SMART ULSS FORUM
“Electricity”

March, 2008

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The Electric Grid is a Complex System with Unique Characteristics

**Physically**
- Never holistically designed, grid developed incrementally in response to local load growth.
  - 30,000 Transmission paths; over 180,000 miles of transmission line.
  - 14,000 Transmission substations.
  - Distribution grid connects these substations with over 100 million loads, i.e. residential, industrial, and commercial customers.
- Diverse industry w/o a common voice.
  - 3,170 traditional electric utilities.
  - 239 investor-owned, 2,009 publicly owned, 912 consumer-owned rural cooperatives, and 10 Federal electric utilities.

**Technically**
- Electricity flows within three major interconnections along paths of lowest impedance (at the speed of light); yet the grid is operated in a decentralized manner by over 140 control areas.
- Demand is uncontrolled; electricity is the ultimate “just-in-time” production process.

**Uniqueness**
- Two things make electricity unique:
  1. Lack of flow control
  2. Lack of large-scale energy storage
- Change either of these and the grid delivery system will be transformed.
Communications Integration

Plug-in Hybrids
Current cyber security initiatives for SCADA/PCS place industry defenses circa 1994, and thus empowers attackers with high-impact (easy) vectors.

Attacker sophistication has decreased due to proliferation of Easy-to-Use (automated) attack tools.

Courtesy of Idaho National Laboratory
Resiliency/N-X Contingency

Isolation of critical services-MUST RUN

Backup, Diversity and Redundancy

Recovery
Phasor Measurements, Real Time Wide-Area Situational Awareness, Visualization, Infrastructure Monitoring, Alarming, and Control

GOAL
Industry Approach to Phasor Technology Research and Applications:
- Visualization
- State Estimation
- Mode Monitoring
- Alarming
- Real Time Controls
Reliability Metrics and Compliance Monitoring Tools

Visualization, Compliance, Monitoring, Infrastructure, Real Time Wide-Area Standards Compliance and Situational Awareness

- 1999 Low Frequency Events on Eastern Interconnection
- Declining System Performance
- Frequency Excursions

Wide-area visualization infrastructure
- Relational time-series database
- Suppliers performance for AGC and frequency response

Wide-area real time ACE-Frequency monitoring tool
- Suppliers performance for AGC and frequency response

Interchange Error (AIE) Monitoring
- Wide-area inadvertent Monitoring

Performance standards research, validation, field trials
- Resources adequacy load-generation analysis and assessment

CPS-BAAL monitoring and analysis
- Research for situational awareness for resource adequacy

GOAL
Common Wide-Area, Real Time Monitoring Platform – Standards Compliance, Key Metrics for Reliability
Intelligent Alarms, Reports, and Event Analysis Situation Awareness Visualization
Dashboards for NERC, DOE, and FERC
### Characteristics (Now and Future)

- **Interoperability**
- **Flexible** (generation diversity, disruptive technologies)
- **Reliable**: N-X contingency (X=1, 2, etc)
- **Eco-centric** (Impact)
- **Provider of Last Resort?**
- **Human behavior** (hybrids, demand response)