DOE/OE Transmission Reliability Program

FY2015 Baselining Studies and Analyses

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Major Technical Accomplishments during the Past Year

- Continued Baselining Efforts for the Eastern Interconnect
  - Applied improvements to the Date/Time Model (establishment of Phase Angle Pair normal operation limits)
  - Developed a phase angle trend monitoring method to complement the Date/Time Model
  - Investigated the amount of data (length of time) needed to establish a stable baseline
- Compared atypical events found with baselining algorithms (data driven) to known events
- Written Data Quality based article to be presented at the IEEE Power and Energy Society General Meeting
- Worked with the **NASPI Engineering Applications Task Team**

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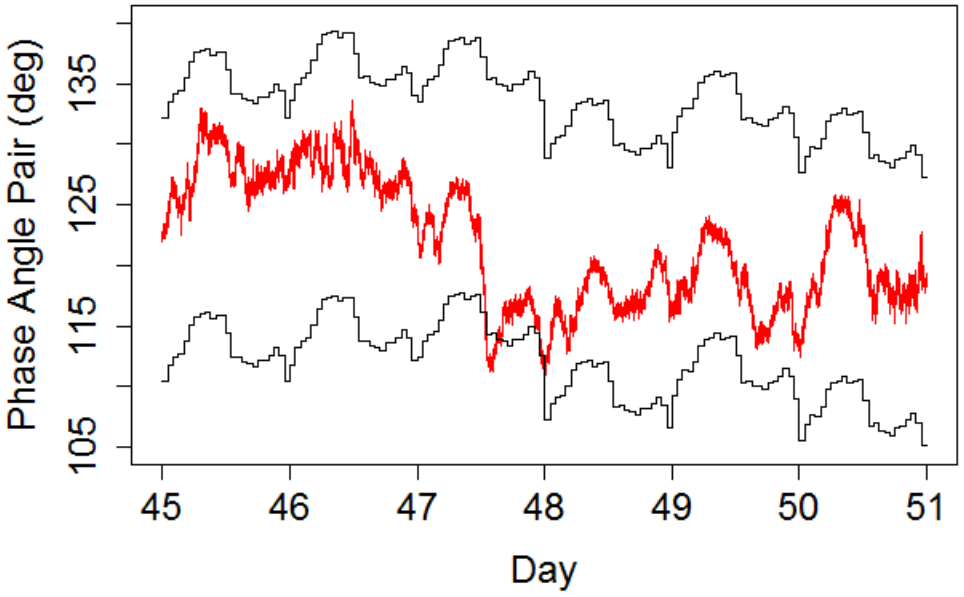
Date/Time Model Improvements



Added a daily regularization term to the model:

$$\widehat{\boldsymbol{A}} = \boldsymbol{\mu} + \boldsymbol{W_j} + \boldsymbol{T_k} + \boldsymbol{M} \times \breve{\boldsymbol{A}}_{\boldsymbol{0}} + \boldsymbol{\varepsilon_{j,k}}$$

where *W* is the week effect, *T* is the time of day effect, *M* is the regularization parameter, and $\breve{A}_0$ is the phase angle pair value at midnight

- At midnight, the day of the week, each hour of the day, and the phase angle pair's value at midnight are fed into the model.
- Model then produces predictions for the phase angle pair at each hour of the day along with prediction intervals.

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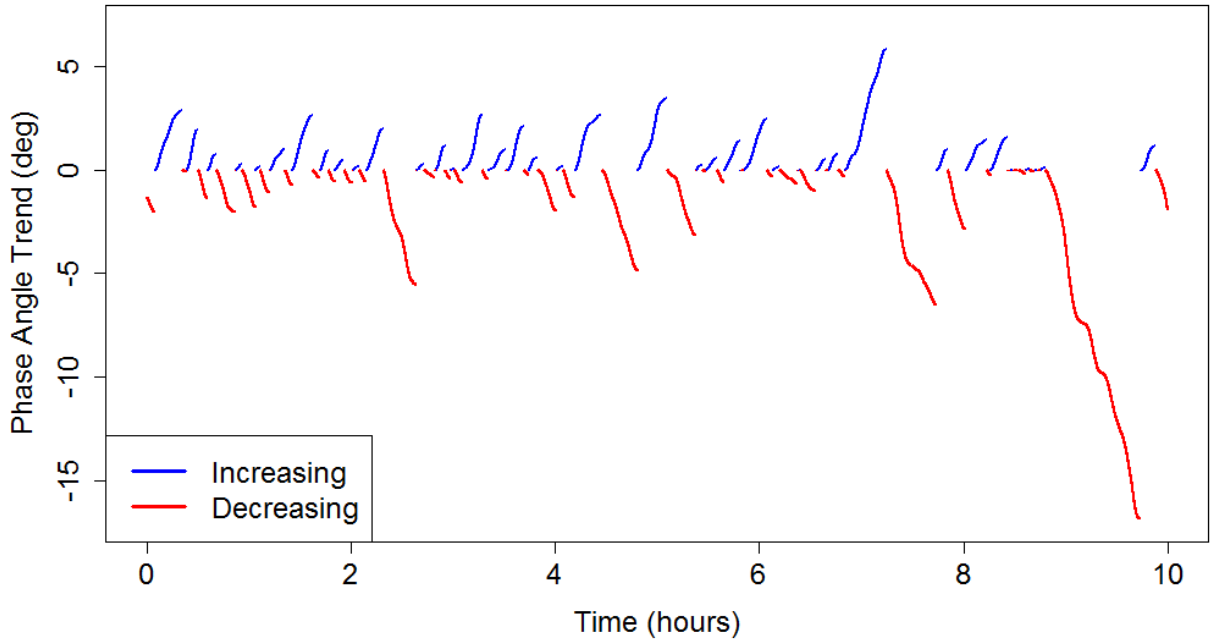
Phase Angle Trend Monitoring



- Increasing and decreasing trends shown in visualization.
- Statistical algorithms can be applied to determine if trend is significant.

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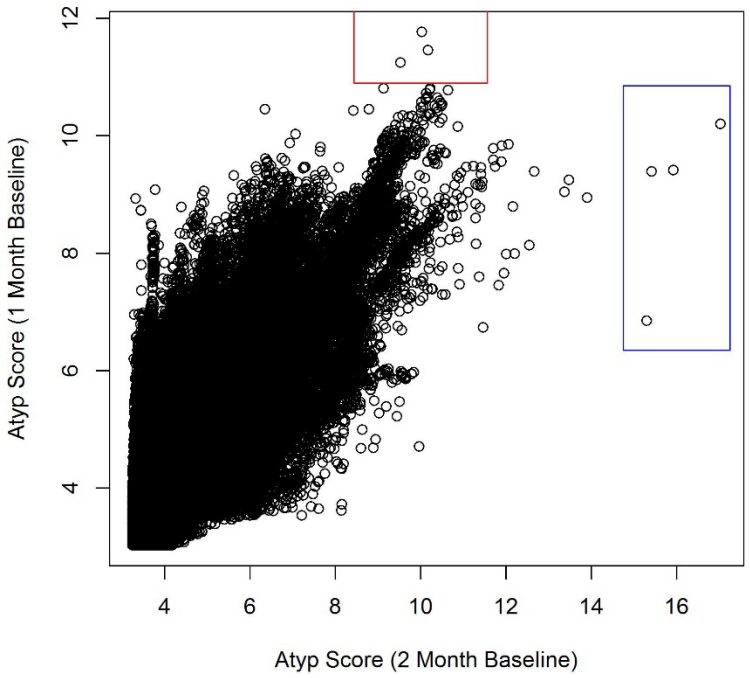
Baseline Stability



- Results using baselines of 2 weeks and 1 month were not consistent with the 2 month baseline
- More data and analyses would be needed to understand stability in baselining (2 months was not enough to build a stable baseline)

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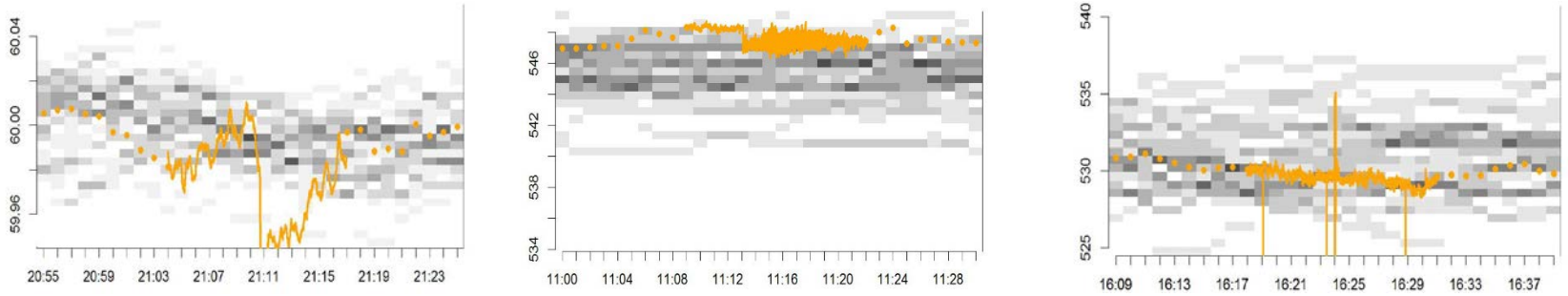
Event Investigation



- All frequency related events were detected. An additional frequency event was detected but was not on the list of events.
- 3 of the line outages were detected. These were major outages. The other 21 line outages were not detected.
- 3 additional events were detected which were not on any event lists.

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Remaining FY15 Deliverables

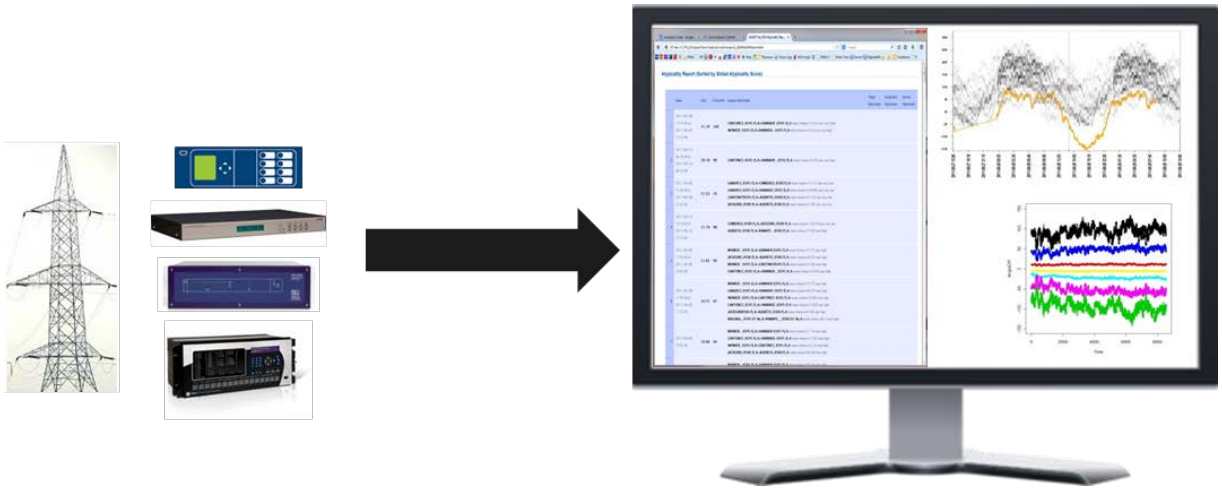
- Final WECC Event and DISAT Comparison Technical Report
  - Report contains details about the previously discussed areas of research
  - Report has been completed and is currently out for review to our partner agencies
  - Final copy should be available by June 20th.

Path Forward: GMLC Category 2

(GM0070 Discovery Through Situational Awareness)

Apply big data analytical techniques (statistical and machine learning based) for a data driven approach to

- Find events,
- Discover pre-cursors to events, and
- Characterize events



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Path Forward: Planned Activities

- Process Phasor Measurement Unit (PMU) data, including data-quality cleaning
- Investigate and implement anomaly and event detection algorithms in near real-time
- Provide informative data visualizations
- Provide insight into equipment failure or misoperation
- Investigate the effect of other data streams to determine which ones are accessible and could possibly provide additional insight
- Apply machine-learning to characterize patterns found in the data and begin initial look at event precursor behavior.

Path Forward: Schedule

Milestone	Date
Obtain, process, and clean data (from industry and/or EIOC)	3 M from start
Initial investigations provided to Industry Partners for feedback	6 M from start
First draft of report sent to Industry Partners for feedback (including revised investigations)	9 M from start
Prototypical situational awareness tool (installed and processing new data)	1 Y from start