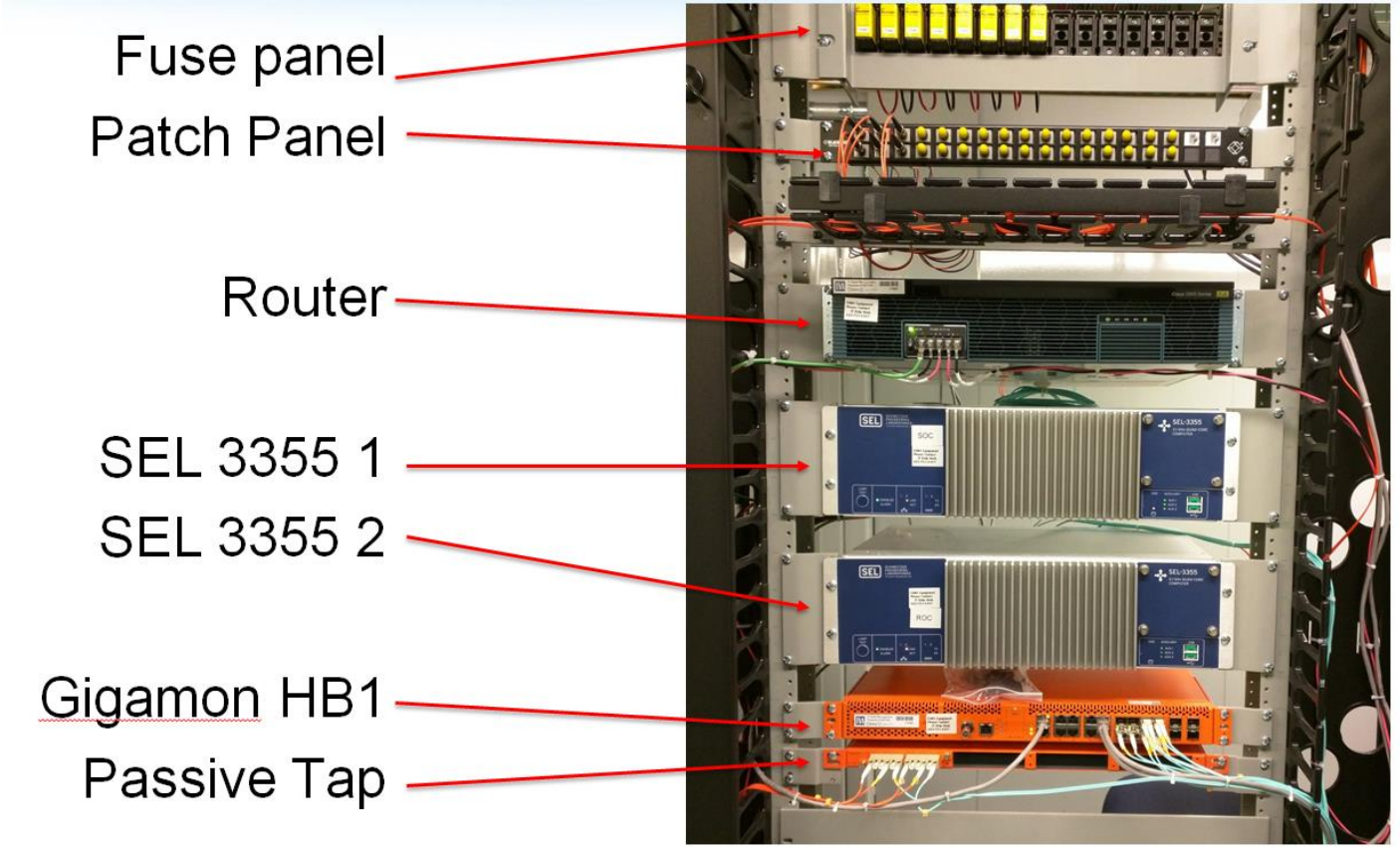
- **Non-Interference**
  - Operational systems had to be monitored with no potential to impact the bulk electric system
- **Power**
  - Plant equipment runs on DC power, while commercial monitoring equipment utilizes AC power
- **Security Landscape**
  - Techniques of threat actors change so the platform had to be adaptable and flexible
- **Non-Standard Device Types**
  - Commercial security tools do not have an ‘out of the box’ ability to process logs from plant equipment

Monitoring in an Operational Environment

Solutions implemented:

- **Non-Interference**
  - Utilized a network tap and syslog through tap
- **Power**
  - Used hardened telecommunications and ICS components designed for DC power
- **Security Landscape**
  - Developed a custom virtual ICS platform that can be updated remotely
- **Non-Standard Device Types**
  - Utilized a customizable solution to process any text-based data from any source or type

Monitoring in an Operational Environment



Innovation Challenges

Sensors | Mobility | Monitoring

Innovation Challenges

- **Technology Sources**
  - How to maximize return on investment through creative sourcing
- **Emergence of Cloud (SaaS, PaaS, IaaS)**
  - Risk and reward
  - Corporate versus operations
- **Workforce Development and Retention**
  - Developing quality and depth of talent
  - Changing approach to labor