Application of Advanced Wide-Area Early Warning Systems with Adaptive Protection

A DOE Smart Grid Project

NASPI Working Group Meeting

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Background

- **Problem:** Analysis of recent cascading blackouts has indicated that some protection systems operate in an unanticipated fashion during contingencies, and such operations are often an important contributing factor in the sequence of events leading to a cascading outage.
- **Cause:** Relays are set to protect critical electrical equipment by relying on local information, or by hierarchical control via communications; in neither case are they able to "see" the effects of their operations on the rest of the system, nor can they adapt intelligently to changing external conditions on the grid.
- **Result:** False trips during normal system conditions are an accepted tradeoff for reliability, i.e., ensuring relays trip when needed. But false trips during outage conditions can exacerbate system vulnerabilities and should be avoided.

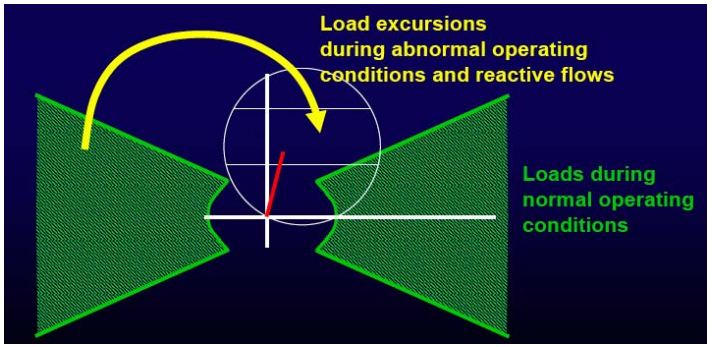
Project Approach

Goal: Improve the dependability and security of the transmission system, especially during contingency conditions, by means of "smarter" protection systems.

Hypothesis: The use of highly accurate and time-synchronized real-time system information from synchrophasor units can be used to improve the operation of protection systems and to enhance the visualization of protection system information.

Project Objectives: Develop and demonstrate tools* using wide-area synchrophasor measurements to:

1. Reduce the frequency of false trips by means of a synchrophasor-based supervisory "voting" algorithm for protection systems.
2. Detect "encroachment" on impedance relay zones and generate alarms for operators when it occurs.
3. Develop interactive displays for visualization of relay information to inform operator decisions.



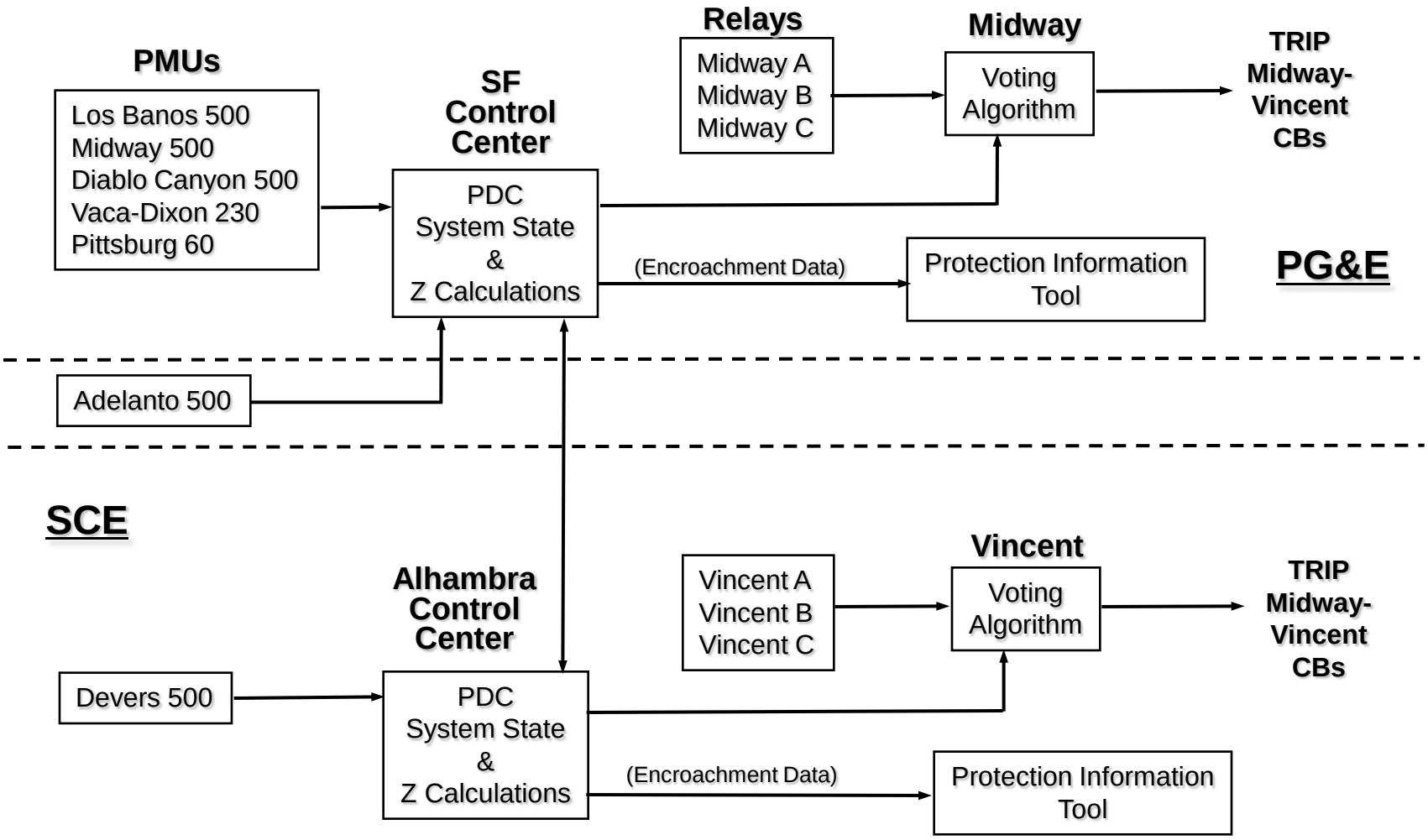
*These three applications were identified as the highest priorities for further R&D in a previous CEC/PIER project, "Phasor Measurement Application Study," Principal Investigator Dr. Damir Novosel, KEMA, Inc.

Project Team

- **DOE:** Project sponsor and major funder.
- **CEC:** Project co-sponsor and co-funder.
- **CIEE:** Overall project management and coordination.
  - Lloyd Cibulka, Project Manager
  - Lorraine Hwang & Larry Miller, Project Coordination
- **Virginia Tech*:** Relay algorithm development, testing and evaluation.
  - Jim Thorp, Principal Investigator
  - Virgilio Centeno, Co-investigator
  - Arun Phadke, Technical Advisor
- **Mississippi State*:** Visualization tool development, testing and evaluation.
  - Roger King, Principal Investigator
  - Surya Durbha & Kari Babski-Reeves, Co-investigators
- **PG&E*:** Field testing and evaluation.
  - Vahid Madani, Technical Lead
- **SCE*:** Field testing and evaluation.
  - Frank Ashrafi, Technical Lead
- **SDG&E:** Historical relay data and technical support.
  - Tariq Rahman, Project Liaison & Advisor
- **Quanta:** Project Advisor
  - Damir Novosel, Principal

*providing cost-sharing

Midway-Vincent Adaptive Protection ("Voting") Scheme



Project Structure

Task 1: Project Management and Administration – CIEE

- **Project management & coordination, DOE reports and deliverables.**

Phase 1: Research

Task 2: Algorithm Development for Adaptive Relaying* – Virginia Tech

- **Verify & implement models, additional logic, data streams for PIT.**

Task 3: Algorithm Development for Relay Encroachment* – Virginia Tech

- **Define alarm outputs, data streams for PIT.**

Task 4: Protection Information Tool Development – Mississippi State

- **Develop end-user requirements, interoperability & performance standards.**

**These algorithms were developed in a previous TRP project, "Advanced Protection Systems Using Wide Area Measurements," Principal Investigator Prof. James Thorp, Virginia Polytechnic Institute.*

Project Structure (cont'd.)

Phase 2: Pilot Studies

Task 5: Adaptive Relaying Algorithms University Prototype Testing – Virginia Tech

- Assemble and evaluate test prototype systems.

Task 6: Protection Information Tool Evaluation – Mississippi State

- Evaluate/modify the PIT using focus groups and simulations.

Task 7: Adaptive Relaying Utility Prototype Testing – PG&E/SCE

- Test & evaluate adaptive relaying algorithms in a laboratory environment that simulates actual in-service operation.

Phase 3: Demonstration

Task 8: Adaptive Relaying Algorithms Field Installation – PG&E, SCE

- Install systems, collect & archive operating data.

Task 9: Adaptive Relaying Data Evaluation – Virginia Tech

- Assess performance of algorithms, modify as required.

Task 10: Protection Information Tool Evaluation – Mississippi State

- Analyze performance of PIT, modify as required.

Project Budget & Schedule

DOE Award: $1,270K
CEC Award: $200K
Participants' Cost-Sharing: $300K
Project Total: $1,770K
Schedule: October 2009 – September 2012

Year:	2009				2010				2011				2012			
Quarter:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Phase 1 Š Research																
Task 1.0 Š Project Management and Planning																
Subtask 1.1 Overall Project Coordination and Organization																
Subtask 1.2 Utility Data Sharing and Resource Planning																
Task 2.0 Š Algorithm Development for Adaptive Relay																
Task 3.0 Š Algorithm Development for Encroachment																
Task 4.0 Š Protection Information Tool Development																
Phase 2 Š Pilot																
Task 5.0 Š University Prototype Testing																
Task 6.0 Š Protection Information Tool Evaluation																
Task 7.0 Š Utility Prototype Testing																
Phase 3 Š Demonstration																
Task 8.0 Field Installation																
Task 9.0 Data Evaluation																
Task 10.0 Protection Information Tool Evaluation																
Task 11.0 Final Report																