

# IEEE Cascading Failures Working Group (CFWG)

Working Group: Understanding, Prediction, Mitigation and Restoration of Cascading Failures

IEEE PES Computer and Analytical Methods Subcommittee (CAMS)

Milorad Papic, Idaho Power Co.

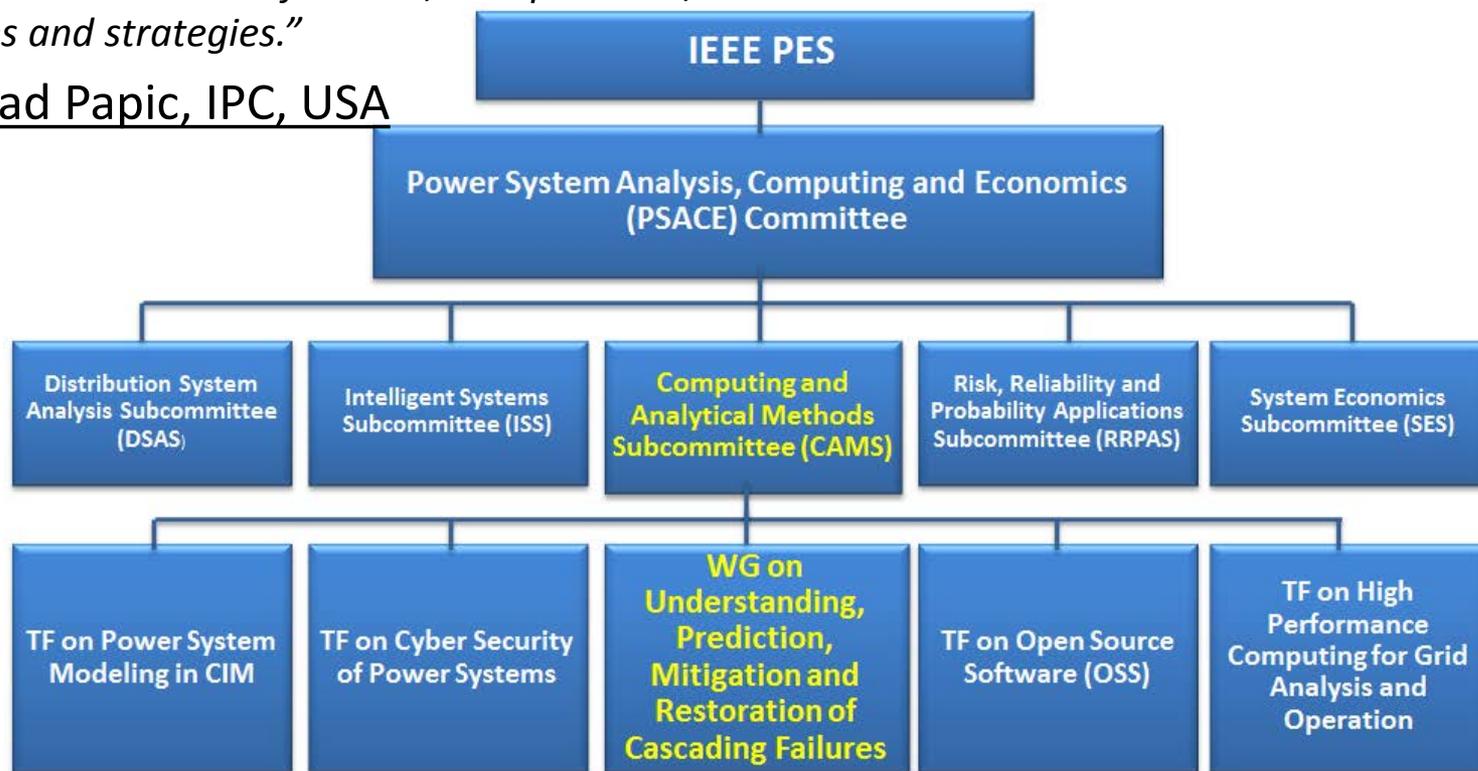
Marianna Vaiman, V&R Energy

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Chicago, IL

# IEEE CAMS WG on Cascading Failures

- Initiated during 2007 IEEE PES GM:
  - *“To investigate new methods, technologies and tools in order to better understand, predict, mitigate and restore cascading failures. Sponsor technical sessions, tutorial courses, workshops, conferences for effective exchange of information on the state-of-the art, best practices, procedures and strategies.”*

- Chair: Milorad Paptic, IPC, USA



# IEEE CFWG – Drivers and Purpose

- Drivers:
  - Blackouts
  - NERC Standards
  - Limited commercially available Tools
- The purpose of WG is to facilitate the following activities:
  - Understanding of Cascading Failures
  - Prediction of Cascading Failures
  - Mitigation of Cascading Failures
  - Restoration from Cascading Failures
  - Availability of Tools for Analysis of Cascading Failures
  - Availability of Data for Analysis of Cascading Failures

# IEEE CFWG Outreach

- We collaborate closely with:
  - Electric utilities, ISOs, and regional entities;
  - Academia;
  - Vendors;
  - Research institutions;
  - Other branches of IEEE;
  - DOE;
  - NASPI;
  - NATF;
  - NERC.

# 2015 WG Current Activities

- Establishing PMU Subgroup
- Restoration from cascading failures
  - The objective is to review the state-of-the-art techniques and industry practice in power system restoration:
    - Analytical models and algorithms
    - Industry decision-support tools, strategy, practice
- Industry survey on practices for analysis of cascading outages
- IEEE PES GM Tutorial on Cascading Phenomenon
- Modeling of dynamics and protection/control systems in cascading

# PMUs for Predicting Cascading Outages

- Functionalities to predict/prevent cascading outages:
  - Situational awareness and wide-area visualization
  - Early detection of events
    - Variations of reactive/active injections
    - Complements the information coming from breaker status signals
  - Voltage stability analysis
    - Used to compute voltage stability margins
    - PMU-based alarms are issued when voltage stability margin is small/decreasing
  - Phase Angle Monitoring
    - Monitors high angle displacements to detect highly loaded lines
    - Importance of phase angle limit computation in real time
  - Oscillatory analysis
    - Predicts oscillations which may trigger line trippings

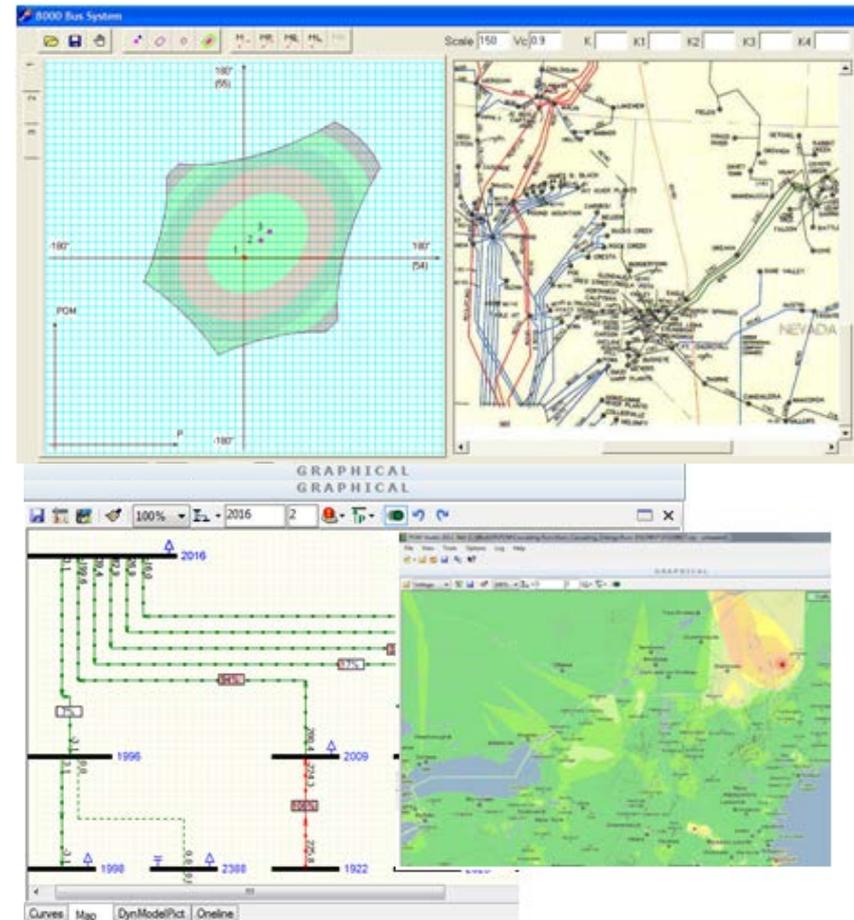
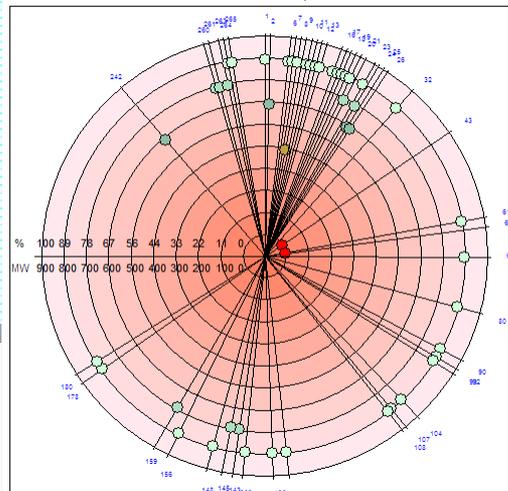
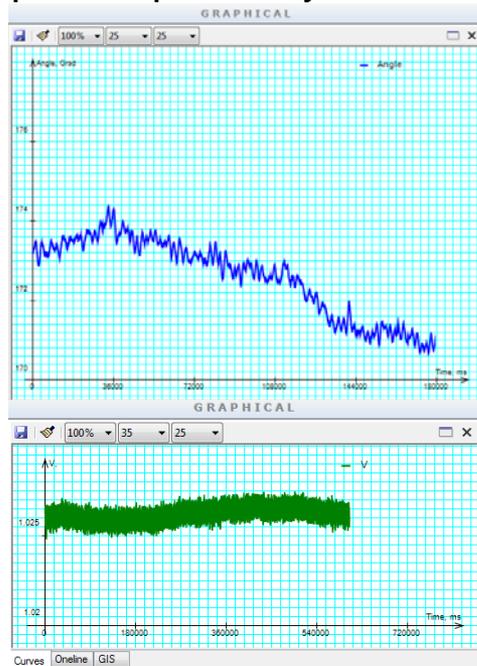
# PMUs for Mitigation/Restoration from Cascading Outages

- PMU measurements allow for faster and more accurate relay operation and enabling *RAS*
- Wide area oscillation *damping control*
- Advanced defense functions, like *coordinated wide area load shedding actions, controlled islanding, etc.*
- System restoration
- No consolidated solutions so far

# PMU Applications for Cascading Analysis

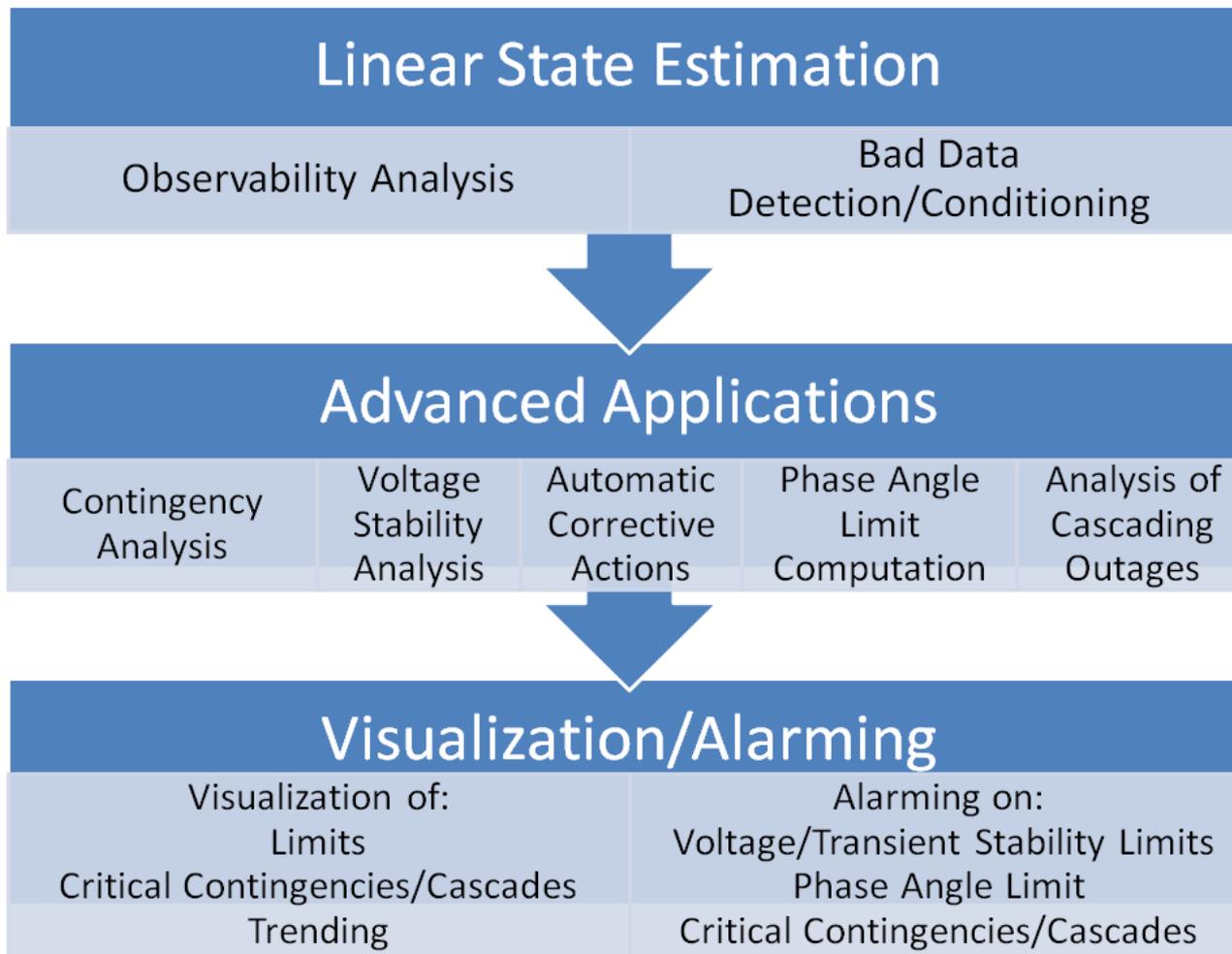
## Phase angle and voltage monitoring

Using PMU measurements to compute system steady-state stability limits and predict proximity to voltage collapse



Source: M. Ya. Vaiman, M.M. Vaiman, S. Maslennikov, E. Litvinov, X. Luo, "Calculation and Visualization of a Power System Stability Margin Based on the PMU Measurements", 2010 IEEE SmartGridComm:31 - 36

# Framework for Measurement-Based Analysis



# Use of PMUs for Analysis of Cascading Outages

- Prediction of “slow” cascading outages:
  - These cascades may be analyzed from steady-state stability perspective
- The most sensitive phase angles are identified in real-time for each scenario/interface/corridor:
  - These quantities are monitored, reported and visualized
  - May change over time as the system conditions change
- The accuracy of the limit values computed off-line may be improved by using real-time PMU measurements
  - These values are adjusted dynamically

# Phase Angle Limit Computation

- Important to compute phase angle difference limit in real time during cascading analysis:
  - Not based on historical data
- Phase angle limit is a physical limit:
  - Depends on system topology and conditions;
  - Depends on how the system is stressed;
  - The limit changes with system conditions.
- Voltage and thermal limits are operating limits:
  - Depend on the equipment/hardware.

# Conclusion

- If you're interested in WG activities, please join the group
- Next WG meeting is during 2016 PES GM:
  - Discussion on the phenomenon of cascading failures and use of PMUs to predict, prevent and analyze cascades.

Thank you!