Suggested MDMS Future Study Scoping Possibilities

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The Major Disturbance Mitigation Study (MDMS) employed using PMU phase angle information from PMU's straddling New York's stability limited interfaces in an effort to predict impending dynamic (angular) instability of the New York system. Where dynamic instability was predicted, controlled separation of key interfaces was tested to determine if the portions of the system could be stabilized. UFLS was simulated and where necessary adjustments were made to achieve a stable result. In addition, a concept was explored in an attempt to develop a fully independent and separate approach to achieve redundancy and security.

The MDMS results show promise but additional work building on these results is needed toward achieving a wide area protection system that can best mitigate the impact of major external and internal disturbances on the New York system as well as avoiding any adverse impacts on its neighboring systems. Potential areas of pursuit include:

- Consider mitigation of voltage instability in addition to angular instability
- Consider mitigation measures in addition to controlled separation of transmission
- Consider a topology where the Northeast is separate from the present Eastern Interconnection by establishing a new, smaller synchronous interconnection; this could consist of New York, New England and the maritimes, and perhaps also Ontario. This new synchronous interconnection would be connected to the remaining Eastern Interconnection by means of asynchronous HVDC ties.
- Consider additional extreme contingencies including those that would likely result from a terrorist attack eg substation loss with 3 ph fault and delayed remote clearing, simultaneous loss of parallel transmission with 3 ph fault - TBD
- Consider using existing FACTS device control systems of both existing and possible additional devices
- Simulation verification testing of proposed schemes should include latencies and delays of all devices in the chain of sensing and control including PMU's, data concentrators, computation delays, teleprotection delays communication delays, relay delays and breaker operation delays
- Include detailed modeling of TO transmission relay systems and UFLS.
- Consider suggesting modifications to TO relay systems
- Develop redundancy concepts that would satisfy NPCC and NERC standards
- Consider increasing renewable DG penetration impact using forward NYand surrounding area transmission planning models say 2020 to 2030

All told, this work requires a contractor with both very broad and in-depth expertise. For reference, a summary of the MDMS findings (Attachment I) and the original scope (Attachment II) are provided below.

Attachment I – Overview of MDMS Project Final Report

MDMS Accomplishments

Filter/Prediction Algorithm

- Employs dual Kalman and Taylor series finite difference methodology-developed by this project
- Fully automated
- Tested PSS/E with dynamic stability cases
- Testing includes measurement noise and delays
- For stable cases- no false predictions
- For unstable cases- accurate, timely prediction

Mitigation Measures

- Controlled Separation of TEI and CEI tested
  - TEI "cleaner" but CEI lack of impact on J/K of interest
- UFLS operation simulated
  - Timing reduction required
- NY system successfully stabilized
  - Two very extreme cases
  - Requires UFLS operation
  - Requires reduction of UFLS timings

Added Security Measures Investigated

- Fully independent system using OOS relays
- PSS/e simulations indicated non-uniform response for all lines of the TEI so full confirmation not achieved
- Project scope limited further work in this area

Summary

- Instability Detection Algorithm Successful
  - Timely identification
  - No false operations
- Mitigation Measures Successful
  - 2 Extreme Contingencies (1 Internal, 1 External)
  - Heavy Loading and Transfers
  - 2 Separation Interfaces tested
  - UFLS Required with modifications
- Full Redundancy Method Investigated
  - Based on completey separate approach
  - Shows promise but needs more work

Recommendations

- Enhanced expertise for future studies

  - System protection – in depth and current
  - HVDC/ FACTS modeling- controls to assist stabilization
  - NYISO AND TO commitment /involvement
  - NPCC and neighbor involvement/oversight
- Consideration of other approaches
  - Separation before the event by establishing new, independent synchronous interconnection in the Northeast
- Continuation of this research - funding
  - NYSERDA PON 3397 due 6/28?
  - Other?

Attachment II – Original MDMS Scope – Technical Sections

Task 2 – Review and Simulation Case Development

Task 2.1: The Contractor shall summarize the state-of-the-art analytical approaches on bulk power system phase angle stability and mitigation schemes of catastrophic disturbances for the New York bulk electric power system. The Contractor shall thoroughly review and analyze prior work including, but not limited to, the NYISO's controlled system separation scheme feasibility study report, the NYISO's 2003 blackout study reports, the New York control area defensive strategies study reports, the NYSRC working group meeting materials, and the Northeastern Power Coordinating Council oscillation study reports. The Contractor shall identify the pros and cons of the existing methodologies for proposing improved and/or new methodologies.

Task 2.2: The Contractor shall develop dynamic simulation cases for a wide range of disturbance scenarios for algorithm and methodology verification. The Contractor shall develop the dynamic simulation cases based on the existing NYISO's most recent representative system operating conditions in terms of generation dispatches, load levels, and transfer levels. The Contractor shall analyze disturbances consisting of those contingencies that are likely to cause instability, uncontrolled separation and possible major loss of load. The Contractor shall, in dynamic simulations, consider disturbance scenarios that consist of:

• Major External Disturbances – (1) extreme power flows through the NY system that result from cascading external transmission outages; (2) voltage collapse external to the NY system; and (3) "beyond criteria" losses of generation external to the NY system.

• Major Internal Disturbances – (1) extreme contingencies within the NY system, including the simultaneous loss of multiple transmission lines, multiple sequential loss of multiple transmission lines, multiple generation unit losses, (2) voltage collapse within the NY system, and (3) "beyond criteria" losses of generation within the NY system.

• Normal Disturbances – the single contingency events that the NY system is designed and operated to withstand and are included to test any control schemes that are developed in this study to insure that they operate properly.

Deliverables: Report detailing the findings and conclusions of the literature review, the dynamic simulations and disturbance scenarios.

Task 3 – Phase Angle Instability Detection and Mitigation Measures Development

Task 3.1: The Contractor shall develop algorithms for real-time and online detection of system angle instability. The Contractor shall utilize the capabilities of new measurement devices to design real-time and online algorithms that can predict impending phase angle instability in the New York power system. The Contractor shall take into account as many monitored system signals, including, but not limited to, generator phase angles and speed, electrical bus phase angles, electrical bus voltages, system frequencies, critical interface power flows, and circuit breaker statuses in defining proposed algorithms. The Contractor shall evaluate the performance of the proposed algorithms and verify their effectiveness in the dynamic simulations developed in Task 2.

Task 3.2: The Contractor shall develop mitigation measures to avoid adverse or even catastrophic impacts of large disturbances to the NY bulk electric power system. The Contractor shall improve the deficiencies of existing control schemes including, but not limited to, under-frequency load shedding, over-frequency generator settings, and controlled system separation. The Contractor shall investigate the coordination of the various protection systems and control schemes to develop effective mitigation measures for system stability improvements. The Contractor shall identify whether the system could suffer from reactive power deficiency or surplus following any mitigation scheme and develop corresponding reactive power compensation schemes. The Contractor shall evaluate the performance of the proposed measures and verify their effectiveness in dynamic simulations.

Deliverables: Report describing the developed detection algorithms and mitigation measures, compensation schemes. The report shall also include a description of the performance evaluation process and the verification of simulation results.

Task 4 – Testing of Algorithms and Mitigation Measures

Task 4.1: The Contractor shall test its proposed algorithm operations and mitigation measures against the disturbance scenarios developed in Task #3.

Deliverables: Report describing the major disturbance mitigation study test results and the analysis of these results along with findings, and conclusions.

Task 5 - Technology Transfer

Task 5.1: The Contractor shall conduct all technology transfer tasks to the Project Manager's satisfaction. Should the project's results differ from the expected outcome, the Contractor shall be allowed to modify the technology transfer plan, with the Project Manager's approval, to facilitate appropriate technology transfer activities.

Deliverable(s): Completion of all technology transfer activities approved by NYSERDA's Project Manager. The Contractor shall hold a workshop to present the results and findings.