

Wide Area Visualization Tools for Responding to Major Energy Disruptions



Tom King
Manager, Electric Delivery Technology Program
Oak Ridge National Laboratory

VERDE Team:
John Stovall, Walter Dykas and Arjun Shankar
Oak Ridge National Laboratory



Managed by UT-Battelle
for the Department of Energy



Driving Forces for Electric Grid Situational Awareness



Blackout 2003



Hurricanes 2005



Department of Energy - Office of Electricity Delivery & Energy Reliability

- **DOE is lead agency for executing Emergency Support Function #12**
- **Activated by DHS when a coordinated federal effort is needed**
 - Coordinate protection of critical energy assets
 - Assist federal, state & local governments involving a disruption
 - Preparation, response, restoration & mitigation



Electric Grid & Energy Infrastructure Situational Awareness

Major power outages over the past decade have occurred due to a lack of wide-area situational understanding

ORNL, in partnership with TVA, is developing a resource for the U.S. DOE's Office of Electricity Delivery & Energy Reliability that will enable real-time status of the electric grid and assess inter-dependencies with critical energy sectors

Assist in coordination of federal response to natural disasters or major events

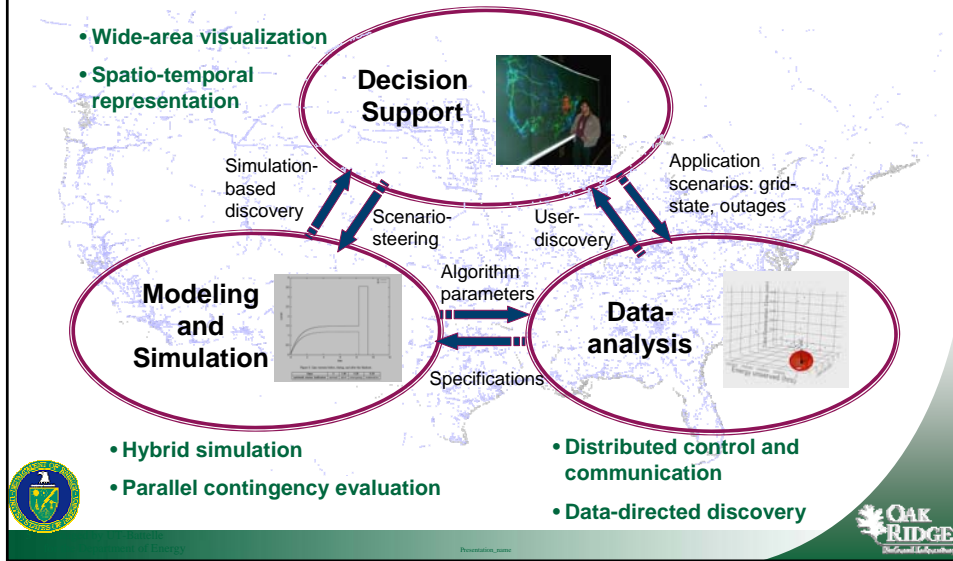


VERDE

Visualizing Energy Resources Dynamically on Earth



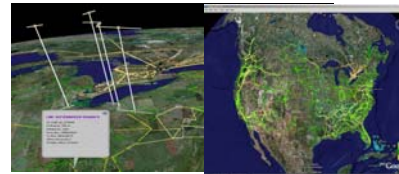
Computational Techniques for Electric Delivery Systems R&D



VERDE Capabilities

Visualizing Energy Resources Dynamically on Earth

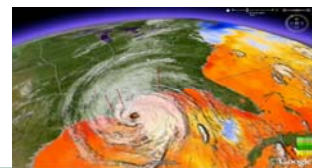
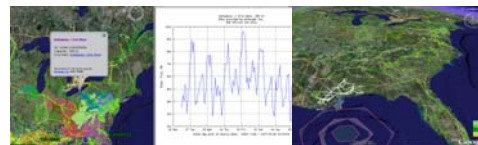
- Platform to provide wide area visualization capability
 - Flexible system
- Real-time status of transmission lines
- Real-time weather overlays
- Predictive impact models & Animated replay
- Data analysis
- Energy infrastructure interdependencies:
 - Coal delivery and rail lines
 - Refinery and oil 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



Proseware.com

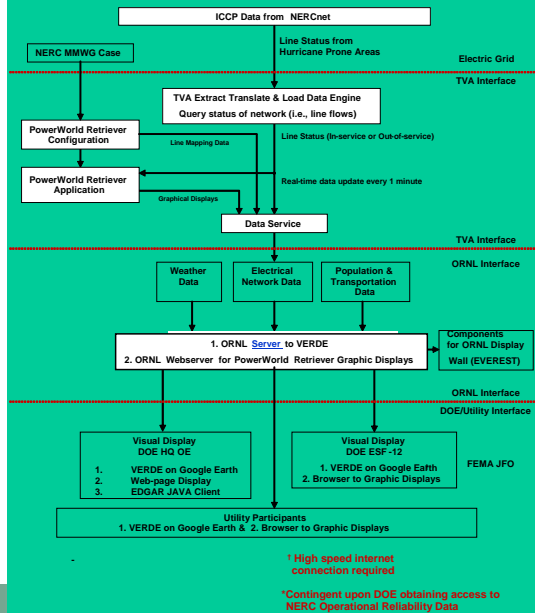


Key Elements of Process Flow

- 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

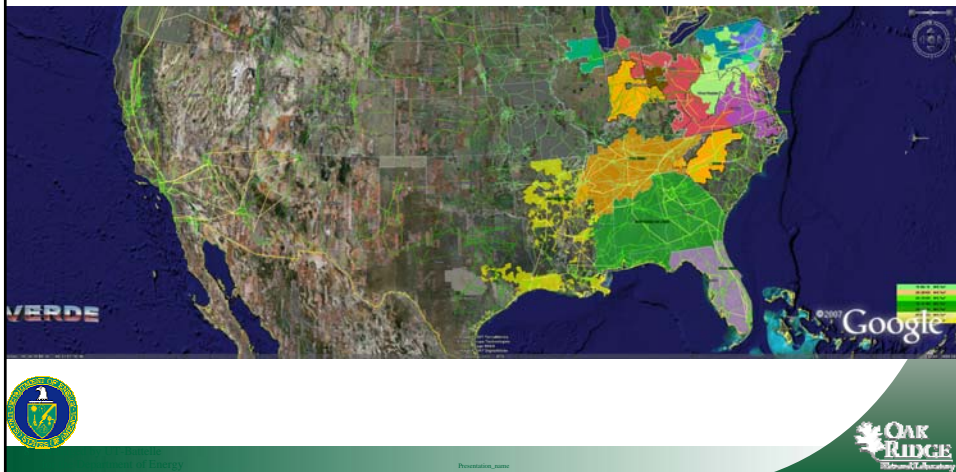


Grid Monitoring Architecture* Phase 1: Hurricane Prone Areas

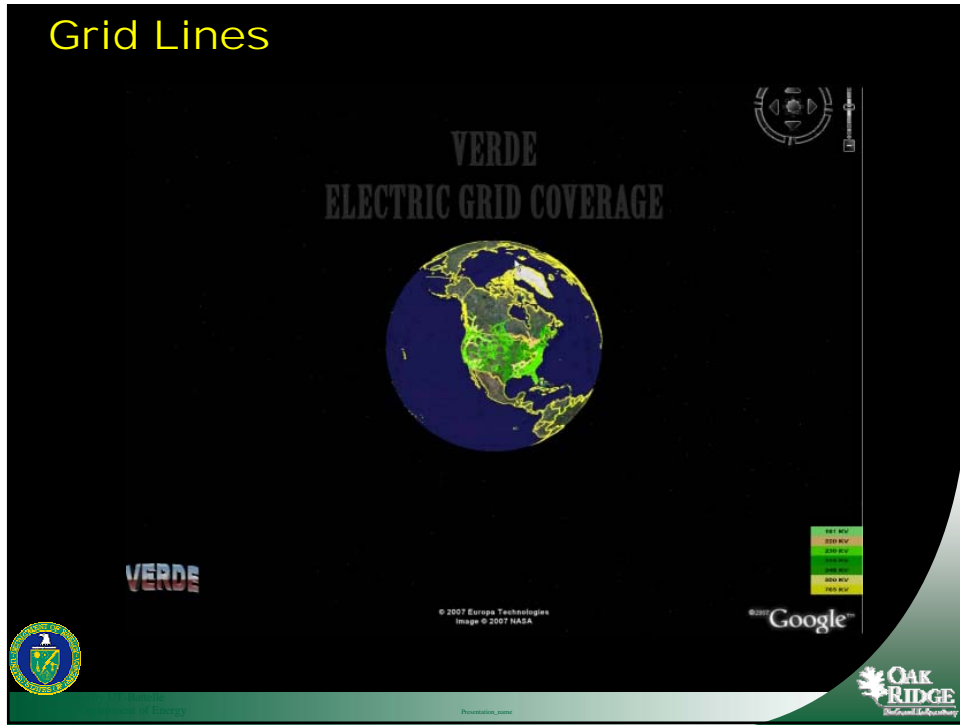


Verde Coverage

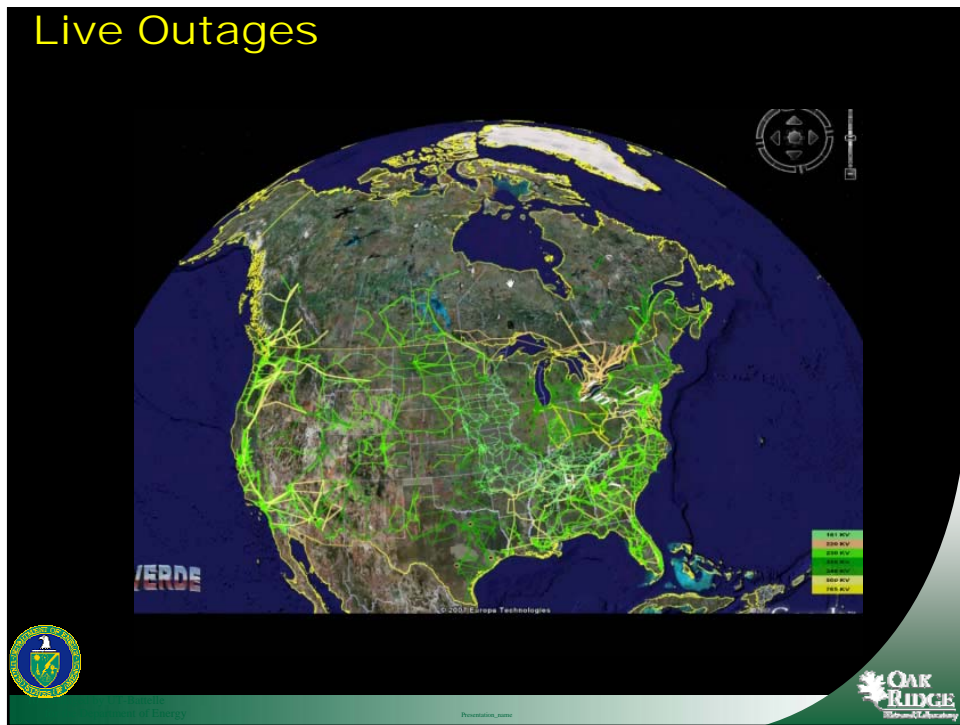
- **2007: Eastern Coastal Regions**
- **2008: Expansion across the U.S.**



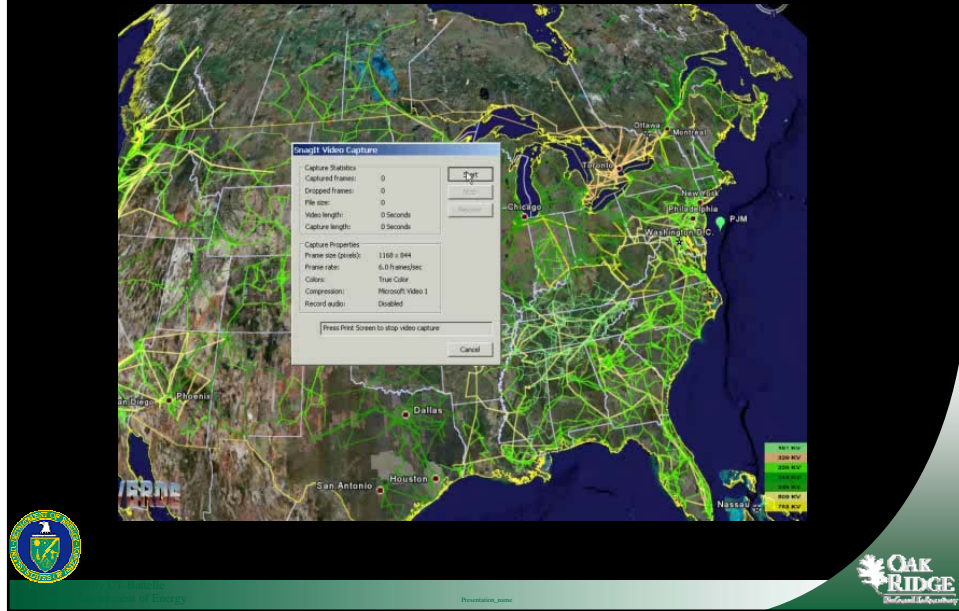
Grid Lines



Live Outages

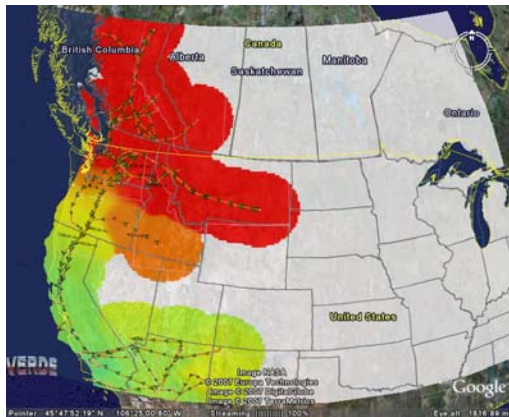


Live Display and Analysis of Feeds



Flexible Visualization Platform to Expand in the WECC region

- Phasor Measurement Data being incorporated into VERDE
- Entergy incorporating PMU data into their system





VERDE Integration with Various Data Sources



Weather Updates

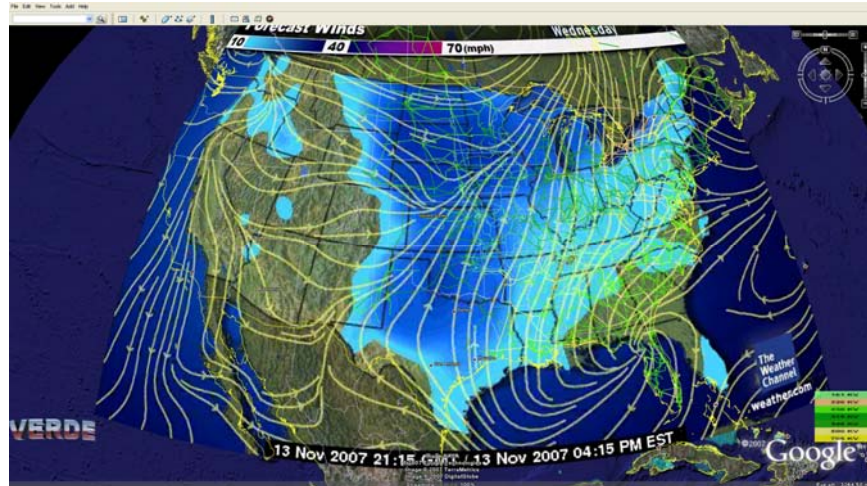
- **Weather overlays from NOAA and other sources**



Sources: VERDE, NOAA



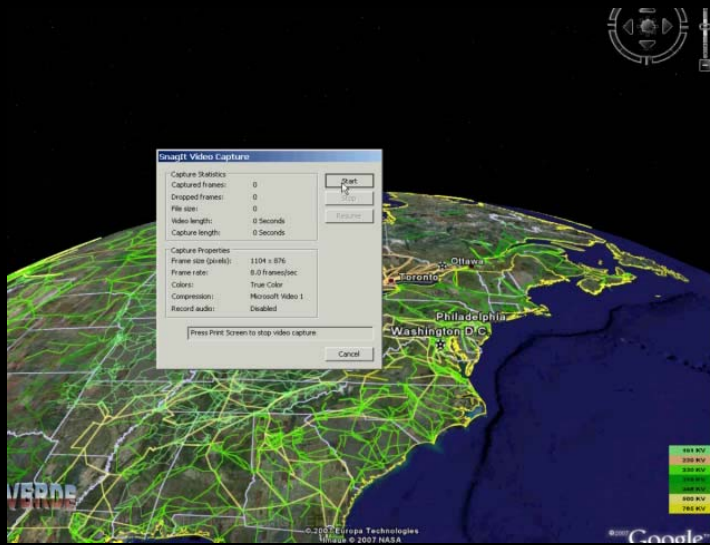
Wind Data



Sources: VERDE, The Weather Channel



Hurricane Views

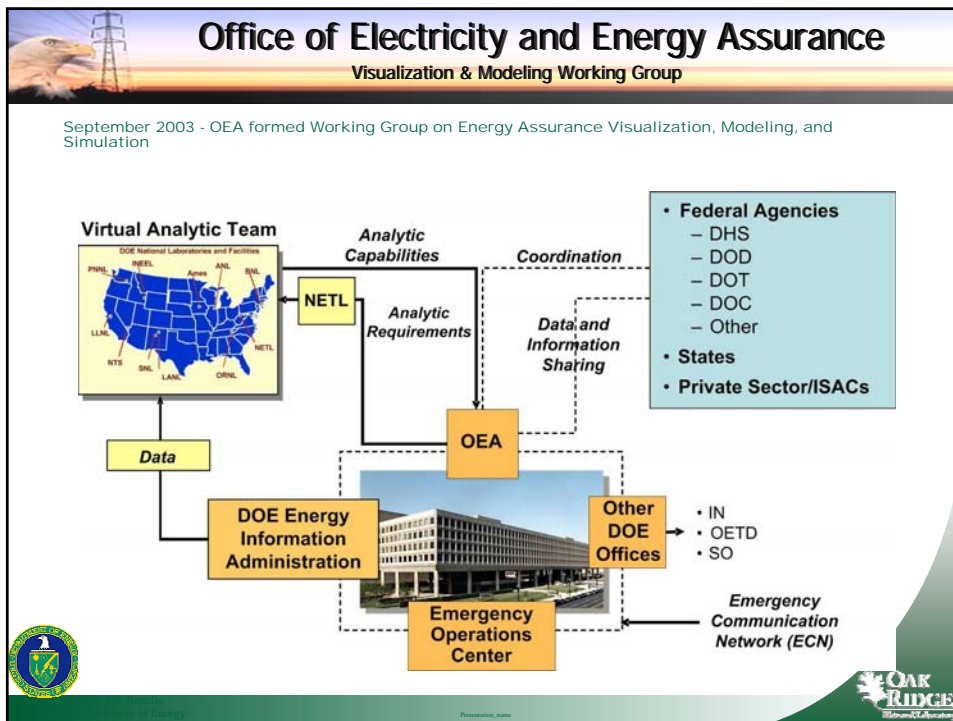


www.ornl.gov



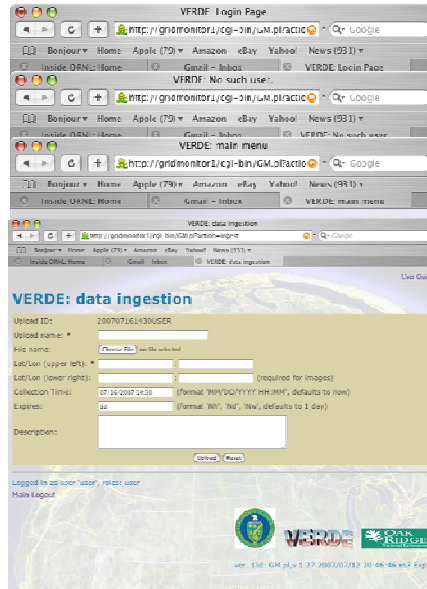


Integration of Analytical Capabilities into VERDE



Operational Capability for VMWG

- Links served to the clients (Verde connector)
- One of the links connects to the upload page
- Authentication on the upload page
- Upload
- Administrators have access to logs and user list

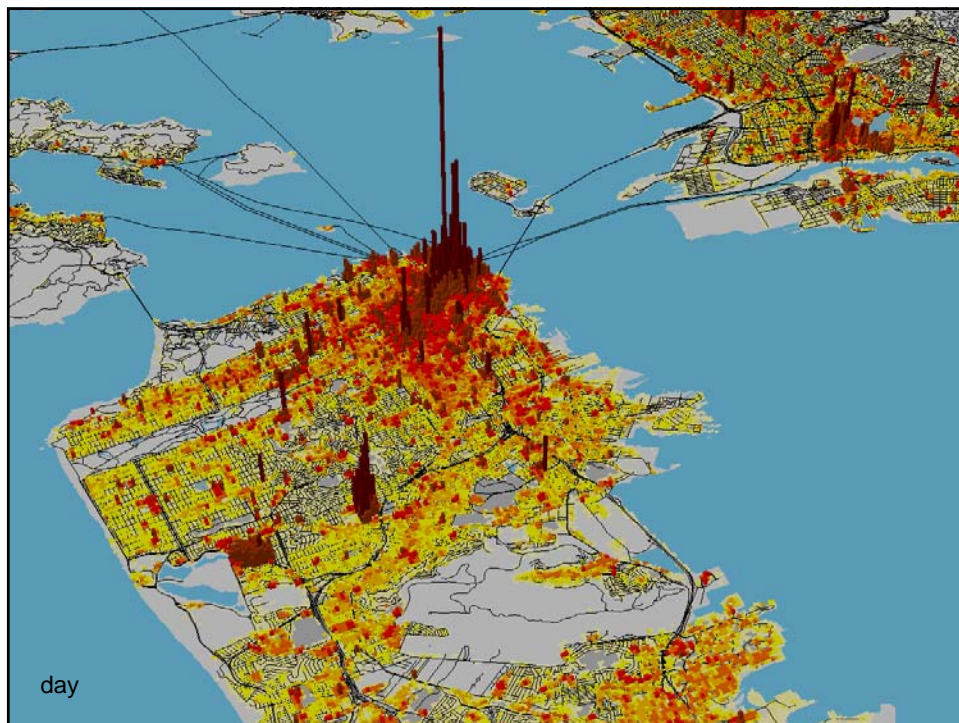
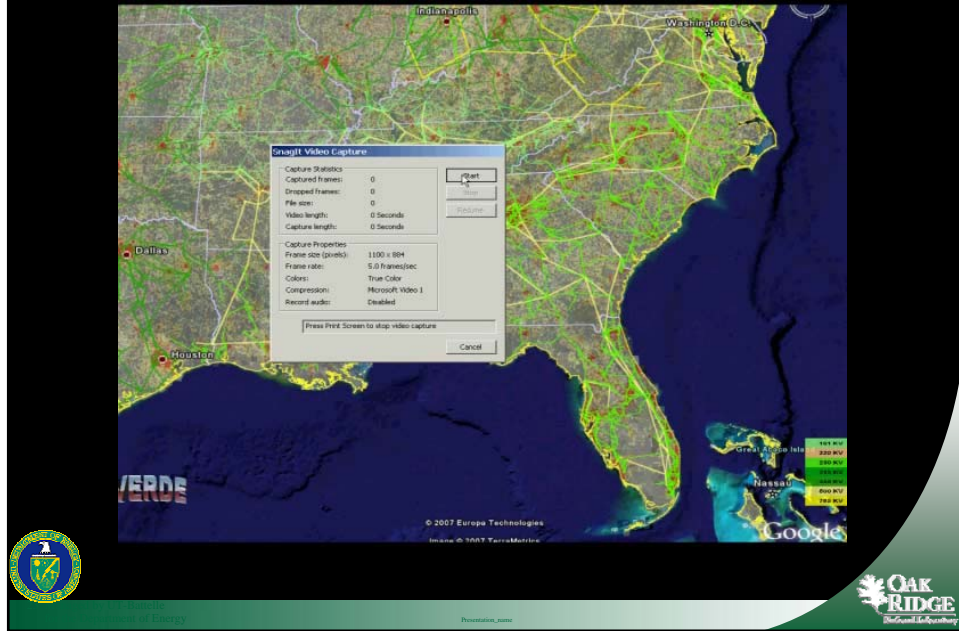


LandScan Population Distribution

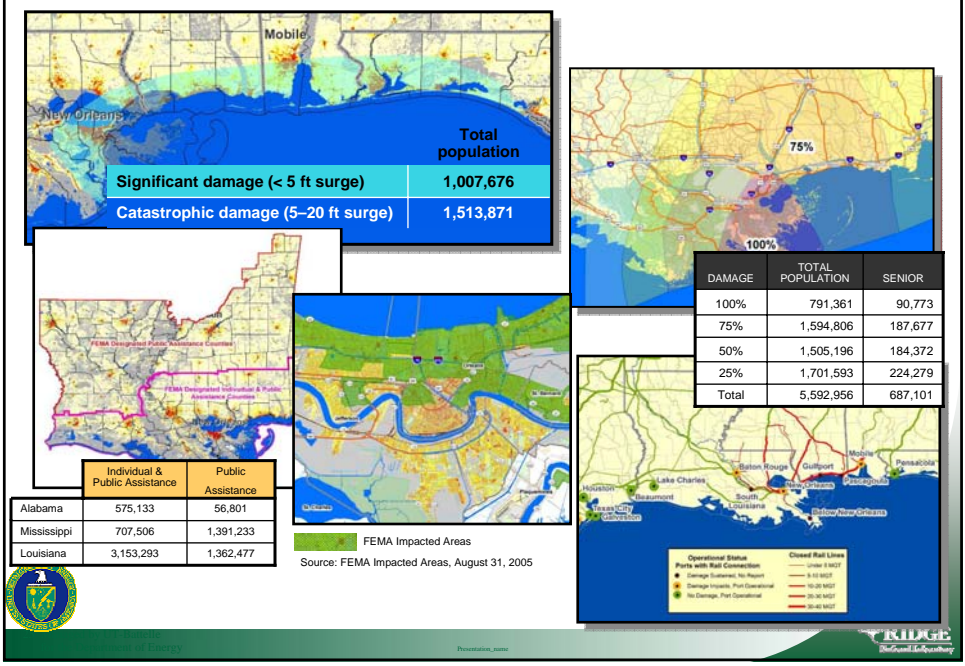
- Population counts for active display



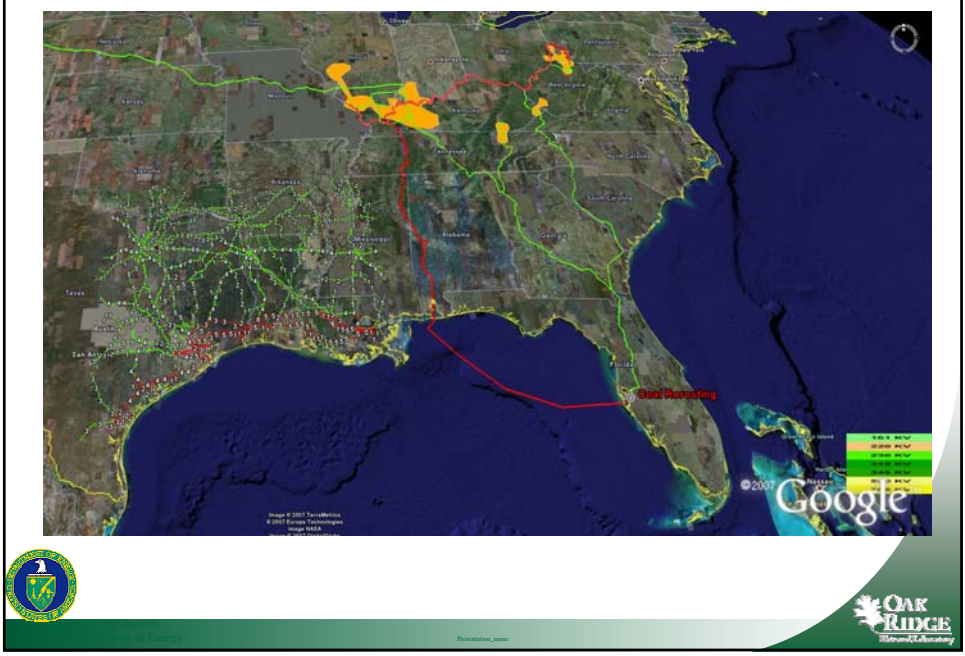
Impacts: Population, Commodities



Hurricane Preparedness and Response



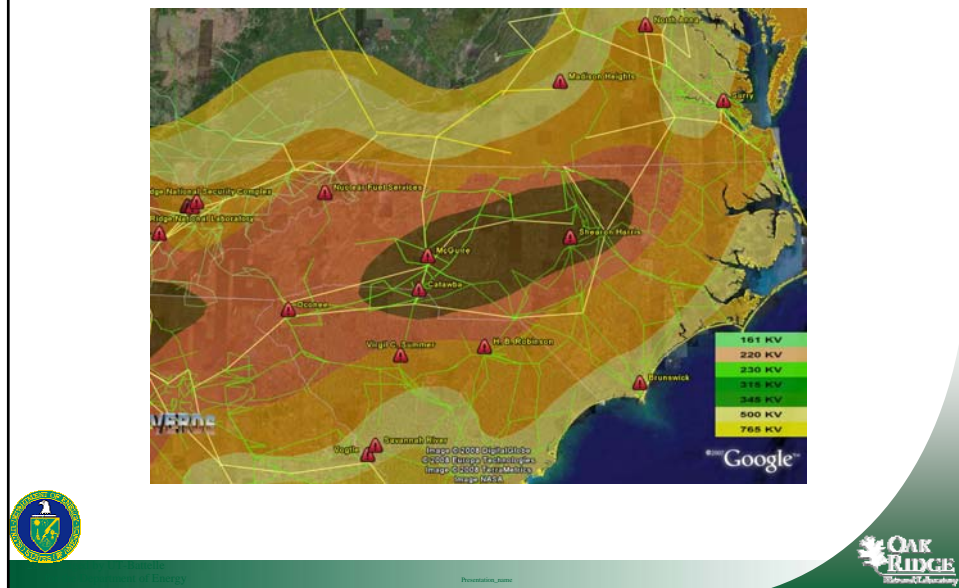
Railroad Routing Analysis



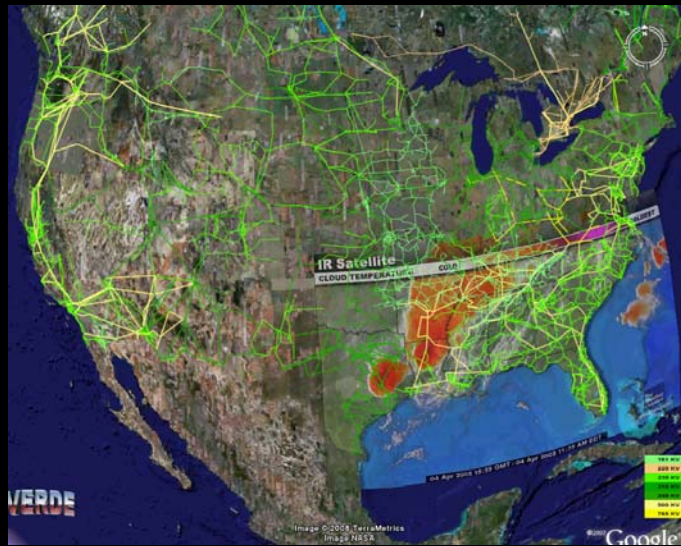
Energy Infrastructure Analysis



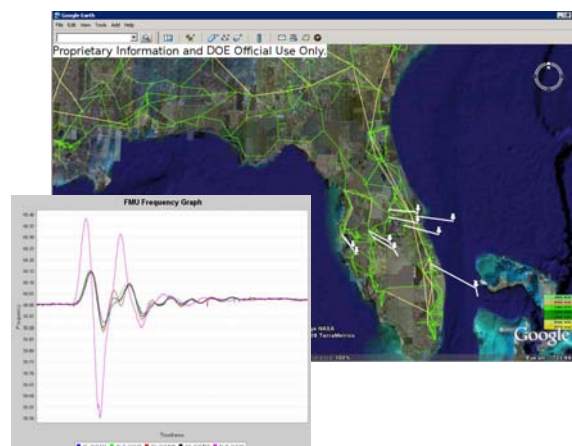
Analysis of Drought Conditions on Energy Infrastructure



Drought Impacts & Analysis



Florida Lines Out and FMU Frequency Graph



FLORIDA POWER OUTAGE

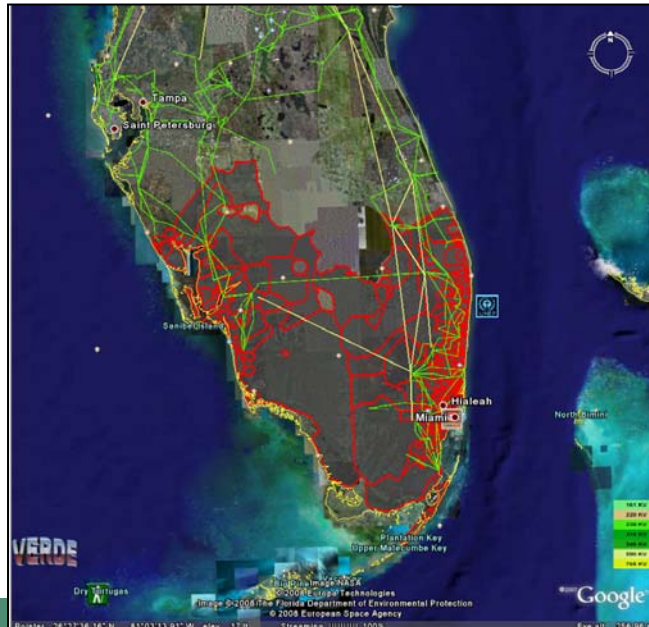


Source: Florida Power & Light, News reports
 By Anne R. Carey, Ron Coddington and
 Oren Dorell, USA TODAY



Outage Prediction Analysis

- Electrical service areas impacted by Florida Blackout
- Feb 26, 2008
 - Estimates derived from news reports of impacted regions



Summary

- DOE Office of Electricity Delivery and Energy Reliability is providing leadership for wide area situational awareness
- Tools, such as VERDE, will help in coordination and federal response of major disruptions to the energy and electric infrastructure

