NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NERC Reliability Initiatives and Smart Grid

IEEE PES
Late Breaking News
July 28, 2009

Robert W. Cummings
Director of Event Analysis & Information Exchange

to ensure the reliability of the bulk power system

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

System Protection and Control Performance Improvement Initiative

Protection & Controls Initiative

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Announced at February Board meeting
- Letter to industry to come out shortly
- NERC Board recognition of the importance of system protection to reliability
- Goal: Improve BES reliability
- Purpose: Improve the performance of power system Protection Systems through fostering technical excellence in protection and control system design, coordination, and practices.

Protection & Controls Initiative

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Elevate System Protection and Control Task Force to Subcommittee status
  - Increased emphasis on the importance of protection
- Collaborative efforts with:
  - IEEE Power & Energy Society
  - IEEE Power System Relay Committee
  - Bridge between IEEE standards and NERC system performance requirements (in NERC standards)
- Coordinate Protection Standards Philosophies and Standards Work
  - Reduce discrepancies
  - Technical basis for all protection standards changes

Initial Targeted Areas

- PRC Standards Technical Support
  - SPCS to provide technical SME support to Standards process
- Relay Loadability
  - Standard PRC-023 – Relay Loadability passed by NERC Board, awaiting FERC approval
- Protection System Reliability (redundancy)
  - SPCS Technical Reference Document & SAR
    - Posted for comments 1/20 – 2/18
- Generator Frequency and Voltage Protective Relay Coordination
  - Standards Project 2007-09 – Generator Verification
  - Drafting of Standard PRC-024-1 — Generator Frequency and Voltage Protective Relay Settings

Initial Targeted Areas

- Transmission and Generation Protection System Misoperations
  - Technical review of PRC-004 -- Analysis and Mitigation of Transmission and Generation Protection System Misoperations
  - Includes NERC-wide definition of protection misoperations for NERC reporting and system performance metrics
- Protection System Maintenance
  - SPCTF 2007 Technical Reference Standards on Protection System maintenance
  - Project 2007-17 – Transmission and Generation Protection System Maintenance and Testing, PRC-005 in re-drafting phase

Initial Targeted Areas

- Protection System Coordination
  - Transmission Protection Coordination
    - Support for revisions to PRC-001
  - Trans & Gen Protection Coordination – IEEE collaboration
    - SPCS Technical Reference – Power Plant and Transmission System Protection Coordination – support for revisions to PRC-001
- BES System Performance & Protection Coordination with Generator Controls
  - Improved modeling of governors and other generator controls
  - New control models need to be applied
  - Model validation to actual system performance essential

Initial Targeted Areas

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- BES System Performance & Protection Coordination with Turbine/Boiler Controls
  - Response to leading trend in system disturbances
  - Largely uncharted area for modeling by planners
  - Discussions with industry experts and turbine control manufacturers on appropriate level of modeling (detailed modeling not appropriate)

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

System Modeling Improvement Initiative

NERC Modeling Initiative

- Purpose – to improve powerflow and dynamics modeling across North America
  - Planning models
  - As-built models for operations planning
  - Forensic analysis models
- Improve MOD series of standards
- Cross-program model flexibility
  - Problems with user-models
  - Validate dynamics models for new equipment

Basis in Blackout Recommendations

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Improve quality of system modeling data and data exchange practices
  - NERC Recommendation 14
  - US-Canada TF Recommendation 24
- Generation and Transmission Performance Report Recommendations
  - Background of original recommendations
  - Strengthened recommendations

TR-4 – Powerflow Modeling

A. Modeling Groups should reinvestigate feasibility of a CIM capable powerflow creation database

B. NERC should create initiative to improve overall powerflow modeling techniques

C. Powerflow cases should be periodically benchmarked to actual system conditions at various load levels

D. All generators should be periodically tested to ensure that their claimed MW and Mvar ratings are accurate and realizable

- Testing should also be done to confirm the performance of generator dynamic controls and that their respective models in the System Dynamics Databases are accurate.

TR-12– Improve & Validate Dynamic Models

A. Create a feedback loop in modeling process – CIM compatible

B. Initiate dynamic model validation in EI for generators and dynamic responsive equipment

C. Codify (with IEEE) new standard for powerflow and dynamics data formats

D. Provide forum for ongoing development, testing, and validation of new and improved dynamic models

E. Improve load modeling for more accurate powerflow and dynamics analysis

Modeling Issues

- If something in not modeled, how can you predict system behavior or interaction????

Dynamics Modeling Issues

- Missing models
- Data errors
- Models may not match field equipment and settings
- Issue of “proprietary models”
- Modeling of wind farms
  - Common-mode failures – same make and model
  - Registrations issues – not collecting all needed data
  - Proprietary models

Need for New Modeling

- Turbine / boiler control models needed
  - Units may remain stable, but ramp to zero and trip
- Far more complex dynamic load models needed to analyze and predict FIDVR (Fault-Induced Delayed Voltage Recovery) behavior
  - More load composition data needed to do this
- Better governor models
- Better SPS/RAS models
- Models for new power electronic devices

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Intelligent Integration of Electronically-Coupled Resources and Demand

Smart Grids – a Reliability Perspective

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Defined from a Reliability Perspective

- Two-way flow of energy and communications enabling new technologies to supply, deliver and consume electricity.
- Functions
  - Enhanced flexibility and control
  - Balancing variable demand & resources
  - Demand Response
  - Large deployment of sensor & automation technologies
  - etc.

Smart Grid Integration

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Reliability Considerations to ***Plan*** a System that Operators can Reliably Operate
  - Design Large-Scale, Non-Linear Control (new tools?)
  - Large & Small Signal Stability maintained (new tools?)
  - Coordination of controls (centralized/decentralized)
  - Device interconnection standards dependent on function
  - System sensitivity analyses **must** be expanded
  - Cyber security considerations in planning, design and operations
  - Operations will change (new tools?)

Renewables and Smart Grid

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- ***Intelligently*** integrate renewable resources
- ***Intelligent*** integration of smart grid technologies to take advantage of tremendous potentials while maintaining reliability

Overall Reliability Concerns

- System inertia – maintaining system stability
- Ability to maintain voltage and frequency control
- Interactions of myriad of control systems

Electronically-Coupled Demand Issues

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Modeling
  - Information on harmonics – power quality concerns
  - Frequency response – behavior during off-nominal frequency conditions
  - Controls and protection characteristics
  - Schizophrenic load behavior (human reaction-based)
- Disturbance ride-through
  - Potential for wide-spread common-mode disconnections
  - Intelligent reconnection (i.e., do not automatically reconnect if under-frequency or under-voltage conditions exist)
  - Avoid motor stalling

Electronically-Coupled Resource Issues

- Disturbance ride-through
  - Stay connected through off-nominal frequency (over- and under-frequency) events, including coordination with utilities' Under-Frequency Load Shedding programs
  - Stay connected through off-nominal voltage events, including coordination with utilities' Under-Voltage Load Shedding program
  - Potential common-mode failures
  - Intelligent reconnection (i.e., do not automatically restart/reconnect if over-frequency or over-voltage conditions exist)

Electronically-Coupled Resource Issues

- Voltage Stability
  - Provide primary voltage control for transient stability
  - Provide secondary voltage control for post-transient stability
  - Carry (or have a linkage to) reactive reserves
- Be capable of a two-quadrant operation, delivering leading and lagging power factor through the entire power output range

Electronically-Coupled Resource Issues

- Frequency Control
  - Primary frequency control for arresting system frequency deviations
  - Secondary frequency control, participation in AGC
  - Ability to dispatch and follow power schedule
  - Ability to carry Frequency Responsive Reserves
- Oscillation Damping
- Contribute to positive damping of power oscillatory modes

Electronically-Coupled Resource Issues

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Additional requirements
  - Make generic powerflow and dynamic models, and associated data sets available for power system studies prior to interconnection. These must be validated by measured performance in operation
  - Provide self-protection and control parameters for power system studies – necessary for evaluation of potential common-mode failures based on controls or performance parameters
  - Disturbance data recorders – 30+ samples per second, time synchronized – needed to validate performance and models
  - Participate in monitoring systems, remedial action schemes, and other reliability schemes as identified in regional planning process

Smart Grid Integration Task Force

NERC Staff Proposal:

- Task Force formed to evaluate reliability considerations to integrate Smart Grids in Planning, Design and Operations
  - Coordinated Effort between PC/OC/CIP, lead by PC
  - Evaluate Changes in Planning, Design & Operations
  - Make Recommendations for next steps
- Complete Report by December 2009

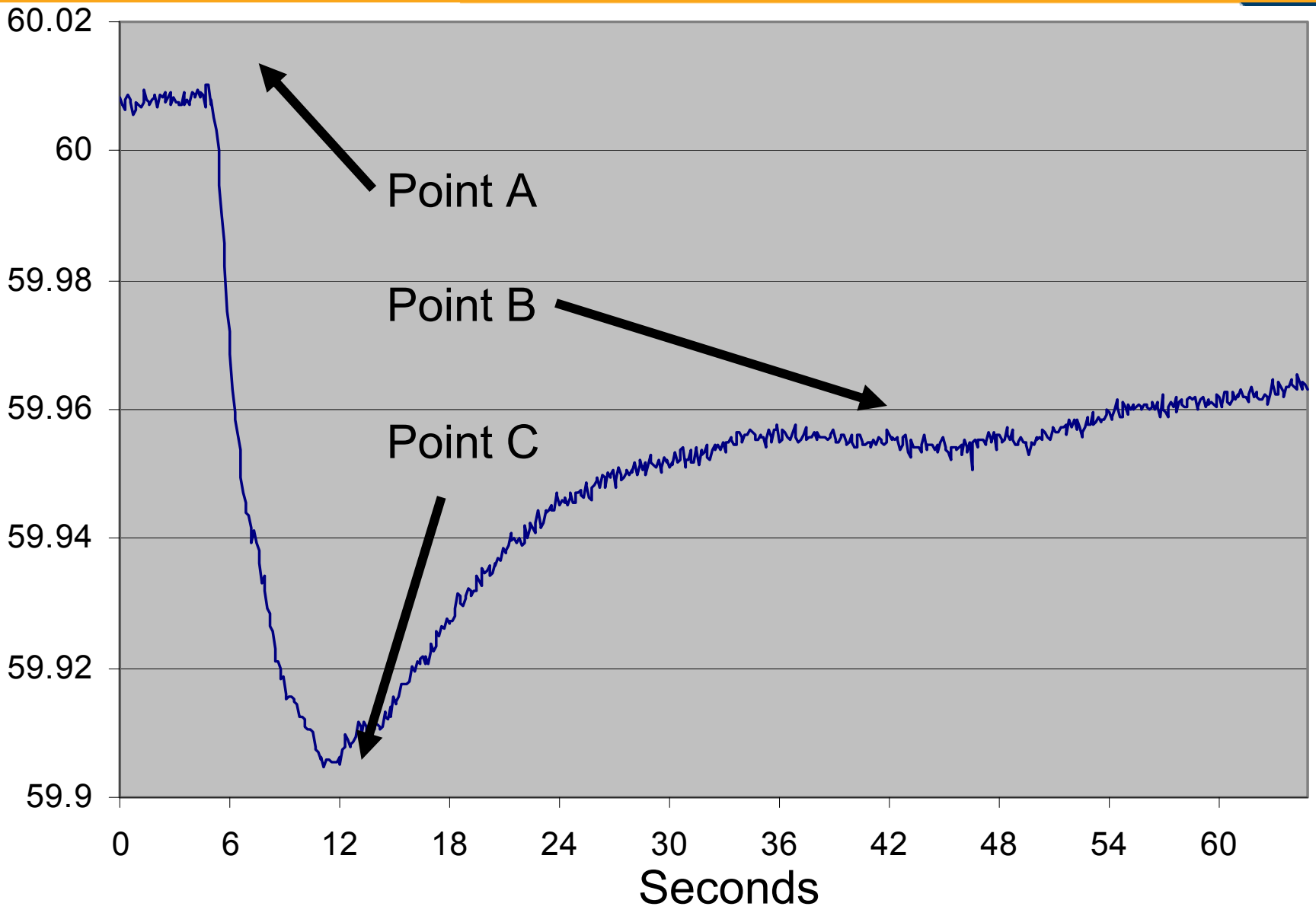
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Frequency Response Initiative

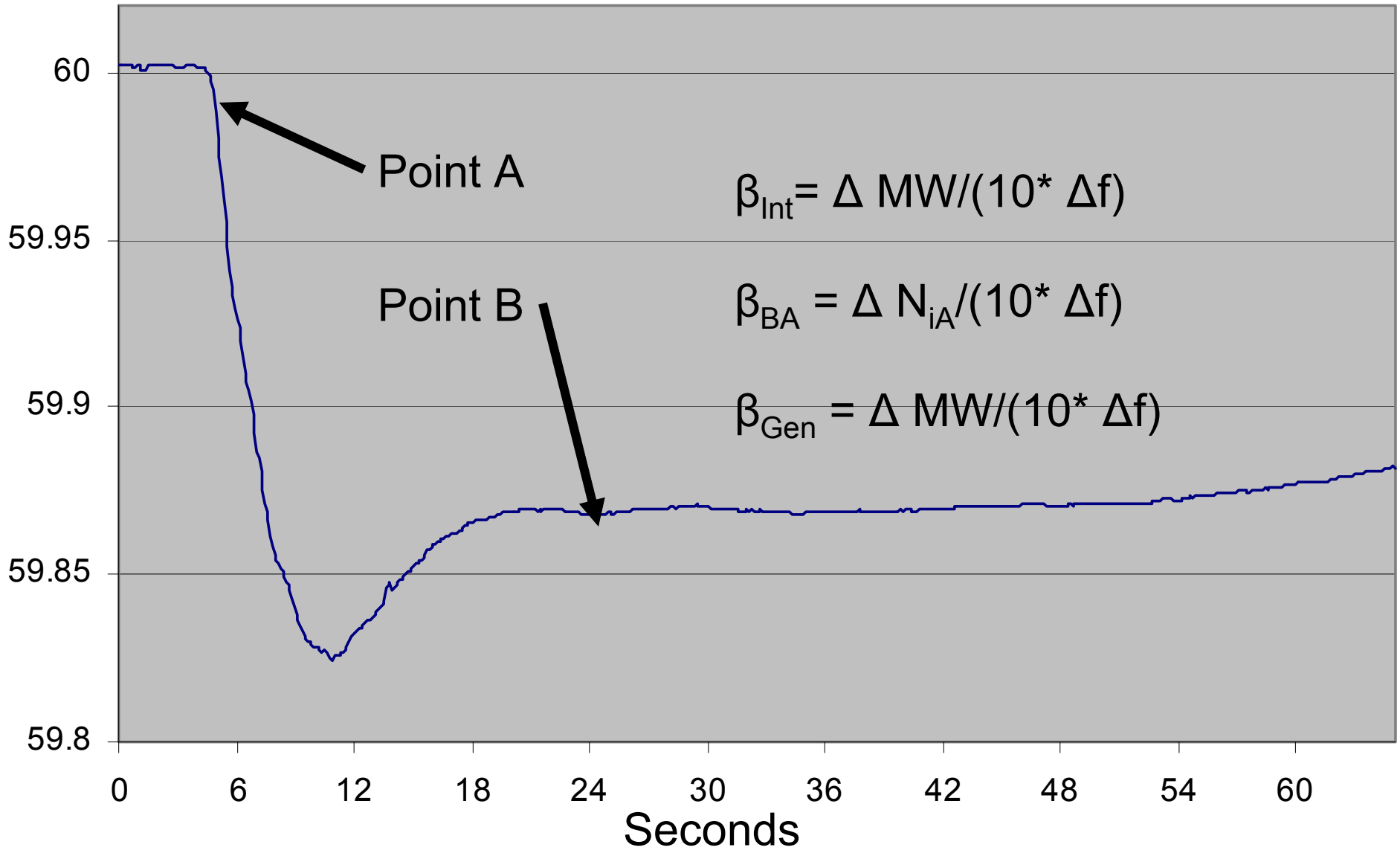
Frequency Response Basics

- Frequency Response, termed beta (β), is
  - a fundamental reliability service
  - a combination of governor and load response
  - Inversely related to frequency excursions
- Frequency Response is declining
  - Should be increasing with load & generation growth
  - Part of the decrease may be better measurement
- Performance-based standards quite possibly on the horizon (FERC Order No. 693)

Typical WECC Frequency Excursion

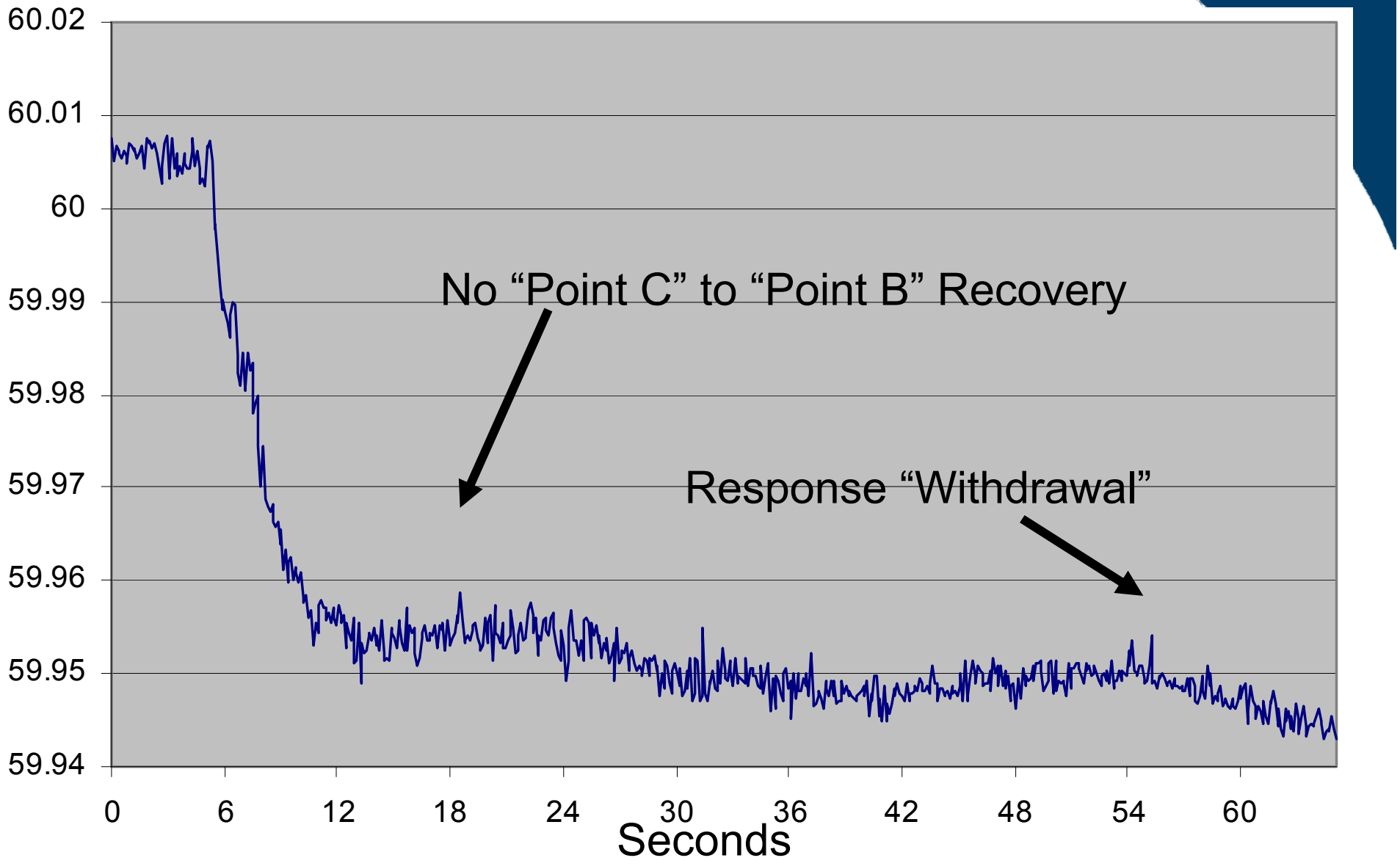


Typical ERCOT Frequency Excursion



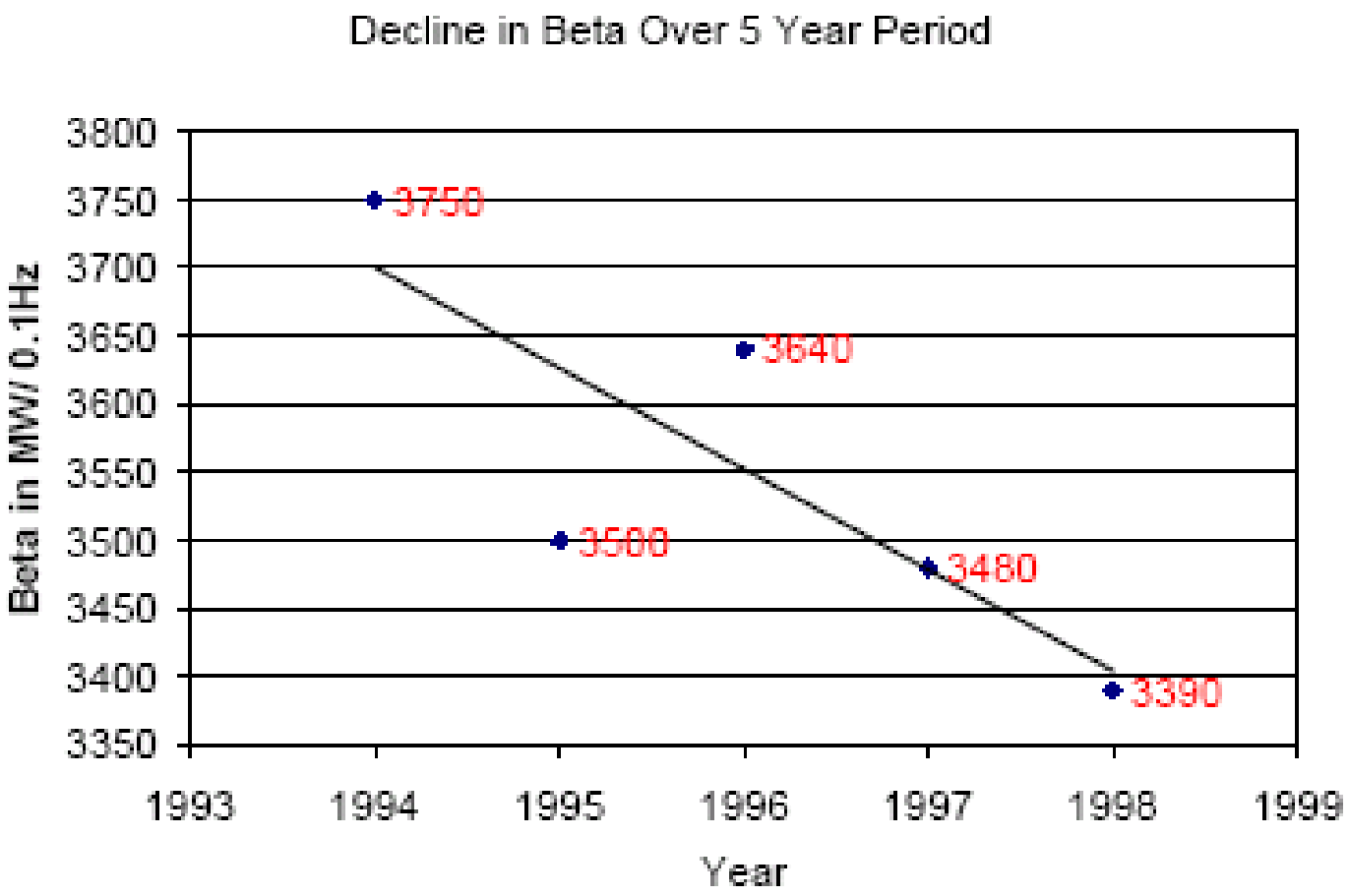
Typical Eastern Interconnection Frequency Excursion

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION



Eastern Interconnection Frequency Response Trend

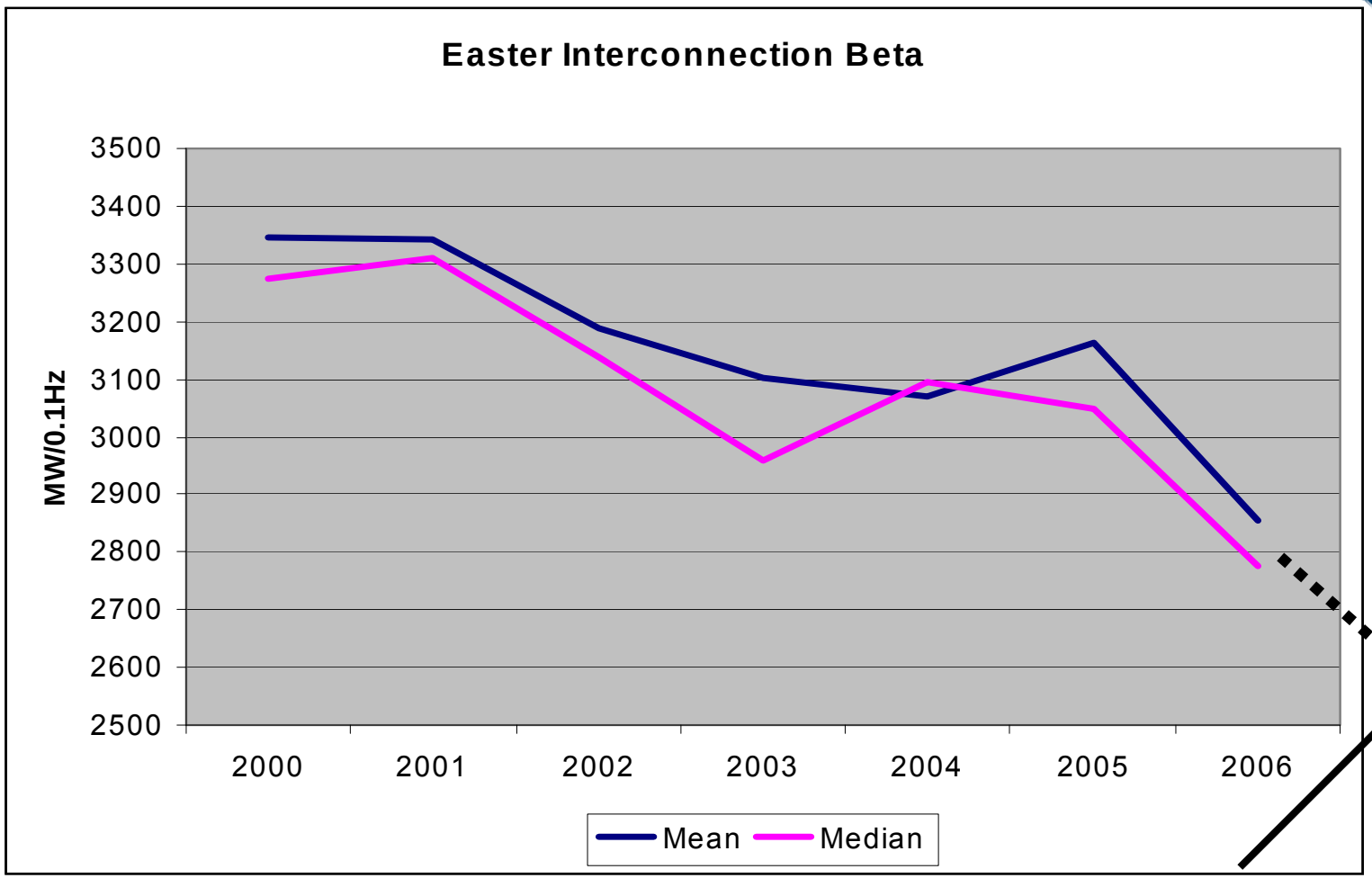
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION



Decline of 72MW/0.1Hz/year

** Ingleson and Nagle Study*

Recent Frequency Response



2007-2008 Response = -2550MW/0.1Hz

** Ingleson and Ellis/NERC Resources Subcommittee/Virginia Tech*

Small Excursions (>28mHz)

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Follows a seasonal pattern, # are increasing
- 28mHz represented loss of about 1000MW in 1994
- Change believed to be primarily due to decline in frequency response (70 MW per 0.1Hz /year since ‘94)
- Pumped storage and interchange schedule changes now causing excursions of this size
- Small excursions are a symptom, not necessarily a problem themselves
- Patterns give a clue to sampling techniques needed to objectively calculate Balancing Authority and Generator Frequency Response

Frequency Response Initiative

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Employ Frequency Monitoring and Analysis tool to look at all FTL excursions
  - Sample events being used for shakedown
- NERC Advisory Alert to be issued on maintaining better frequency response
- One target – to improve modeling of actual response in studies
- Stay Tuned…still being developed!

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Questions?