



## ***Big Data for Government Symposium***

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# Integrated System Modeling for Handling Big Data in Electric Utility Systems and Microgrids

*Stephanie Hamilton, Smarter Grid R&D,  
Global and Regional Solutions  
Directorate, BNL ISGAN/SRFIN Meeting,  
Government BIG DATA Symposium  
June 18, 2014*

**BROOKHAVEN**  
NATIONAL LABORATORY

*a passion for discovery*



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

# Capability Summary: Brookhaven National Laboratory (BNL)

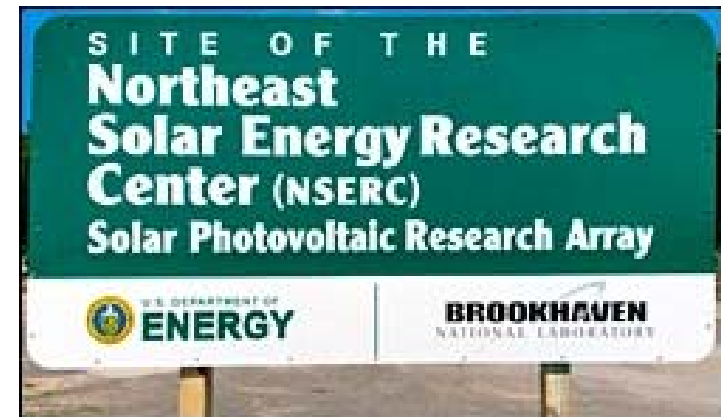
- Northeast Solar Energy Research Center (NSERC)
- SGRID3: Smarter Electric Grid Research, Innovation, Development, Demonstration, Deployment Center



*Distribution Automation that responds to model-centric control will create the 21st Century Grid*

# Northeast Solar Energy Research Center (NSERC)

- Grid-connected 1MW solar energy research array with reconfigurable architecture for field testing innovative new smart grid technologies
  - Renewable Energy Integration
  - Advanced Smart Grid Sensors
  - Distribution Simulation and Automation
  - Distributed Generation and Storage
  - Advance Power Electronics
  - Interoperability, Communications & Security
  - Solar Technology & Grid-Related Standards & Codes



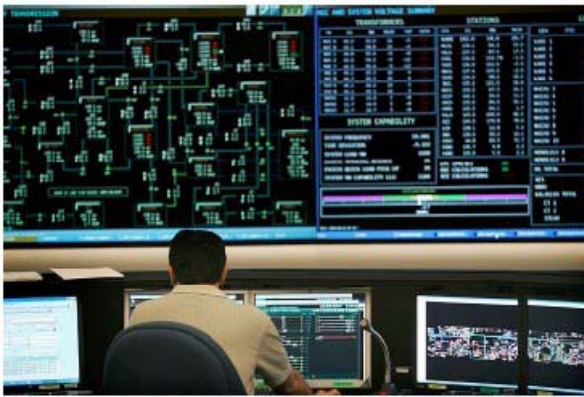
**NSERC will provide unique capabilities for renewable energy and smart grid research:**

- 1MW grid-connected solar research array
- Field testing under actual northeastern US conditions
- No UL listing or interconnect permits needed
- Instrumented smart micro-grid test bed
- Access to data from eastern interconnection



# Smarter Electric Grid Research, Innovation, Development, Demonstration, Deployment Center (SGRID3 )

- With the vision of model-forward, SGRID3 will provide the facility and focus on the Northeast electric grid with modeling and simulation using actual power systems in real time operation
  - Integrated System Models
  - Historical and real time data and measurements
  - Geographically-based information
  - Component Models
  - Simulations of natural and unnatural events
  - Developing and testing advanced micro-grid management strategies



Brookhaven Science Associates

**SGRID<sup>3</sup> via its Advanced Electrical Grid Innovation and Support (AEGIS) Center will facilitate the development of new capabilities to allow utilities to monitor and model their grids in real time – a capability that currently does not exist.**

- Develop knowledge that will guide future utility investments in the electrical transmission and distribution systems in the Northeast.
- Provide computing capability for grid studies with simulation focused on natural and unnatural events

# Collaborative Research at BNL Distribution Automation

- BNL is currently working with utilities and other Smarter Grid stakeholders and would like to expand its collaborations, especially for *resiliency*, *restoration*, and *reliability*
- BNL's focus is for distribution but can easily simulate Transmission and Distribution grids in one integrated system analysis in real time
- BNL is looking for research collaborators for Smarter Grid in general & especially Distribution Automation (DA)
- BNL believes Model-Centric is the Foundation for Smarter Grid DA



# **Smart Grid Distribution Automation Using Model-Centric Control with Cost/ Benefit Analysis**

**Orange & Rockland Utilities**

***Charlie Scirbona – Department Manager  
Smart Grid Engineering***

**August 28, 2013**



**Orange & Rockland**  
a conEdison, inc. company

# Path to Creating Hard Dollar Savings

- Benefits quantified by comparing investment and operating costs of alternative designs
- Model-centric approach from analysis to real-time automation – Simplicity, Flexibility
- Use simulation over time varying load and time varying cost curves to evaluate costs of alternatives
- Smart Grid Lab tests of most promising designs using hardware-in-the-loop testing
- Carry out pilots and demos

*As in other automated industries, analyze alternate designs before investing in construction...*



# Integrated System Model Concept

## *ISM Living Model Concept*

### Real-time integrated analysis:

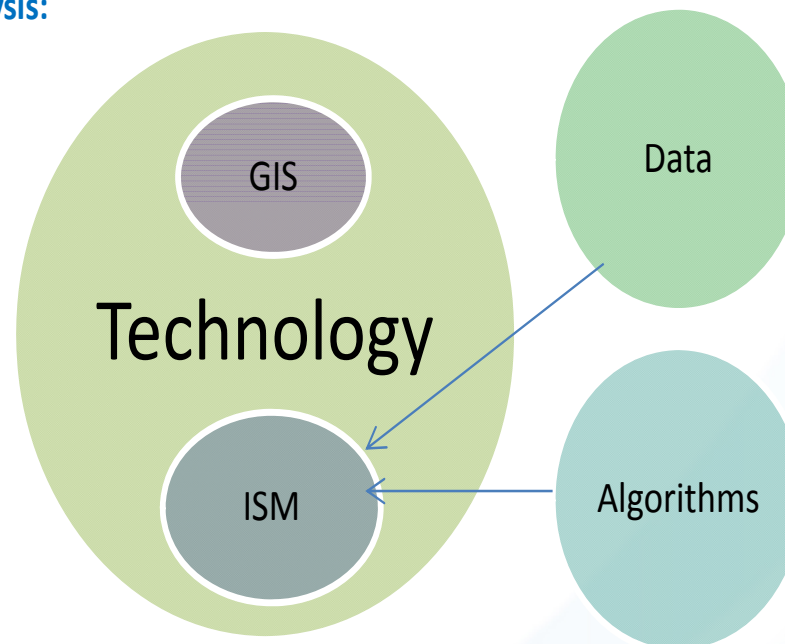
- **Transmission**
- **Distribution**
- **Customer load**

#### **GIS**

Up-to-date Geospatial mapping of utility system components.

#### **ISM**

Exact, precise, integrated representation of utility system.



#### **All measurement data**

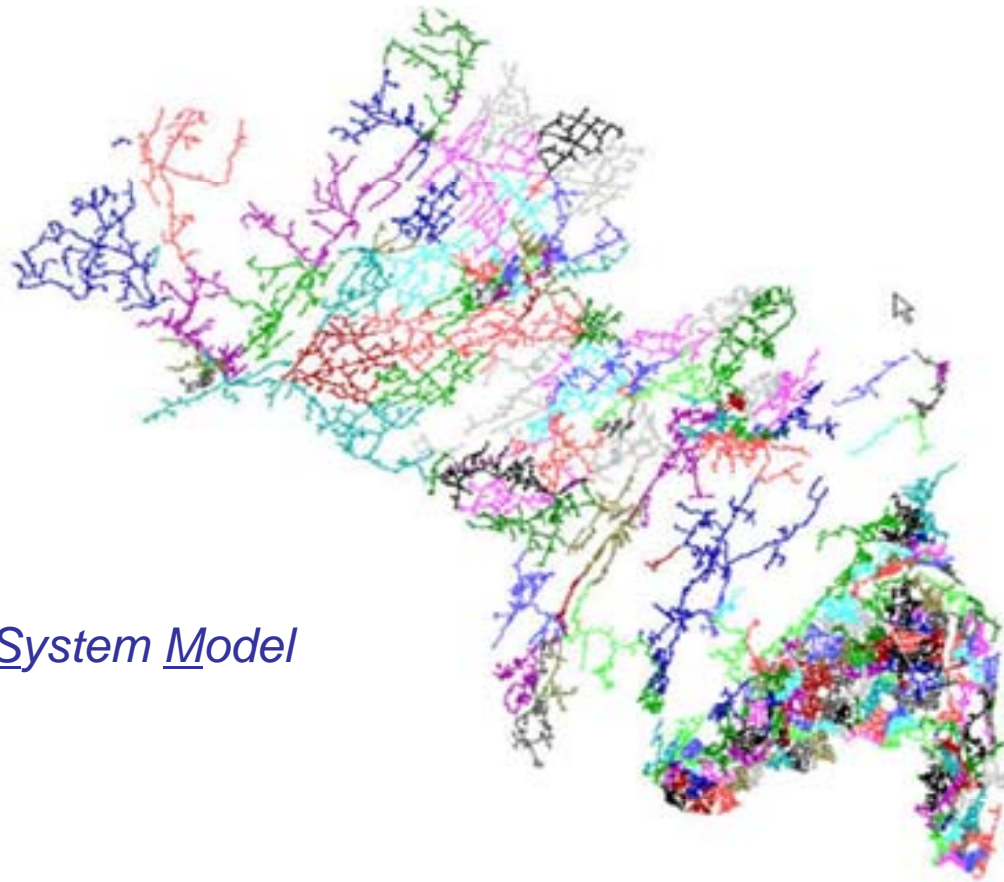
Customer Load, SCADA, Switch change, Outage Data, Weather Data, Field Reports, GIS Updates, etc.

#### **Algorithms**

Proven on IEEE Standard Models. Run in real-time on detailed model of entire T&D system.

*The utility's ISM is the only, real and true representation of its electrical and geospatial physical system*

# ISM Provides the Means

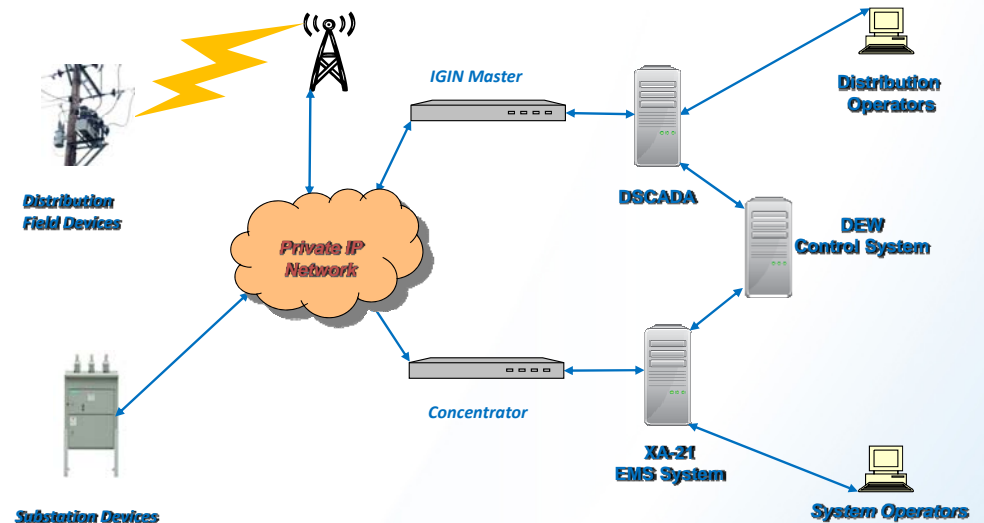


*ISM = Integrated System Model*

*Use one, detailed, root model for all analysis, from planning to real-time analysis and control, maintained in synch with physical models...*

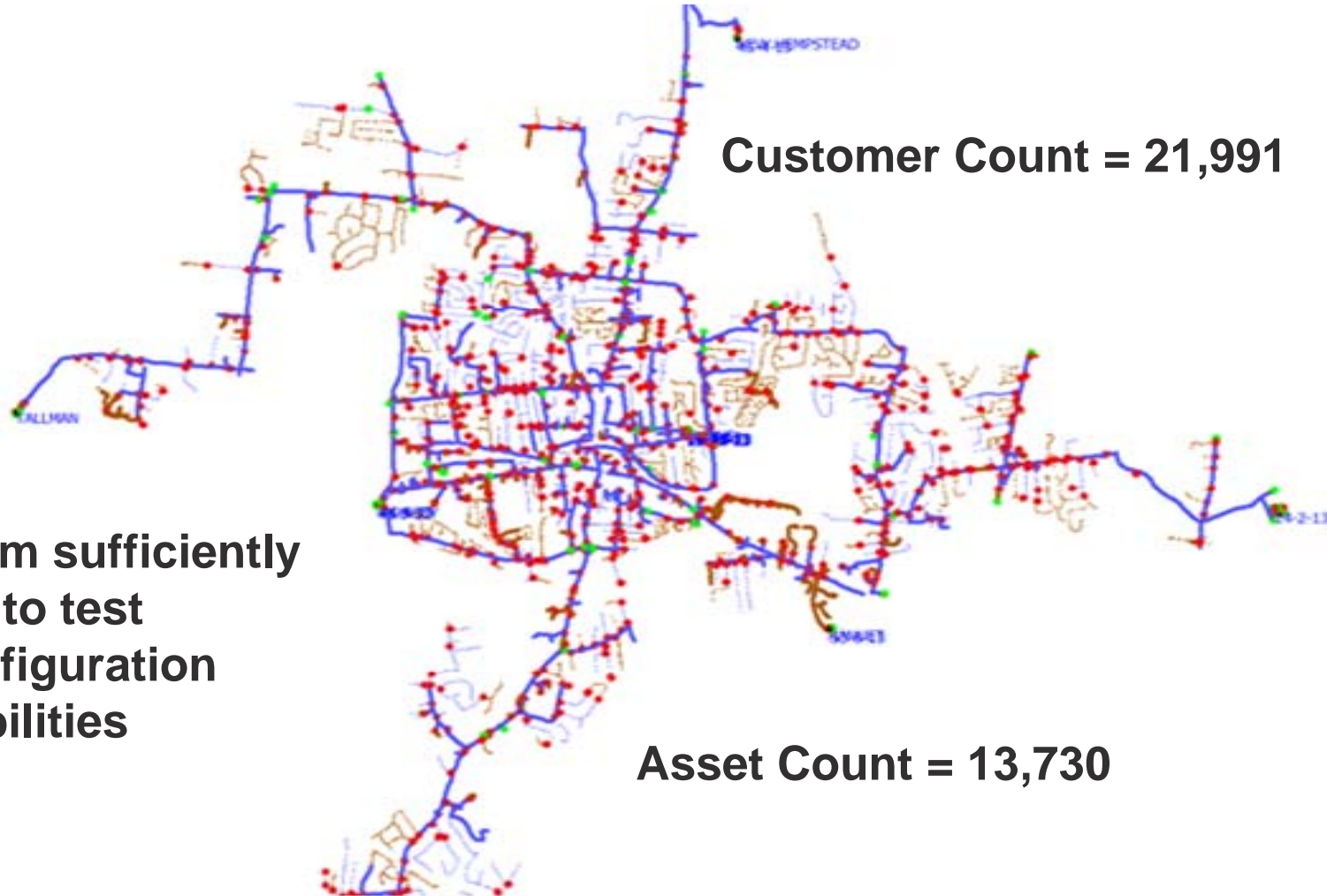
# Model Centric Approach to DA

- Relies on the system model that replicates the physical electrical system in GIS
- Primary meteorological data sources are radial Doppler velocity and reflectivity measurements from existing weather radar systems (NWS, JFK).
- Other meteorological data sources include Numerical Weather Prediction Model output, NWS radiosondes, local surface meteorology stations.



**Define a robust statistical model based on relationships between meteorological observations of severe weather conditions, electrical outage information GIS vulnerability mapping.**

# 14 Feeder Model Considered for Automation

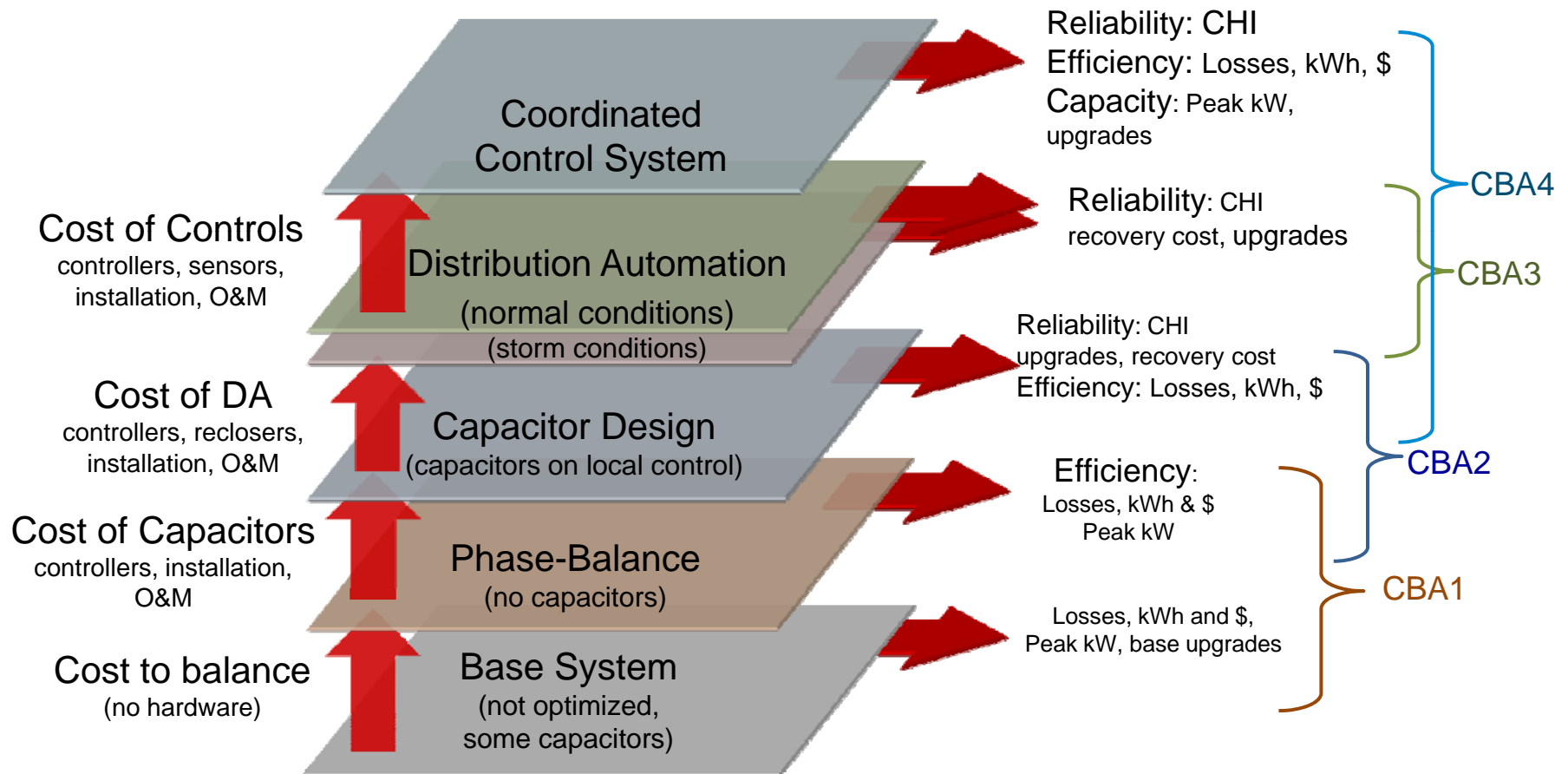


**System sufficiently  
sized to test  
reconfiguration  
capabilities**



# The study examines a complex project in stages, addressing a series of Cost/Benefit Analysis questions

## “Stacking Order” of CBA Questions

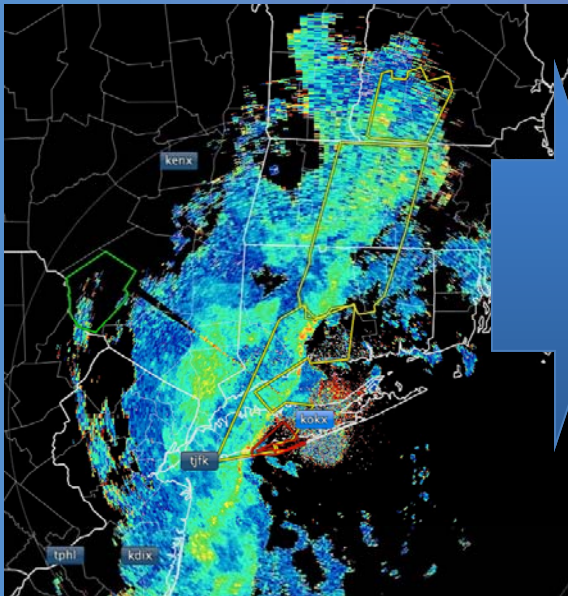


# 10 Year Savings Across Storm Types

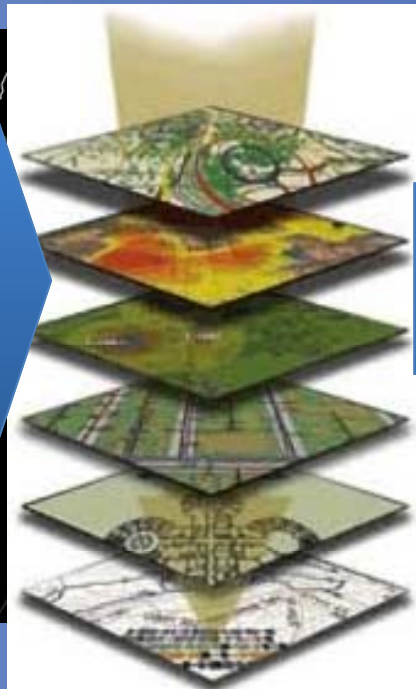
Storm Type	Switching Crew Hours	Number of Crews	Hourly Storm Cost (\$k)	Number of Storms	Non-discounted Savings
High Temp	40	100	\$70k	13	\$364k
Moderate Temp	60	100	\$70k	12	\$504k
High Temp Strong Wind	213	142	\$100k	17	\$2,550k
Moderate Temp Strong Wind	168	142	\$100k	23	\$2,721k
Low Temp	127	171	\$120k	7	\$624k
Low Temp Strong Wind	403	171	\$120k	10	\$2,830k
Total Savings					\$9,592k

# Predictive Tools for Forecasting Weather Impact on Utility Electric Systems

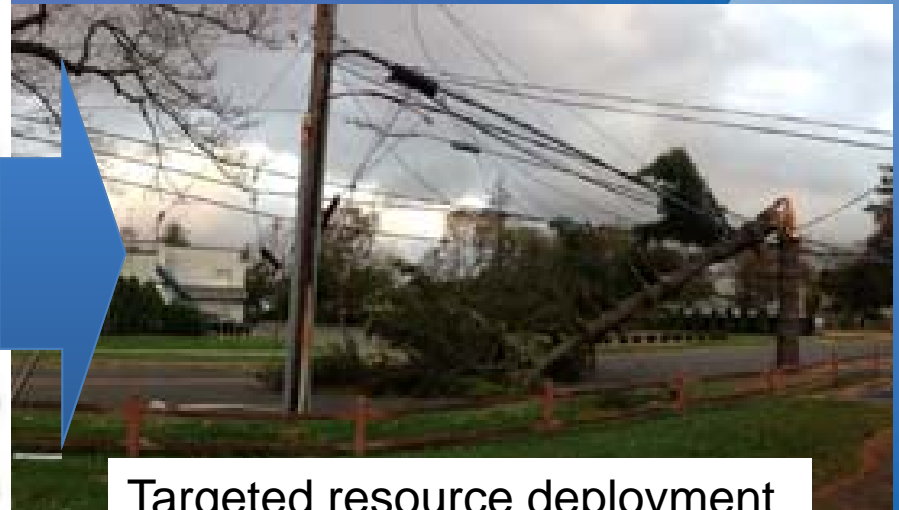
*Gerald Stokes, Associate Laboratory Director,  
Global and Regional Solutions Directorate*



Meteorological Data



Predictive Analysis



Targeted resource deployment

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# **Development of Tools for Use by Utility Grid**

- **Phase 1: Analysis of historical data (damage and meteorological) to generate weather-vulnerability statistical models.**
  - Relationships between occurrence of severe weather and damage to the electrical utility infrastructure
  - Calculations of Vulnerability Indices/Maps (VI)
  - Simulations to Design of Distribution Automation to harden (e.g. undergrounding, vegetation management) systems against storms
  
- **Phase 2: Interface model with real-time threats for operational “Damage-cast” (1 hour post-event) and “Nowcast” (0-3 hour forecast)**
  - Identification of storm conditions and threat level
  - Prediction of outages based on storm characteristics
  - Based on VI, establish real-time response actions by location
  - Develop survivability plan for affected customers based on VI



# Development of statistical model based on historical data



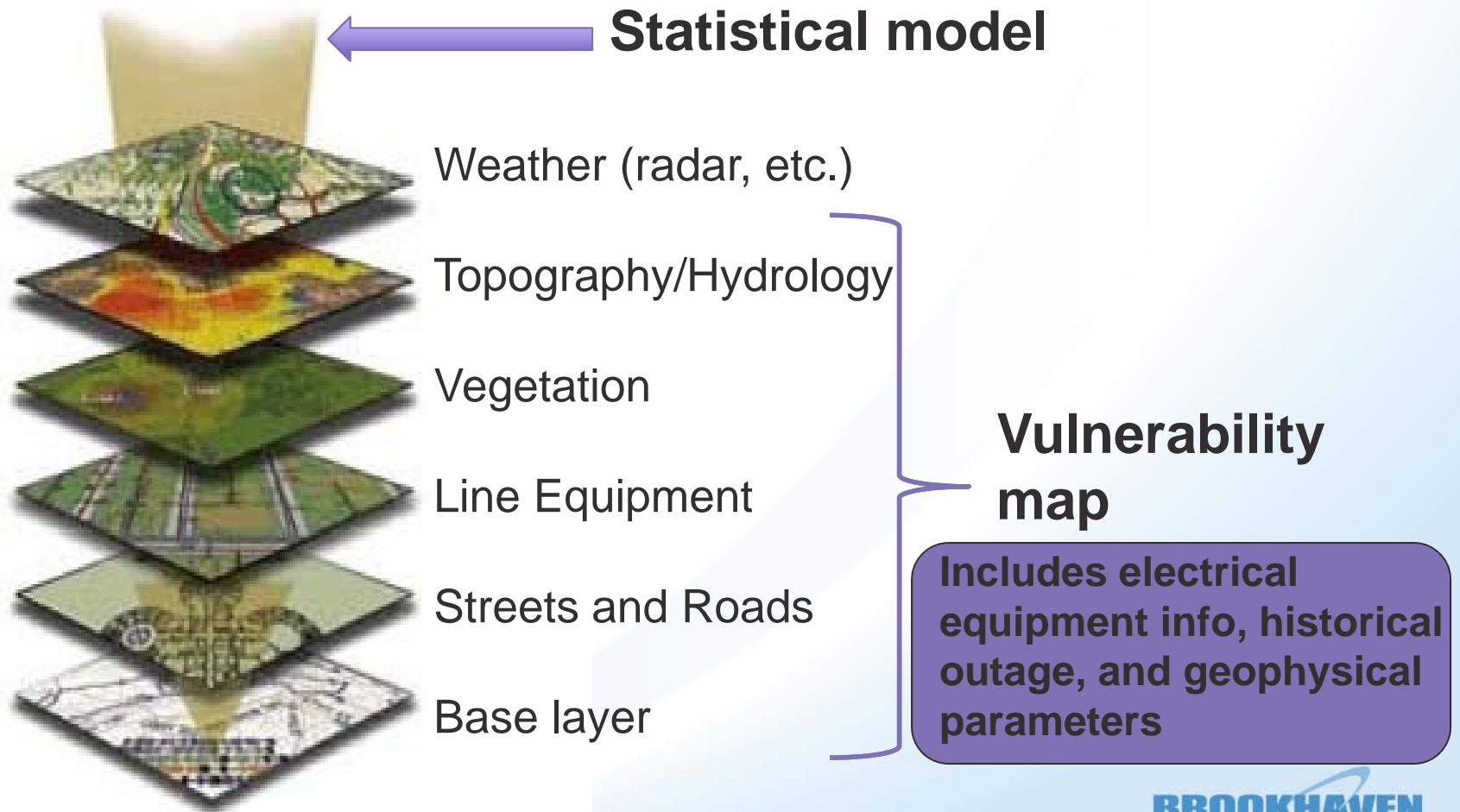
**Define a robust statistical model based on relationships between meteorological observations of severe weather conditions, electrical outage information GIS vulnerability mapping.**

- Analysis based on meteorological observations and outage data.
- Primary meteorological data sources are radial Doppler velocity and reflectivity measurements from existing weather radar systems (NWS, JFK).
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# GIS: Vulnerability map coupled with statistical models

**“Damage-cast”**

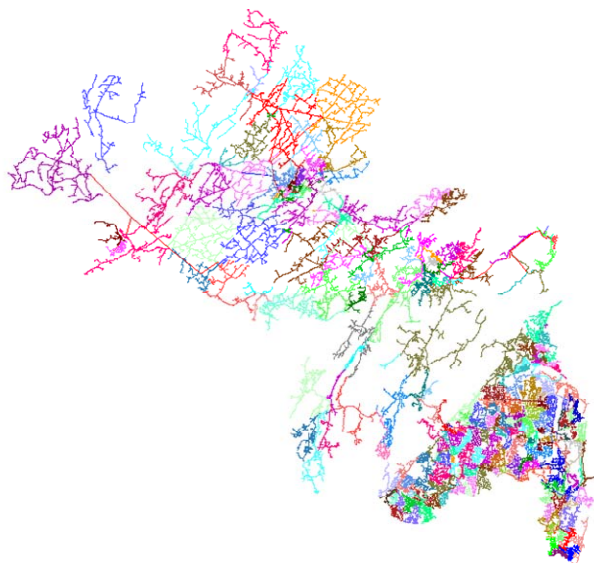
\* Post-event within one hour,  
extendable to 0-3 hour forecast



# Integrated System Models

Merge many existing, models together, relating all measurements in context of ISM

Reusable



Planning?  
Automation?

Integration of renewables?  
Training?

Load forecasting?  
Storm response?

*BNL is working to facilitate solutions that enable the Grid to provide reliable, low cost, electricity*

# **Smarter Electric Grid Research, Innovation, Development. Demonstration, Deployment Center (SGRID<sup>3</sup> ) at BNL**

**Use Model to simulate and show Benefits**

- **Show how to establish VI and simulate benefits**
- **Determine whether it is replicable to other grids**
- **Establish how grid can make use of model and VI**
- **Develop Action Plan and evaluate through simulation**
- **Storm training using historical storm data using problem domain language**



Brookhaven Science Associates

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