Situational Awareness (SA) in SCADA EMS/GMS/DMS
(Data Visualization and Alarm Processing)

The Structure Group
Introductions

Mario Marchelli
Director
SCADA & Energy Management Systems Practice Lead
(832) 563-0897
mario.marchelli@thestructuregroup.com
Today, we will focus on...

- Problem Statement
- Definition & Goal of Situational Awareness
- Data Visualization and Alarm Processing
  - Visualization Tools Selection
  - Alarm Processing Strategy
- Situational Awareness in SCADA
  - GMS
  - EMS
  - DMS
# Agenda

- **Problem Statement**
- Definition & Goal of Situational Awareness
- Data Visualization and Alarm Processing
  - Visualization Tools Selection
  - Alarm Processing Strategy
- Situational Awareness in SCADA
  - GMS
  - EMS
  - DMS

## Situation Awareness in SCADA EMS/GMS/DMS
What is the problem?... The 2003 NE Blackout

Adequate situational awareness could have prevented the August 14th 2003 North East Blackout¹...

- **12:15p** MISO State Estimator fails due to telemetry error
  - (in development) State Estimator not restarted after error is fixed
  - Flowgate Management Tool (FMT) not getting real-time data
- **13:31** FirstEnergy Eastlake 5 Gen unit trip
  - Contingency Analysis not used to evaluate loss
- **14:14** FirstEnergy EMS Alarm system failure
  - No dynamic map-board used for visualization
  - Since no alarms or audible or logs showed... system “looked good!”
  - 90 min: until alarm failure was suspected
- **14:41 – 14:54:** Primary and Backup EMS server failure
  - Failover to Backup Server with corrupted alarm data
  - SCADA GUI refresh slows to 59 sec/screen
  - Warm reboot of servers do not fix the problem
- **15:05 – 15:42:** Several 345KV Ties trip
  - Overgrown Trees with FirstEnergy Right of way
  - This caused cascade trip of 16 much smaller 138KV lines
  - Load Shed of 1.5 GW could have save the blackout...
- **16:05** One more 345KV line trip caused domino effect
- **16:13** End of cascading failure – 256 power plants off-line

¹ “Technical Analysis of the August 14, 2003, Blackout.” (1)

- 8 states/2 provinces
- Over 50 million people
- Cost Estimated $ 6 Billion
- 65,000 MW Loss
- 531 generators tripped
- 96+ hours to restore
What is the problem? The 2003 NE Blackout

NERC formed the Real-time Tools Best Practices Task Force to respond to the recommendations of the Final Report...

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00</td>
<td>Phase 1: A normal afternoon degrades 12:15-14:14</td>
</tr>
<tr>
<td>13:00</td>
<td>Phase 2: FE’s computer failures 14:14-15:59</td>
</tr>
<tr>
<td>14:00</td>
<td>Phase 3: FE 345 kV line failures 15:05-15:57</td>
</tr>
<tr>
<td>15:00</td>
<td>Phase 4: Collapse of 138 kV system 15:39-16:08</td>
</tr>
<tr>
<td>16:00</td>
<td></td>
</tr>
</tbody>
</table>

Grid Events:
- 13:31: Eastlake 5 trips
- 14:02: Stuart-Atlanta 345 kV fails (tree)
- 14:27: Star-S Canton 345 kV trips & recloses (tree)
- 15:05: Harding-Chamberlain 345 kV fails (tree)
- 15:32: Hanna-Juniper 348 kV fails (tree)
- 15:41: Star-S Canton 345 kV fails (tree)
- 16:05: Sammis-Star 345 kV line fails

Computer Events:
- 12:15: MISO SE problems begin
- 14:14: FE EMS alarms fail
- 14:20: FE loses half its remote consoles
- 14:54: FE back-up EMS server fails
- 15:08: FE primary EMS server fails
- 15:41: FE primary EMS server restarts
- 15:46-15:53: FE IT rebooting H4, H1

Human Events:
- 14:32: AEP calls FE re: Star-S Canton trip
- 15:35: AEP & PJM work 1UL
- 15:42: FE operator tells IT alarms out
- 15:45: FE mening substitutions
- 15:57: FE calls MISO re: line outages

- No Situational Awareness
- Bad Reliability Tools
- Failure of Alarm Systems
- Data Telemetry Failure

What is the problem? ... Feb 2nd 2011 in Texas

Situational Awareness in a Market System includes both reliability and market monitoring...

- Extreme cold weather conditions
- Loss of several generating facilities
- Plus record MW demand levels

\[
\text{= 1,000} - 4,000 \text{ MW Load Rolling Blackouts.}
\]

- Texas Reliability Entity (TRE)
  - Reliability Compliance Check

- Independent Market Monitor (IMM)
  - Detect & prevent market manipulations
  - Evaluate operations of the market

\(^1\)The Public Utility Commission called on ERCOT to look into everything that happened last week and to investigate if anyone profited from the outage and rolling blackouts.
What is the problem? ... for a Power Marketer

A QSE in Texas missed non-spin deployments for a generator

- No Portfolio dashboard
- No visual or audible alarm configured
- SCADA/GMS vendor screens typically not designed with “operations” in mind
- Market data not always available at the SCADA/GMS level
- Real-time business rules are not the same for each market
- Visualization strategy is not a priority
- Alarm strategy is not a priority

As a consequence, the generating unit was not started in time, resulting in ISO compliance penalties and settlement charges...
In summary, the situational awareness problem...

Lack of good situational awareness causes operators to miss important information...

Users end up with...

- Too many screens not designed for doing business
- Too much data on screens
- No human factor consideration
- Critical Alarms are missed
- “Flood” of stale and nuisance alarms messages...

Inadequate Screens or Visualization Tools

None or Poor Alarm Strategy
[Inadequate Alarm Filters and Tools]

None or Poor Visualization Strategy
Agenda

Situation Awareness in SCADA EMS/GMS/DMS

- Problem Statement
- Definition & Goal of Situational Awareness
- Data Visualization and Alarm Processing
  - Visualization Tools Selection
  - Alarm Processing Strategy
- Situational Awareness in SCADA
  - GMS
  - EMS
  - DMS
What is Situation Awareness (SA) ?

**SA is simply “knowing what’s going on so you can anticipate what to do...”**

Inadequate Situation Awareness has been identified as one of the primary factors in accidents attributed to human error.

**Levels of Situation Awareness**

1. **Level 1 Perception**
   - Focus on Critical Elements
   - Monitoring & recognition
   - Current state

2. **Level 2 Comprehension**
   - Understand Big Picture impacts
   - Interpretation & evaluation
   - Check against targets & goals

3. **Level 3 Projection**
   - Understand future system impact
   - Generate proactive action
   - Future state

---

ISO New England (ISONE) control room

---

2 Dr. Mica Endsley Theoretical model
SA depends on human factors, the complexity of the system, technology and environmental factors...

Most operators’ view of what’s happening is limited by the “system” and “training” level.
Achieve effective response to current and future events that threaten the business goals...

- The goal might be “dynamic”
- SA is technology independent
- Focus on presenting “critical” data in context
- SA design w/ goal-oriented dashboard screens
- Remove Information not related to SA
- Higher SA requires adequate projection level
- Proactive user interface better than reactive
- Other components of SA:
  - Adequate communication (telemetry/control)
  - Adequate level of detail
  - Efficient Procedures
  - Effective training
Situation Awareness in SCADA EMS/GMS/DMS

- Problem Statement
- Definition & Goal of Situational Awareness
  - Data Visualization and Alarm Processing
    - Visualization Tools Selection
    - Alarm Processing Strategy
- Situational Awareness in SCADA
  - GMS
  - EMS
  - DMS
Apollo 13 Incident

“Houston we have a problem”
## Data Visualization and Alarm Processing

### Apollo 13 Screen at Time 1

<table>
<thead>
<tr>
<th>CTE 055:46:51</th>
<th>GET 055:53:47</th>
<th>SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>-----LIFE SUPPORT-----</strong></td>
<td><strong>-----PRIMARY COOLANT-----</strong></td>
<td></td>
</tr>
<tr>
<td>GF1571 LM CABIN P PSIA</td>
<td>CF0019 ACCUM QTY PCT 34.4</td>
<td></td>
</tr>
<tr>
<td>CF0001 CABIN P PSIA 5.1</td>
<td>CF0016 PUMP P PSID 45.0</td>
<td></td>
</tr>
<tr>
<td>CF0012 SUIT P PSIA 4.3</td>
<td>SF0260 RAD IN T F 73.8</td>
<td></td>
</tr>
<tr>
<td>CF0003 SUIT ΔP IN H2O -1.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF0015 COMP ΔP PSID 0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF0006 SURGE P PSIA 891</td>
<td>CF0020 RAD OUT T F 35.4</td>
<td></td>
</tr>
<tr>
<td>SURGE QTY LB 3.67</td>
<td>CF0181 EVAP IN T F 45.7</td>
<td></td>
</tr>
<tr>
<td>02 TK 1 CAP ΔP PSID 21</td>
<td>CF0017 STEAM T F 64.9</td>
<td></td>
</tr>
<tr>
<td>02 TK 1 CAP ΔP PSID 17</td>
<td>CF0034 STEAM P PSIA .161</td>
<td></td>
</tr>
<tr>
<td>CF0036 02 MAN P PSIA 105</td>
<td>CF0018 RVAP OUT T F 44.2</td>
<td></td>
</tr>
<tr>
<td>CF0035 02 FLOW LB/HR 0.181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF0008 SUIT T F 50.5</td>
<td>SF0266 RAD VLV 1/2 ONE</td>
<td></td>
</tr>
<tr>
<td>CF0002 CABIN F 65</td>
<td>CF0157 GLY FLO LB/HR 215</td>
<td></td>
</tr>
<tr>
<td>CF0005 CO2 PP MMHG 1.5</td>
<td>CF0072 ACCUM QTY PCT 36.8</td>
<td></td>
</tr>
<tr>
<td>CF0009 WASTE PCT 24.4</td>
<td>CF0070 PUMP P PSID 9.3</td>
<td></td>
</tr>
<tr>
<td>WASTE LB 13.7</td>
<td>CF0072 ACCUM QTY PCT 36.8</td>
<td></td>
</tr>
<tr>
<td>CF0010 POTABLE PCT 104.5</td>
<td>SF0262 RAD IN T F 76.5</td>
<td></td>
</tr>
<tr>
<td>POTABLE LB 37.6</td>
<td>SF0263 RAD OUT T F 44.6</td>
<td></td>
</tr>
<tr>
<td>CF0046 URINE NOZ T F 70</td>
<td>CF0073 STEAM P PSIA .2460</td>
<td></td>
</tr>
<tr>
<td>CF0041 H2O NOZ T F 72</td>
<td>CF0071 EVAP OUT T F 66.1</td>
<td></td>
</tr>
<tr>
<td><strong>-----H2O-----</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF0036 02 MAN P PSIA 105</td>
<td>CF0120 H2O-RES PSIA 25.8</td>
<td></td>
</tr>
<tr>
<td>CF0035 02 FLOW LB/HR 0.181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF0008 SUIT T F 50.5</td>
<td>SF0266 RAD VLV 1/2 ONE</td>
<td></td>
</tr>
<tr>
<td>CF0002 CABIN F 65</td>
<td>CF0157 GLY FLO LB/HR 215</td>
<td></td>
</tr>
<tr>
<td>CF0005 CO2 PP MMHG 1.5</td>
<td>CF0072 ACCUM QTY PCT 36.8</td>
<td></td>
</tr>
<tr>
<td>CF0009 WASTE PCT 24.4</td>
<td>CF0070 PUMP P PSID 9.3</td>
<td></td>
</tr>
<tr>
<td>WASTE LB 13.7</td>
<td>CF0072 ACCUM QTY PCT 36.8</td>
<td></td>
</tr>
<tr>
<td>CF0010 POTABLE PCT 104.5</td>
<td>SF0262 RAD IN T F 76.5</td>
<td></td>
</tr>
<tr>
<td>POTABLE LB 37.6</td>
<td>SF0263 RAD OUT T F 44.6</td>
<td></td>
</tr>
<tr>
<td>CF0046 URINE NOZ T F 70</td>
<td>CF0073 STEAM P PSIA .2460</td>
<td></td>
</tr>
<tr>
<td>CF0041 H2O NOZ T F 72</td>
<td>CF0071 EVAP OUT T F 66.1</td>
<td></td>
</tr>
<tr>
<td><strong>-----CRYO SUPPLY-----</strong></td>
<td><strong>-----02-1-----</strong></td>
<td><strong>-----02-2-----</strong></td>
</tr>
<tr>
<td>SC0017-38-39-40 P PSIA 876.5 906 225.7 (03-1) 235.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC0012-33-30-31 QTY PCT 77.63 O/S 73.24 74.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC0041-42-43-44-T QTY LBS 251.1 260.0 20.61 20.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Visualization and Alarm Processing

Apollo 13 Screen at Time 2
**Apollo 13 Screen at Time 3**

### LM12839

<table>
<thead>
<tr>
<th>CTE 055:57:02</th>
<th>GET 055:54:53</th>
<th>SITE 0613</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTE</strong></td>
<td><strong>GET</strong></td>
<td><strong>SITE</strong></td>
</tr>
<tr>
<td><strong>LIFE SUPPORT</strong></td>
<td><strong>PRIMARY COOLANT</strong></td>
<td></td>
</tr>
<tr>
<td>GF3571 LM CABIN P</td>
<td>PSIA</td>
<td>CF0019 ACCUM QTY PCT</td>
</tr>
<tr>
<td>CF0001 CABIN P</td>
<td>PSIA</td>
<td>CF0016 PUMP P</td>
</tr>
<tr>
<td>CF0012 SUIT P</td>
<td>PSIA</td>
<td>SF0260 RAD IN T F</td>
</tr>
<tr>
<td>CF0003 SUIT P IN H2O</td>
<td>-1.8</td>
<td>Δ</td>
</tr>
<tr>
<td>CF0015 COMP P</td>
<td>PSID</td>
<td>0.27</td>
</tr>
<tr>
<td>CF0006 SURGE P</td>
<td>PSIA</td>
<td>839</td>
</tr>
<tr>
<td>SURGE QTY</td>
<td>LB</td>
<td>3.9</td>
</tr>
<tr>
<td>02 TK 1 CAP</td>
<td>PSID</td>
<td>19</td>
</tr>
<tr>
<td>02 TK 1 CAP</td>
<td>PSID</td>
<td>17</td>
</tr>
<tr>
<td>CF0036 02 MAN P</td>
<td>PSIA</td>
<td>108</td>
</tr>
<tr>
<td>CF0035 02 FLOW</td>
<td>LB/HR</td>
<td>0.178</td>
</tr>
<tr>
<td>CF0008 SUIT T</td>
<td>F</td>
<td>50.5</td>
</tr>
<tr>
<td>CF0002 CABIN</td>
<td>F</td>
<td>65</td>
</tr>
<tr>
<td>CF0005 CO2 PP</td>
<td>MMHG</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>H2O</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF0009 WASTE PCT</td>
<td>28.9</td>
<td>CF0072 ACCUM QTY PCT</td>
</tr>
<tr>
<td>WASTE LB</td>
<td>14.9</td>
<td>CF0070 PUMP P</td>
</tr>
<tr>
<td>CF0010 POTABLE PCT</td>
<td>109.9</td>
<td>SF0262 RAD IN T F</td>
</tr>
<tr>
<td>POTABLE LB</td>
<td>39.1</td>
<td>SF0263 RAD OUT T F</td>
</tr>
<tr>
<td>CF0460 URINE NOZ T</td>
<td>F</td>
<td>105</td>
</tr>
<tr>
<td>CF0461 H2O NOZ T</td>
<td>F</td>
<td>78</td>
</tr>
<tr>
<td><strong>CRYO SUPPLY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC0037-38-39-40 P</td>
<td>PSIA</td>
<td>872</td>
</tr>
<tr>
<td>SC0032-33-30-31 QTY</td>
<td>PCT</td>
<td>72.3</td>
</tr>
<tr>
<td>SC0041-42-43-44-T</td>
<td>F</td>
<td>-189</td>
</tr>
<tr>
<td>QTY</td>
<td>LBS</td>
<td>251.1</td>
</tr>
</tbody>
</table>

**Did Anything important just happen?**
Graphical representation of the same data

Data becomes information when shown in context to reference values (limits, past data, what’s expected)
When data is large or abstract, visualization can help make the data easier to read or understand ...

- Effective visualization shall stimulate viewer engagement and attention
- Reliability coordinators are leading the way and pushing innovation
- Allow operators to more quickly understand and react to critical situations
- Visualization tools are the GUI for the tools/apps necessary to monitor the system.
Use of human factors in display design will reduce errors and training time as well as increase efficiency and user satisfaction...

**Perception**
- Make Legible Displays (or Audible Alarms)
- Avoid absolute judgment limits (color, size, etc)
- Top-down processing – Show data in context
- Redundancy gain, e.g. Color, Value and Trend
- Similarity causes confusion, e.g. acronym labels

**Mental Model**
- Pictorial realism – High Limits on top in vertical level
- Moving parts – gauge needles, trends, power flow

**Attention**
- Minimizing information access cost – Location...
- Proximity compatibility – may cause too much clutter
- Multiple resources – visual + audible

**Memory**
- Replace memory with visual information – tool tips
- Predictive aiding – target vs. actual, performance %
- Consistency

---

3 Christopher Wickens 13 principles of display design, "An Introduction to Human Factors Engineering"
Use color schemes in tabular data and dashboards to improve awareness...

- Add color where appropriate for emphasis - important data stands out
- Use a color scheme to group like data (e.g. Input vs calculated points)
- Use a color scheme to represent the status of the data displayed
Situational Awareness Design Examples

Represent tabular data graphically for redundancy to help with comprehension...

- Bar graphs are useful when the value being monitored must be within a range; user can quickly assess if within limits
- Bars graphs with dynamically changing colors
Situational Awareness Design Examples

Represent tabular data graphically for better context to improve comprehension and predictability...

- Use trends to visualize how data is trending over a period of time
- Show values relative to expected results and limits; make adjustments before reaching a violation condition
- Use for dispatch, plant output, limits
Situational Awareness – Alarm Tools

**Alarm tools emit real-time visible and audible signals to alert operators to events and conditions affecting the state of the bulk electric system...**

### Alarm Examples

- Analog point violates a limit
- Digital point changes to abnormal
- Control Failure
- Return-to-Normal status change
- RTU communication failure
- Monitored system hardware fails
- Performance violation
- MW Reserve shortage
- Fuel consumption violations
- Dispatch violations
- Stability violations

### Alarm Strategy Configuration

- **Category/Group**
  - SCADA, AGC, SE, common events, etc
- **Class**
  - Define alarms presentation: color, audible, blink, etc
  - Define “triggers” email, pager, display call-up, etc
- **Priority**
  - 8 priorities, from critical (1) to events (8)
- **Console’s AOR and Priority**
  - To filter responsibilities to users and consoles
### Situational Awareness – Alarm Summary Example

#### Example of Alarm Summary on a Ventyx/ABB Network Manager Screen

<table>
<thead>
<tr>
<th>Console</th>
<th>Unacknowledged Alarm List</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23/Feb/2010 12:56:56</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:56:56</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:54:54</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:54:54</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:54:12</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:52:10</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:52:07</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:47:04</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:47:02</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:42:00</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:41:56</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:36:54</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:36:50</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:31:45</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:26:42</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:26:30</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:36</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:38</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:36</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:36</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:36</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:36</td>
</tr>
<tr>
<td></td>
<td>23/Feb/2010 12:23:36</td>
</tr>
</tbody>
</table>

**All priorities displayed**

**User may not need to see ‘maintenance’ alarms**
Without alarms, events indicating severe deviations from the system goal may go undetected...

Considerations

- It shall be highly available and redundant
- High Priority alarms should require operator action
- Alarm strategy shall resolve:
  - Standing Alarms (stale problem)
  - Background Alarms (nuisance)
  - Alarm Flooding
- NERC working on new standard⁵:
  - Make Alarm Tool Mandatory
  - Alarm Tools Availability monitor
  - Conditional alarming
  - Intelligent alarm processing (filters)

⁵NERC Reliability Tools for Situational Awareness Section 2.0
Situation Awareness in SCADA EMS/GMS/DMS

• Problem Statement
• Definition & Goal of Situational Awareness
• Data Visualization and Alarm Processing
  • Visualization Tools Selection
  • Alarm Processing Strategy
• Situational Awareness in SCADA
  • GMS
  • EMS
  • DMS
CT GMS Goals

- Monitor resource status
- Monitor resource output
- Monitor resource limits
- Monitor Ancillary Service Capacity and Availability
- Monitor Prices for Loads & Gens
- Monitor Dispatch Deviations
  - Project real-time imbalance
  - Avoid real-time penalty charges
- Monitor resource performance
  - Project compliance score
  - Avoid compliance violations

© BP p.l.c
Sometimes it takes many “screen jumps” to find all the information required to determine the conditions of the resources being monitored.
Situational Awareness - Commercial Trading GMS
Situational Awareness - Commercial Trading GMS

Table:

<table>
<thead>
<tr>
<th>Performance</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Unit 4</th>
<th>Unit 5</th>
<th>Unit 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hour</td>
<td>93</td>
<td>99</td>
<td>100</td>
<td>96</td>
<td>98</td>
<td>94</td>
</tr>
<tr>
<td>Day</td>
<td>99</td>
<td>89</td>
<td>100</td>
<td>90</td>
<td>92</td>
<td>90</td>
</tr>
<tr>
<td>Month</td>
<td>97</td>
<td>84</td>
<td>94</td>
<td>96</td>
<td>100</td>
<td>99</td>
</tr>
</tbody>
</table>
**BA GMS Goals**

- Control System Frequency
- Control MW Interchange
- Control Time Error
- Minimize Area Control Error
  - Project performance compliance scores
  - Avoid compliance violations
- Monitor Disturbances
- Monitor resource status
- Monitor resource outputs
- Monitor resource limits
- Monitor Dispatch Deviations
- Monitor resource performance
Situational Awareness Balancing Authority EMS

Source: NERC Project 2007-18 Reliability-based Control

©2011 Copyright. Confidential and proprietary to The Structure Group, LLC.
EMS Goals

- Monitor Voltages
- Monitor Lines/Transformer Overload
- Tolerance to Contingencies
- Monitor reactive power reserves
- Load margin to voltage collapse
- Monitor dynamic disturbances
Reliability Tools

- SCADA Telemetry* (RTU, ICCP, other)
- Alarm Tools*
- Visualization Tools*
- Network Topology Processor*
- Topology & Analog Error Detection
- State Estimator (SE)*
- Contingency Analysis (CA)*
- Critical Facility Loading Assessment (CFLA)
- Power Flow (PF)
- Voltage Stability Assessment (VSA)
- Dynamic Stability Assessment (DSA)
- Capacity Assessment

* Proposed to be mandatory by NERC Real-time Tools Best Practices Task Force (RTBPTF) Report. Section 2.0 Reliability Tools for Situational Awareness
Best Practices

- Voltage contouring
- Flow (MVA/AMP) contouring
- Phase angle difference contouring
- Flowgate contouring
- Reactive reserve for each busbar shown using bar graphs
- Violations caused by contingencies
- Dynamic coloring in one-lines
- Dashboards to show the overall network state summary

Voltage Contour with Transmission

ieso voltage contour example

PSERC Phasor contour example
Situational Awareness – Visualizations in EMS

Operational displays using Alstom Grid Vision...
Operational displays using OSI’s Monarch OpenView...
A view into the PJM Control Room – PI Process Book...
3D Visualizations

- Applied to one-line diagrams
- To highlight variable relationships
- Depth provides more information
- Less cluttered than 2D
- Used for Contingency Analysis
  - Multiple contingency voltage violation
  - Contingencies vs violated elements
- When single color contour won't do
- Still in experimental phase
  - May cause vertigo on large screens
  - Foreground objects block ones in back

OSI Monarch OpenView example

PSERC Contingency severity visualization
Industry Trend Summary

- Volume of data is much higher than EMS
- Concentrated in heavily populated areas
- Data analytics tool to filter alarms in DMS environment
- SG Analytics combined with Data Warehousing tools
- The goal is to reduce human error
- Slow adoption of advanced SA tools in control rooms
- Some vendors provide SG Analytics tools (dashboards),
  - Teradata
  - Obvient (Ventyx/ABB)
Outage Management dashboards and portals from Obvient...
Conclusions

• Lack of good situational awareness causes operators to miss important information

• The goal of SA is to achieve effective response to current and future events that threaten the business goals, which is different for each organization:
  • Commercial Trading
  • Balancing Authorities
  • Transmission Operators
  • Reliability Coordinators

• SA design shall target a higher level of perception, comprehension and generate proactive action

• Human factors shall be considered when designing dashboards/alarms

• NERC Real-time Tools Best Practices Task Force (RTBPTF) Report describes the current Reliability Tools for Situational Awareness
Data Visualization and Alarm Processing – Questions?
Mario Marchelli
Director
SCADA & Energy Management Systems Practice Lead
(832) 563-0897
mario.marchelli@thestructuregroup.com

www.thestructuregroup.com