"WAMS East:" A Synchronized System Measurements (SSM) Network for the Eastern Interconnection

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CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Presentation Elements

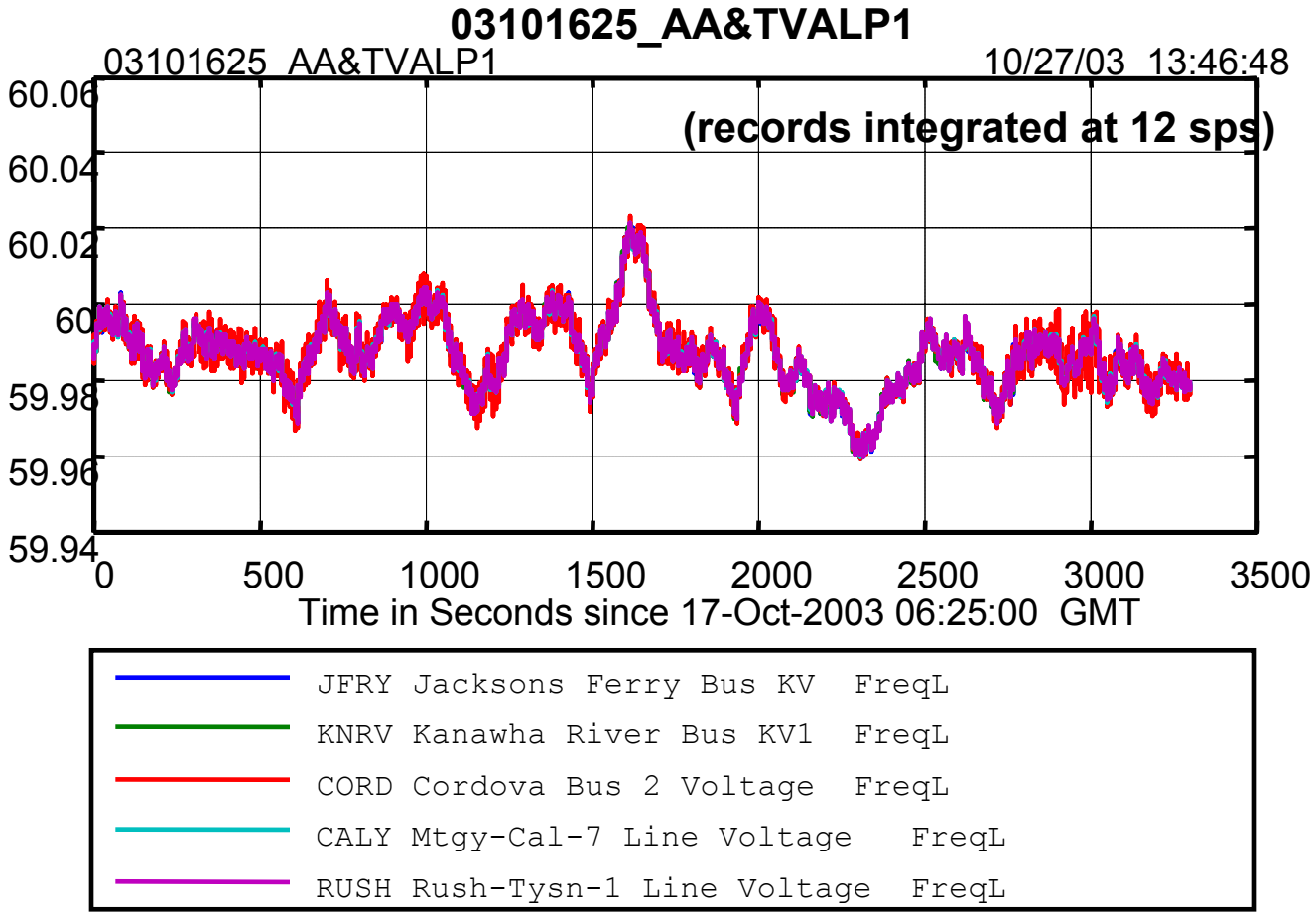
1. Roles for wide area dynamic information in the eastern interconnection
2. Performance of WAMS East for the blackout of August 14, 2003
3. Initial performance of the TVA synchronized phasor measurement system (SPM) within WAMS East

Contributors of Synchronized Dynamic Measurements for the August 14 Blackout

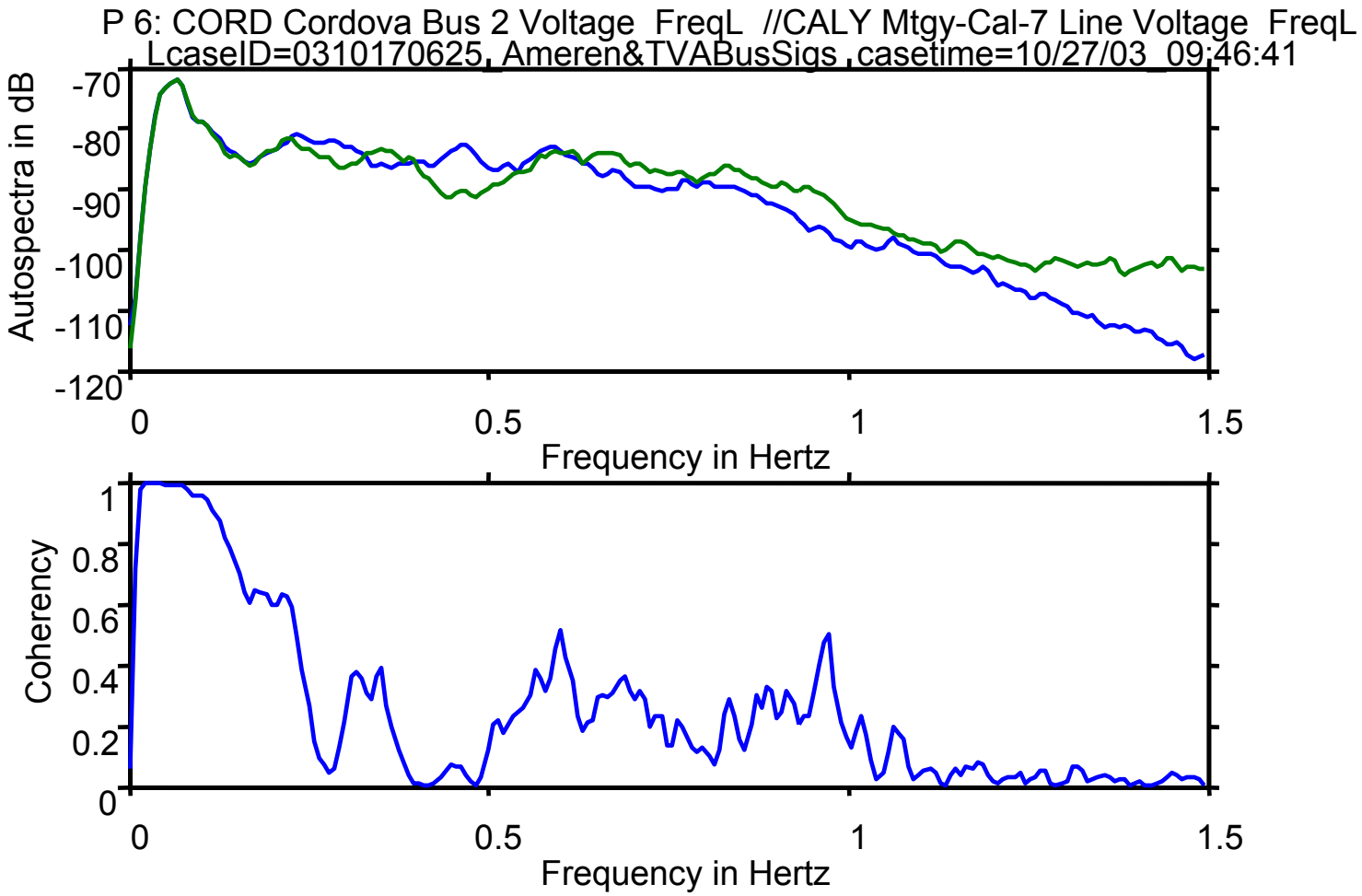
- **American Electric Power (AEP)**
  Continuous recording to corporate server, 2 PMUs at 12 sps
- **Ameren**
  Continuous recording to central PDC, 2 PMUs at 60 sps
- **Entergy**
  Continuous local recording, 3 PPSM DataTake units at 20 sps
- **NYPA/NYSEG**
  "Snapshot" recordings, 3 PMUs at 6 sps
- **New Brunswick Power**
  "Snapshot" recordings, graphics only

Data Integration Check for New Synchronized Phasor Measurements (SPM) Network at TVA

Integration of SPM Records for TVA, AEP, and Ameren (data filtered to remove noise from TVA signals)



Correlation Check of TVA and Ameren Signals



WAMS: The Next Horizon

Extending the phasor network:

From synchrophasors to synchronized system measurements.

WAMS Outreach in Post-Analysis of the August 14 Blackout

- **Immediate Task:**

  Assist "WAMS East" utilities to archive, integrate, and analyze PMU and other synchronized system measurements collected for the blackout of August 14, 2003.

- **Benefits:**
  - **detailed timeline representation of system events and their immediate effects**
  - **opportunity for the data owners to increase the information value and the utility of their data by merging them into a broader picture of power system behavior**
  - **opportunity for the data owners and regional grid managers to develop the agreements and procedures relating to the costs, benefits, and risks of a system-wide WAMS infrastructure**

- **Initial Support:**

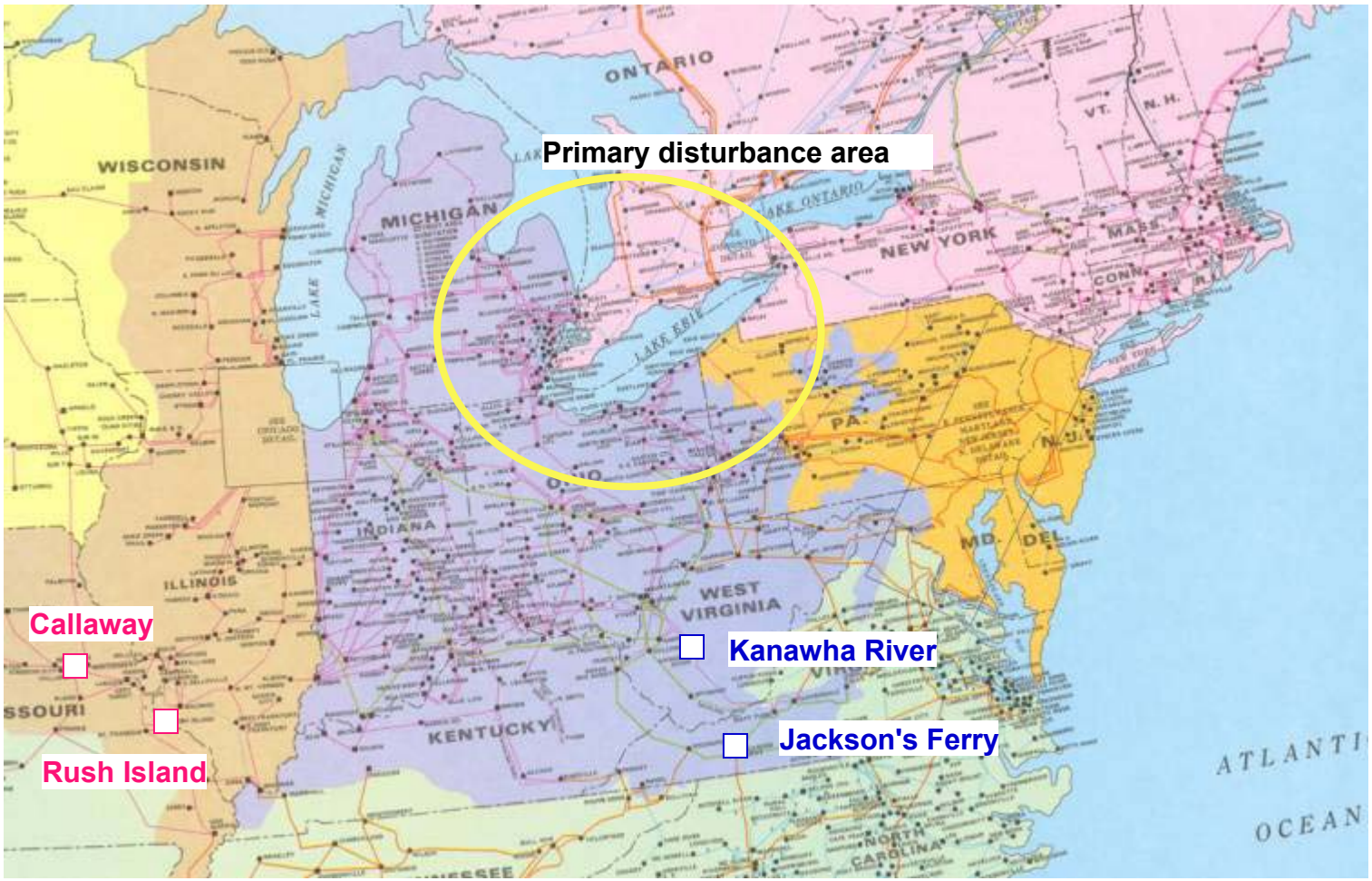
  Ongoing DOE/CERTS "WAMS Outreach" to the eastern interconnection

Presentation Element 2

Performance of WAMS East for the blackout of August 14, 2003

AEP & Ameren PMU locations

(revisions? Show TVA locations? Larger figure for Entergy?)



Performance of "WAMS East" in the Blackout of August 14, 2003

A. Phasor Data Concentrators (PDCs) continuously recorded 38 primary signals, from PMUs at 4 locations. Records extend from 12:00 EDT to 17:00 EDT. Additional data available for August 14 and for other days.

B. PPSM units continuously recorded 39 primary signals , from analog transducers at 3 locations. Records extend from 12:00 EDT to 17:00 EDT. Additional data available for August 14 and for other days. Records integrate with PMU data.

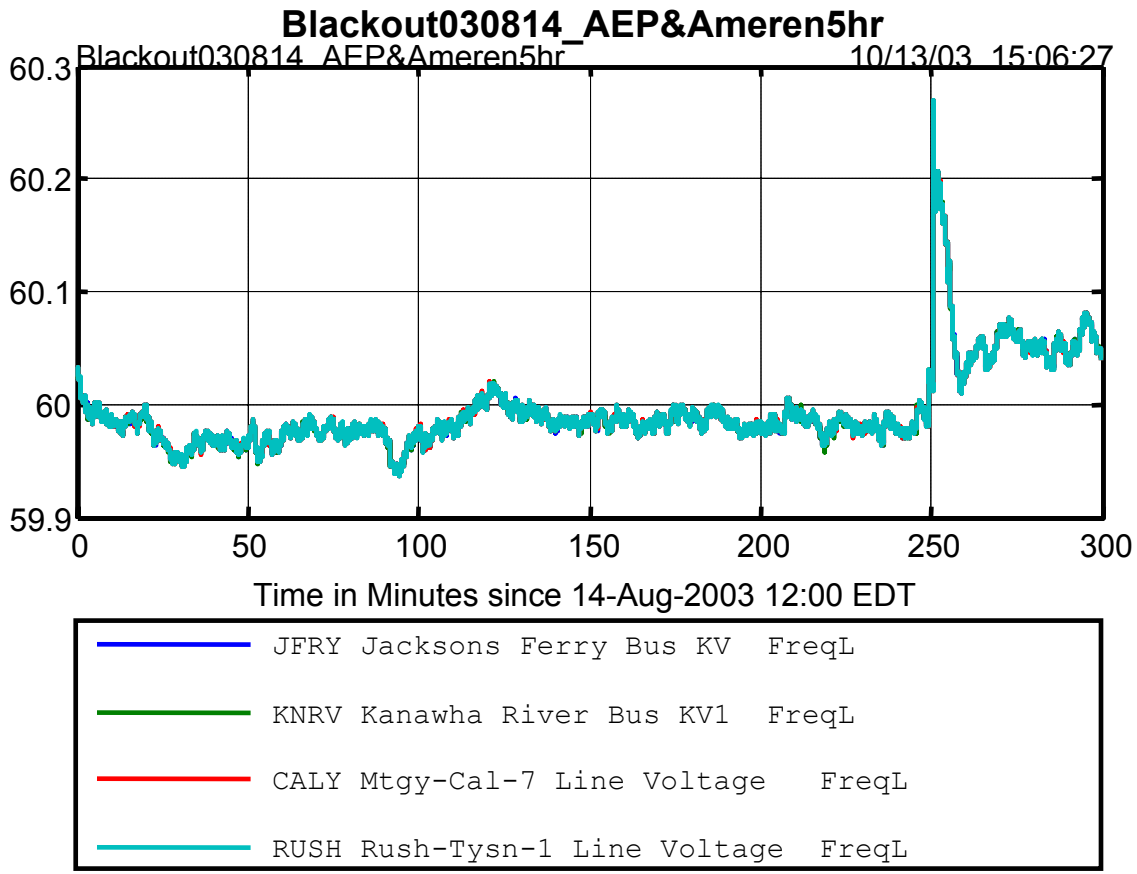
C. "Snapshot" records of breakup event were collected on 3 additional PMUs plus other other devices (e.g., generator monitor).

D. Long-term PMU data integrated immediately, despite different hardware systems and different sample rates. Integration of data from legacy "snapshot" systems was slowed by lack of up-to-date translators.

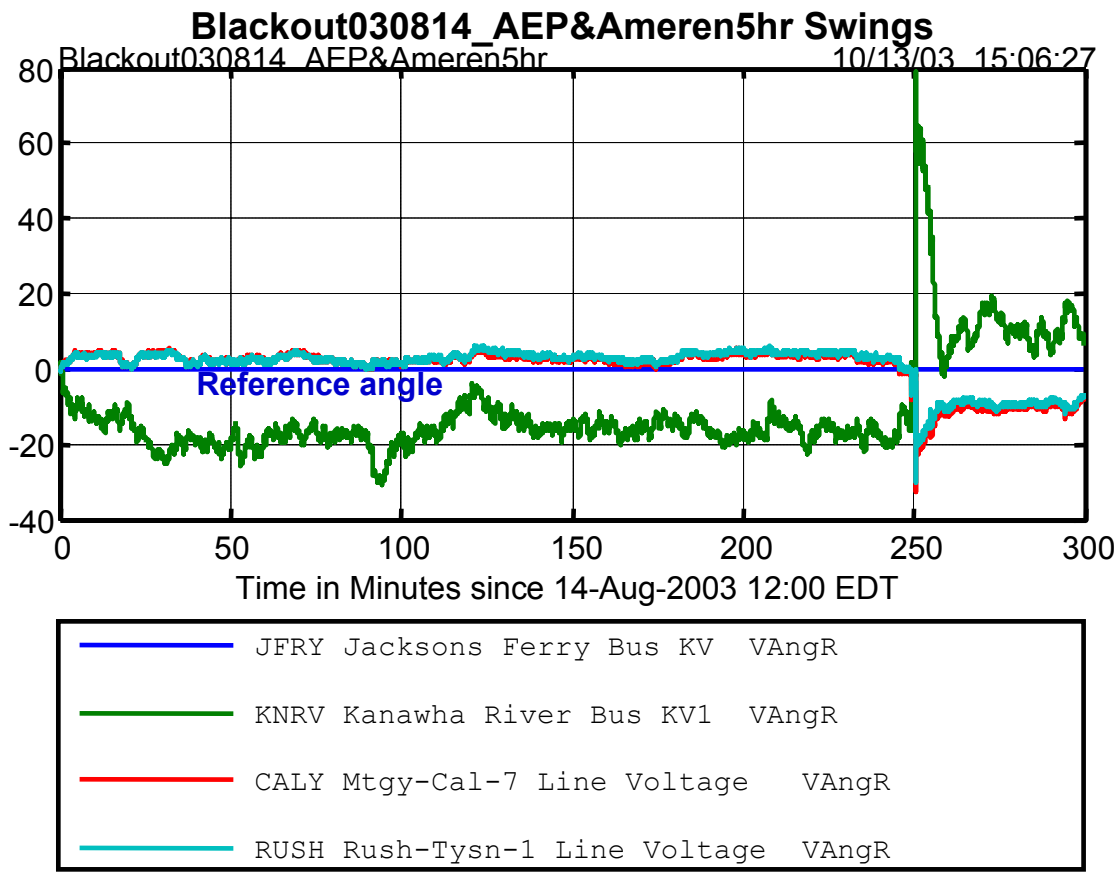
E. Long-term records provide
   - a high resolution frame of reference aligning records that are shorter or without accurate time stamps
   - a comprehensive profile of system conditions and dynamic behavior
   - general insights into underlying dynamics of the eastern interconnection

F. This event demonstrated the value of well synchronized data collection, and of strategically located continuous recording systems to facilitate their integration.

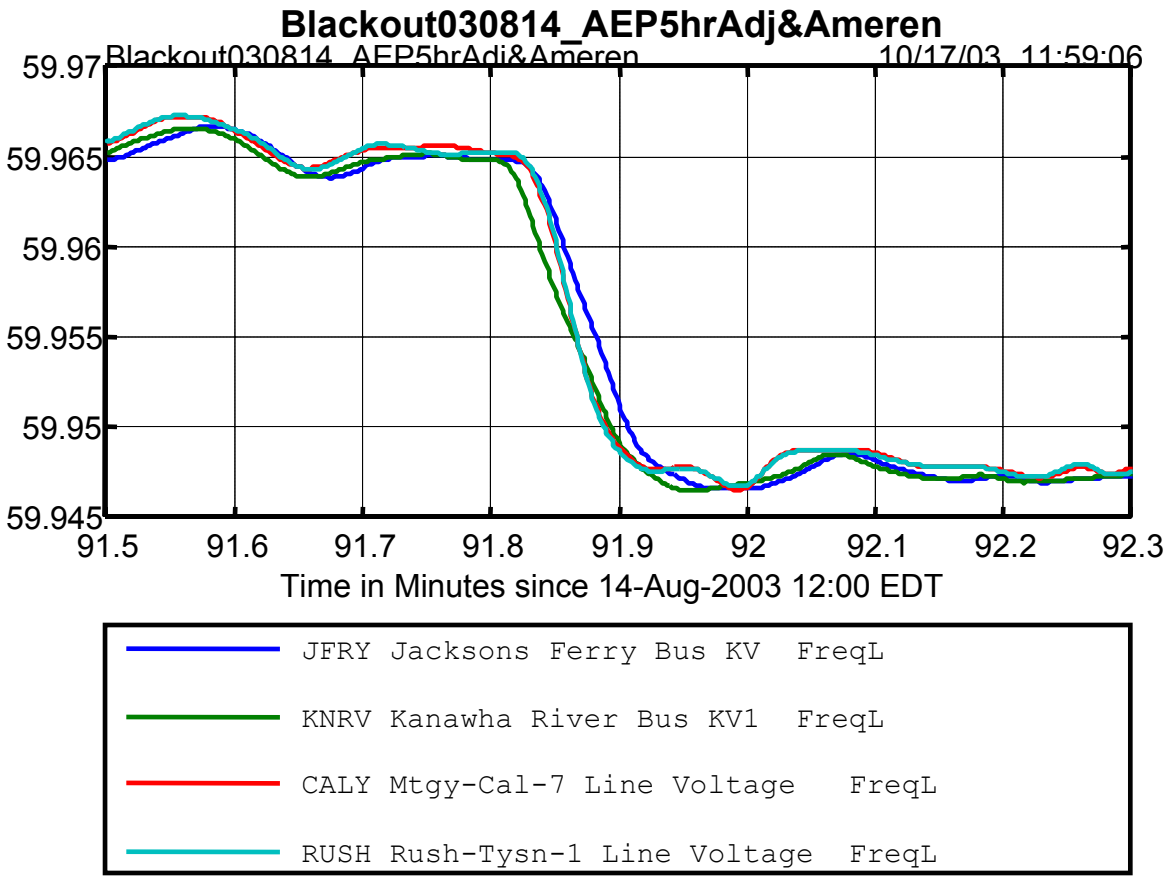
Bus frequencies for Aug14 Blackout



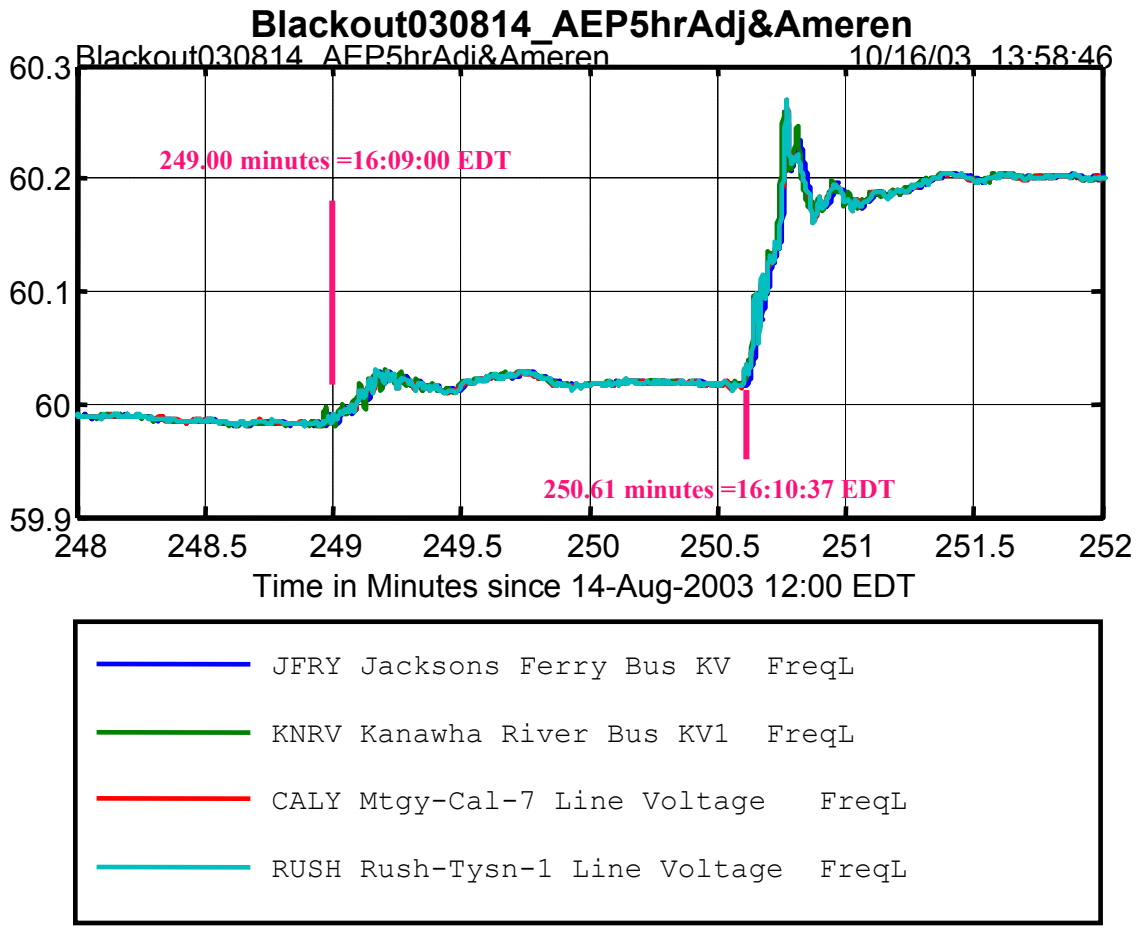
Details of bus angles for Aug14 Blackout (Relative angles referenced against Jackson's Ferry bus)



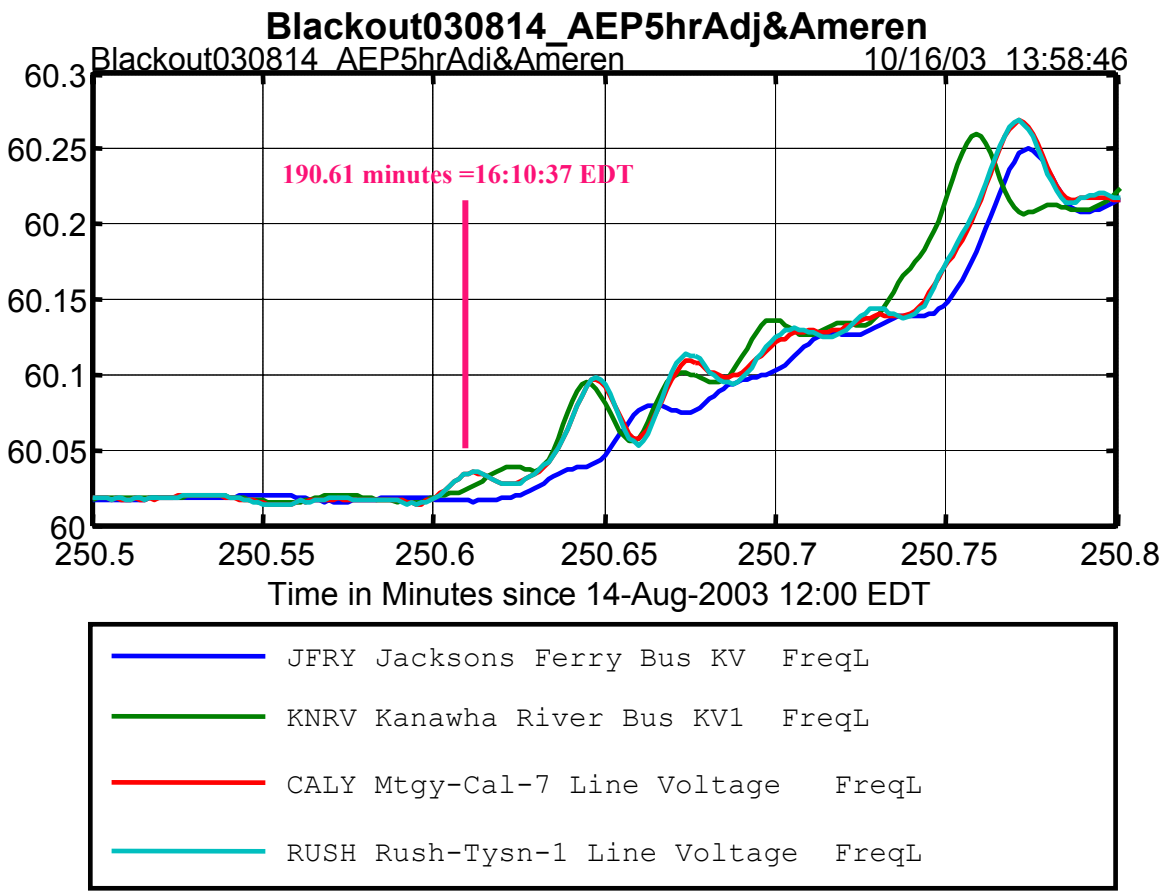
Record alignment check: filtered data



Bus frequencies for Aug14 Blackout (detail 1)



Bus frequencies for Aug14 Blackout (detail 2)



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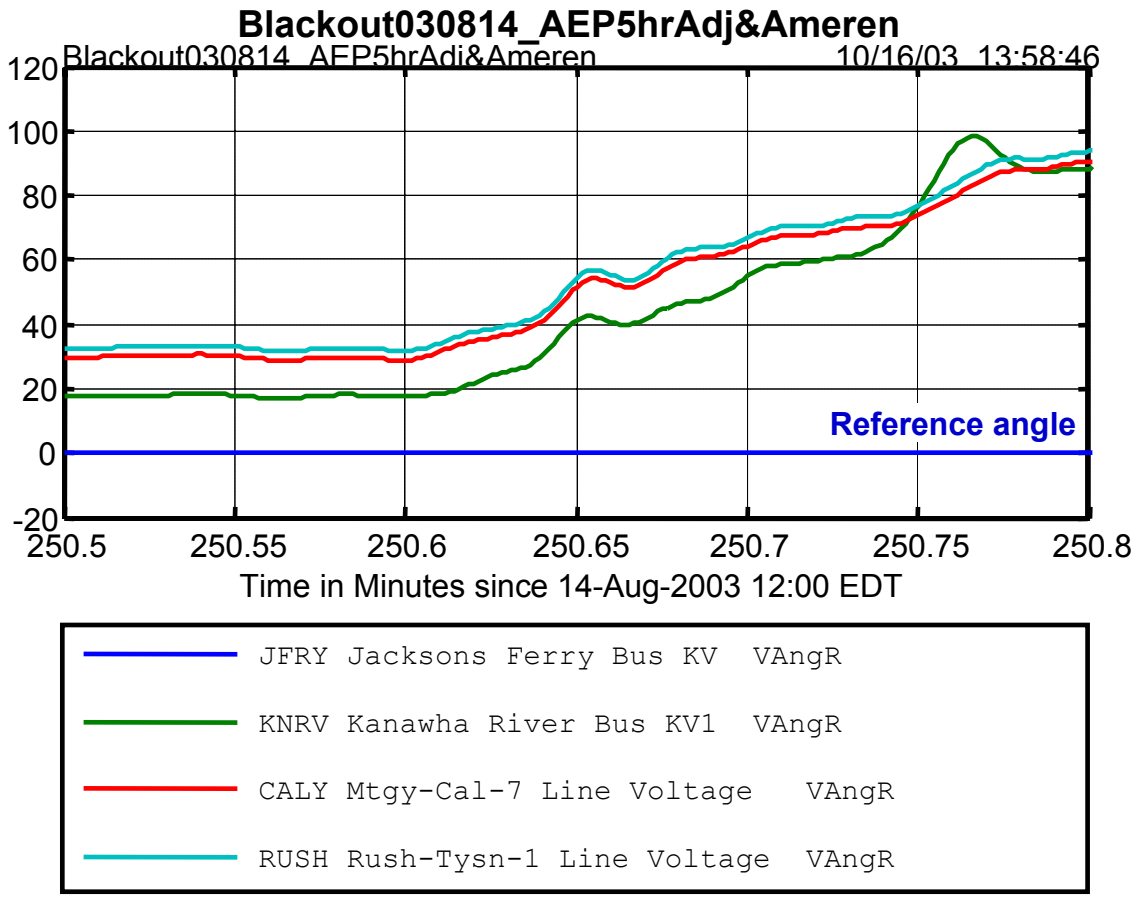
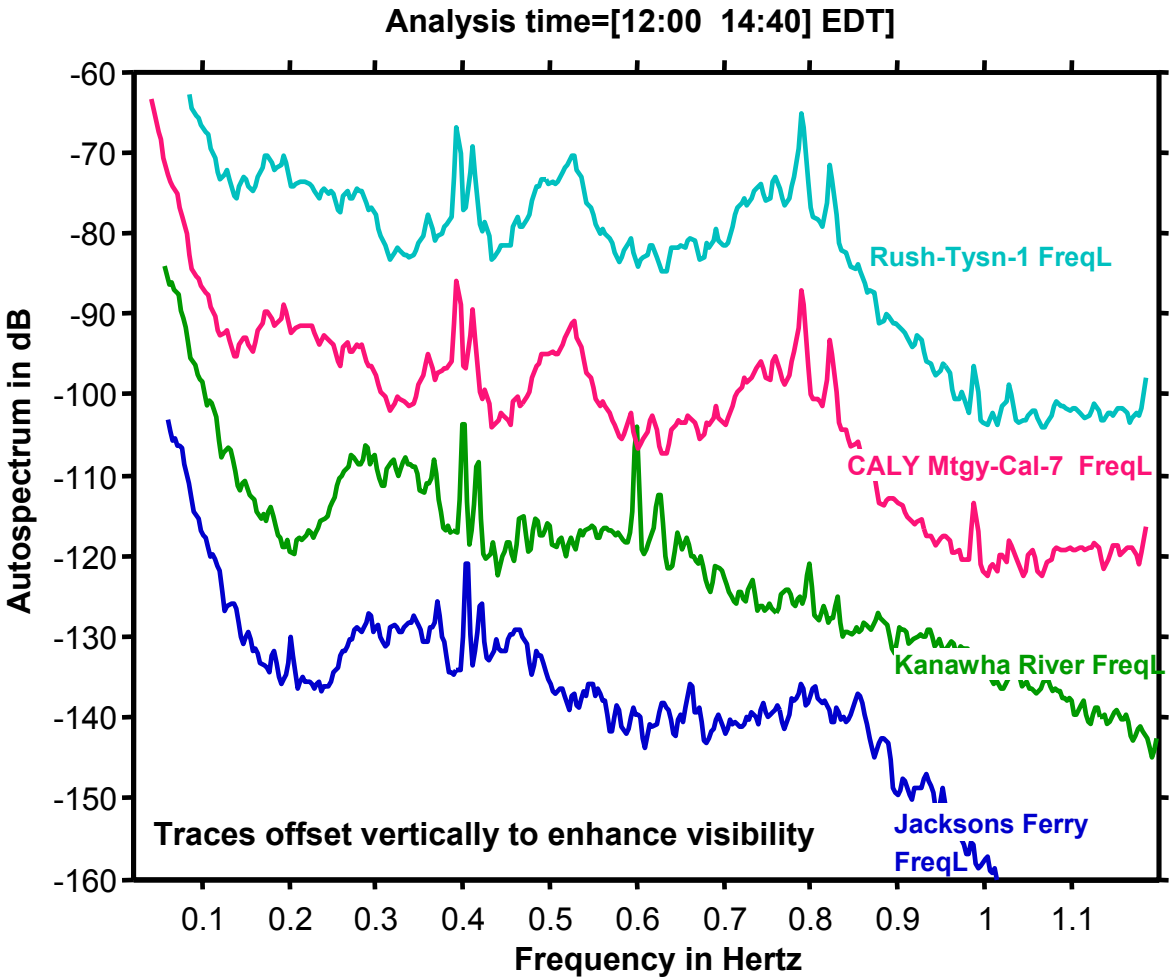


Frequency-Domain Analysis for the Blackout of August 14, 2003

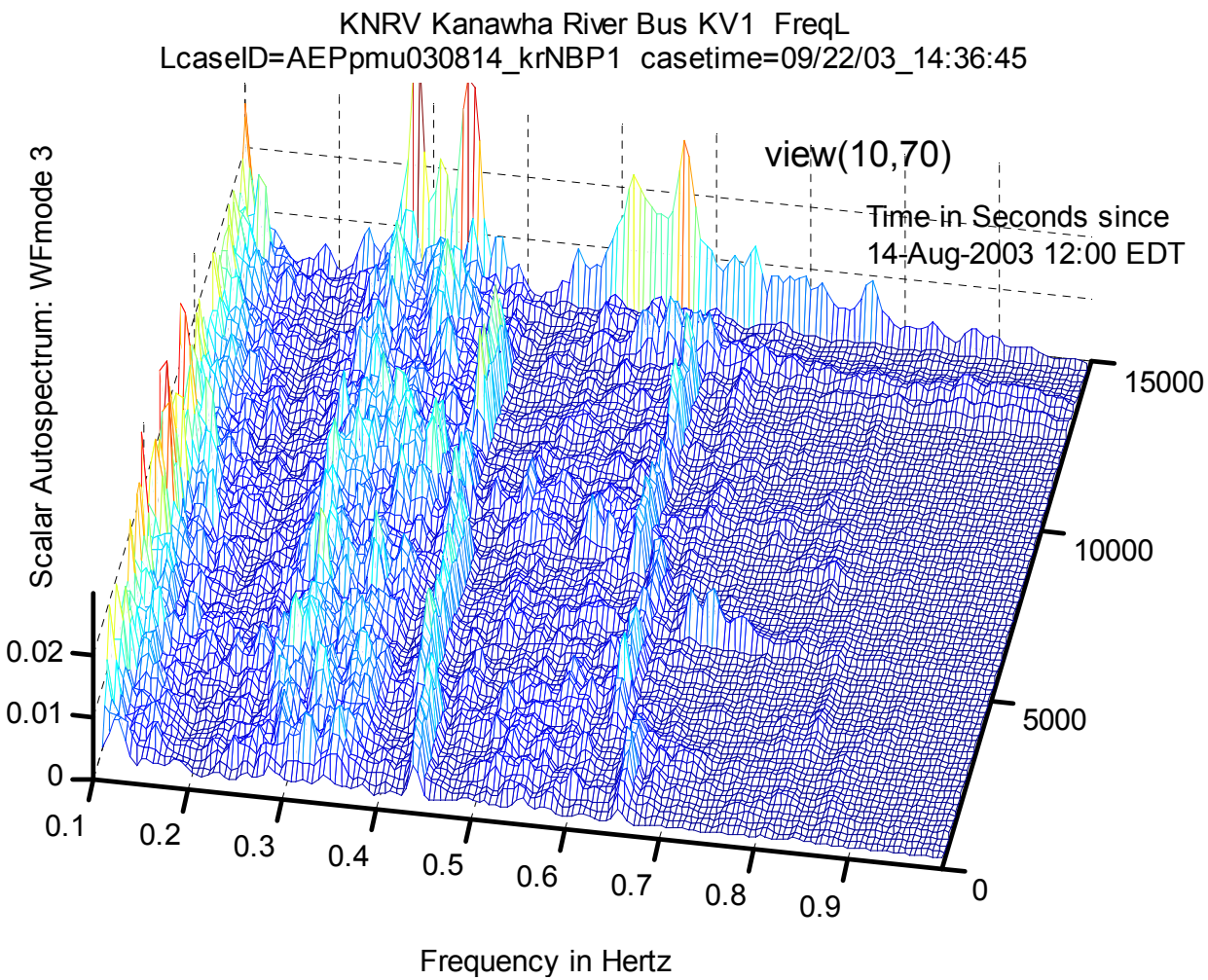
Spectral analysis of bus frequencies for Aug14 Blackout

(Analysis time=[12:00 14:40] EDT)

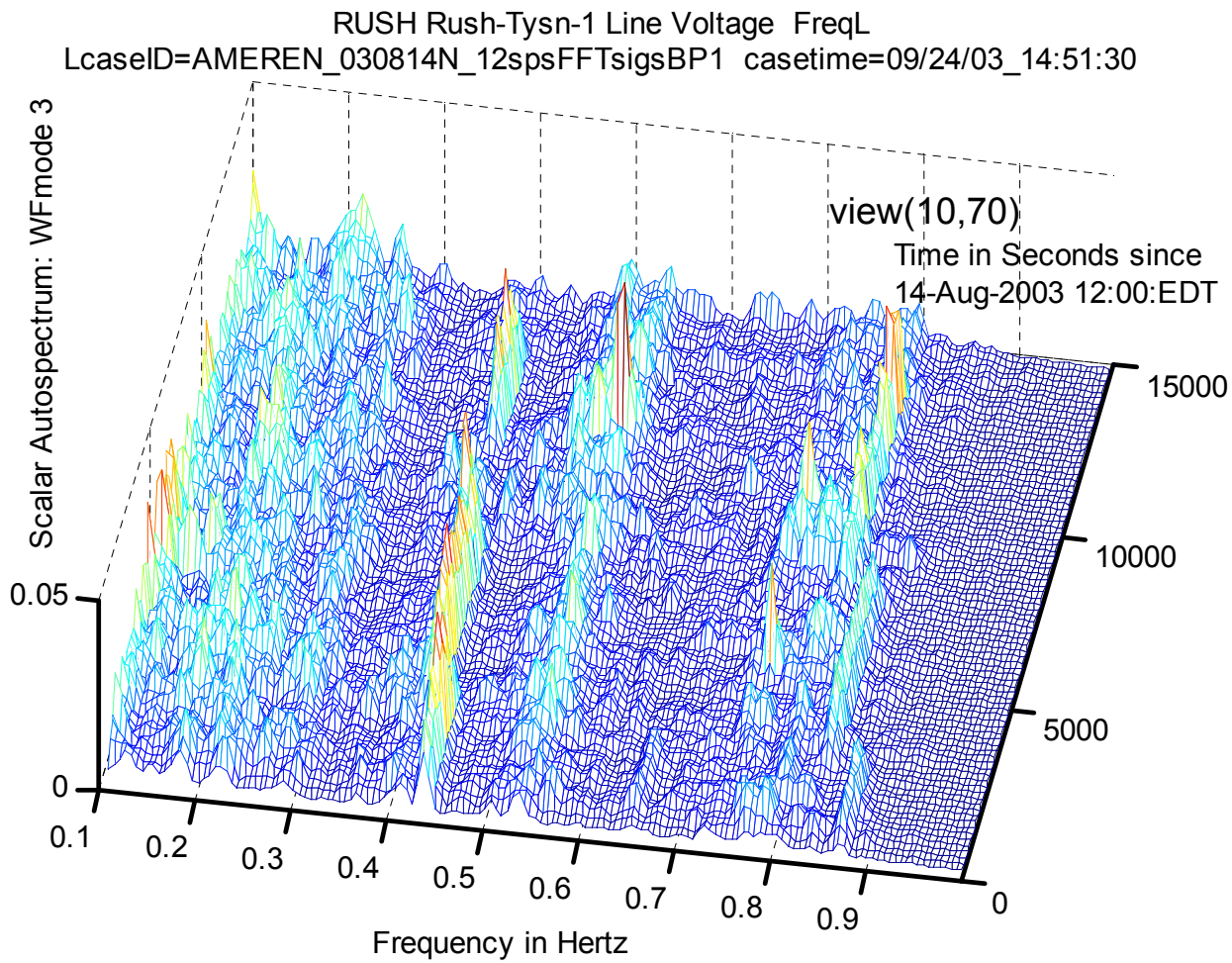


Spectral "Waterfall Plots" show intensity of signal fluctuations vs. time and frequency.

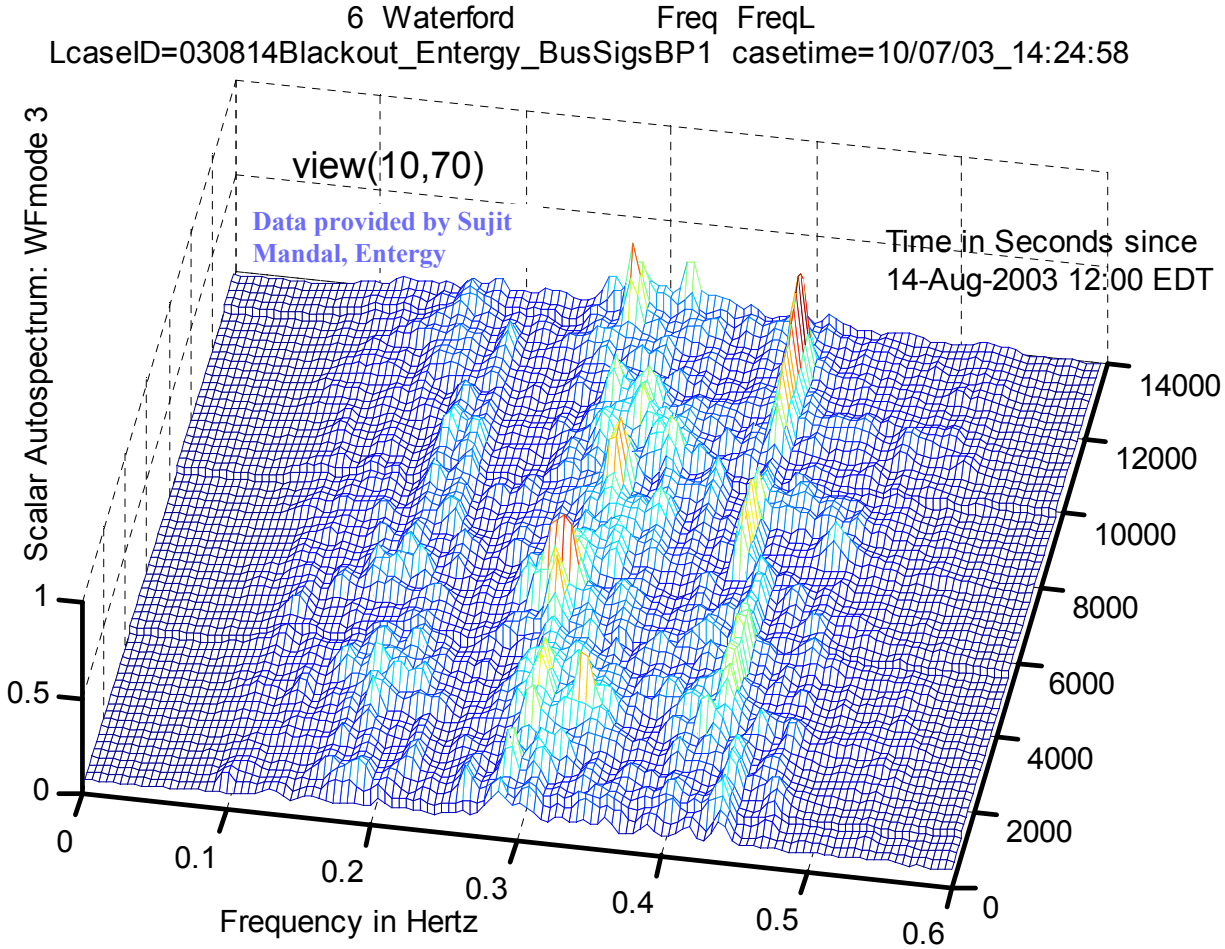
AEP Kanawha River bus frequency for Aug14 Blackout 12:00-16:10 EDT



Ameren Rush Island bus frequency for Aug14 Blackout 12:00-16:10 EDT



Spectral History of Entergy Waterford frequency signal for Aug14 Blackout



Some General Observations

A. Analysis here is for ambient activity for four hours prior to blackout event.

B. Activity resembles that of dynamic swing modes, of which some seem to be either lightly damped or subject to unusual stimulation.

C. Ambient activity shows a general downward trend, plus sharp discontinuities associated with system events. This is typical of a stressed system.

D. BUT, apparent mode shifts could merely be result of topology changes exposing different regions to ambient stimulation.

E. Don't read too much into system measurements without knowing the context!

Spare Slides

Technology Targets for "WAMS East"

- Extend IEEE SynchroPhasor standard[1] to include
  - major control systems, especial HVDC and FACTS
  - generation projects that are critical to power system performance
  - critically placed relays
  - high level SCADA
- Adapt WAMS technology and operating experience to needs of the eastern interconnection:
  - lower data rates for flowgate monitoring
  - technology deployment strategies adjusted to information needs and legacy equipment in the eastern interconnection

[1] "IEEE Standard for Synchrophasors for Power Systems," K. E. Martin et al., IEEE Trans. Power Delivery, Vol. 13 Issue 1 , pp. 73 -77, Jan. 1998.

DOE/CERTS Activities Involved in "WAMS East"

- Demonstration of Synchronized Phasor measurements (SPM) Technologies for the Eastern Interconnection (SPM applications different from those of Western Interconnection)
- Framework for Real-Time Management and Analysis of Grid Performance Data (includes NERC-level SCADA)
- Certification Tools for Regional Damping Controllers (includes hardware, mathematical software, staged tests, operating practices)
- DOE Outreach for Refinement and Sharing of WAMS Technology (includes testing, certification, advice to industry and vendors)
- DOE Outreach for Validation of Power System Performance and Modeling (in association with Federal Utilities, WECC technical groups, NERC & others)

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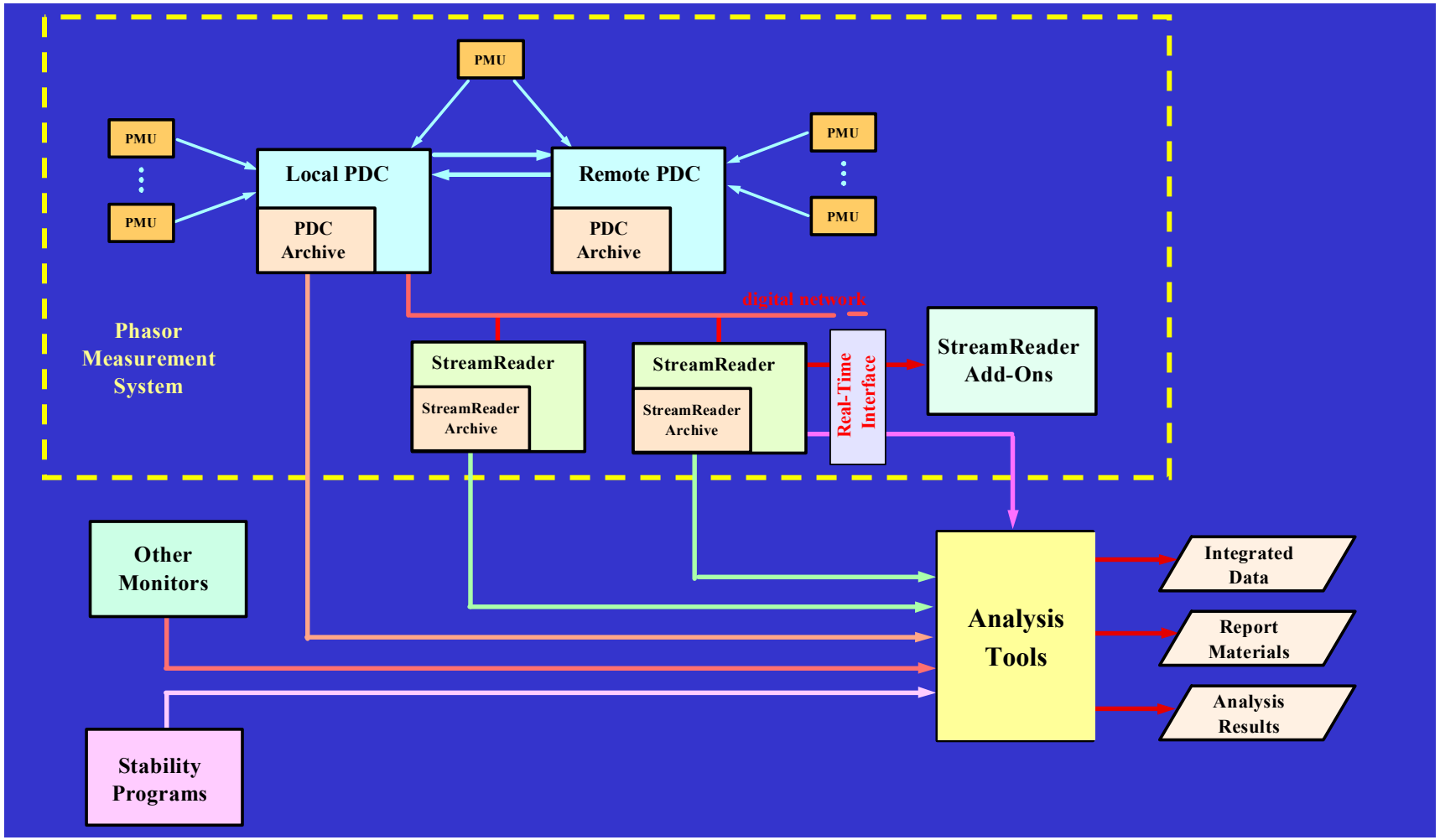
Flow of multi-source data within an integrated WAMS network



Post-Disturbance Monitor Issues (from DOE WAMS Report and related materials)

- **Integration of operating records**
  - initiating and trans-disturbance events
  - pre-disturbance activity & conditions
  - system performance and consequences
- **Search for warning signs**
  - dynamic signatures in prior swing activity
  - information from model-based stability tools (DSA, voltage stability)
- **Support for countermeasures**
  - engineering review
  - model development and analysis
  - operator alerts & guidelines