Oscillation Detection and Source Location

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Panel: Using Synchrophasor Applications to Determine Disturbance Locations

NASPI General Meeting

Oct. 24, 2018

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Outline

- **Oscillation Applications in RTDMS**
  - > Mode Meter
  - > Oscillation Detection

- **Case Studies**
  - > ERCOT wind farm
  - > TVA nuclear plant

- **Summary**

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Mode Meter and Oscillation Detection Applications in RTDMS

- **Montana Tech MAS 2.0 Integration**
- **Mode Metering Module (MMM)**
  - > Result is Frequency, Damping, Energy & Mode Shape
  - > Allows multiple input signals
  - > Detailed quality flag
- **Oscillation Detection Module (ODM)**
  - > Detection based on 4 oscillatory frequency bands
  - > Result gives signals RMS energy for each band
  - > Spectral Analysis on the highest RMS Energy band to identify exact oscillatory frequency
  - > Built-in Alarming
- **Quick Identification of Oscillation Source using Map-based Visualization**
- **Dissipating Energy Flow method for source location**
  - > Work in progress

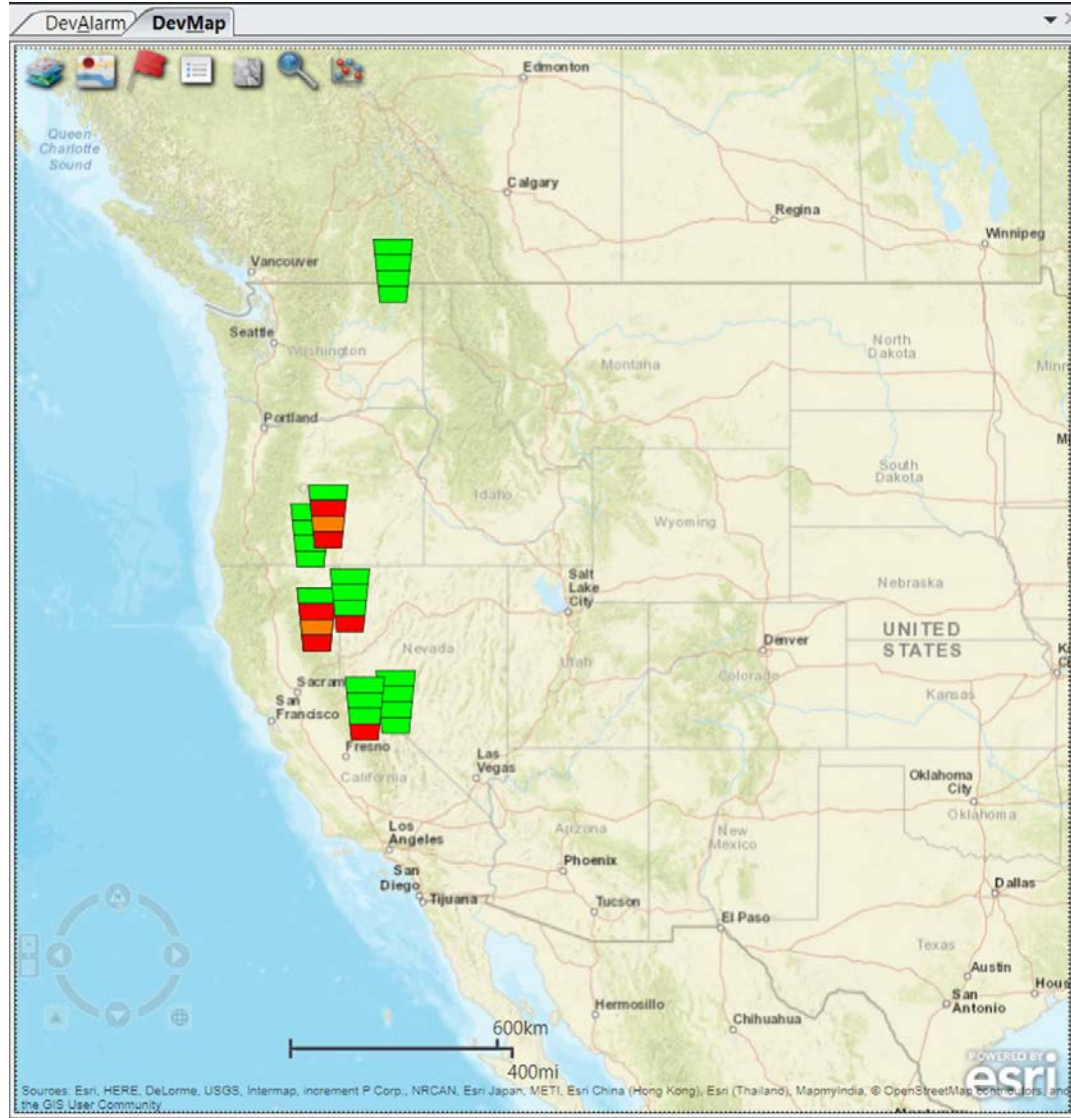# Mode Meter Display Example
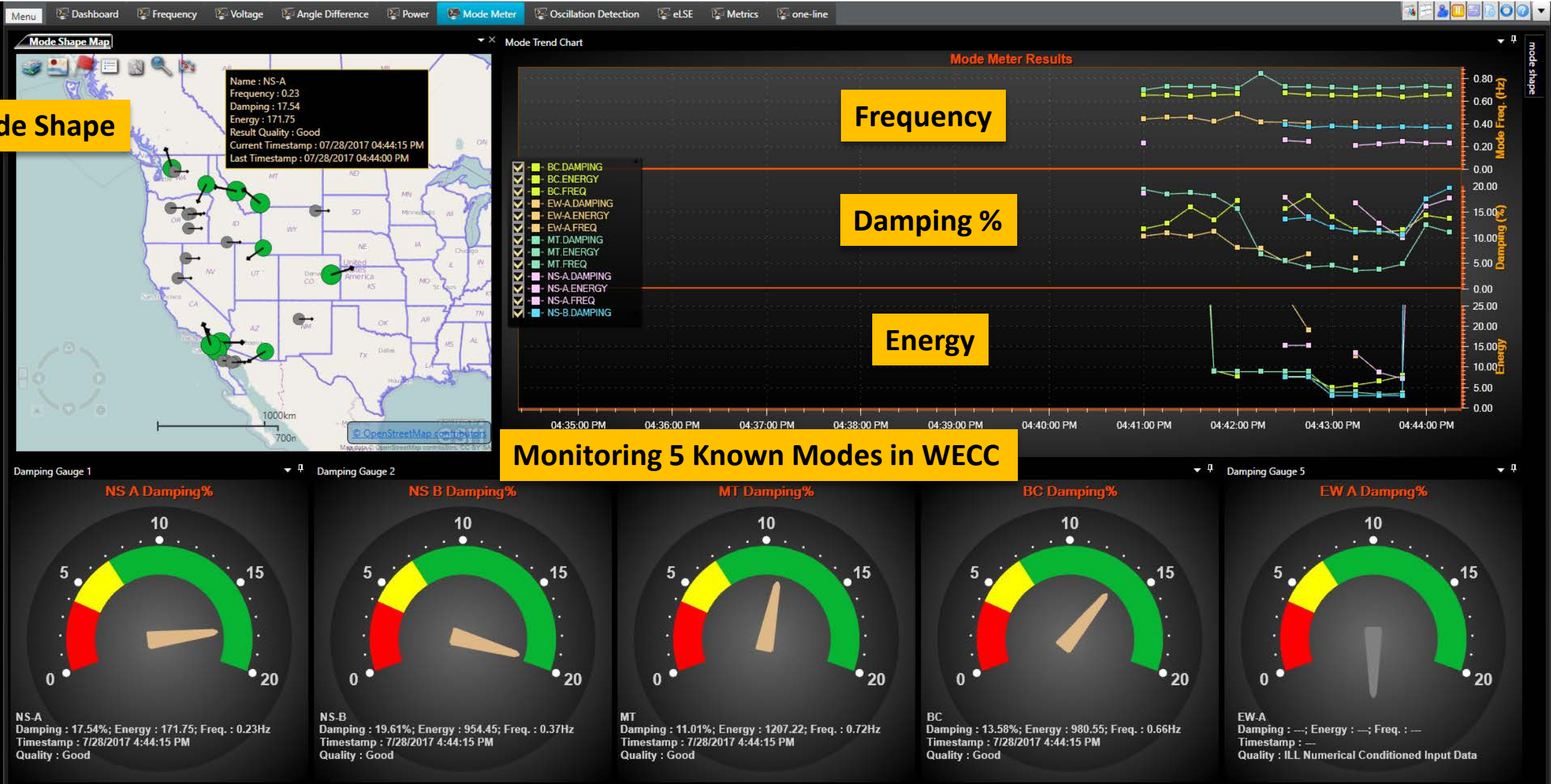
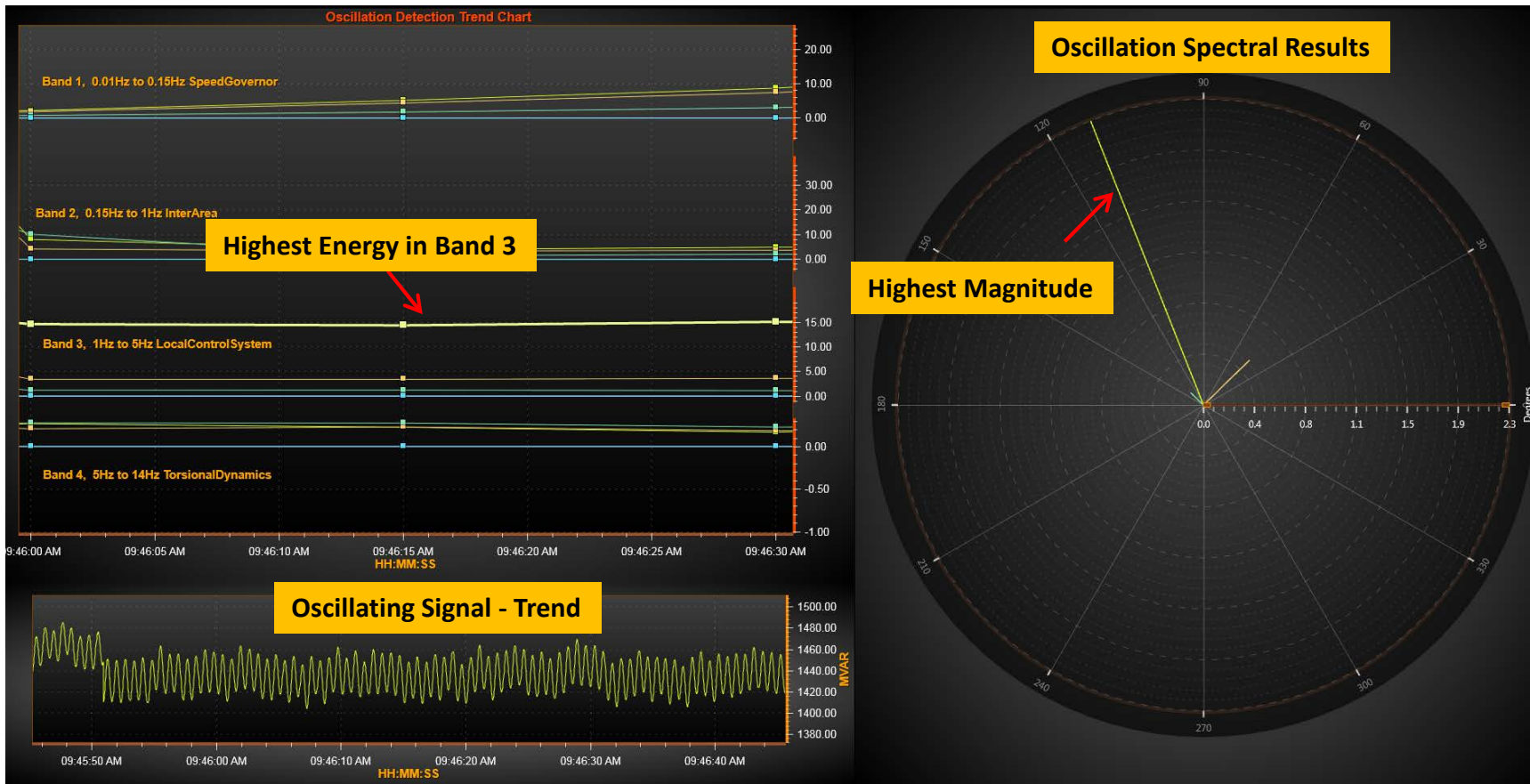# Mode Shape Visualization
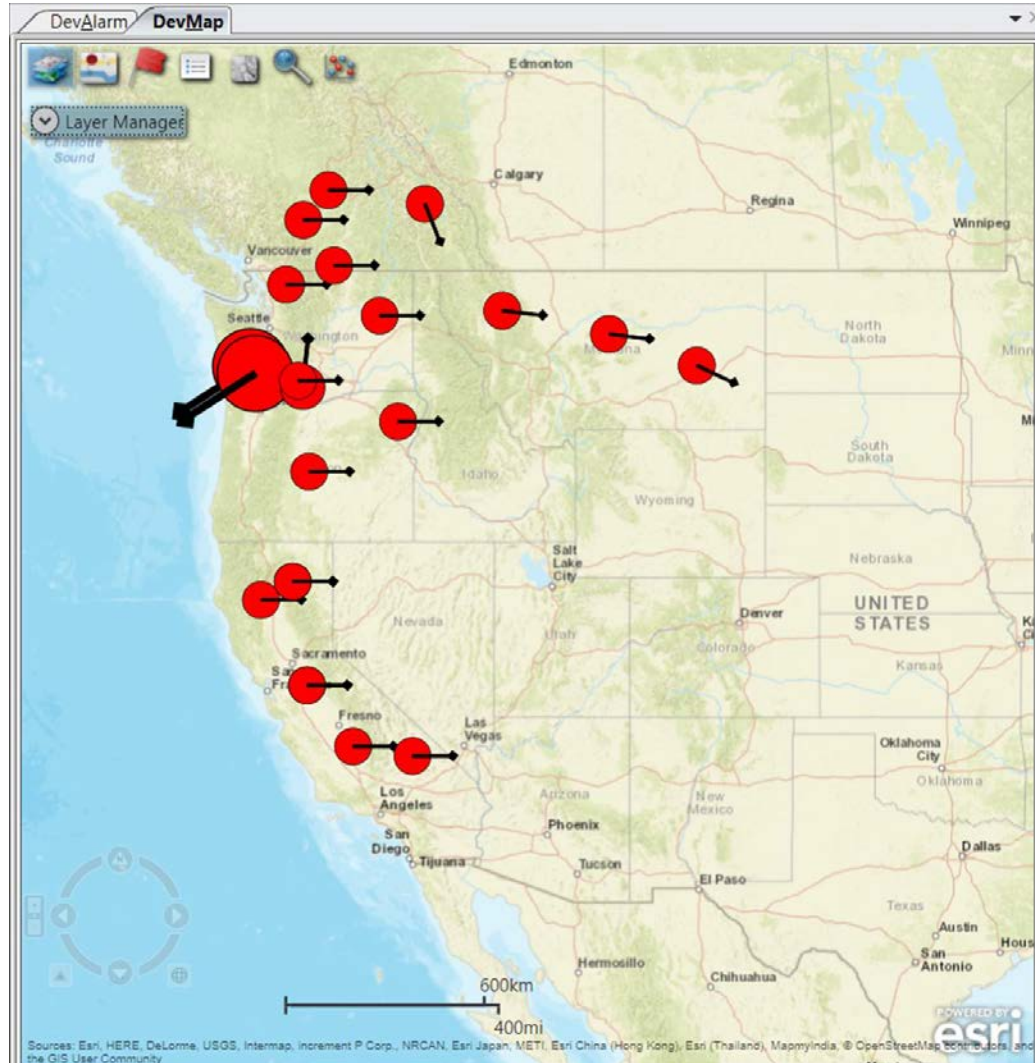
- Mode shape Location: signal participating
- Amplitude: Size of circle
- Arrow : represents shape phase
- Color: damping alarm

Oscillation Detection Visualization

- Location: configured signal
- Icon shows 4 alarm bands for each PMU
- Color: alarmed

Oscillation Detection Alarm Popup – Drilldown Info

Oscillation Detection Trend Chart

Band 1, 0.01Hz to 0.15Hz SpeedGovernor

Band 2, 0.15Hz to 1Hz InterArea

Highest Energy in Band 3

Band 3, 1Hz to 5Hz LocalControlSystem

Band 4, 5Hz to 14Hz TorsionalDynamics

Oscillating Signal - Trend

Oscillation Spectral Results

Highest Magnitude

- OD 4 band chart of the alarmed signal
- Line chart of the alarmed signal
- Spectral shape of the alarmed signal + the highest top 10 RMS energy signal identified for the alarm

ERCOT Example in Real Time Operations

- Detection:
  - \> Oscillation detected in real time by Operations Support engineers
  - \> Lasted more than 2 hours
  - \> Can be observed with several PMUs in west Texas
  - \> Mainly in voltage magnitude and reactive power signals

- Diagnostics:
  - \> Largest PMU VM swing peak to peak: 1.5-2 kV;   PI data at wind POI: 4-5 kV
  - \> Largest PMU MVar swing peak to peak: 5-10 MVar;   PI data at wind POI: 15-20 MVar;
  - \> Dominant frequency for the oscillation: 0.52 Hz
  - \> Highest energy close to one wind farm

- Mitigation **in Real Time**:
  - \> Operation Support engineers tracked the root cause by locating the largest unit MVAR swings at two possible units, WND1 and WND2
  - \> The unit operators were notified and given control room instructions to turn off their AVR, and the oscillations died down when the AVR

- Fun Fact:
  - \> Similar oscillations were recorded twice in the prior month
  - \> The resource operator was able to locate the error in the voltage controller and return the AVR to service later in the day without triggering the oscillation
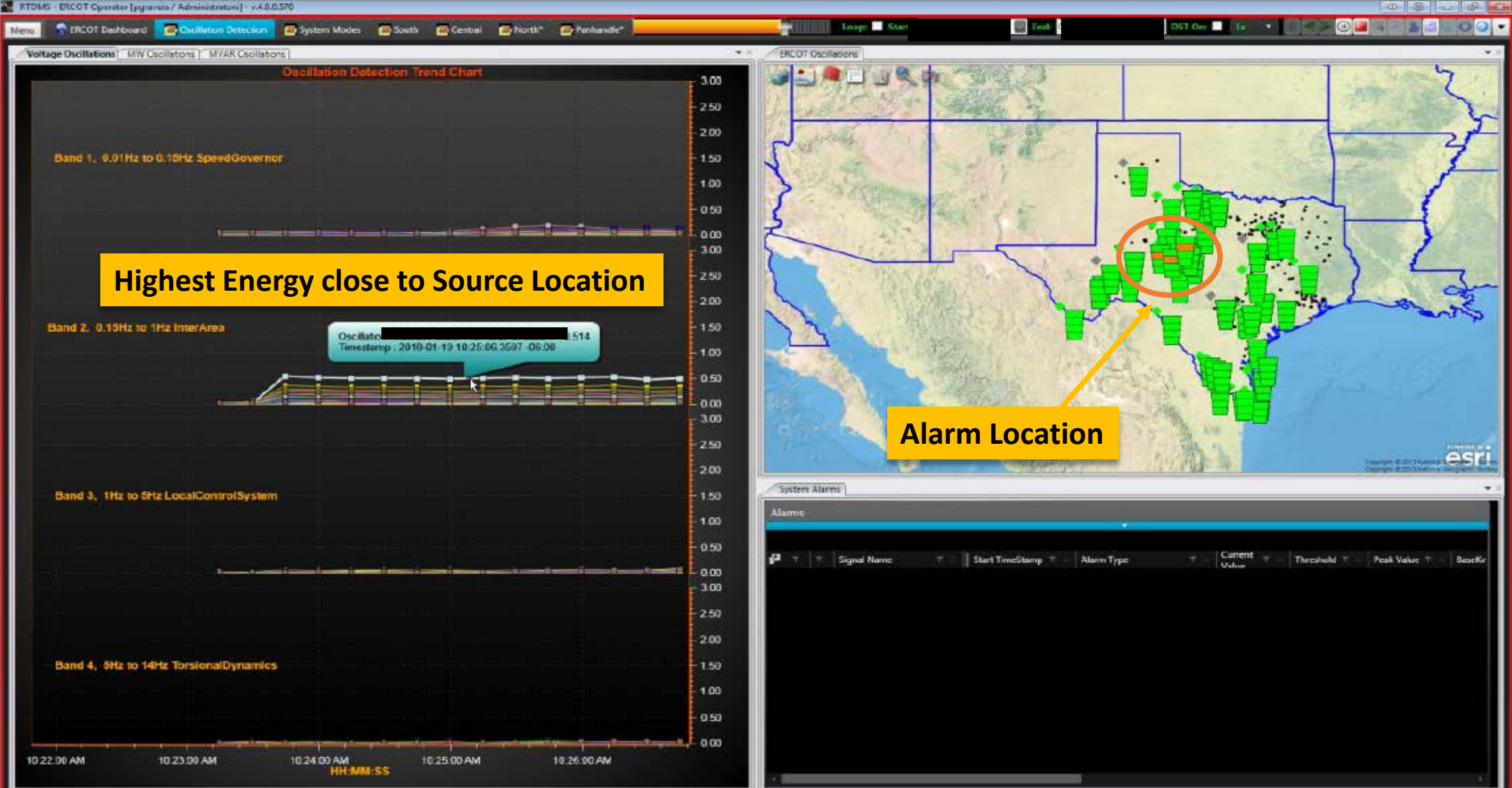
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ERCOT Example – Oscillation Alarm on Dashboard

ERCOT Example – Oscillation Detection Display

Highest Energy close to Source Location

Alarm Location

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ERCOT Example – Oscillation seen in VM & MVar

TVA Example in Operation

- Background
  - > One nuclear plant implementing Extended Power Uprate (EPU) for all three units.
  - > EPU will increase electrical output of each unit from 1155 MW to 1318 MW
  - > Unit 3: first unit to undergo EPU; returned from outage on April 6th

- Detection:
 - > Identified oscillation for Unit 3 after ascending pre-EPU output limits

- Diagnostics:
  - > 0.5 Hz oscillation; damping between 5-10%; peak to peak swing: 20-30 MW
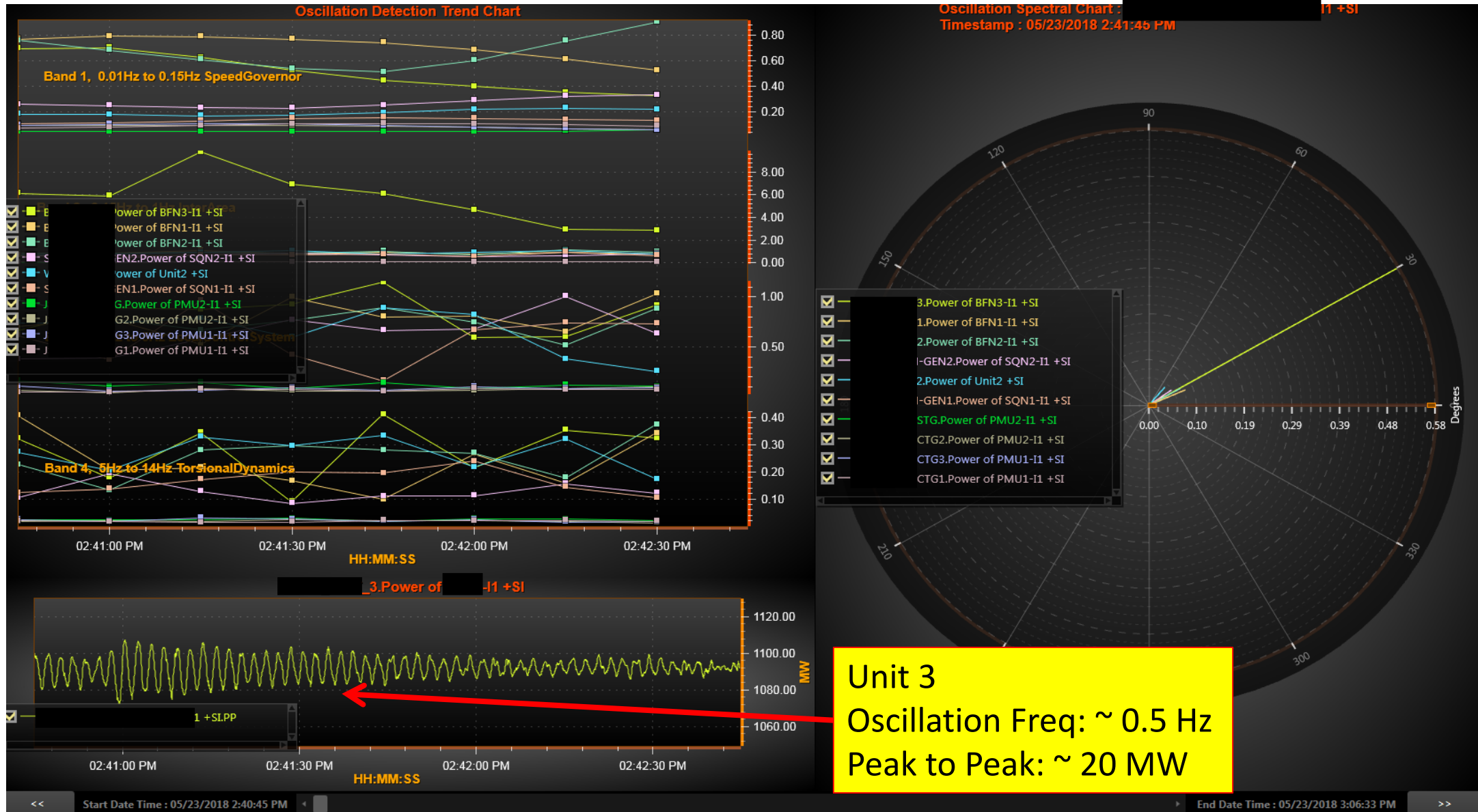
- Action:
  - > Called plant; Plant is aware of oscillation seen
  - > Initial assessment: may be related to a valve issue
  - > Still under investigation for official report
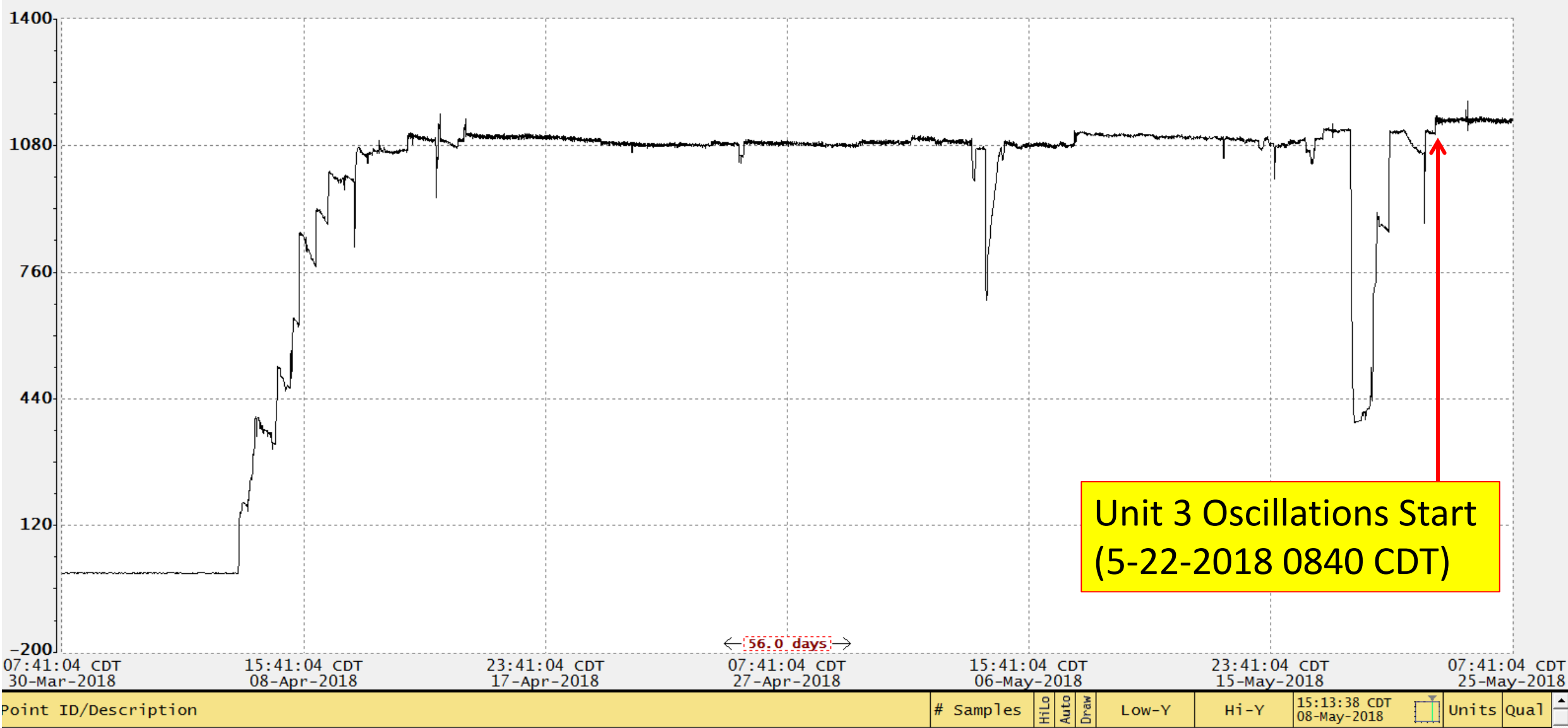 - > Continue monitoring to see if this reappears again (and it did last week!)

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TVA Example – Alarm on Oscillation Detection Display

Unit 3 – Alarm
- First alarm Setting
(>10 MW Pk to Pk for 30 sec)
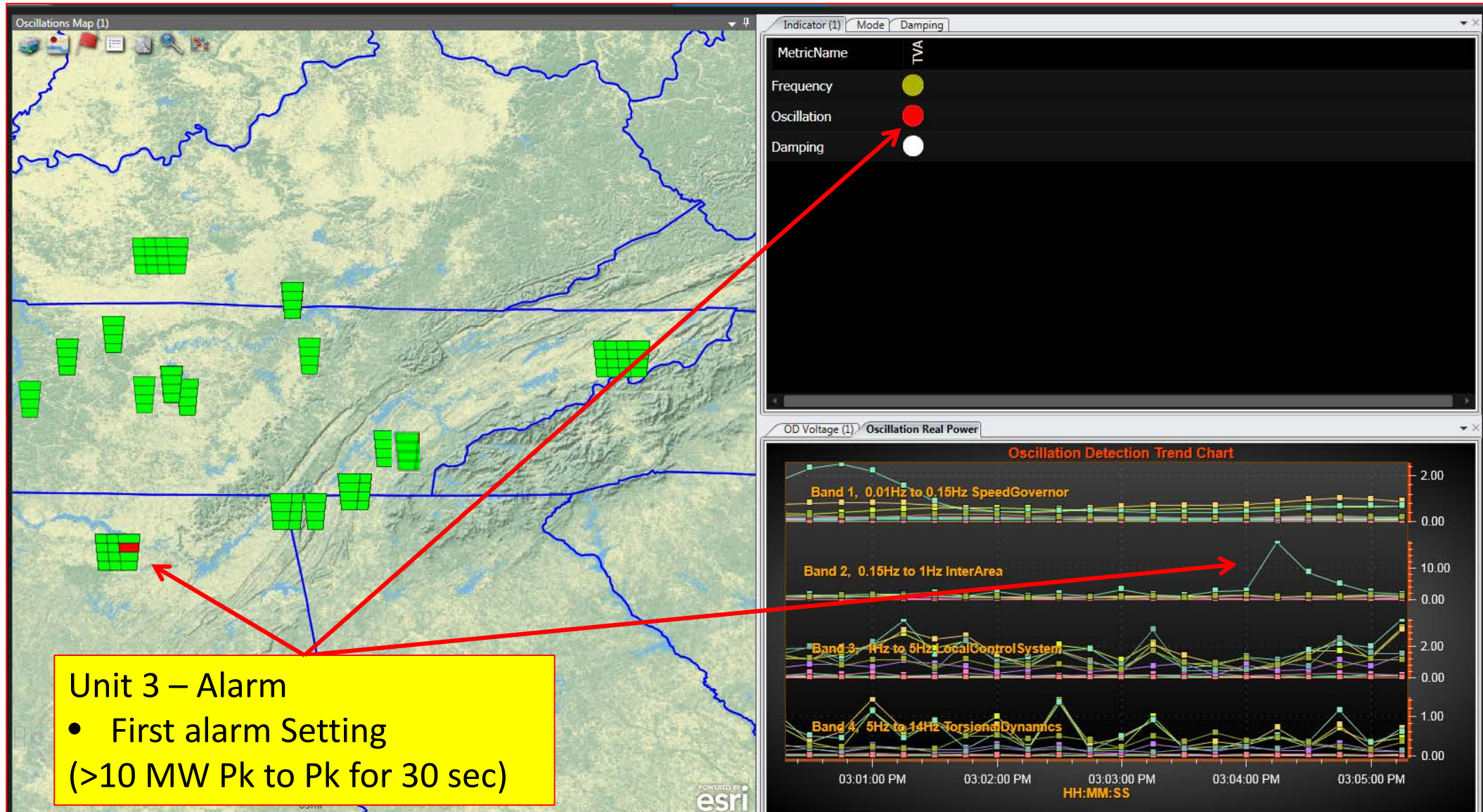
TVA Example – Oscillation Event Analyzer

Unit 3
Oscillation Freq: ~ 0.5 Hz
Peak to Peak: ~ 20 MW

Unit 3 – SCADA Data (Two Months)

Unit 3 Oscillations Start
(5-22-2018 0840 CDT)
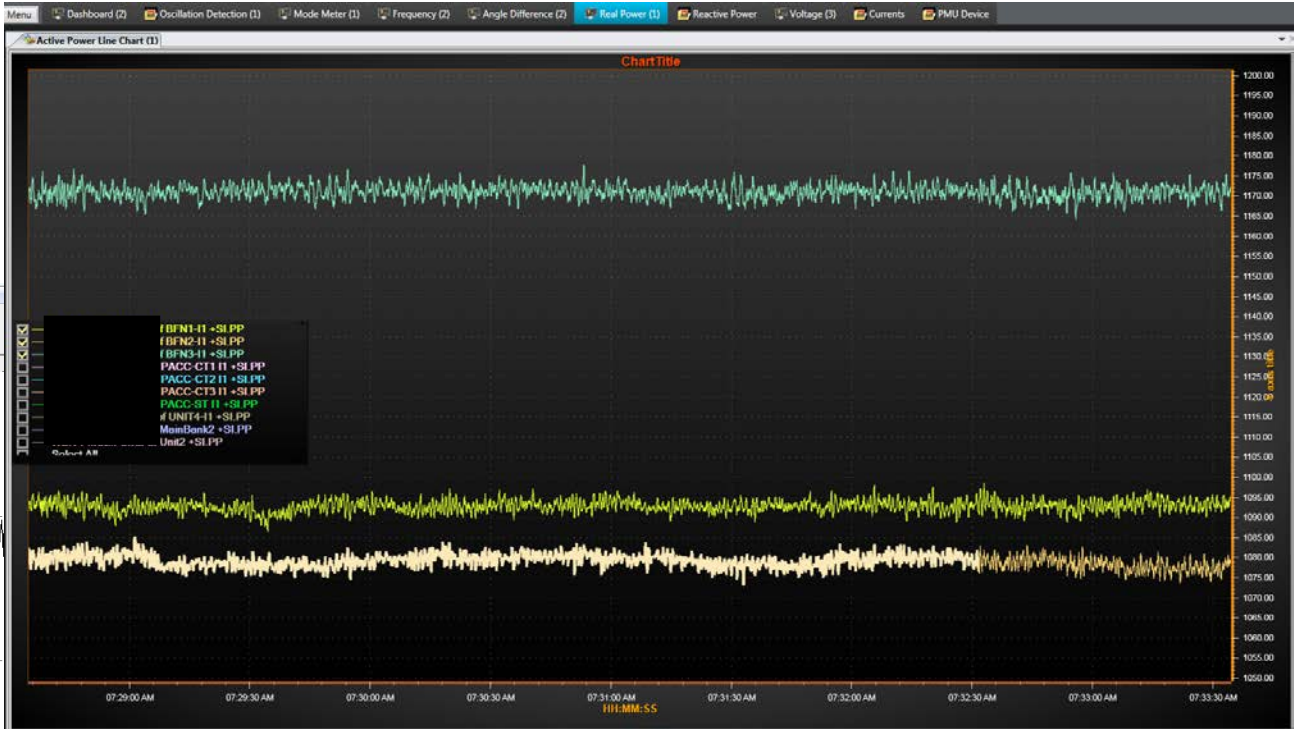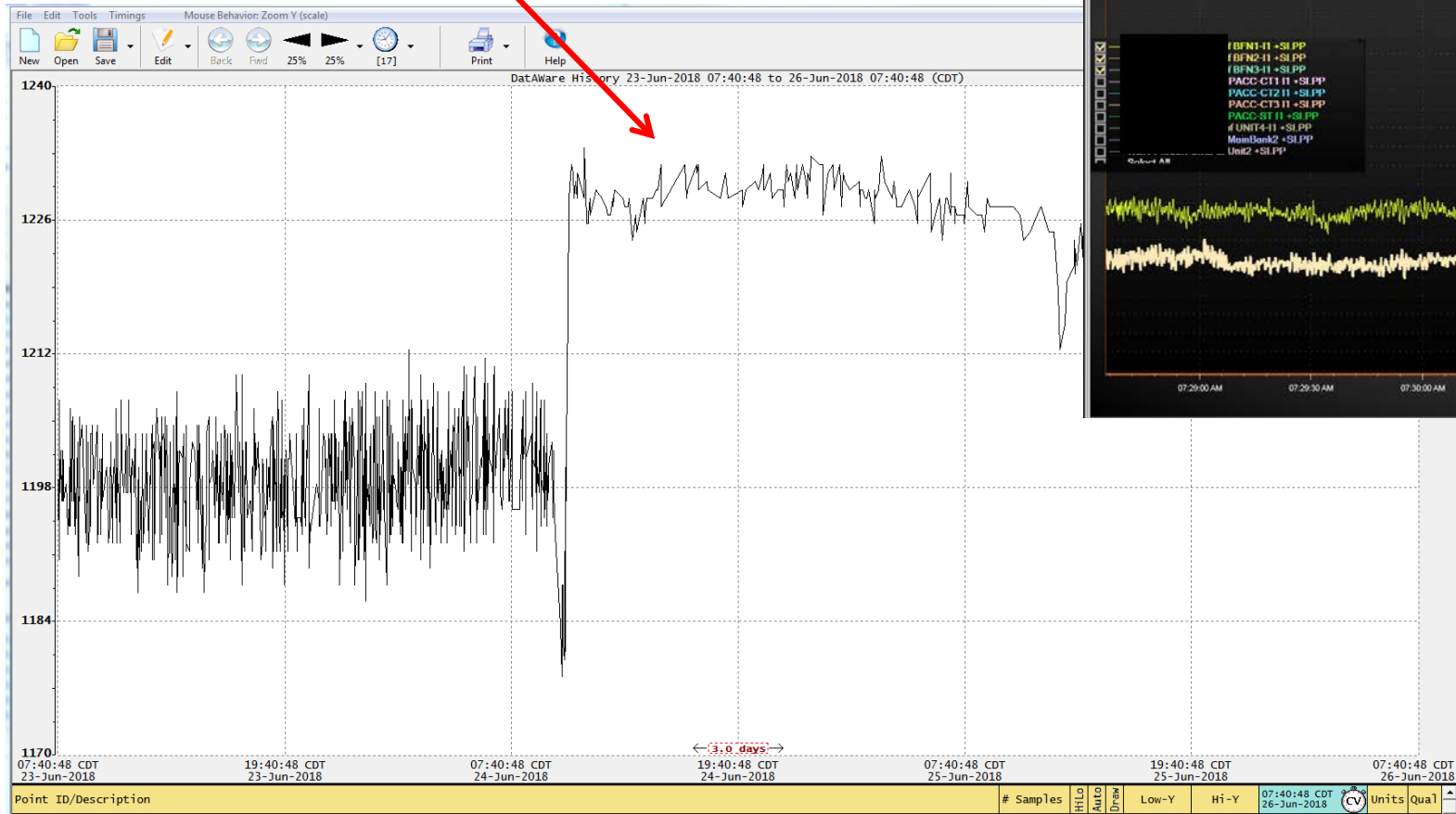
Unit 3 Oscillation – After 30 MW ascension (6/24/2018)

Oscillation Stops

TVA Example – Oscillation also observed when plant doing testing

Summary

Summary

- **Oscillation Disturbance**

  - > Mode meter & oscillation detection in production

  - > ERCOT and TVA success stories for detection and mitigation

  - > New method for source location - work in progress

- **Planned "RTDMS 2020" – Q1/2020**

Thank You

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