UT-BATTELLE

Electric Grid Situational Awareness

VERDE

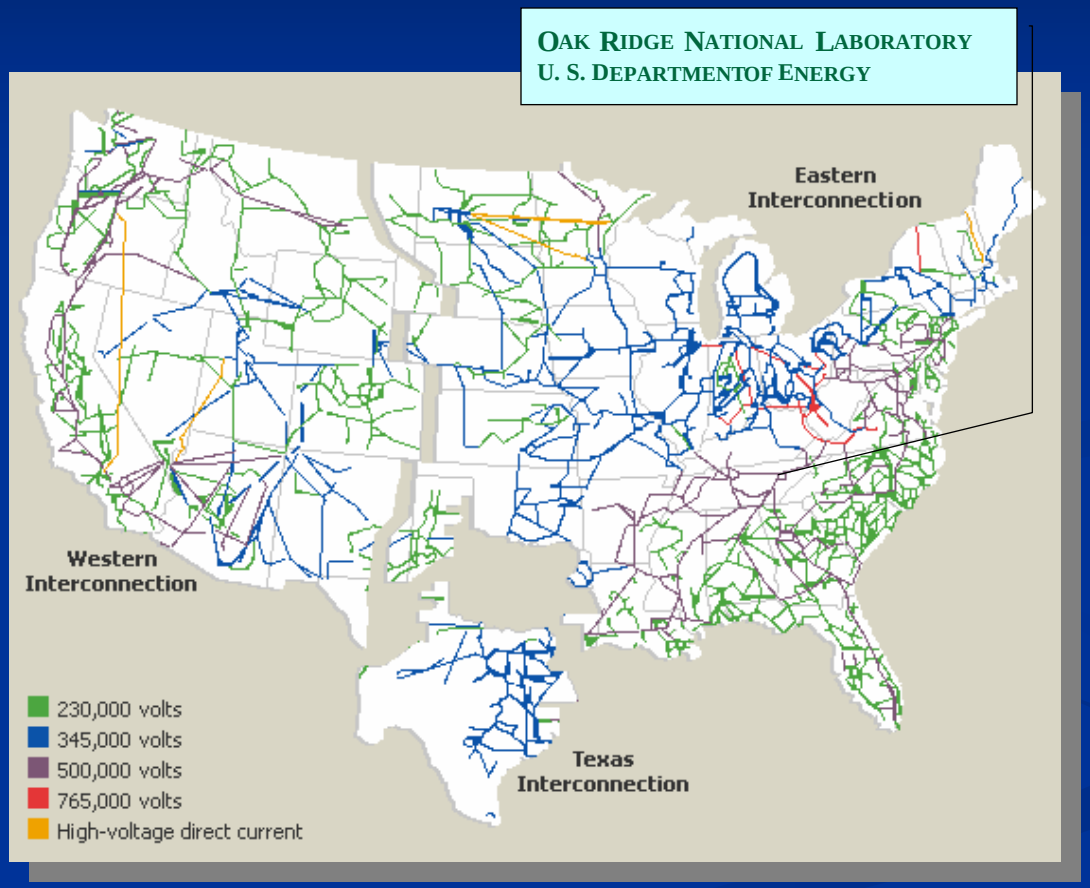
Visualizing Energy Resources Dynamically on Earth

NASPI Meeting

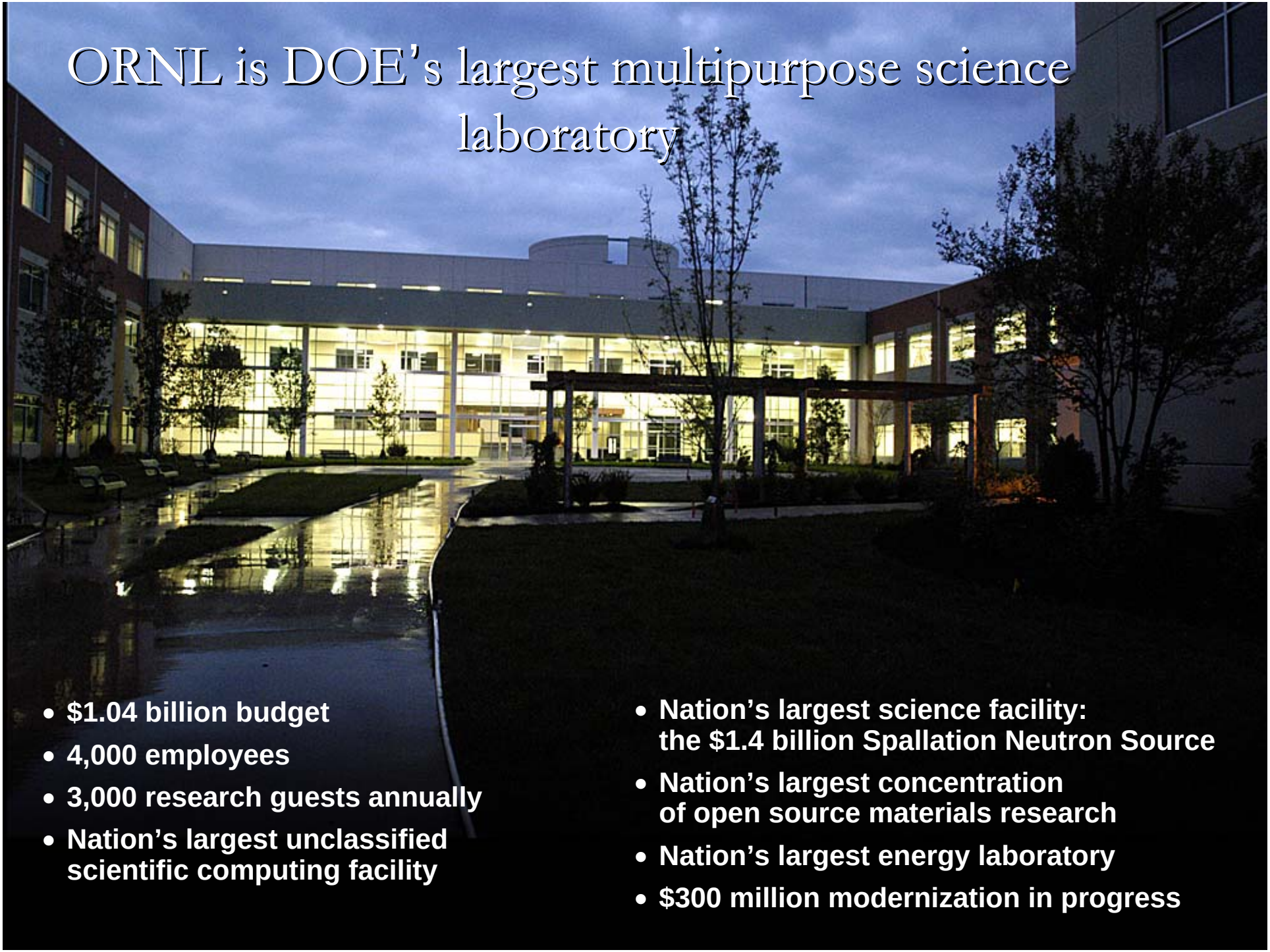
Tom King
John Stovall

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

Where is Oak Ridge, TN?



ORNL is DOE's largest multipurpose science laboratory



- **$1.04 billion budget**
- **4,000 employees**
- **3,000 research guests annually**
- **Nation's largest unclassified scientific computing facility**
- **Nation's largest science facility: the $1.4 billion Spallation Neutron Source**
- **Nation's largest concentration of open source materials research**
- **Nation's largest energy laboratory**
- **$300 million modernization in progress**

ORNL performing R&D to assist DOE in improving electric grid reliability

Power Delivery Testing Facilities

Power Electronics Test facility

HTS cable & subsystems

DE Systems (DECC)

Advanced Materials

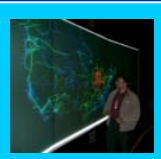
HTS - 2G wire & components

Power Electronics

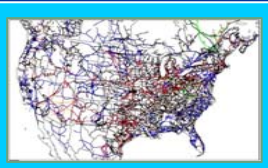
Next-Gen components

Energy Storage

Computation & Modeling



Transmission Monitoring



Computational Modeling & Controls

National Security

Micro-grids – Reconfigurable Grid

Critical Infrastructures – Distributed Energy Integration

Ensure the Reliability & Security of the Nation's Grid

- Reduce Transmission Congestion
- Improve Power Quality
- Reduce Major Outages
- Improve Restoration Times

ORNL Simulation and Modeling

- ORNL-led team selected to build the National Leadership-class Computing Facility
- Cray X1 evaluation completed
  - Expanded from 256 to 512 processors
  - Global ocean simulation: 50% higher simulation throughput than on Japanese Earth Simulator for equal number of processors
- Plan is to increase capability to 1 petaflop (1,000 trillion calculations per sec)
- Research Areas include:
  - astrophysics - supern
  - ...a energy research
  - industrial innovation - combustion simulation
  - materials research - precise calculations of molecular structures
  - nanomaterials theory

Is there an opportunity to utilize this resource?

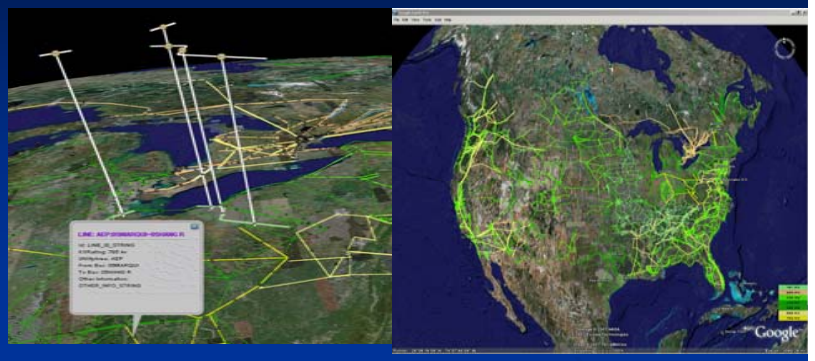
Developing tools to improve situational awareness of the electric grid

- DOE Office of Electricity Delivery and Energy Reliability sponsored effort
- Response to the devastating hurricanes in 2005
- Coordinate federal response to natural disasters or major events
- ORNL, in partnership with TVA, developing real-time grid visualization tool
- Initially assess status of transmission lines in the Southeast

- Two platforms have been developed
  - Google Earth
  - ORNL developed EDGAR

VERDE Capabilities

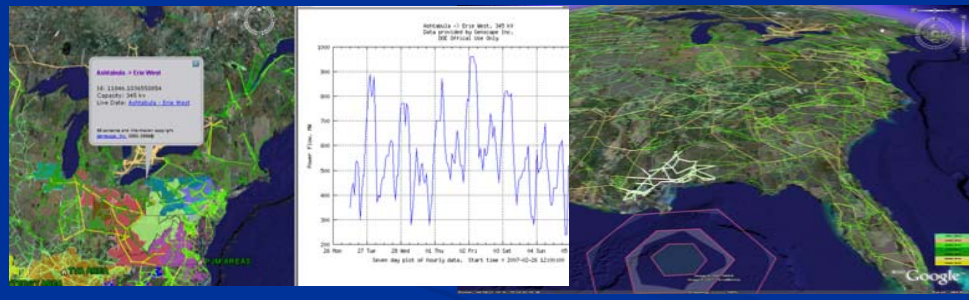
- Platform to provide wide area visualization capability
  - Flexible system
- Real-time status of transmission lines
- Real-time weather overlays
- Predictive impact models & Animated replay
- Data analysis
- Energy infrastructure interdependencies:
  - Coal delivery and rail lines
  - Refinery and oil wells
  - Natural gas pipelines
  - Transportation and evacuation routes
  - Population impacts - LandScan

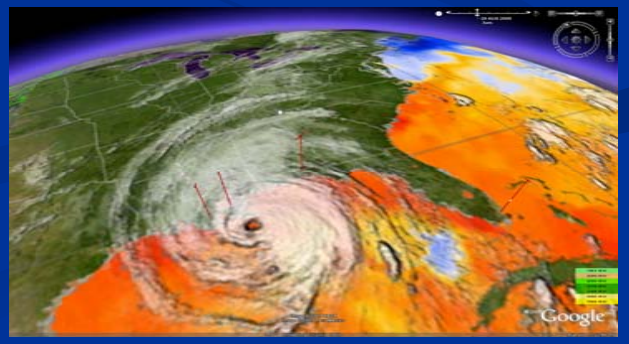


Wide-Area Power Grid Situational Awareness

Streaming Analysis

Impact Models





Real-time Weather Overlays

Key Elements of Process Flow

- ICCP data from NERCnet provides real-time data every minute
- TVA extracts data and translates line status – in or out of service
- ORNL overlays weather, population, transportation, electrical network data – electric dynamic grid analysis
- Visual displays are sent to DOE every minute

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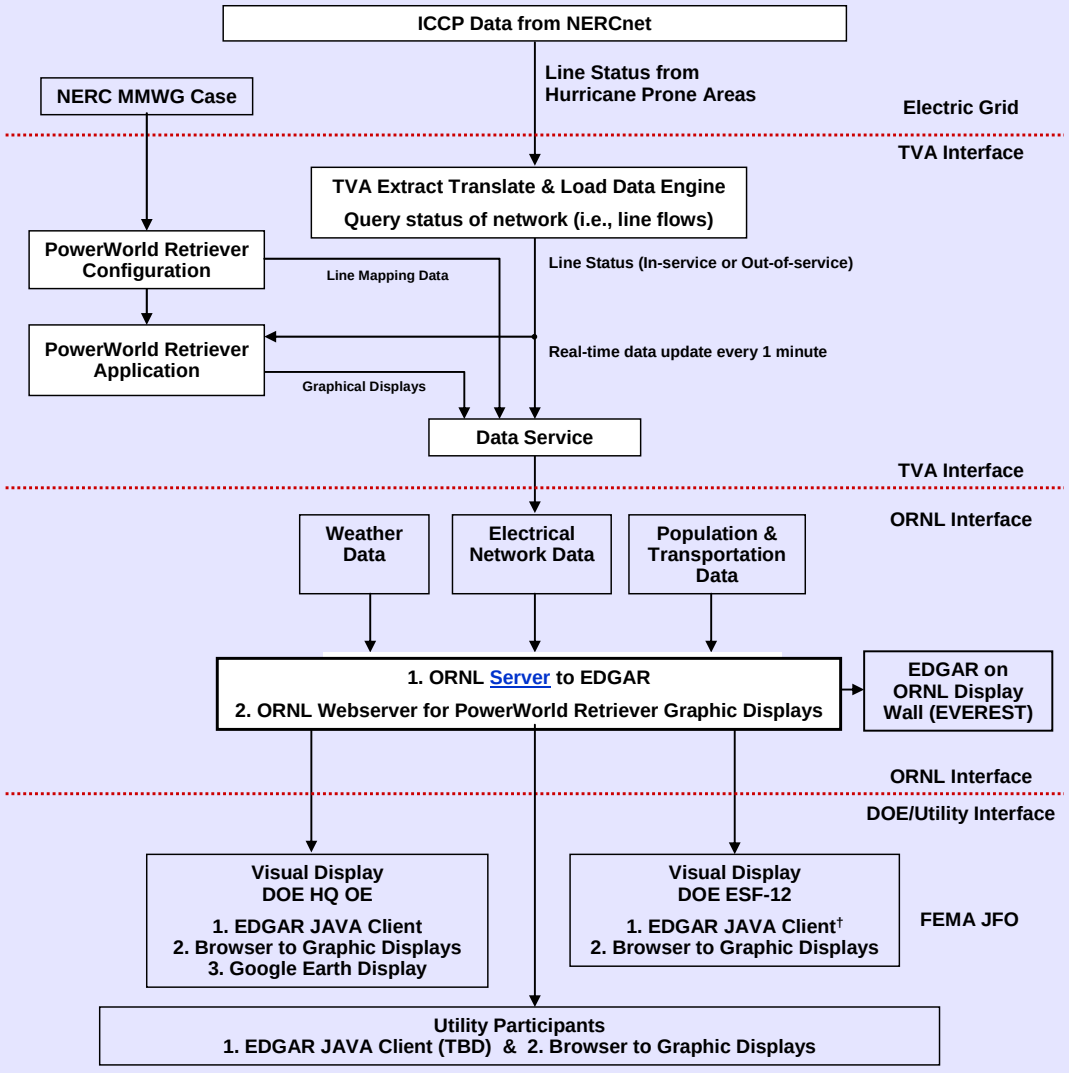
Grid Monitoring Architecture*

Phase 1: Hurricane Prone Areas



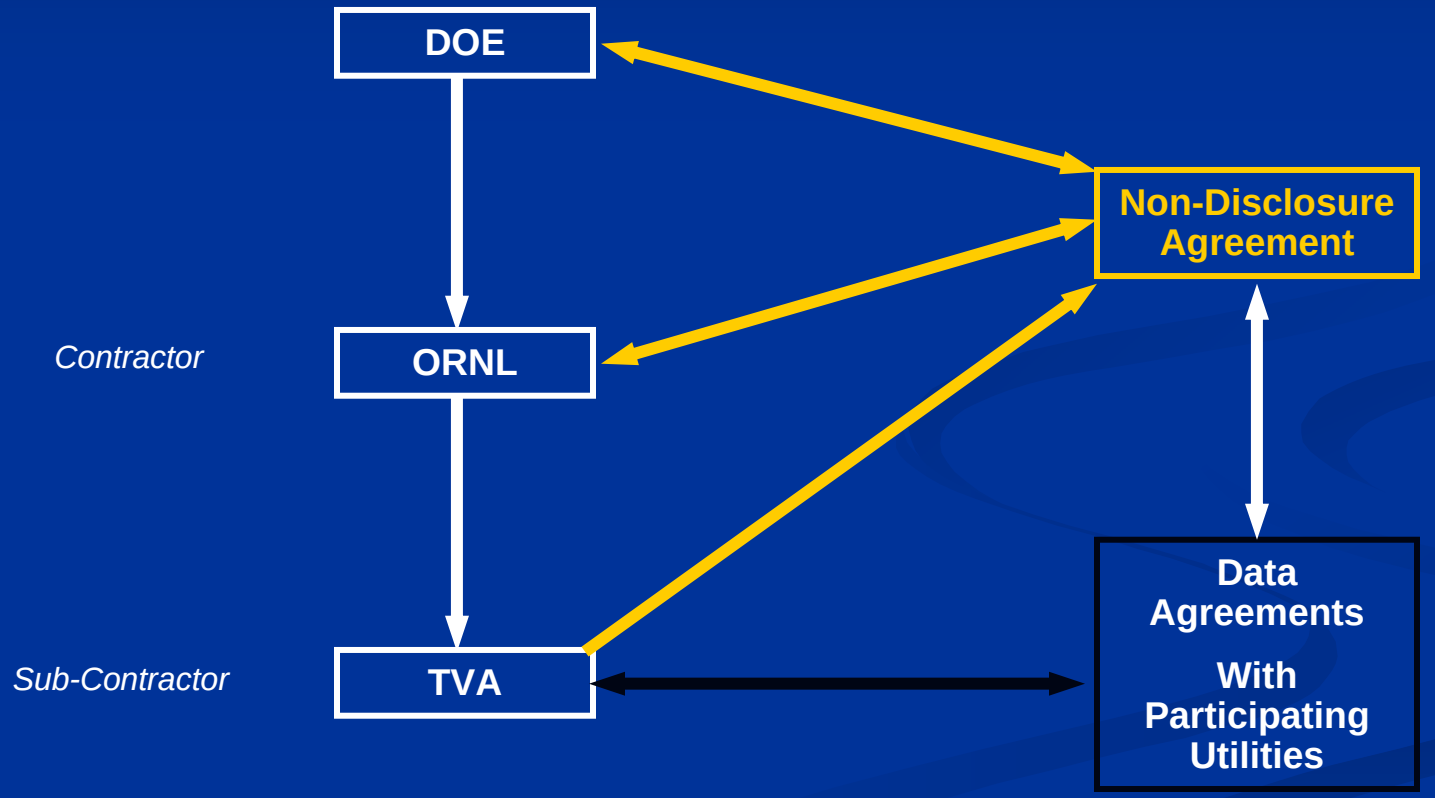
EDGAR - Electric Dynamic Grid Analysis and Review

† High speed internet connection required

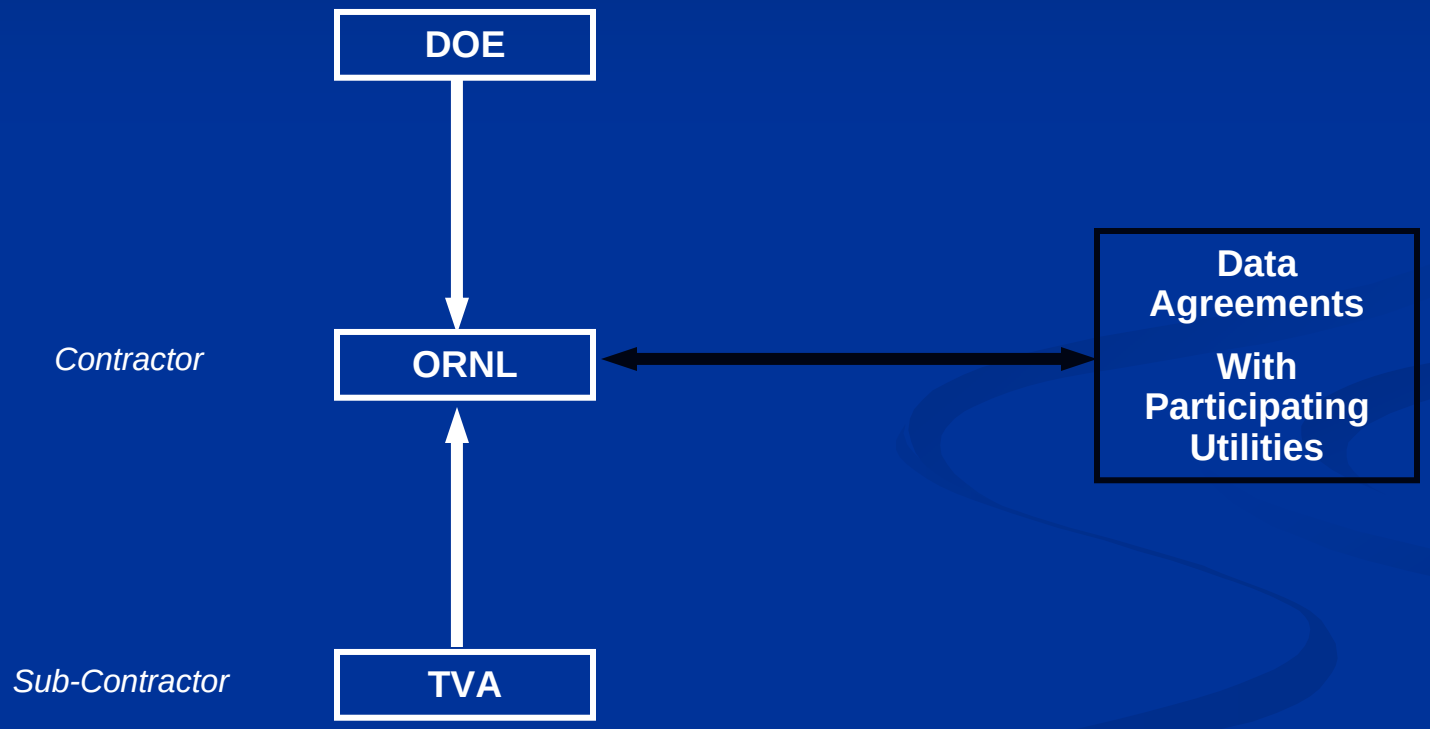
*Contingent upon DOE obtaining access to NERC Operational Reliability Data

Agreements Protect Data

Because the data is owned by each utility company, agreements have been executed to allow DOE access.



Agreement Structure to Reflect National Effort

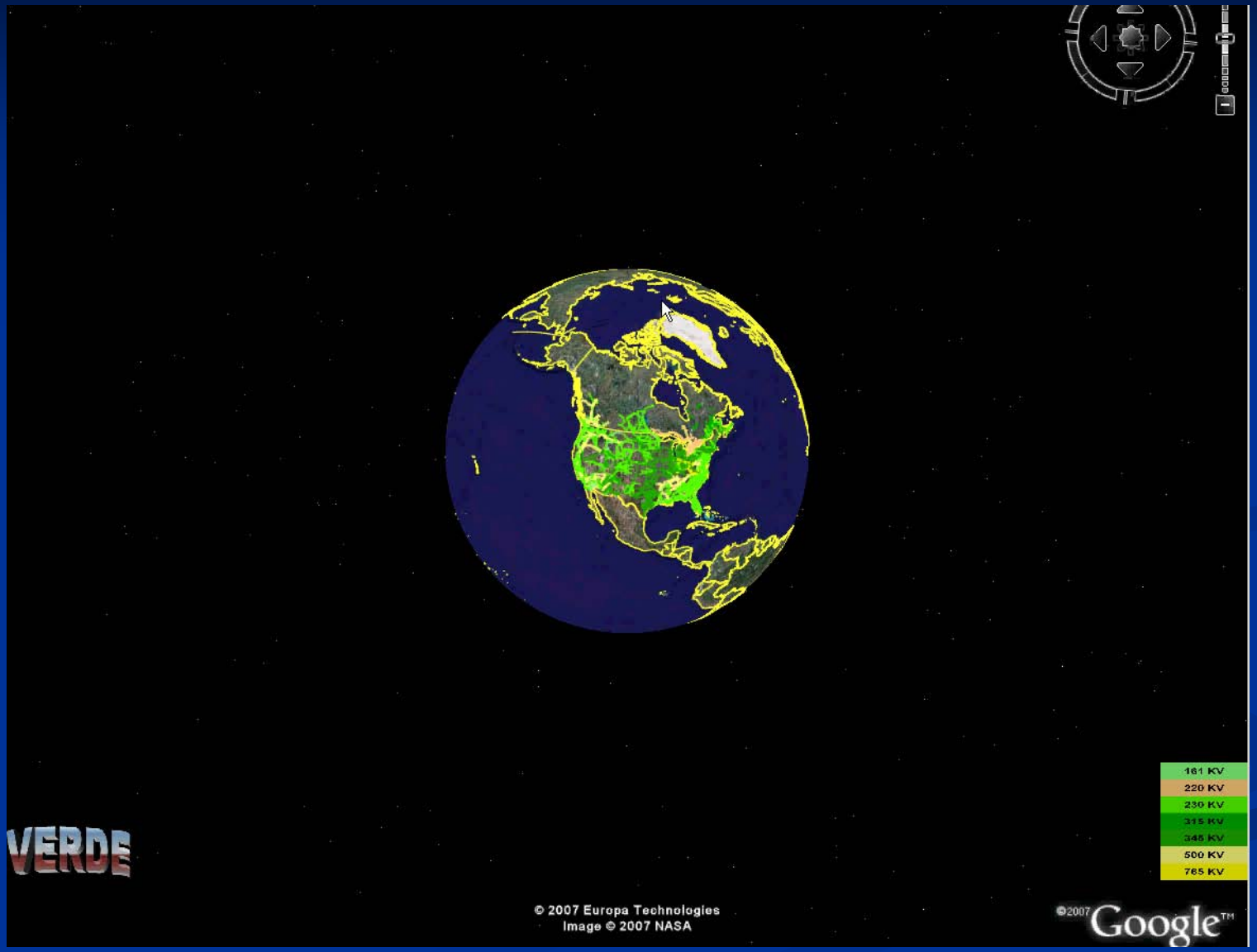


Transmission Line Status

- Line flow in megawatts is retrieved every minute
  - If flow is greater than 5 MW then line status is "On"
  - If flow is less than 5 MW then line status is "Abnormal"
    - Low power flow
    - Actually out-of-service
  - Data quality flag from SCADA is also retrieved
    - No update due to communications failure

Line Status	Data Quality		Total
(number of lines)	Good	Bad	
On, greater than 5 MW flow	675	2	677
Abnormal, less than 5 MW flow	20	6	26
Total	695	8	703

VERDE Tool


161 KV
220 KV
230 KV
315 KV
345 KV
500 KV
765 KV
VERDE
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Displaying Outages

Next Steps

- Complete Atlantic Coast mapping of real-time transmission line status
- Next phase is to look at national visualization effort
  - Storms, earthquakes, fires, physical and cyber attack
- Define additional value to utilities
  - Incorporate PMU data into visualization tool
  - Develop different permissions depending on stakeholder