Grid Stability Awareness System (GSAS) - A Software Suite for Stability Monitoring and Analysis (DOE-OE0000700)

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Project Overview

- **Objectives**
  - Develop a suite of production level software applications (named Grid Stability Awareness System - GSAS) for power grid real-time monitoring and analysis of oscillation stability, voltage stability and transient stability.
  - Deploy the software suite to one of Southern Company's control centers

- **Project Duration**
  - 10/1/2014 - 12/31/2016

- **Funding**
  - DOE Funds: $1,458,181 (48.6% of total budget)
  - Recipient cost share: $1,541,936 (51.4% of total budget)

- **Partners**
  - Southern Company
  - Washington State University
  - Grid Protection Alliance
Project Achievements

- Developed a software suite: Grid Stability Awareness System - GSAS
  - Oscillation monitoring tool
  - Voltage stability monitoring tool
  - Angle instability monitoring tool
  - Angle difference monitoring tool
  - Event detection tool

- Deployed the software suite on Southern Company's real-time synchrophasor facilities
  - Release 1 (11/18/2015), Dashboard, oscillation tool, voltage stability tool
  - Release 2 (3/9/2016), Event detection and alarm triggers and archival
  - Release 3 (7/27/2016), Angle instability tool, angle difference monitoring tool
  - Release 3.1 (8/31/2016), Final release
Project Achievements (cont.)

- **Performed extensive off-line validation of analytical engines**
  - Using transmission planning model
  - PSSE simulation of known events
  - Validating based on different stability category

- **Performed comprehensive evaluation of software on-line performance**
  - Bi-weekly WebEx demo to demonstrate software performance based on real-time data
  - Receive feedbacks from all stakeholders at the on-line demo
  - Address feedbacks quickly

- **Training materials and training sessions**
  - Facilitated by off-line validation effort
  - For different user groups
GSAS Design Considerations

- Operator view oriented
  - Real-time data streams
  - Event triggers
- Scalable for larger numbers of PMUs
- Extensible framework for new functionality
  - Stability monitoring
  - Dynamic response validation
  - Wide-area awareness
- Server / Client structure

GSAS Modules Implemented

- Oscillation monitoring
- Visualization and situational awareness
- Voltage stability monitoring
- Transient stability monitoring
- Event data playback
- Event detection and alarming
- Wide-area angle difference monitoring

Event data playback

GSAS Modules Implemented
Oscillation Monitoring

- Mode frequency, damping ratio, mode energy, confidence level, mode shape for each mode
- Playback of historical alarm data

(Note: Data displayed is for illustration only.)
Voltage Stability Monitoring

- Local/remote voltage stability index and confidence level for each line
- User selectable signals based on locations and voltage levels
- Playback of historical alarm data

(Note: Data displayed is for illustration only.)
Angle Difference Monitoring

- Angle difference for each user-defined angle difference pair
- Playback of historical alarm data

(Note: Data displayed is for illustration only.)
GSAS Alarm Mechanisms

- **Oscillation Stability Alarming**
  - Real time modal analysis (damping ratio, mode frequency, mode shape, mode energy)
  - User-configurable damping ratio limit and confidence thresholds

- **Voltage Stability Alarming**
  - Real time voltage stability index based on deltaQ/deltaV sensitivity
  - User-configurable voltage stability limits and confidence thresholds

- **Transient Stability Alarming**
  - Real time angle separation after transient event
  - User-configurable generator clusters

- **Angle Difference Alarming**
  - Real time phase angle difference
  - User-configurable phase angle difference limits
GSAS Alarming Dashboard

- Real-time status of system stability
- Historical (last 24 hours) status of system stability
- User clickable event/alarm retrieval
- Event/alarm log and acknowledgements

(Note: Data displayed is for illustration only.)
Historical Alarm Playback

- Alarms captured for playback mode (configurable)
- Alarm logs and operator acknowledgements
- Alarm filtering, grouping, and report generation
- Post-event replay and analysis

(Note: Data displayed is for illustration only.)
Actual Oscillation Event Detected

Event Date: June 17, 2016
This event occurred outside of Southern Company’s footprint...

Damping of 0.26 Hz mode starts to decrease dramatically

Damping of 0.26 Hz mode reaches in warning range (< 5%).

Damping of 0.26 Hz mode reaches in critical alarm range (< 3%).

Damping of 0.26 Hz mode keeps in critical alarm range for several minutes.

0.26 Hz mode

Energy of 0.26 Hz mode starts to increase dramatically
## Project Progress

### Key Milestones (as of October, 2016)

<table>
<thead>
<tr>
<th>Milestones</th>
<th>Estimated Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Kick-off meeting at Southern Company</td>
<td>Complete</td>
</tr>
<tr>
<td>An on-site interview meeting at Southern Company</td>
<td>Complete</td>
</tr>
<tr>
<td>Draft software requirement specifications</td>
<td>Complete</td>
</tr>
<tr>
<td>Define software roadmap and plans for development and deployment</td>
<td>Complete</td>
</tr>
<tr>
<td>Develop and refine analytical tools (engines)</td>
<td>Complete</td>
</tr>
<tr>
<td>Release 1 of GSAS</td>
<td>Complete</td>
</tr>
<tr>
<td>Release 2 of GSAS</td>
<td>Complete</td>
</tr>
<tr>
<td>Release 3 of GSAS</td>
<td>Complete</td>
</tr>
<tr>
<td>Complete training materials and user manuals</td>
<td>On going</td>
</tr>
<tr>
<td>Complete grid operator training sessions</td>
<td>On going</td>
</tr>
<tr>
<td>Complete topical report on software off-line validation</td>
<td>On going</td>
</tr>
<tr>
<td>Complete topical report on evaluation of software on-line performance</td>
<td>On going</td>
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THANKS

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