

# Defense-in-Depth

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**RELIABILITY | ACCOUNTABILITY**



# 2003 Northeast Blackout

Interaction of protection and control systems rampant:

- Generator and turbine controls
- Generator and Transmission protection schemes
- UFLS / UVLS and other system protection
- Transmission Controls and protection systems

The system truly behaved as a SYSTEM!

- Special Protection Scheme (SPS) operated in New Brunswick – Caused the separation of New England
- Triggered by a transient event in Michigan

# TR 16 – 2003 Technical Analysis Report

“Evaluate and Implement “Defense in Depth” System Monitoring, Control, and Protection Measures to Slow Down and Mitigate the Severity of Cascades”

- Wide-area and local monitoring of operating conditions
- Wide-area, high-speed (phasor) measurements of overall system indicators
  - Relative phase angles across each interconnection and transmission interfaces
- Monitoring of inter-area, slow-speed oscillations
- Priority based alarm processing
- State-estimation of existing system conditions
  - Identify metering discrepancies

- Early-warning contingency analysis of the existing and potential system conditions – operate within limits
- Pattern recognition of operationally dangerous system configurations
- Emergency operations plans for severe contingencies
- Operator training, including severe condition scenarios
- Coordinated UVLS and UFLS systems
- Adaptable system restoration plans – highly variable conditions exist after a disturbance

## Event Analyses 2005 - 2010

- 12 Major Event Analyses
- 133 Events analyzed – Top 10 Elements
  1. 56 Protection System Misoperations
    - 12 - Gen. vs trans. protection miscoordination
    - 7 - Protection equipment failures
    - 6 - Wiring errors
    - 5 - Lack of Redundancy, Human Error, Relay Settings, Relay loadability
    - 4 - Design Errors / Misapplications
    - 2 - Logic Errors, Communications Failure, Other

# Actions Based on EA Risk Assessments

- 133 Events analyzed – Top 10 Elements (cont.)
  2. Unexpected Gen. Turbine Control Action (35)
  3. Transmission equipment failures (24) (most initiating)
  4. Human Error (17)
  5. Voltage sensitivity of gen. aux. power systems (13)
  6. Near-term load forecasting error (6)
  7. Wiring errors (incidental) (6)
  8. Loss of station observability (5)
  9. Disturbances during abnormal configurations (5)
  10. Inter-area oscillations (5)

- Improved and validated powerflow and dynamics models
  - Benchmarking against actual system performance
- Library of standardized component models for generators and other electrical equipment
- Composite load modeling
- Move toward node-breaker modeling
- Tie to protection setting databases
- Interaction of System Protection and Turbine Controls

- Relay Loadability
- Protection System Reliability
- Protection System Coordination
- Generator Frequency and Voltage Protective Relay Coordination
- Transmission and Generation Protection System Misoperations
- Protection System Maintenance
- Interaction of System Protection and Turbine Controls



**Questions?**