NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

The 9th Annual Monitoring and Situational Awareness Technical Conference – Session 1

New Normal in Energy Management Systems

NERC EMS Working Group
September 23, 2021

Today's Agenda

- Welcome and Introduction
  - Phil Hoffer, Chair of NERC EMS Working Group, AEP
- Analysis of EMS Event Outages
  - Wei Qiu, NERC
- NERC System Awareness --- Department Overview and PI Integration
  - Brent Kane, NERC
- **10-minute Break**
- Real-time Assessments --- FERC and ERO Enterprise Joint Report
  - Dwayne Fewless, ReliabilityFirst
  - Clayton Calhoun, NERC
- Session Summary
  - Matt Lewis, NERC

Phil Hoffer

Phil Hoffer is currently the manager of EMS Applications at AEP. He has been with AEP Transmission Operations since 1986. His group is responsible for the state estimator and contingency analysis systems and maintaining the operational model of the transmission system network.

He has a BSEE from The Ohio State University and is a registered Professional Engineer in the state of Ohio.


2021 NERC Situational Awareness Conference
The New Normal in EMS


STAHLER. 2020
ANDREWS MCMEEL SYNDICATION
GOCOMICS.COM
THIS NEW NORMAL IS GETTING OLD.

EMS Working Group

- Since 2013
- 40+ members
- Rob Adams - *Rob.Adams@fpl.com*
- Phil Hoffer - *pehoffer@aep.com*
- Wei Qiu - *Wei.Qiu@nerc.net*

Your Role

- **“Where you are today will impact where others are tomorrow.”**
  - **Individually**
  - **Collectively as an industry**

Conference Topics

1. Analysis of EMS events – 9/23 13:00-15:00
   - Trends, Concerns, Tools
2. DERs – 10/7 13:00-15:00
   - DERs in operations
3. Technique & Workforce challenges – 10/28 13:00-15:00
   - Information in the cloud

Thank You & Enjoy !

Wei Qiu

Wei Qiu is a Lead Engineer of Event Analysis, in the Reliability Risk Management group at NERC. As an EMS SME, Wei is responsible for analyzing the EMS events reported, understanding the causes, and working with the industry to develop remediation strategies.

Wei earned his Ph.D in Electrical Engineering from Illinois Institute of Technology, Chicago. He is an IEEE senior member.

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Analysis of EMS Outages

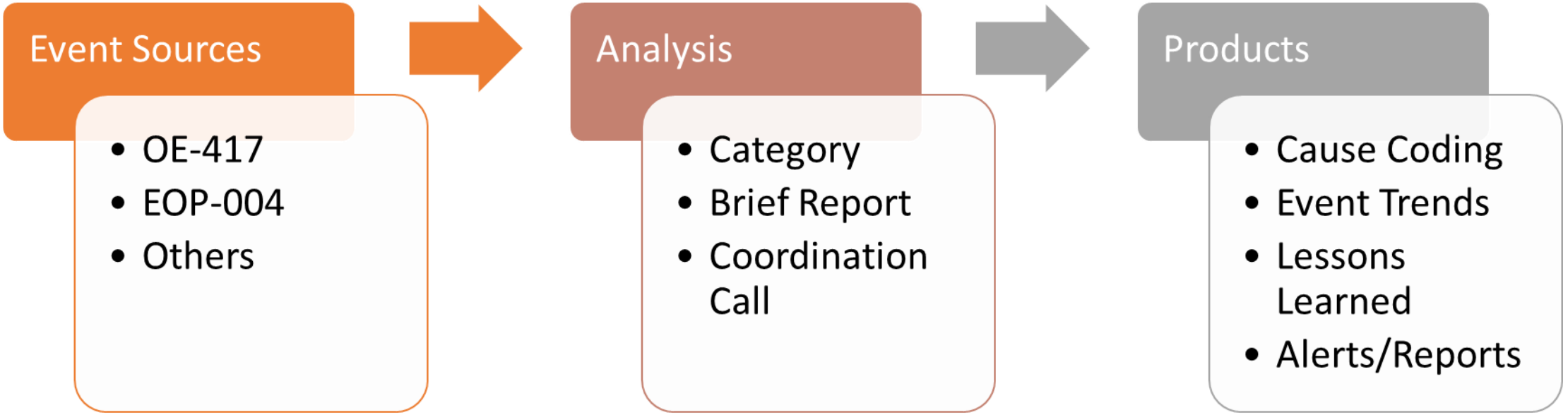
Wei Qiu, Lead Engineer of Event Analysis, NERC EA
NERC 9th Annual Monitoring and Situational Awareness Conference
September 23, 2021

Agenda

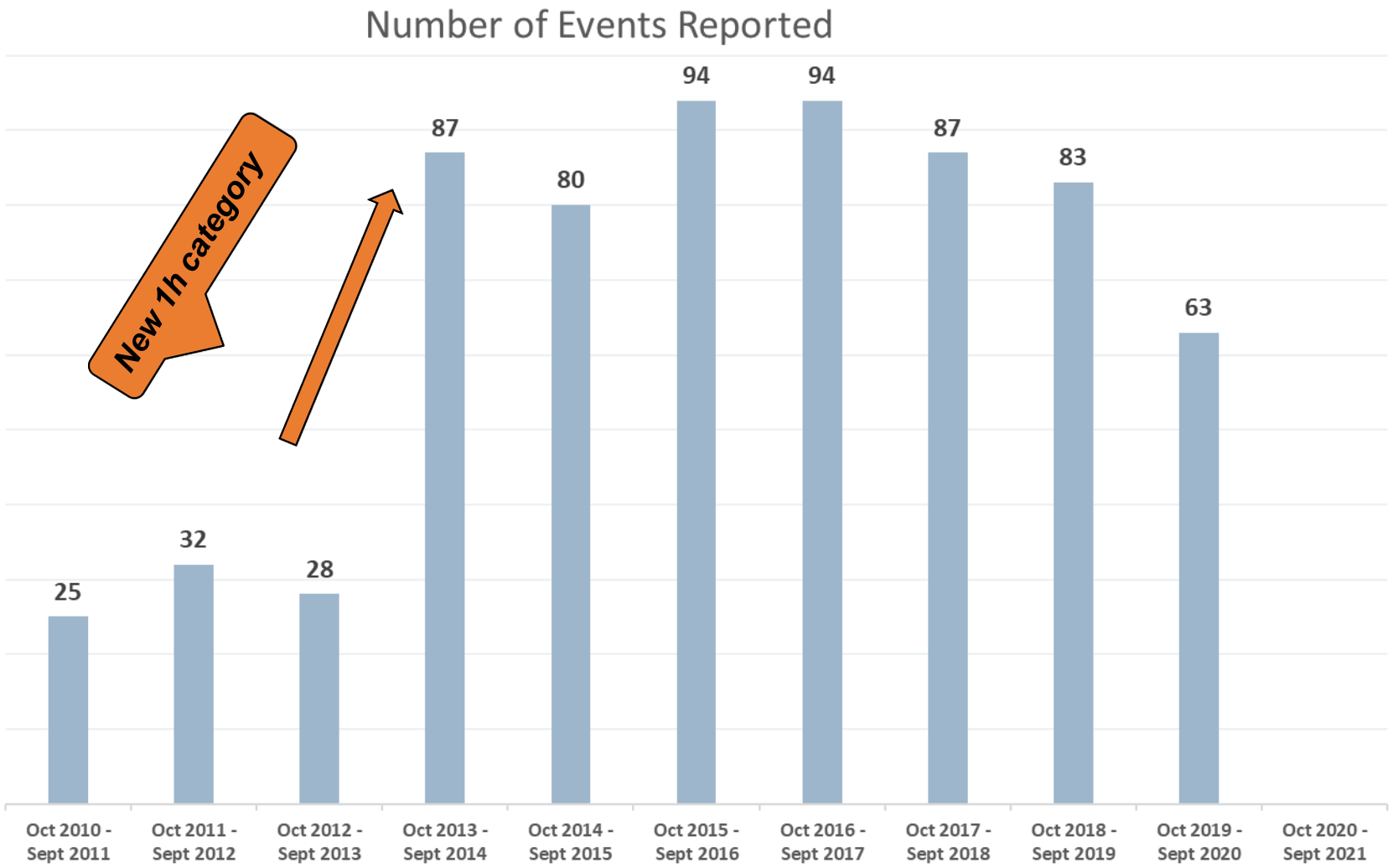
- ERO Event Analysis Process
- Data, Analysis, and Trends
- Key Takeaways
- Q&A

ERO Event Analysis Process

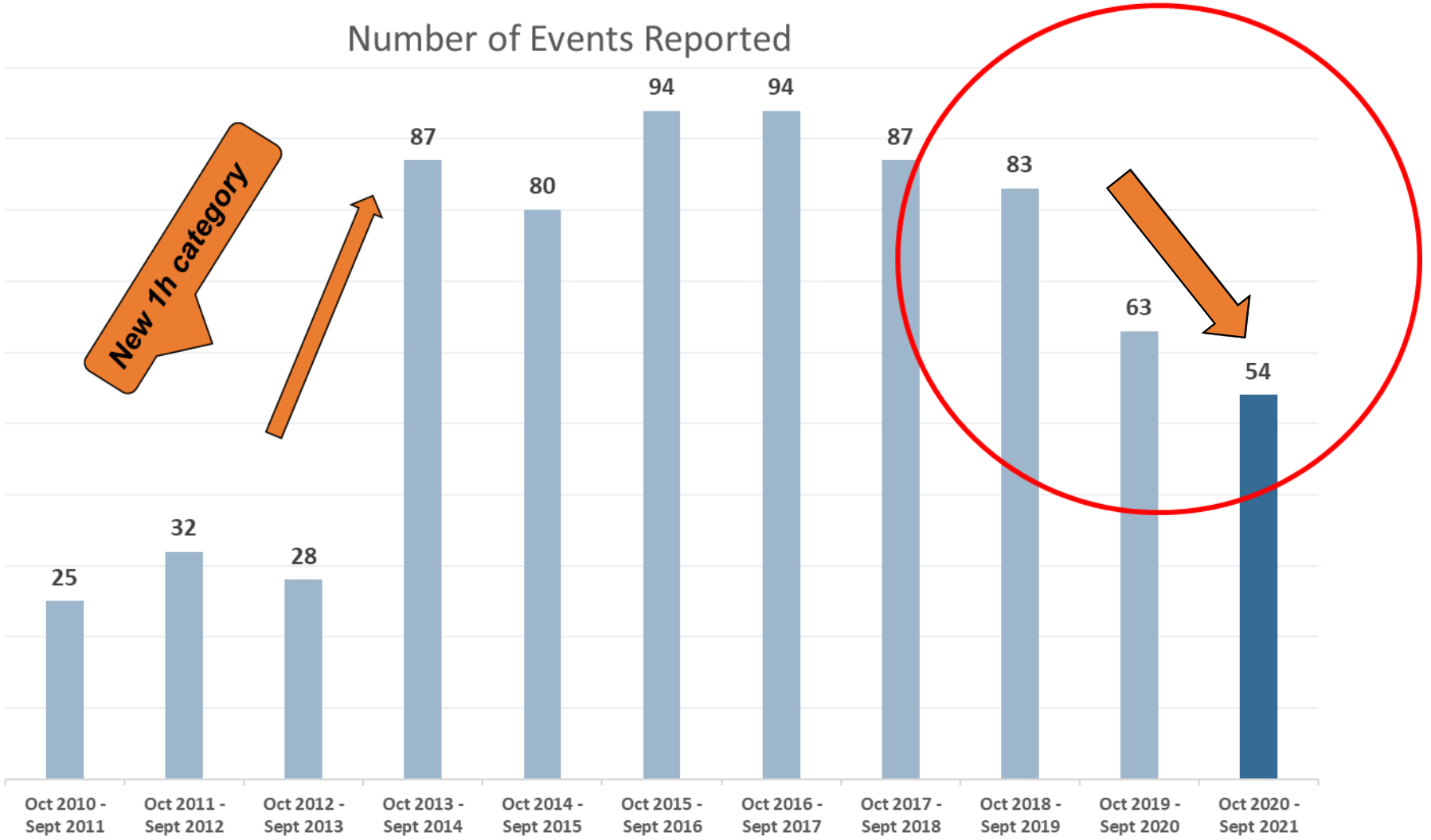
- Promote a structured and consistent approach to performing event analysis
- Learn from events and share information with industry
  - Not every event results in a succinct lesson learned, but we learn from every event
- Collaborate between registered entities, Regional Entities, and NERC



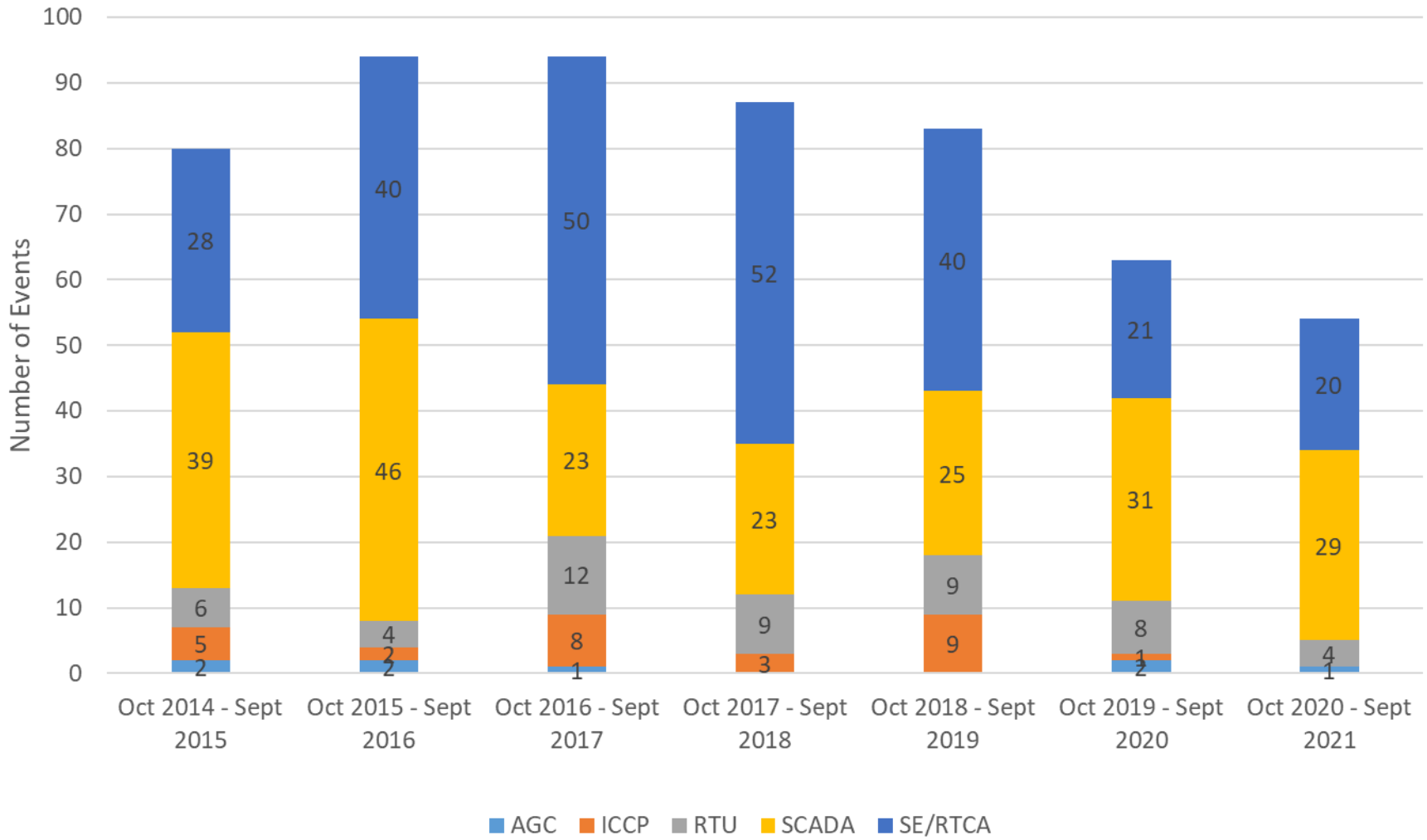
EMS Event Counts Trend



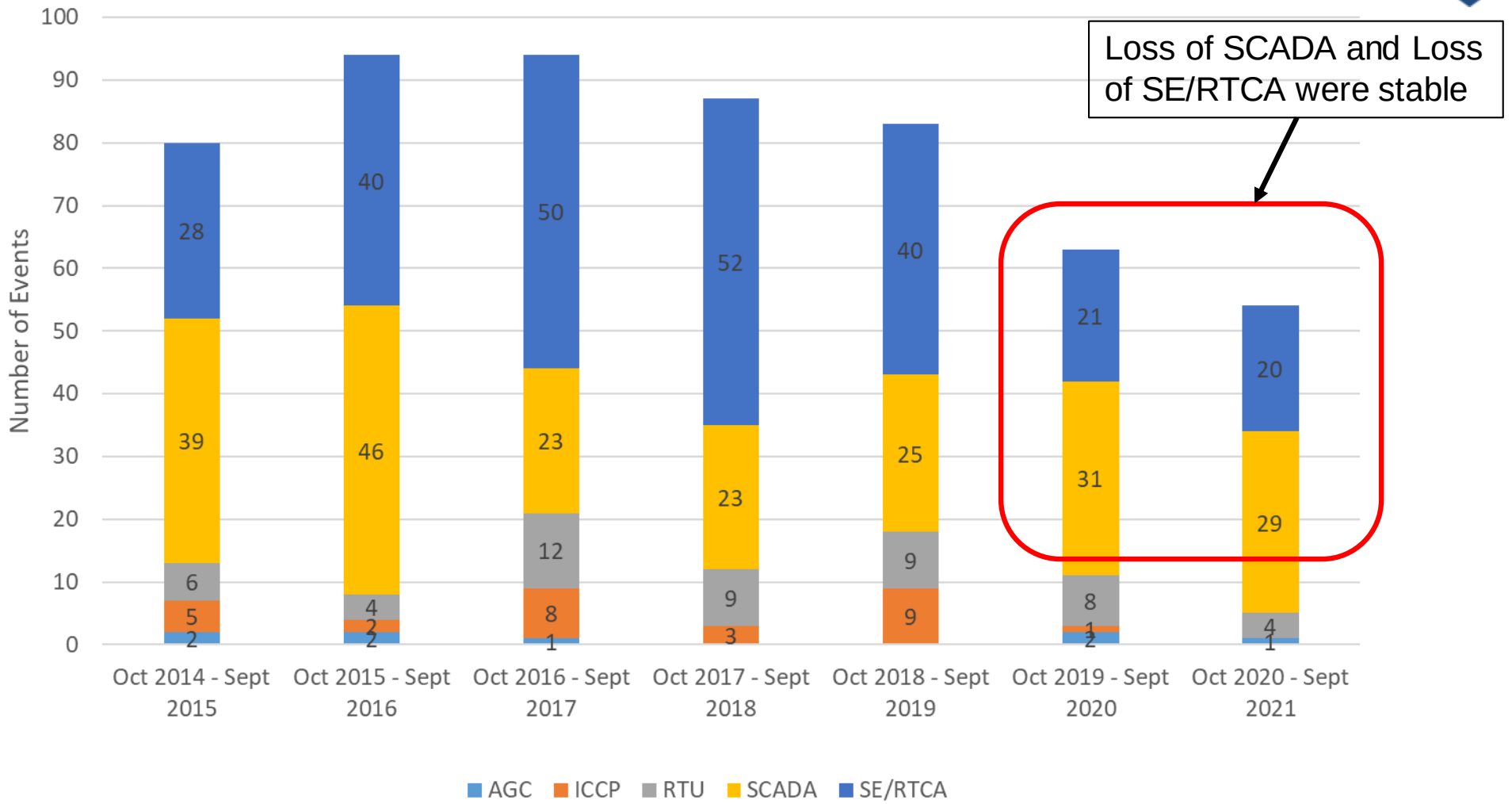
EMS Event Counts Trend



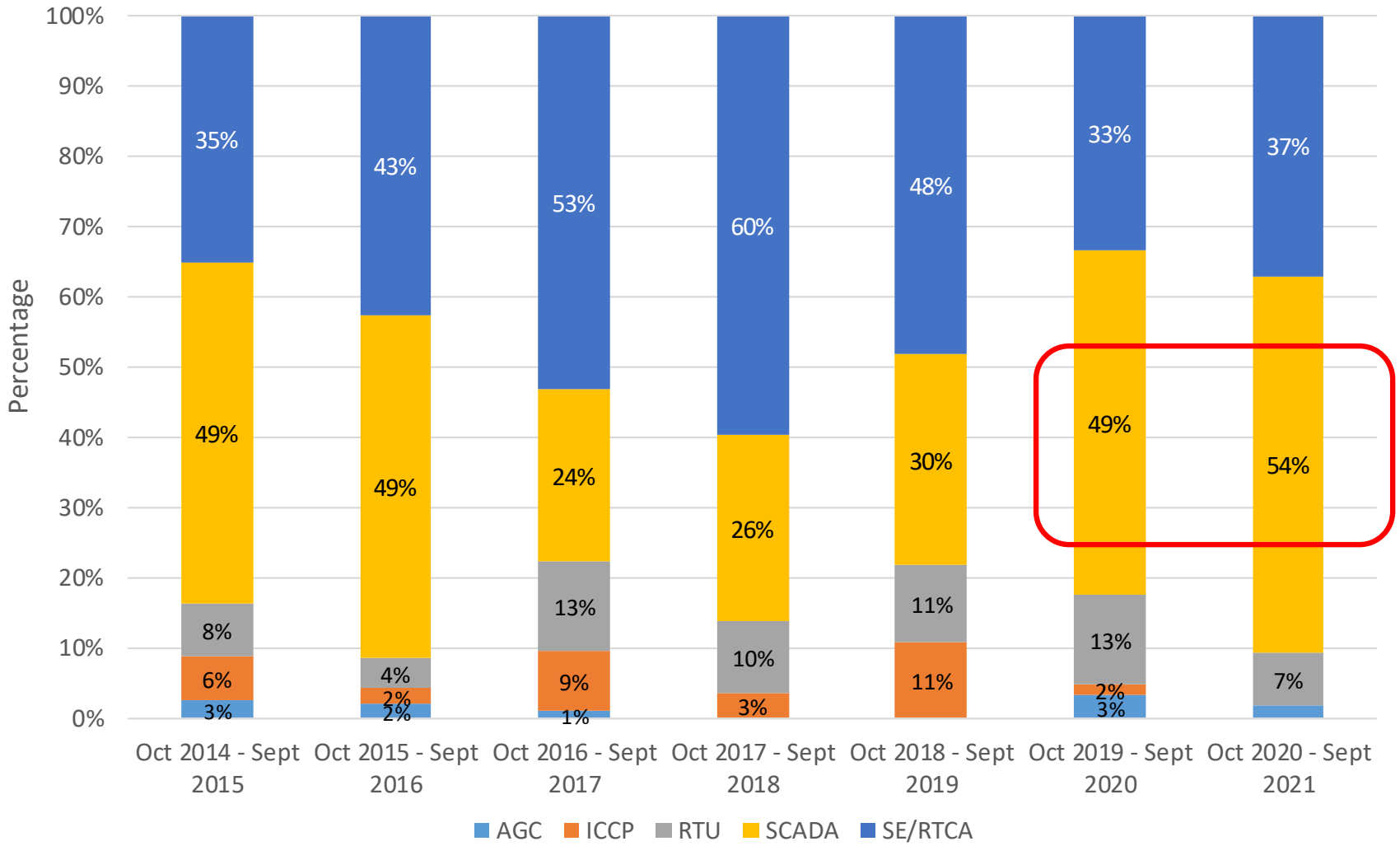
EMS Functions Trend



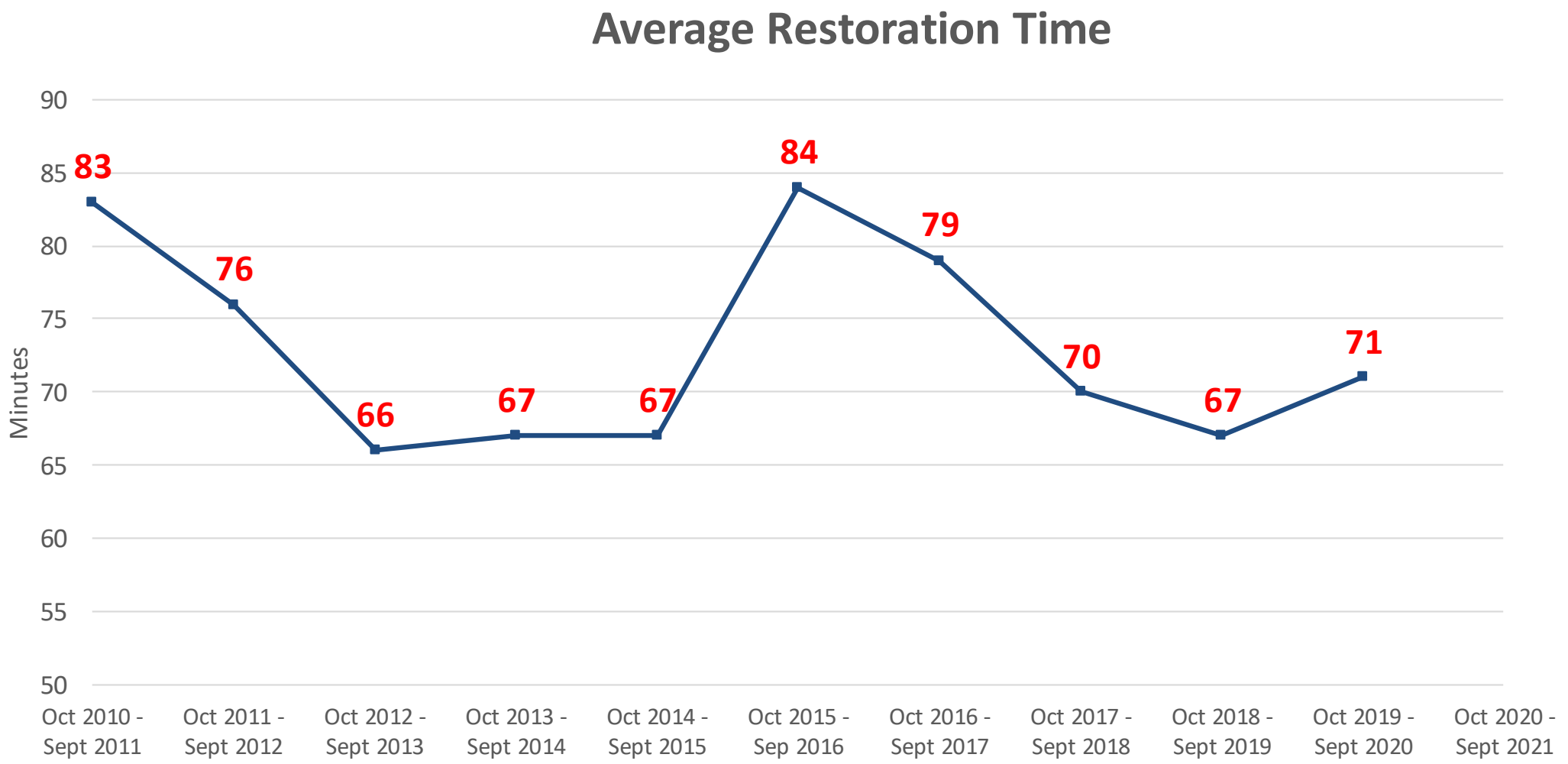
EMS Functions Trend



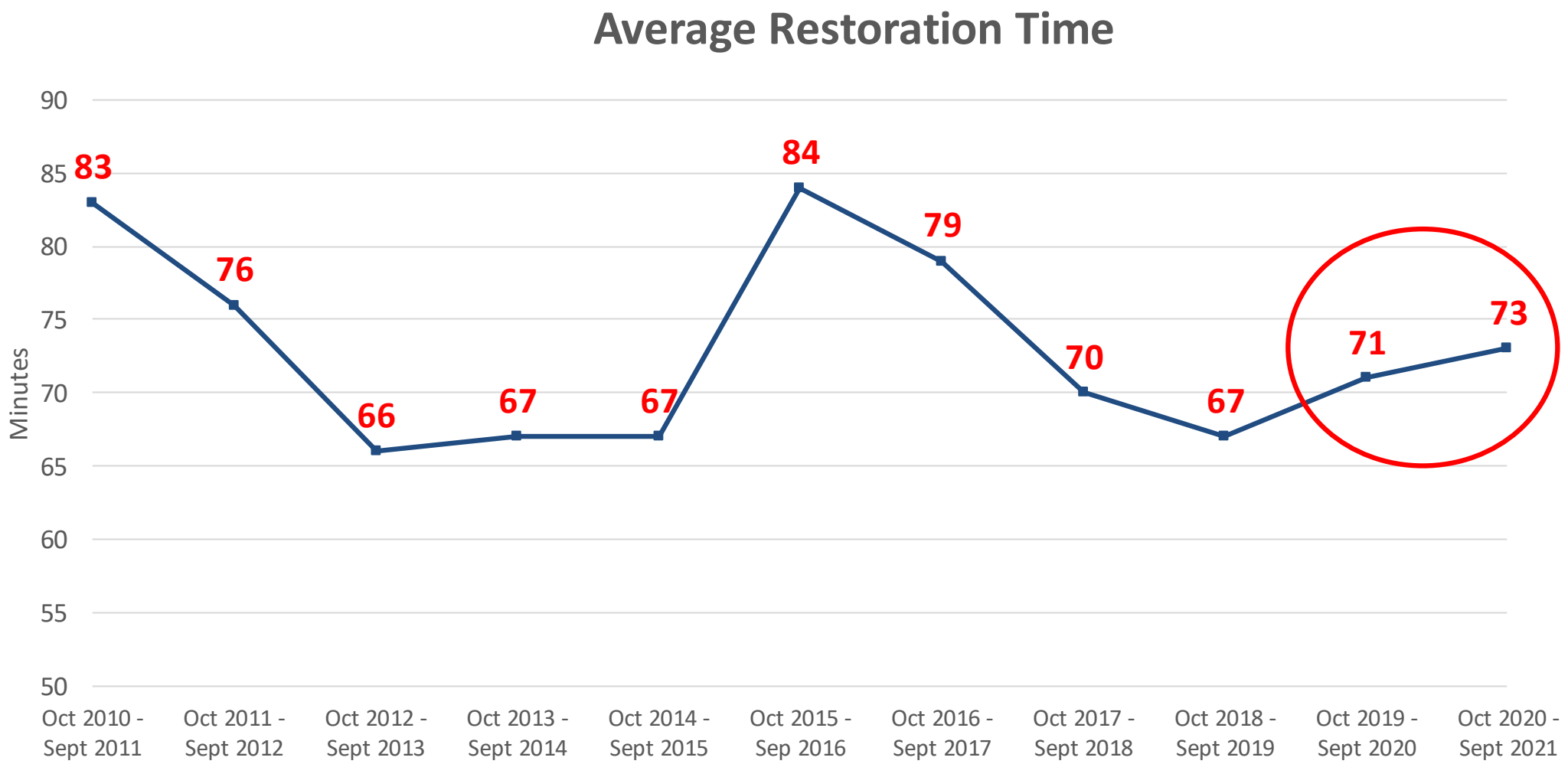
EMS Functions Trend (cont'd)



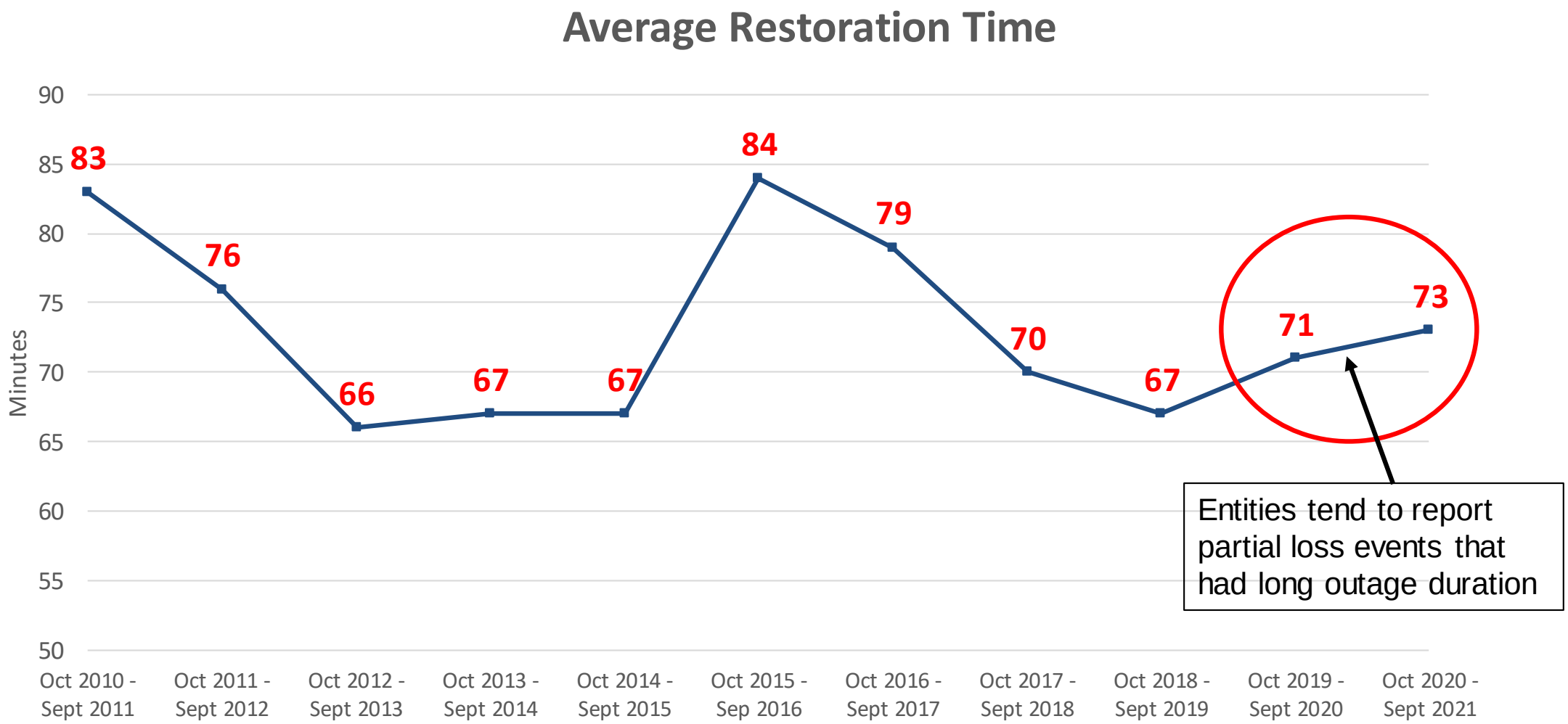
Average Restoration Time Trend



Average Restoration Time Trend



Average Restoration Time Trend

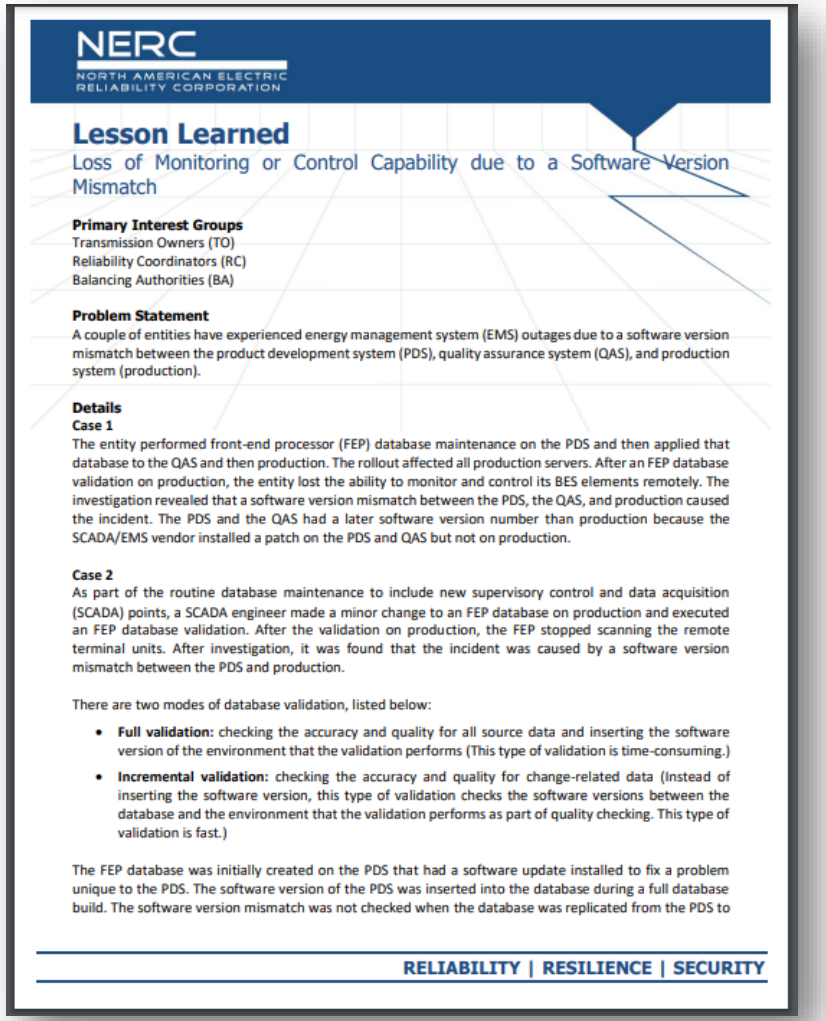


Why Loss of SCADA Went Up?

- New Normal Working Environment
  - Work from home: Onsite -> Remote fashion
  - Working split shifts
  - Suggestions
    - Job Scope
      - Communication between working groups both directly involved and those potentially affected
      - Peer review of design, implementation, and testing
    - Work package preparation
      - Checklist, instruction, documents, etc.
      - Up to date
    - Appropriate materials/tools in backup control centers

Why Loss of SCADA Went Up?

- Software Version
  - Mismatch between PDS, QAS, and production
  - Database Rollout
  - Suggestion:
    - Patch procedures and database maintenance processes (Entity)
    - Software detection and alarm (EMS Vendors)



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Lesson Learned

Loss of Monitoring or Control Capability due to a Software Version Mismatch

Primary Interest Groups
Transmission Owners (TO)
Reliability Coordinators (RC)
Balancing Authorities (BA)

Problem Statement
A couple of entities have experienced energy management system (EMS) outages due to a software version mismatch between the product development system (PDS), quality assurance system (QAS), and production system (production).

Details
Case 1
The entity performed front-end processor (FEP) database maintenance on the PDS and then applied that database to the QAS and then production. The rollout affected all production servers. After an FEP database validation on production, the entity lost the ability to monitor and control its BES elements remotely. The investigation revealed that a software version mismatch between the PDS, the QAS, and production caused the incident. The PDS and the QAS had a later software version number than production because the SCADA/EMS vendor installed a patch on the PDS and QAS but not on production.

Case 2
As part of the routine database maintenance to include new supervisory control and data acquisition (SCADA) points, a SCADA engineer made a minor change to an FEP database on production and executed an FEP database validation. After the validation on production, the FEP stopped scanning the remote terminal units. After investigation, it was found that the incident was caused by a software version mismatch between the PDS and production.

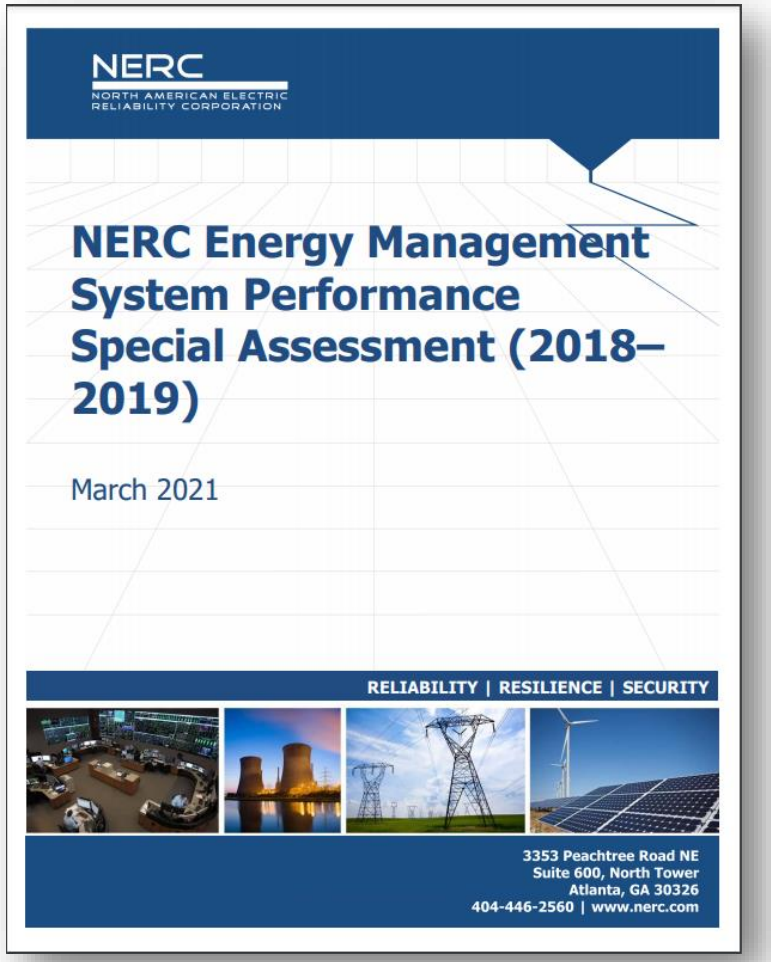
There are two modes of database validation, listed below:

- **Full validation:** checking the accuracy and quality for all source data and inserting the software version of the environment that the validation performs (This type of validation is time-consuming.)
- **Incremental validation:** checking the accuracy and quality for change-related data (Instead of inserting the software version, this type of validation checks the software versions between the database and the environment that the validation performs as part of quality checking. This type of validation is fast.)

The FEP database was initially created on the PDS that had a software update installed to fix a problem unique to the PDS. The software version of the PDS was inserted into the database during a full database build. The software version mismatch was not checked when the database was replicated from the PDS to

RELIABILITY | RESILIENCE | SECURITY

NERC EMS Special Assessment



- The assessment was approved by the RTSC in April, 2021
  - EMS Events (2018-2019)
  - Evaluate the effect of EOP-004-4 on EMS partial function loss reporting
  - Update the EMS performance based on outage duration, EMS functions, and entity reliability functions
  - Offer recommendations to improve EMS reliability, security, and resiliency of the BPS

https://www.nerc.com/pa/rrm/ea/PapersDocumentsAssessmentsDL/EMS_Special_Assessment_March2021.pdf

Key Takeaways

- EMS reliability and resilience is continuously improving
- Loss of SCADA events became the most prevailing failure for the second year in a row
- Loss of SE/RTCA events were stable in the 2019-2020 and 2020-2021 period
- Things we all can improve
  - Dealing with new normal working environment
  - Software Versions in PDS, QAS, and Production

Questions and Answers

Contact Information:
wei.qiu@nerc.net

Brent Kane

Brent Kane is a NERC Certified System Operator working as a Senior Bulk Power System Awareness Coordinator at NERC. Joining NERC in April, 2018, Brent works closely with the NERC and Regional System Awareness teams to ensure reliable operation of the bulk electric system on a daily basis. Brent is also the subject matter expert for NERC's PI Data Historian and has been instrumental in developing the system as well as collaborating with the Regions to integrate mission critical data, both for real time awareness and event analysis.

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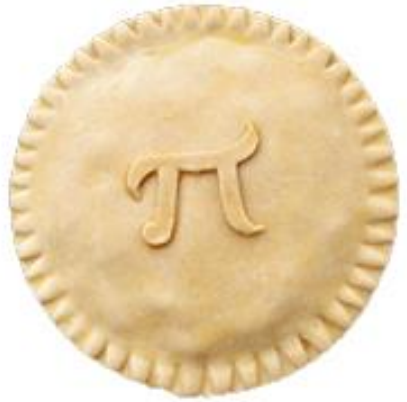
NERC System Awareness

Department Overview and PI Integration

Brent Kane, NCSO
Senior Bulk Power System Awareness Coordinator
2021 Monitoring and Situational Awareness Conference
September 23, 2021

Agenda

- Overview of NERC Bulk Power System Awareness (BPSA) mission and responsibilities
  - What we do
  - How we do it
- NERC BPSA “Tools of the trade”
  - The tools we use
  - How we integrate them
- NERC BPSA PI integration
  - How we use PI now
  - What we are working on
  - What we hope to do



Vision Statement

One Bulk Power System Awareness (BPSA) team of experienced, talented and accountable system operations professionals, in unison with the regions and industry, equipped with the right tools and training, serving as the eyes and ears of NERC working with the Enterprise Reliability Organization (ERO) to improve and ensure the reliability of the North American bulk power system (BPS).

Mission

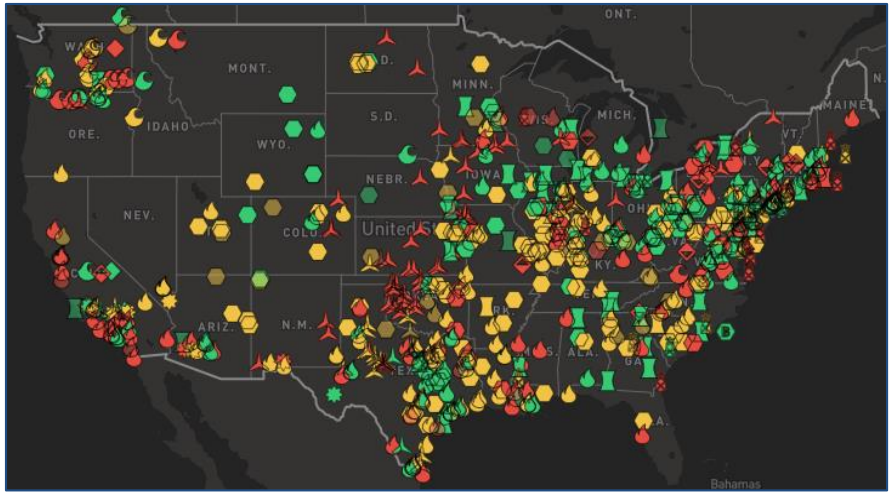
NERC's BPSA group acquires and disseminates timely, accurate and complete information regarding the current status of the BPS and threats to its reliable operation, to enable the ERO to effectively assure the reliability of the BPS. During major system disturbances, facilitate effective communications between industry and government stakeholders.

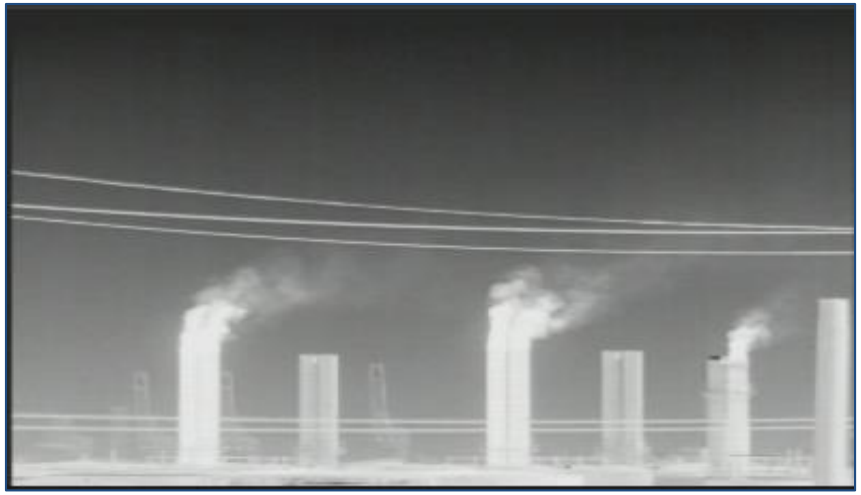
NERC BPSA Overview

- Receive and process all EOP-004, OE-417, and Brief Reports
- Manage the Reliability Coordinator Information System (RCIS)
- Manage the Reliability Coordinator Hotline (RC Hotline)
- Ensure sufficient generation and reserves across the Electric Reliability Organization (ERO)
- Monitor and track weather conditions, large transmission and generation outages, and any emerging conditions that pose a threat to the Bulk Electric System (BES)
  - Coordinate with ERO, Federal Energy Regulatory Commission (FERC), United States Department of Energy (DOE), United States Department of Homeland Security (DHS), and other agencies as needed during a large scale event

System Awareness Tools

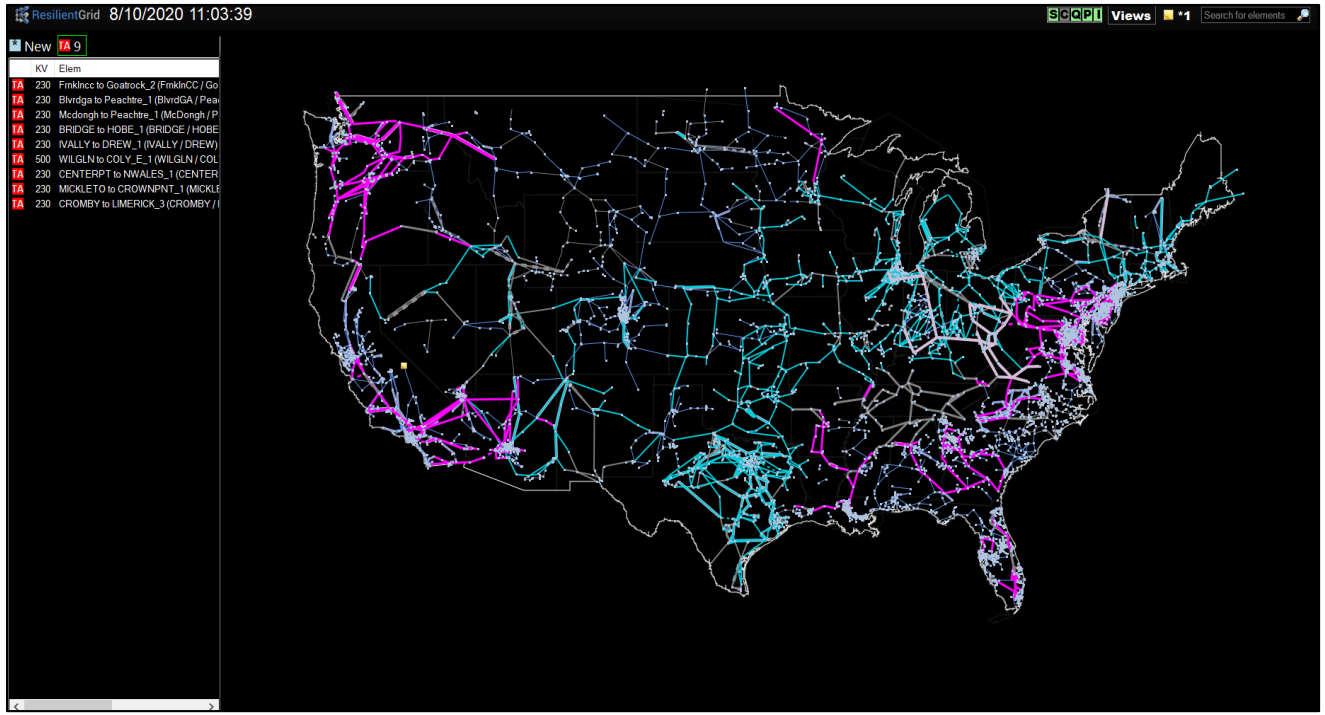
- GENSCAPE
  - Private network of in-field monitors provide alternate data across the energy spectrum
    - Real-Time plant output and transmission flow data using patented energy monitors
    - Near real-time flows for 190+ North American natural gas pipelines





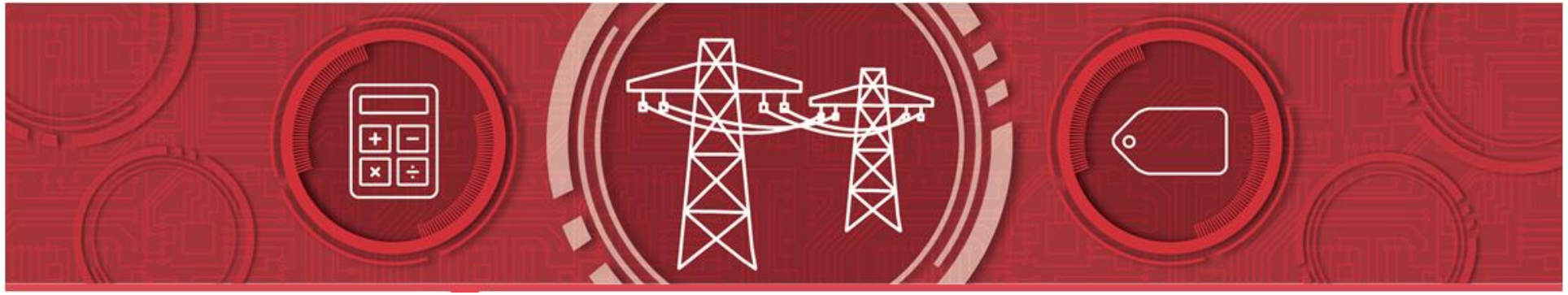
System Awareness Tools

- Situational Awareness for FERC, NERC, and Regional Entities Version 3 (SAFNR v3)
  - NERC application monitors over 30,000 data points in real-time from generation and transmission facilities across North America



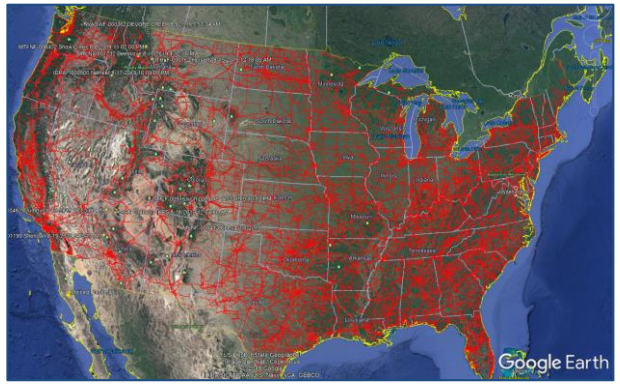
System Awareness Tools

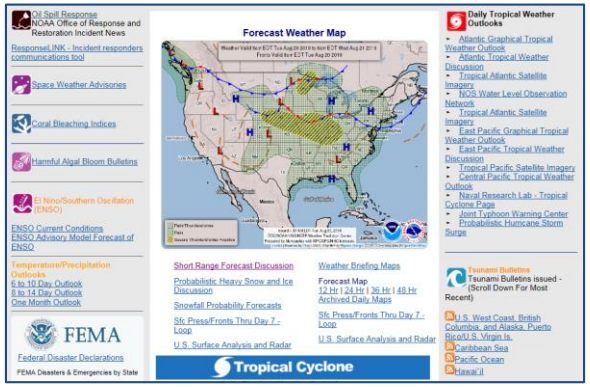
- Open Access Technology International (OATI)
  - Interchange Distribution Calculator (IDC)
    - Monitor real-time and historic transmission congestion between markets and Balancing Authorities
  - webSDX
    - Monitor reported forced or scheduled transmission and generation outages and return times

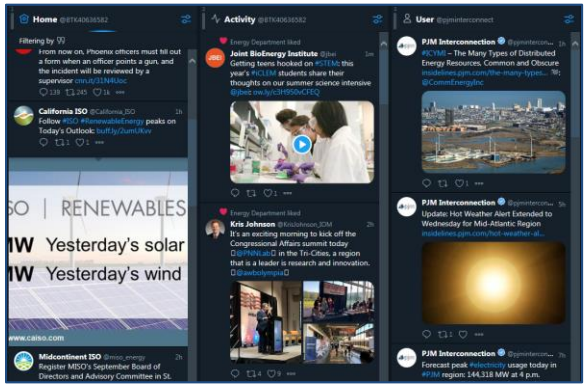


System Awareness Tools

- Web Applications
  - Google Earth Pro
    - Overlay Transmission, Generation, Wildfire etc. shapefiles
  - Weather Applications
    - Ventusky, NOAA
  - Social Media
    - Twitter

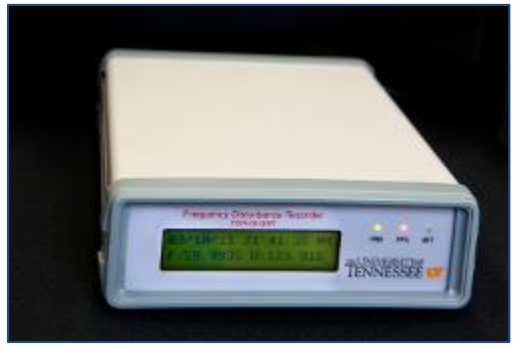


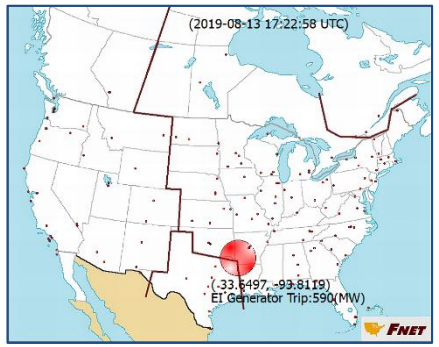


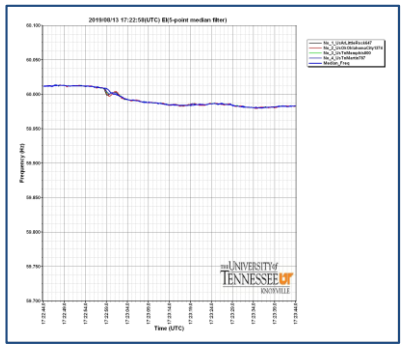


System Awareness Tools

- FNet/GridEye
  - Operated by the Power Information Technology Laboratory at the University of Tennessee, Knoxville (UTK) and Oakridge National Laboratory (ORNL) in Oak Ridge, TN
    - GPS synchronized wide-area power system frequency measurement network using Frequency Disturbance Recorders (FDRs) for:
      - Event detection and location
      - Oscillation detection
      - Islanding detection
      - Animations of frequency and angle perturbations







OSI PI

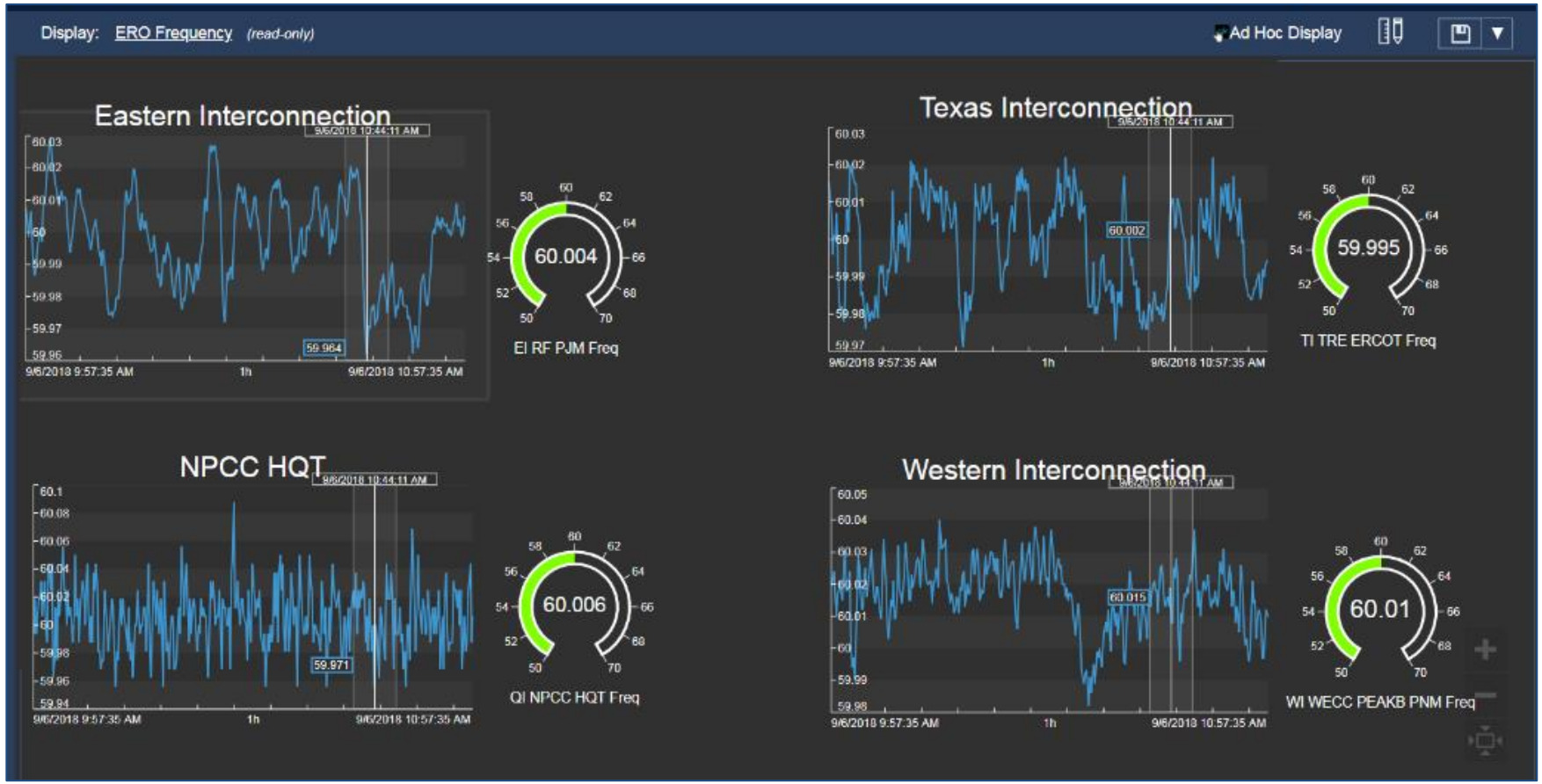
- PI Cloud Connect (PICC) usage
  - NERC receives frequency data from FNet via UTK through PICC
    - Frequency values update every 1 second vs 5 to 10 seconds from previous sources
      - Median frequency of all the FDRs in each Interconnection
    - During an event (large generation or load loss) NERC also receives the 5 most perturbed FDRs
      - Geographically close to the event
      - Values update 10x per second
    - Provides much greater detail and accuracy during real-time operations and post event analysis.

OSI PI

- NERC uses OSI PI as our primary data historian for key real-time Interconnection information
  - Data is provided to NERC via ICCP connections with the ERO Enterprise Balancing Authorities (BAs) and Reliability Coordinators (RCs).
  - The data is viewable in real-time and also permanently retrievable.
  - Depending on the source, the data is updated anywhere from 1 second to 10 minute intervals.
  - NERC currently collects ACE and Frequency values from all BAs and RCs.
  - NERC also collects Load, Real-time Reserve, and System Inertia data from the Western and Texas Interconnections.
    - NERC is currently in progress expending these points into the Eastern Interconnection.

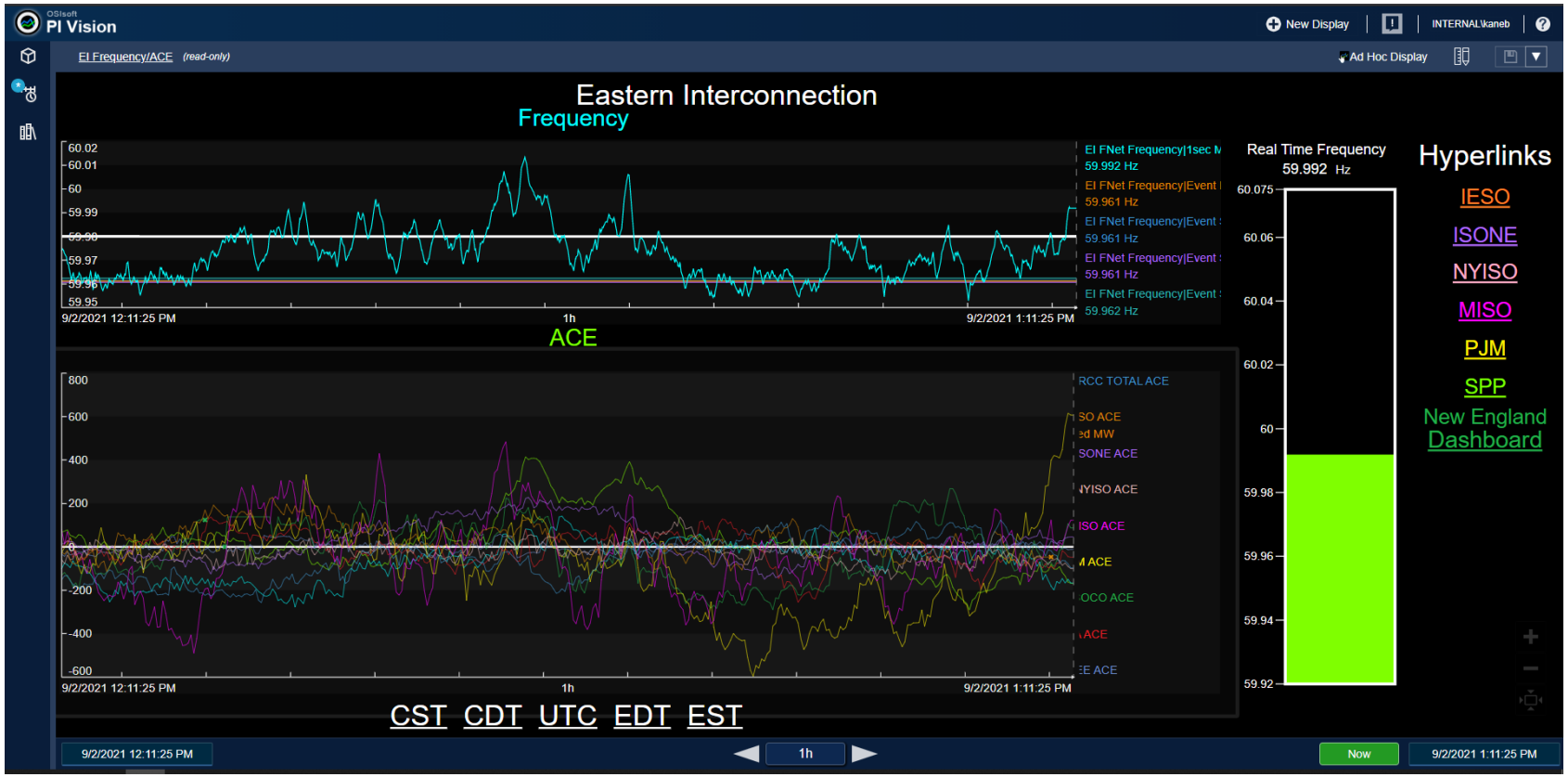
ACE And Frequency

- One “At a glance” Display



ACE And Frequency

- Separate “Overview” display for each Interconnection

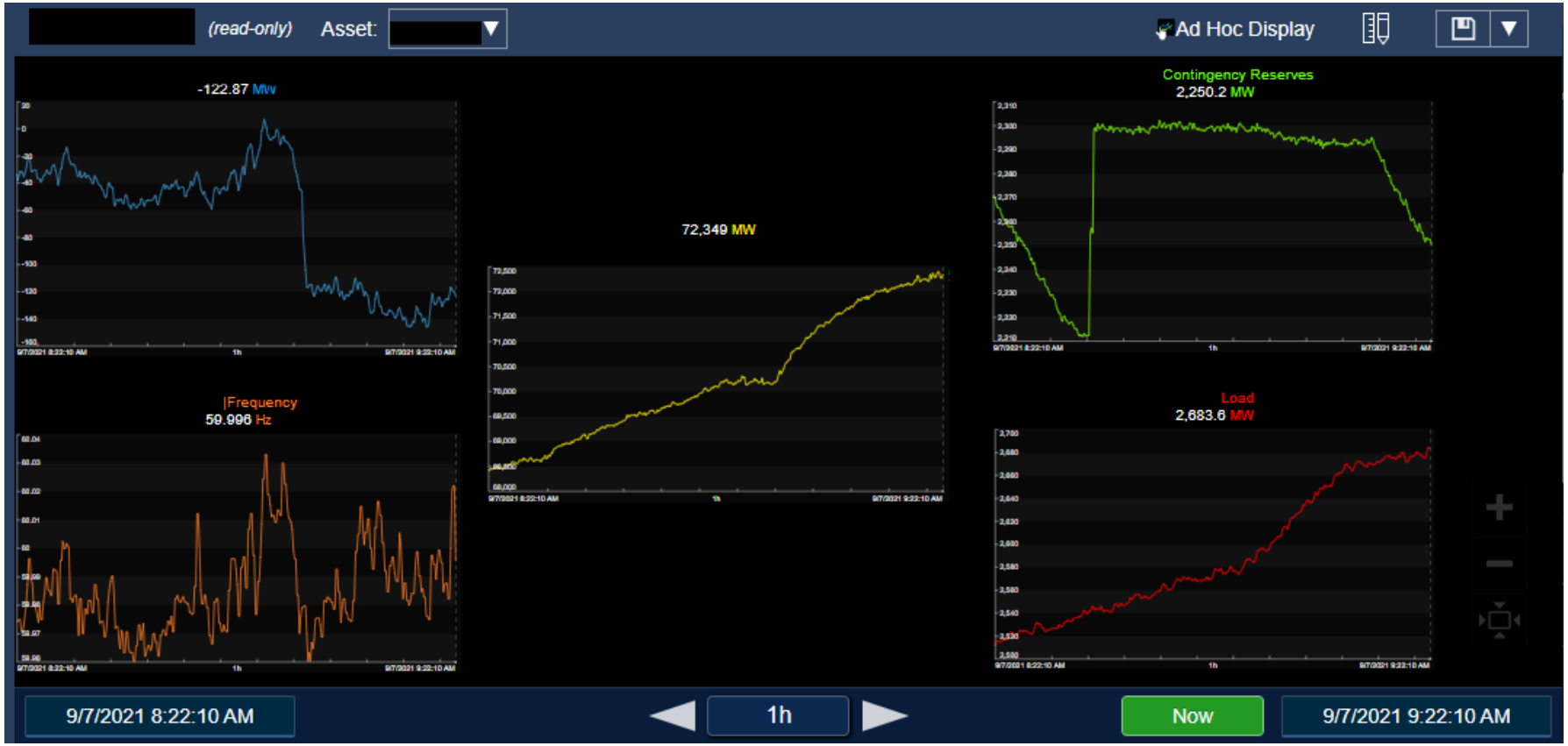


ACE And Frequency

- Frequency value is updated every second. During a sudden event, frequency is updated 10x/second for more in depth analysis.

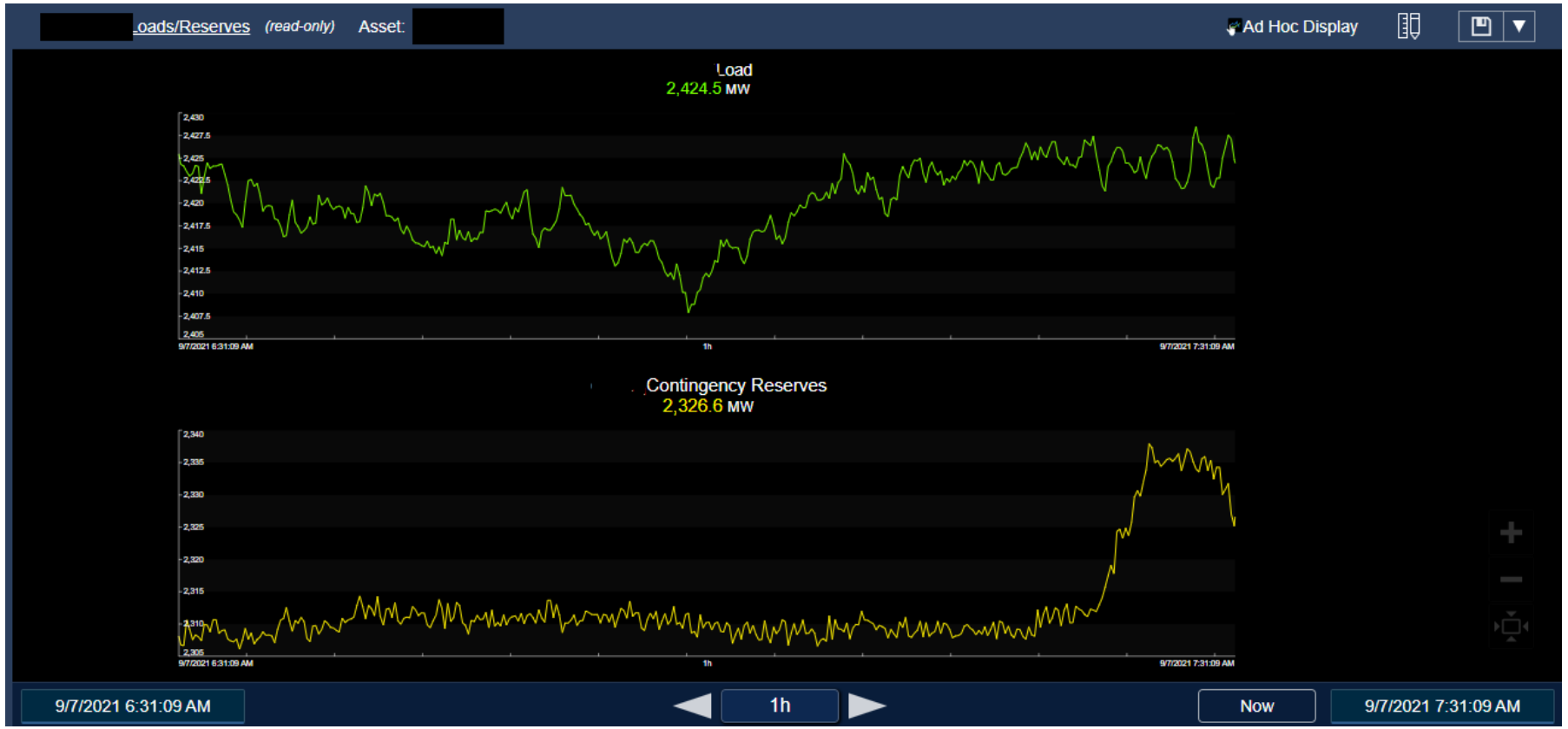
Load and Reserves

- Overview Display for each RC/BA
  - ACE, Frequency, BA Load, BA Reserves, RC Load



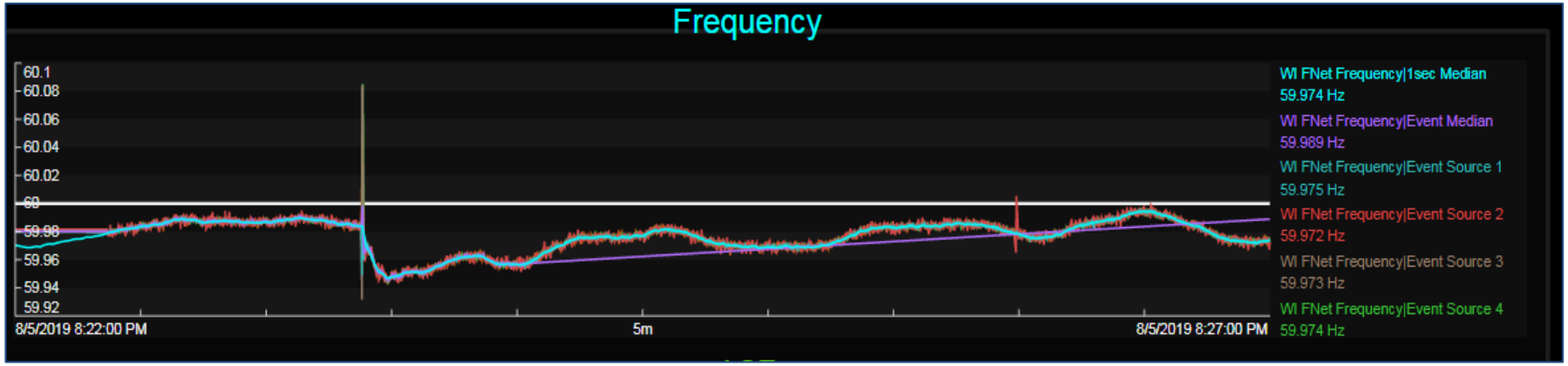
Load and Reserves

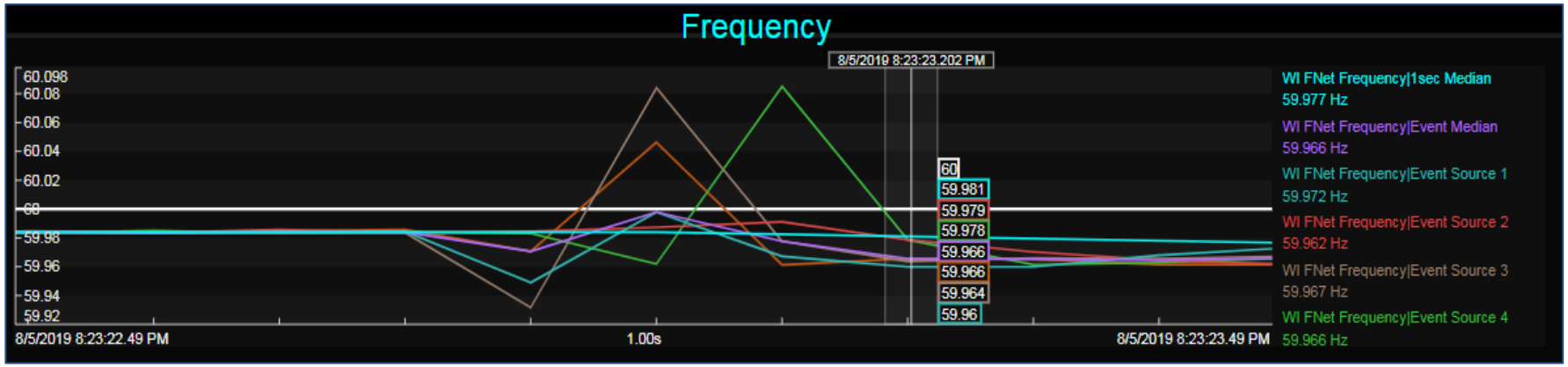
- BA Load and Reserves



Event Analysis

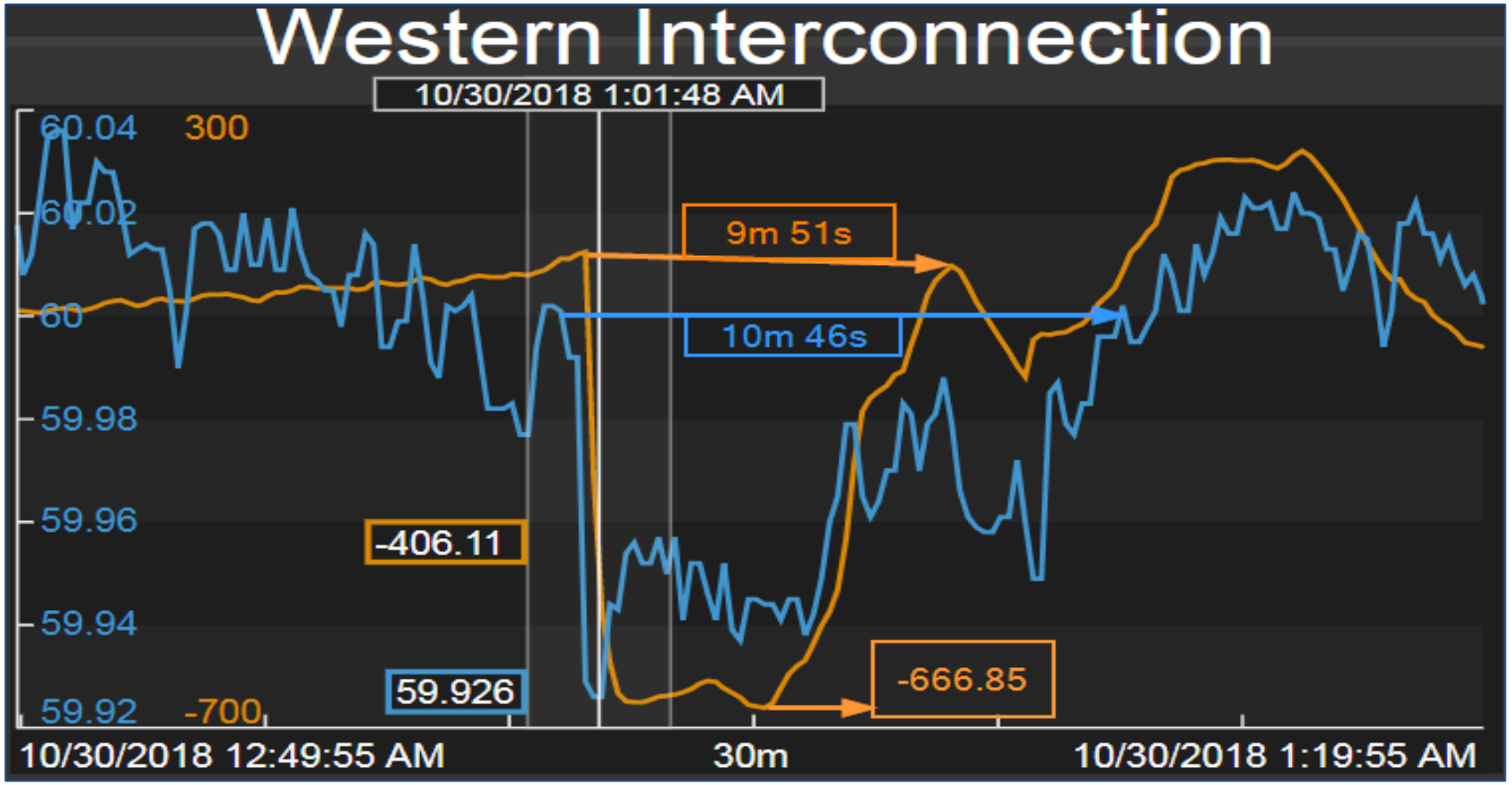
- TRV capacitor explosion, transmission line trips, and generation loss





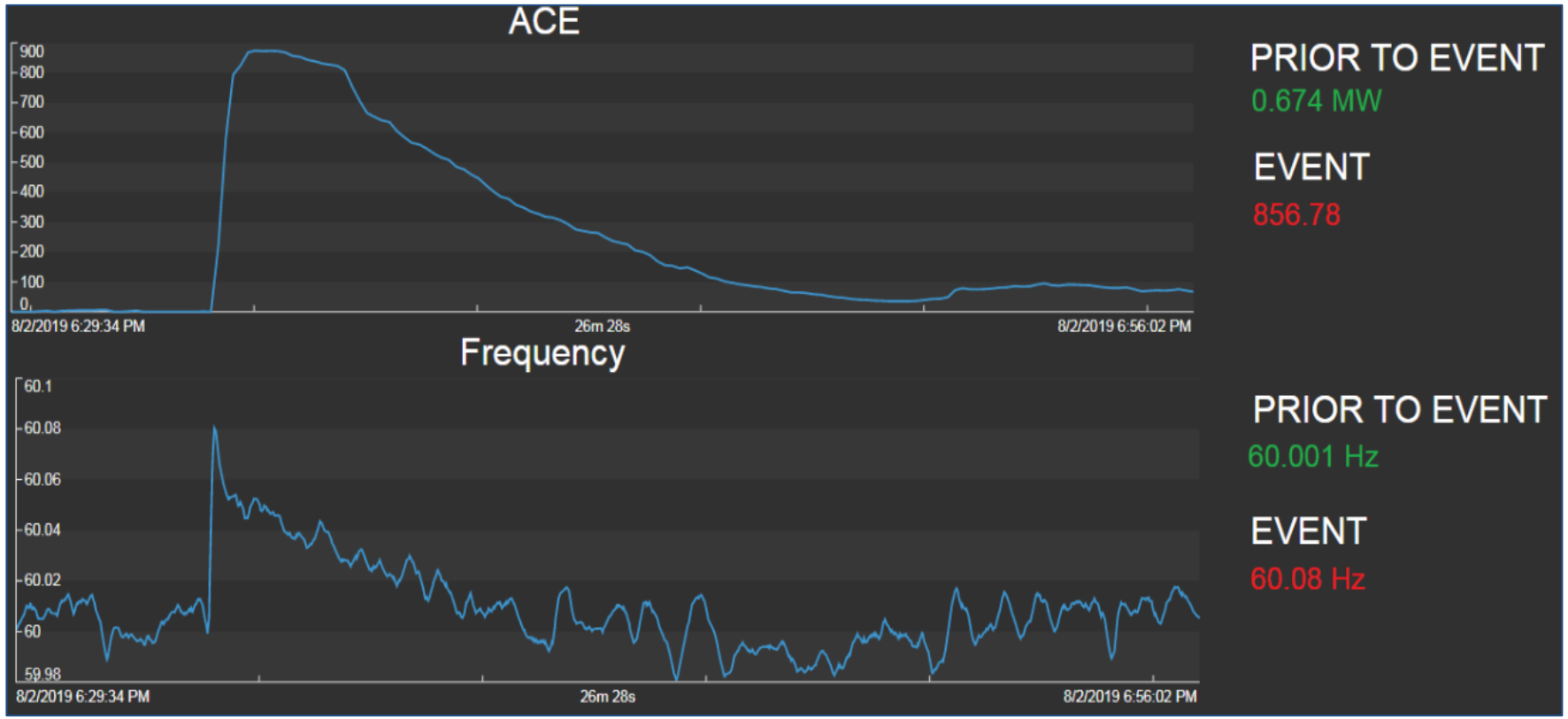
Event Analysis

- Large generator trip



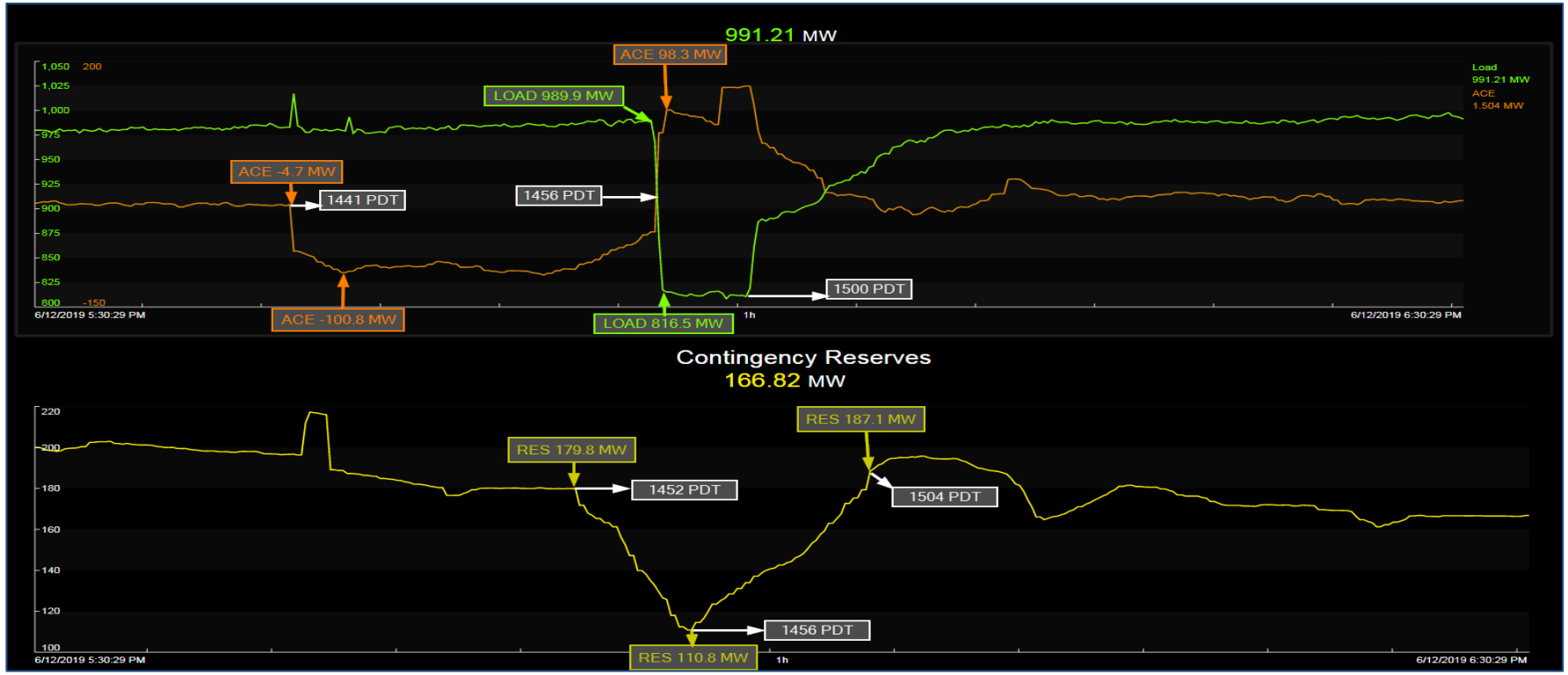
Event Analysis

- Large Load Loss

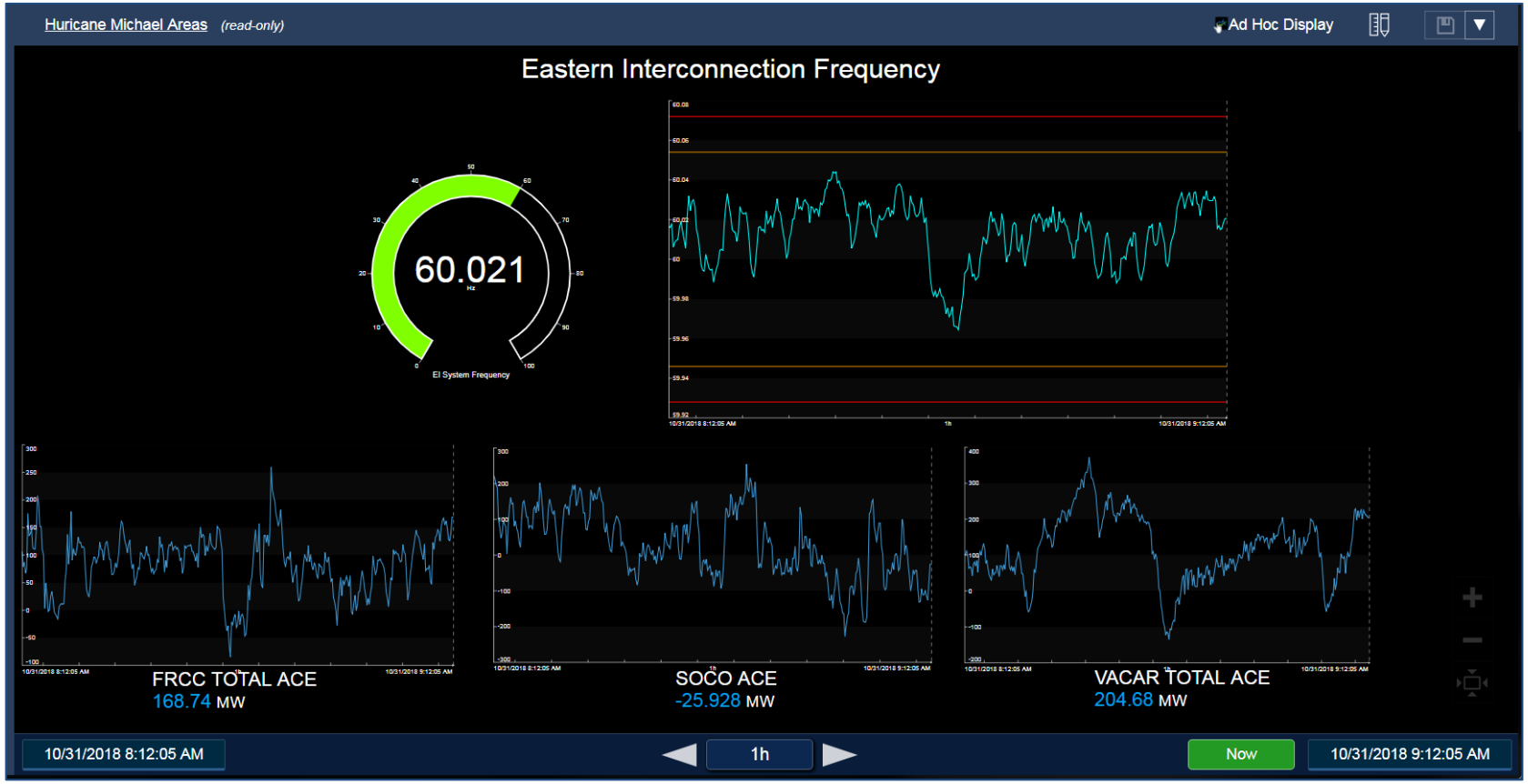


Event Analysis

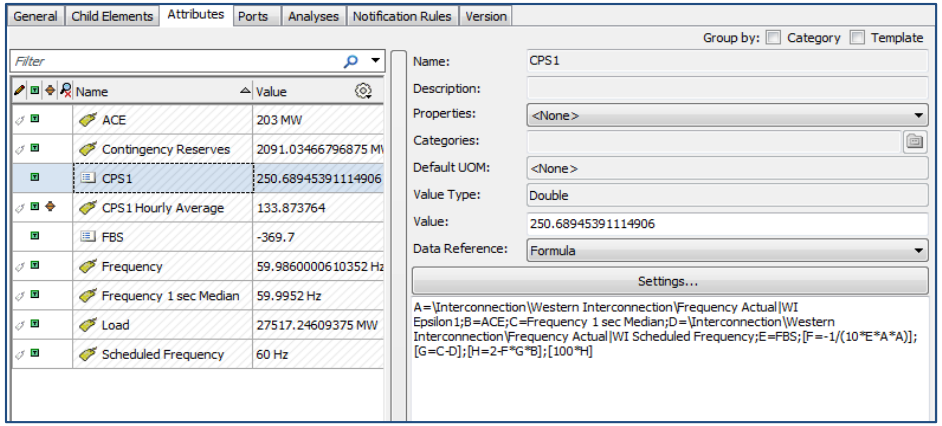
- Load Shed Event

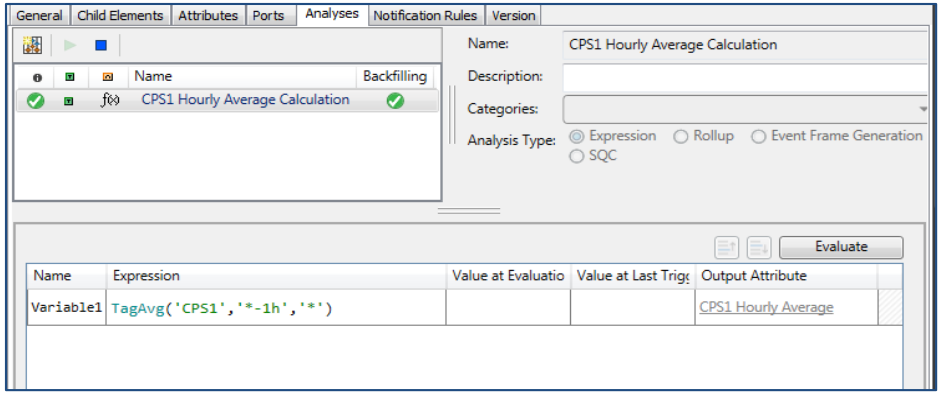


- On the fly displays during real-time emergencies
  - Hurricane Michael



- Formula and Analysis usage
  - Used to calculate Control Performance Standard 1 (CPS 1)
    - BAs ability to balance ACE and frequency to control steady state Interconnection frequency





Data Sharing

- NERC to WECC
  - Daily
    - Hourly peak load and reserves for each BA in the Western Interconnection
  - Monthly/Annually
    - One-minute Average system inertia for each RC in the Western Interconnection

- NERC to Texas RE
  - NERC BPSA was able to provide key ERCOT load and reserve data to Texas RE during the February, 2021 extreme cold event.

What's Next

- Working with UTK to get locational data for all their FDRs
  - Right now, we know the 5 most perturbed are electrically close to the event
    - We do not have a way to get the Lat/Long coordinates for exactly where they are
    - We are working to overlay that data on the SAFNR v3 map

Questions and Answers

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10 minute Break

Dwayne Fewless

Dwayne Fewless is currently a Principal Analyst in the Operational Analysis & Awareness Department at ReliabilityFirst. He has over 14 years of utility industry experience working in Transmission Operations as a System Operator at Wolverine Power and as a Technical Trainer at MISO and ITC.

Clayton Calhoun

Clayton Calhoun is a Senior Engineer in Grid Planning and Operations Assurance. Clayton joined NERC in July 2009.

Clayton began his career in 1999 in substation maintenance and design for the Dow Chemical Company. He later joined Associated Electric Cooperative, Inc. with positions in Transmission Planning and Operations.

Clayton holds a Bachelor of Science Degree in Electrical Engineering with an emphasis in Power from the University of Missouri – Rolla

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RELIABILITY FIRST

Real-time Assessments

FERC and ERO Enterprise Joint Report

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Agenda

- Background and Summary
- Data Quality for EMS and SCADA
- Alternate Real-time Assessments
- Conclusions

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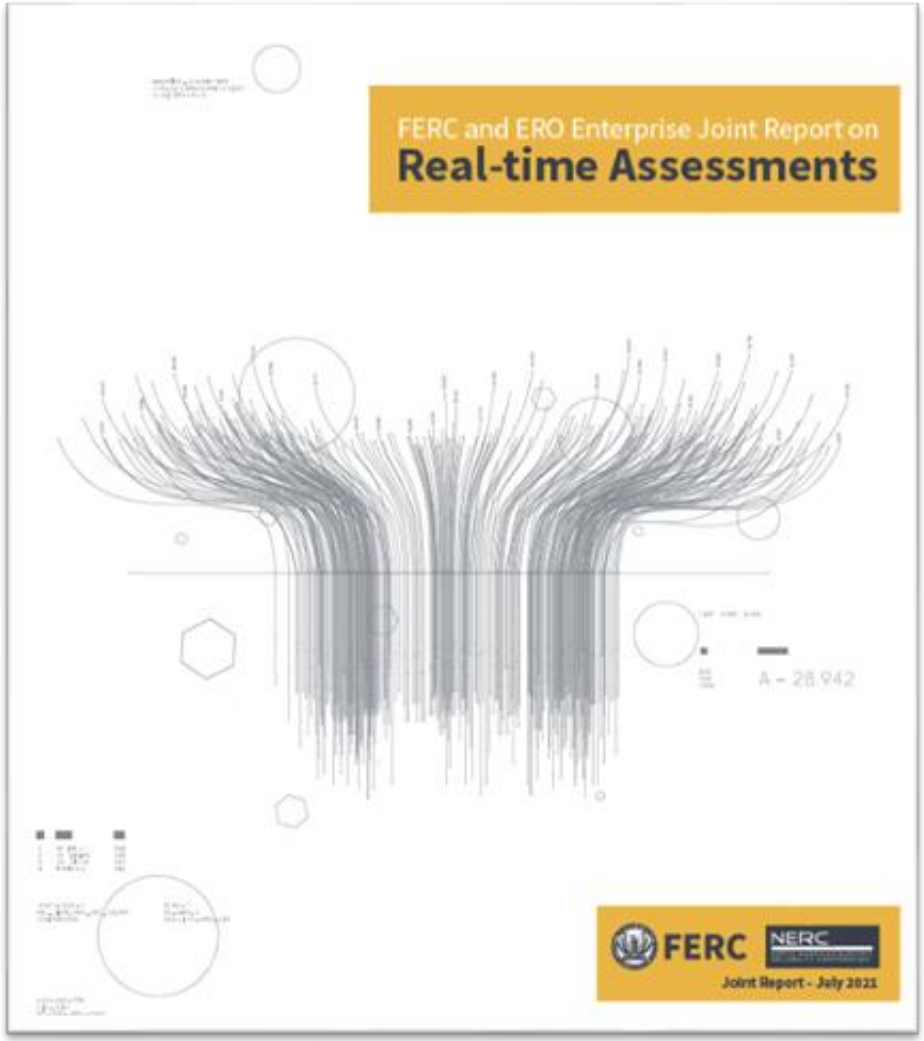


Background and Summary

- The Risk is the **Loss of Situational Awareness**
- EMS outages are reported via EOP-004 and OE-417 submissions
- FERC, NERC, and the regions visited nine Reliability Coordinator / Transmission Operator Control Rooms to discuss
  - How do we define (and perform) a Real-time Assessment?
  - What are best practices?
  - How do we measure data quality and confidence in tools/technology
  - What are the backup plans and internal controls (i.e., Alternate RTAs)
    - How do we train, drill on these?

Real-time Assessment

- What is a Real-time Assessment?
  - An evaluation of system conditions using Real-time data to assess existing (pre-Contingency) and potential (post-Contingency) operating conditions. The assessment shall reflect applicable inputs including, but not limited to: load; generation output levels; known Protection System and Remedial Action Scheme status or degradation, functions, and limitations; Transmission outages; generator outages; Interchange; Facility Ratings; and identified phase angle and equipment limitations. (Realtime Assessment may be provided through internal systems or through third-party services.)
- NERC Compliance Implementation Guidance

Report Findings

- **Seven Technical Areas**
  - Real-time Assessment tools under normal operating conditions
  - Real-time data and data quality
  - Manage the loss of Real-time data
  - Alternative Real-time Assessment and study tools
  - Model Management
  - Control Center hardware configuration
  - Major system upgrades/vendor changes
- **Five Recommendation Focus Areas**
  - Maintaining situational awareness when tools are impacted
  - Ensuring actions are known and consistent in timing and scope
  - Having feasible, accurate backup plans with related training programs
  - Establishing verification procedures to ensure that models are accurate and consistent
  - Maintaining awareness of changes/upgrades to the EMS

Data Quality

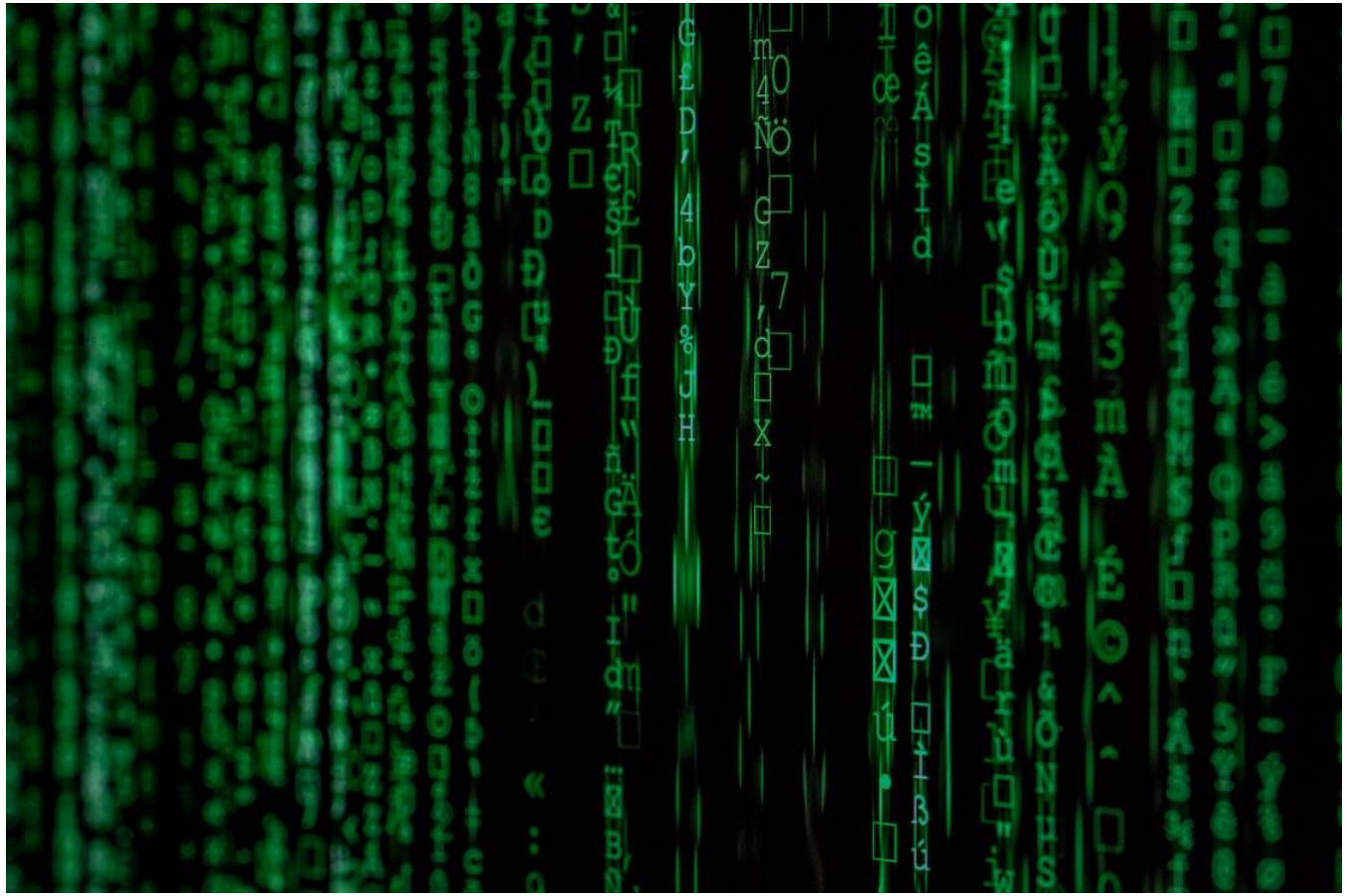
Data Quality

- Most participants stated that their systems and their neighbors' systems provided redundant data through overlap between RTUs and ICCP data links.
  - Some entities were able to switch between redundant data sources on a point-by-point basis.
- Develop procedures and metrics that provide System Operators with the means to measure the impact of data accuracy
- Continue to improve Real-time data quality metrics to ensure that all data and analysis on the screens are relevant, useful, and accurate

Data Quality - Continued

- Some participants were measuring convergence rates and could anticipate an SE failure if they saw it was taking longer to solve.
- Some entities were performing stress tests on backup systems
  - They removed a large piece of data
  - Assess how the system responds
  - Helps identify if redundancy is sufficient or not
- At what point is stale data causing unacceptable results? At what point is a State Estimator solution no longer providing results within an acceptable threshold? These are the key issues that each control center needs to determine for their particular system.

Alternate Real-time Assessments



Alternate Real-time Assessments and Study Tools

- The Reliability Standards do not provide exceptions to the 30-minute requirement to complete a Real-time Assessment.
  - Reliability Coordinators and Transmission Operators are required to perform a quality Real-time Assessment even during the partial or complete loss of primary tools or Real-time data.
  - This includes Real-time Contingency Analysis (RTCA)
- So let's focus on the Alternate RTCA practices that the members shared with the team.
  - 6 of the 9 participants indicated that they can perform RTCA with off-line tools, such as powerflow programs.
    - If a planning model is used instead of a EMS model snapshot, that planning model needs to be maintained daily to reflect current system conditions.

Alternate Real-time Assessments and Study Tools

- Alternate RTCA practices:
  - Two of the Transmission Operator participants did not use offline tools and instead relied on their RC's RTCA results to meet their RTCA portion of their Real-time Assessment. Typically, the RC already is using the full contingency set from the TOP.
  - One RC participant obtained the RTCA results from its Transmission Operators when its own RTCA is not available.
  - One RC, in addition to its offline tool capability, developed its own separate contingency analysis tool that it uses when its primary RTCA application is not available.

Alternate Real-time Assessments and Study Tools

- It is critical to have documented thresholds for when to initiate your alternate RTA
  - A solution doesn't necessarily mean it is a quality solution
  - Develop predictive analytics to better identify when alternate RTA is needed
- Now let's look at a few examples of ***when*** entities initiate the use of offline RTCA tools:
  - One TOP would rely on their RC's RTCA if their State Estimator failed three consecutive times (15 mins).
  - One RC, upon a failed SE solution for 10 mins, would download the last successful SE model and perform RTCA offline with a redundant copy of their primary RTCA program. This RC could also load the last SE model into an offline powerflow program, if necessary.

Other Report Findings

- Assessment recognized best practices with
  - Real-time Assessment tools under normal operating conditions
  - Real-time data and data quality
  - Managing the loss of real-time data
  - Alternate Real-time Assessments and study tools
  - Model Management
  - Control Center Hardware Configuration
  - Major System Upgrades / Vendor Changes
- **Reminder**: continue to report EMS outages as per EOP-004-4, working with Events Analysis to determine root causes and Lessons Learned

Conclusion

- Data Quality– have you identified all the data you need to maintain proper SA?
- How do you define the loss of (or degraded) data?
- What are your requirements and how is the data flagged?
- How do you identify stale data and what alarms or processes are in place?
- At what point can you not rely on your State Estimator solution and need to look at Alternative Real-time Assessments?
- Have you identified your Alternative Real-time Assessment process?

Questions and Answers

Future Sessions

- Session 2
  - Theme: Distributed Energy Resources
  - Time: 1:00-3:00 p.m. Eastern
  - Date: Thursday, October 7, 2021
- Session 3
  - Theme: Technique and Workforce Challenges
  - Time: 1:00-3:00 p.m. Eastern
  - Date: Thursday, October 28, 2021