Transplant Testing of Protective Relays: Study of Benefits and Methodology

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PSerc IAB Meeting
Berkeley, California, December 9, 2004
Outline

- Background
- Goals
- Tasks
- Participants
- Budget
- Schedule
- Deliverables
NERC Aug 13, 2004 Blackout Recommendations

1. Fix the direct causes
2. Strengthen the compliance enforcement program
3. Initiate readiness audits
4. Monitor vegetation management
5. Track recommendations
6. Improve training
7. Evaluate the effectiveness reactive planning
8. Improve system protection
9. Clarify responsibilities
10. Establish real-time tool guidelines
11. Evaluate system restoration lessons learned
12. Install Time Synch
13. Re-Evaluate system design and criteria
14. Improve system modeling data and its exchange
15. Develop a standing capability for NERC to investigate future blackouts and disturbances.
16. Accelerate the standards transition.
17. Evaluate NERC actions in the areas of cyber and physical security.
Recommendations

- **Strategic (#5):** Need to **improve relay protection** schemes and coordination.

- **Technical (#8):** Improve system protection to slow or limit the spread of future cascading outages:
  a.) better application of **Zone III relays**
  b.) selective use of **under-voltage load shedding**
  c.) revision to the **criteria** for slowing/limiting propagation of cascading failures
Recommendation #8

• #8a.: Zone III relays
  - Zone III relay should not operate at or below 150% of the emergency power rating of a line assuming .85% p.u. voltage and line phase angle of 30 degrees
  - Out of step conditions should not “confuse” the relay
• #8b.: Under-voltage load shedding
  - Low voltage with both high and low frequencies should be considered
  - Coordination with generator under- and over-frequency protection and controls
• #8c.: propose revisions to the planning criteria
Implementation Timeline for NERC Recommendation 8a Activities

2/1/2006
Regions report TPSO responses of 12/31/05 to SPCTF

1/31/2005
Regions report TPSO responses of 12/31/04 to SPCTF

10/31/2004
Regions report TPSO completion of 9/30 review to SPCTF

2/10/2004 - 9/30/2004
TPSOs review Zone 3 relays for conformance

9/30/2004
TPSOs report to Regions on Zone 3 reviews

2/10/2004
NERC Rec. 8A Issued by Board

Today

12/31/2004
TPSOs Submit to Regions:
- Certification of conformance to loadability
- Violation mitigation (before 12/31/05) plans
- Applications for exceptions

1/1/2005 - 12/31/2005
TPSOs mitigate violations

12/31/2005
TPSOs Submit to Regions:
- Certification of full conformance
- Implementation dates for outstanding violations

12/31/2004
TPSOs Submit to Regions:
- Certification of conformance to loadability
- Violation mitigation (before 12/31/05) plans
- Applications for exceptions

2/10/2004 - 9/30/2004
TPSOs review Zone 3 relays for conformance

9/30/2004
TPSOs report to Regions on Zone 3 reviews
UVLS and UFLS
Recommendation 8b

- Evaluate and establish standards for the deployment of Undervoltage Load Shedding as a means to mitigate cascading blackouts
- Review UFLS systems inter-regionally for coordination and with varying island boundaries
- UFLS must have a design basis (interconnection) for:
  - Maximum rate of frequency decline
  - Undervoltage cutoff – coordinate with UVLS systems
  - Islanding initiating events
  - Number of steps and amount of load shed
- UFLS must coordinate with Gen UF Relays
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Goals

• Relays can missoperate for two reasons:
  - “wrong” settings
  - “wrong” designs

• Investigate comprehensive test methods to be applied so that the unexpected protective relaying behavior can be better understood and avoided

• Provide comprehensive methodology for transient testing and assess the benefits and practical means of performing transient tests.
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Project Tasks


• Task #2. Improvements in EMTP/ATP models needed for relay transient testing (effects of GPR, system oscillations, etc.).

• Task #3. Development of system specific Library of test cases.

• Task #4. Evaluation criteria for assessment of transient test results.

• Task #5. Execution of transient tests on selected relays.

• Task #6. Assessment of the results obtained through transient tests.
Typical Hardware Tools

- Relay
- Commercial Amplifiers
- Commercial Test Sets
- Commercial D/A Boards
- PC bus
- Custom I/O Hardware
- Std. comm. Interface
- Custom Interface
- Simulation Computer (PC)
Typical Software Tools

- Transient Simulation Program (EMTP, ATP, etc.)
  - DFR Files
  - ContraFiles
  - ATP/EMTP Files
  - Other Waveform Files

- File Format Conversions
  - Data Generating Routine

- GUI
  - Processing Relay Response
  - Waveform Replaying Engine
  - Editing Cut, Paste
  - Comm. Program

To I/O Hardware
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Participants

Universities
- Mladen Kezunovic, P.I.
  Texas A&M University
- Sakis Meliopoulos, Co-PI
  Georgia Institute of Technology
- Ward Jewell, Co-PI
  Wichita State University
- Bajarang Agrawal, APS
- Ali A. Chowdhury, MidAmerican
- Hyder DoCarmo, CenterPoint
- Dan Hamai, WAPA
- Mike Ingram, TVA
- Paulette Kaptain, WAPA
- Tom Kay, EPRI
- Art Mander, Tri-State
- Farnoosh Rahmatian, NxtPhase
- Devin Van Zandt, G.E.
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## Budget

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Deliverables

• Library of “standard” test cases
• Specification of criteria for evaluating relay test results obtained using transients
• Improvements in power system models used for transient testing of transmission line relays
• Publicly available results of tests performed on certain selected types of transmission line relays and generator relays