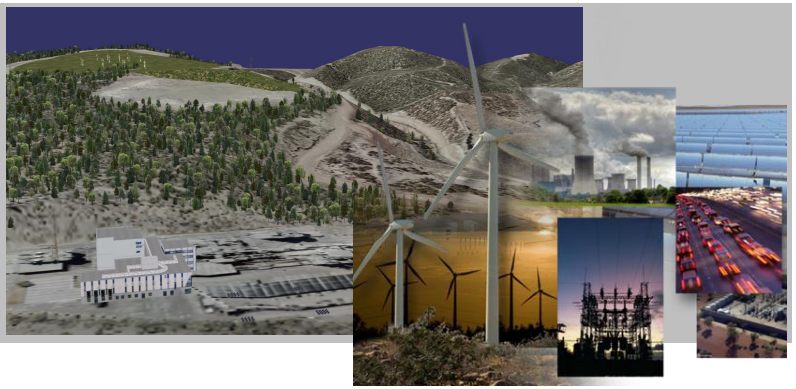
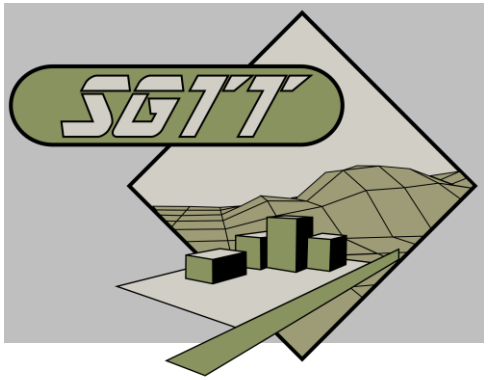
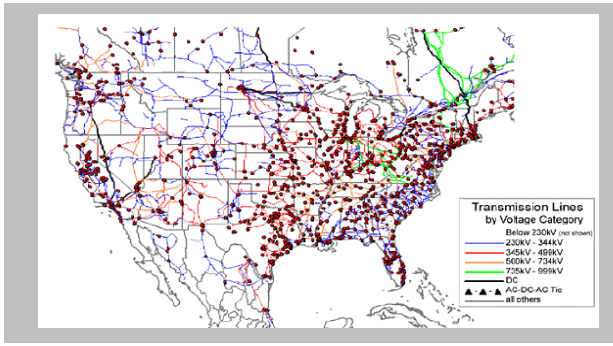
SAND2012-1656C

Exceptional service in the national interest

Sandia National Laboratories







SGTT Support of Vermont Project

Visualization, Simulation, Gaming, and Cartography

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Introduction

Sandia National Laboratories

Team Members

Melissa Sisneros - Overview

Brian Jeantete - Geographic Information Analysis

Tam Le - Serious Gaming and Gamification

James Rivera - Security (Physical/Cyber/Threats)

- Matrixed personnel and support across SNL
- Access to multiple GIS agencies for best available data
- Access and expertise in Sandia developed tools
- Security Clearances

Areas of Expertise

- **Visualization**
  - Umbra
  - OpShed
- **Simulation**
  - Umbra
  - Dante
- **Serious Gaming**
  - Unity
  - VBS2
- **Cartography**
  - GIS
  - CAD Civil
  - Terra Vista
  - Topological
- **Model Development**
- **Analysis**
  - Site Security
  - Cyber
  - OpShed
- **3D Scanning**
  - Point Cloud
  - Interior
  - Exterior
- **Data Curation**

Support of Vermont Project

Sandia National Laboratories

- **Cyber - Pathway depiction and cascading impact could have on grid**
  - Game as part of control-room training
  - Gamifying complex systems
  - Trainer based on complex systems

- **In-Home and/or Computer-Based Displays**
  - Vital to consumer interaction with smart meters
  - Depict real-time electrical usage
    - In consumer-enticing way (utility rebates, tax credits)
  - Build energy efficiency calculators
    - Property owners obtain personal energy efficiency potential
    - Compare cost analysis for solar vs. utility power
  - Build solar efficiency calculators
    - Enable users to draw location of potential solar array on roof
    - Calculate projected production
    - Calculate various financial benefits using local incentives, utility rate and insulation data

Support of Vermont Project (Cont'd)

Sandia National Laboratories

- **Data Curation**
  - Front ends applicable to what you want to accomplish
  - Collect already established user data into centralized database
  - Multiple applications:
    - In-home console
    - Web application
    - iPad
    - iPhone
    - Android
  - Real-time feedback compared to current and historical energy uses
  - Suggestions on how to lower energy consumption -- save $$

- **Collaboration With Multiple Stakeholders and University**
  - Depict and encourage further efficiency gains as part of efficiency exercise
    - (undertaken by Vermont State College System - supported by IBM)

Support of Vermont Project (Cont'd)

Sandia National Laboratories

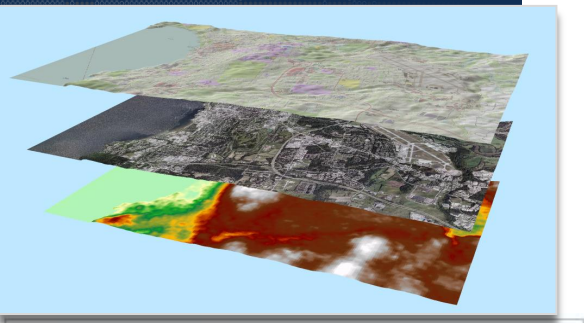
- **Create Dynamic Topological Map**
  - Showing Vermont's statewide smart grid
    - with various levels and combinations of renewable resources
      - (including plug-in electric vehicles)
  - Utilize GIS for:
    - Efficient Transmission Line Siting
    - RADAR Siting and Analysis
    - Linear Facilities Siting
    - Implement GIS Methodology for High Voltage Electric Siting
    - Implement Methodology and System Development of Wind Farm Siting
    - Studies in Visual Impact Siting

- **Create Similar Dynamic Topological Map for Secure, Scalable Microgrid**

Support of Vermont Project (Cont'd)

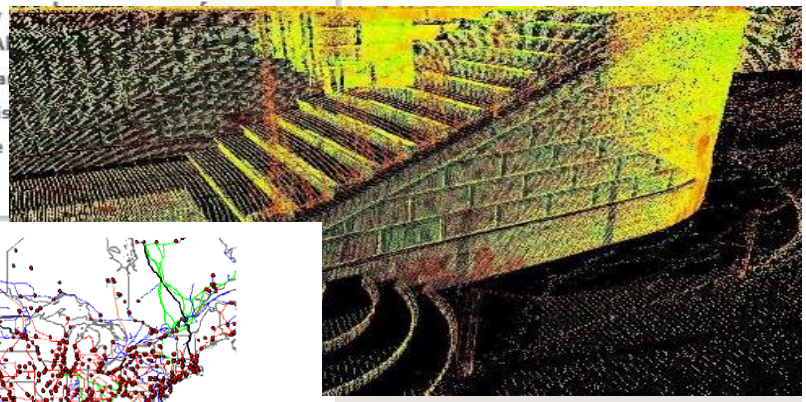
Sandia National Laboratories

- **Promote Education**
  - Science Center display or kiosk
    - Allows citizens to explore impact of efficiency, renewables, etc on:
      - electricity generation
      - carbon emissions, etc.
  - Serious game development - creating virtual games allowing people to see how their lifestyles can be changed based on new technologies
  - Create large network game
    - To predict energy usage
    - Simulate based on historical/current data
  - Develop game allowing people to upgrade their home to:
    - Virtually see direct return on investments in energy saving vs. budget
  - Generate game similar to Sim City
    - Users can build and upgrade their city with smart grid technology
    - User can see how system works on a larger scale

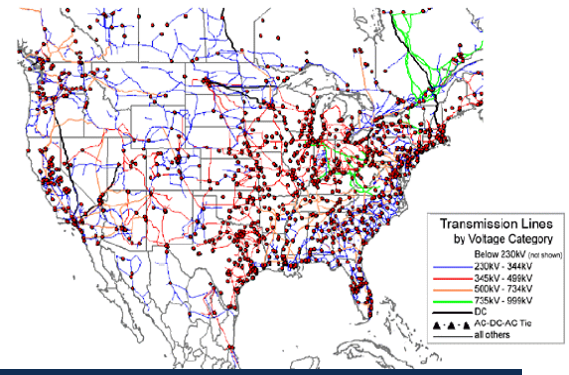


Geographic Information Analysis

Studies, 3D Analysis and Planning, Data Set Development



Brian Jeantete



U.S. DEPARTMENT OF ENERGY

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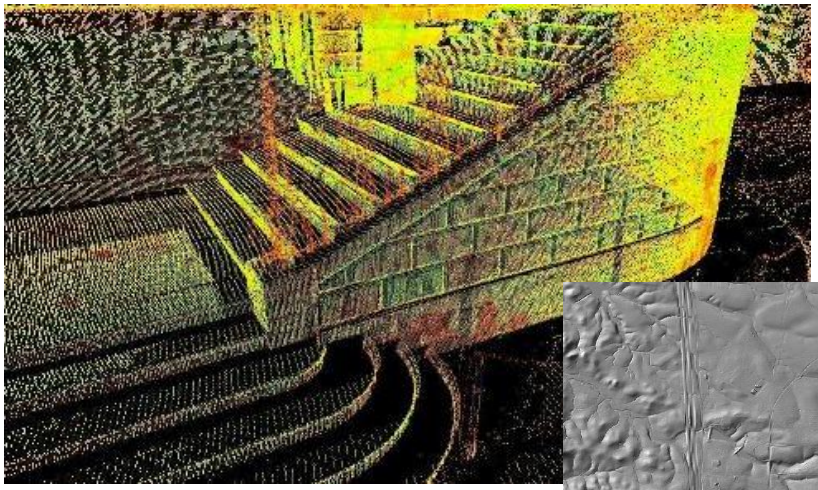
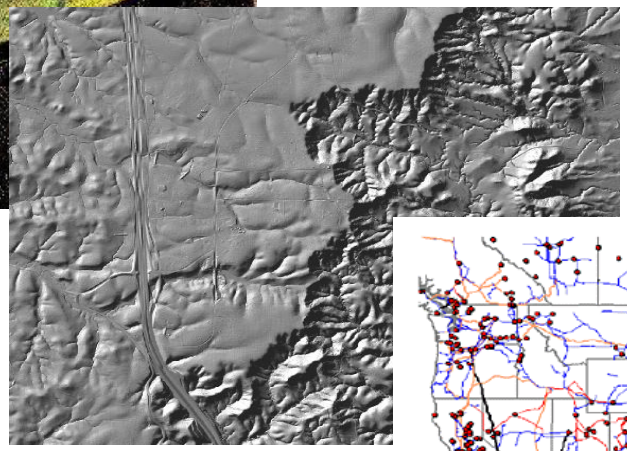
Focus of Discussion

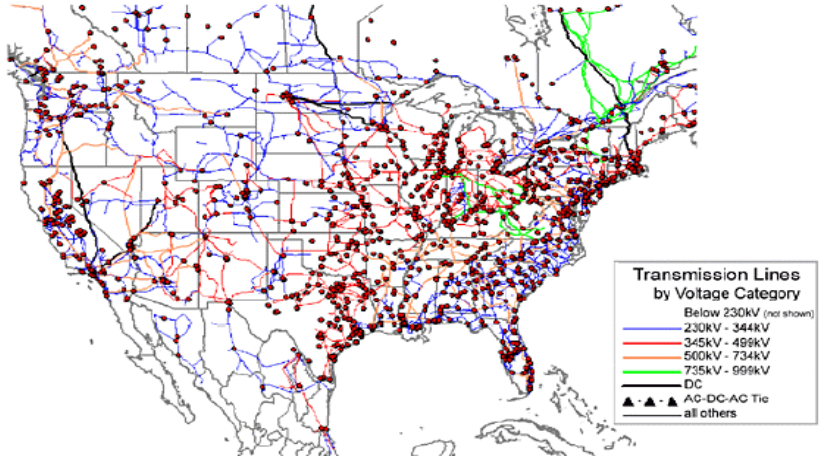
Sandia National Laboratories

- Overview of GIS
- GIS Studies
- Data Organization
- 3D Analysis and Planning
- 3D Data Set Development
- Network Analysis and Planning
- Importance of GIS to Implement Smart Grid
- Applications
- Equipment

Geographic Information Analysis



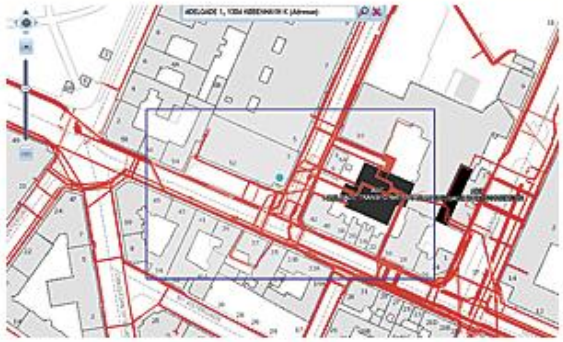




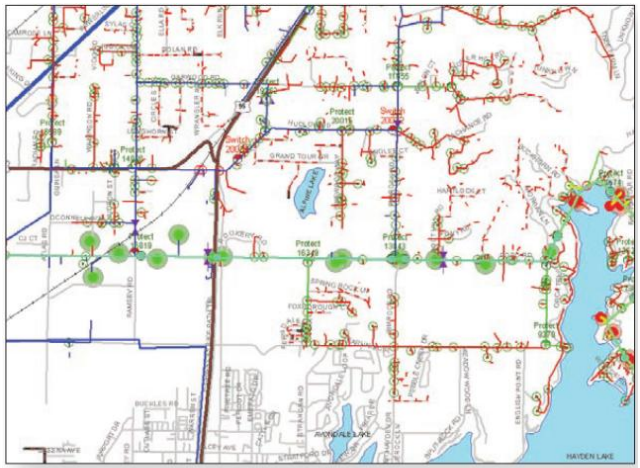
Studies of GIS Utilization

Sandia National Laboratories

- GIS is utilized by many different agencies to manage transition and use of smart grid technology.



External contractors can use the web to order a map with information on lines and networks in the ground before they dig. The whole process runs automatically, and the PDF is generated and sent immediately. The solution handles approximately 30,000 orders a year.

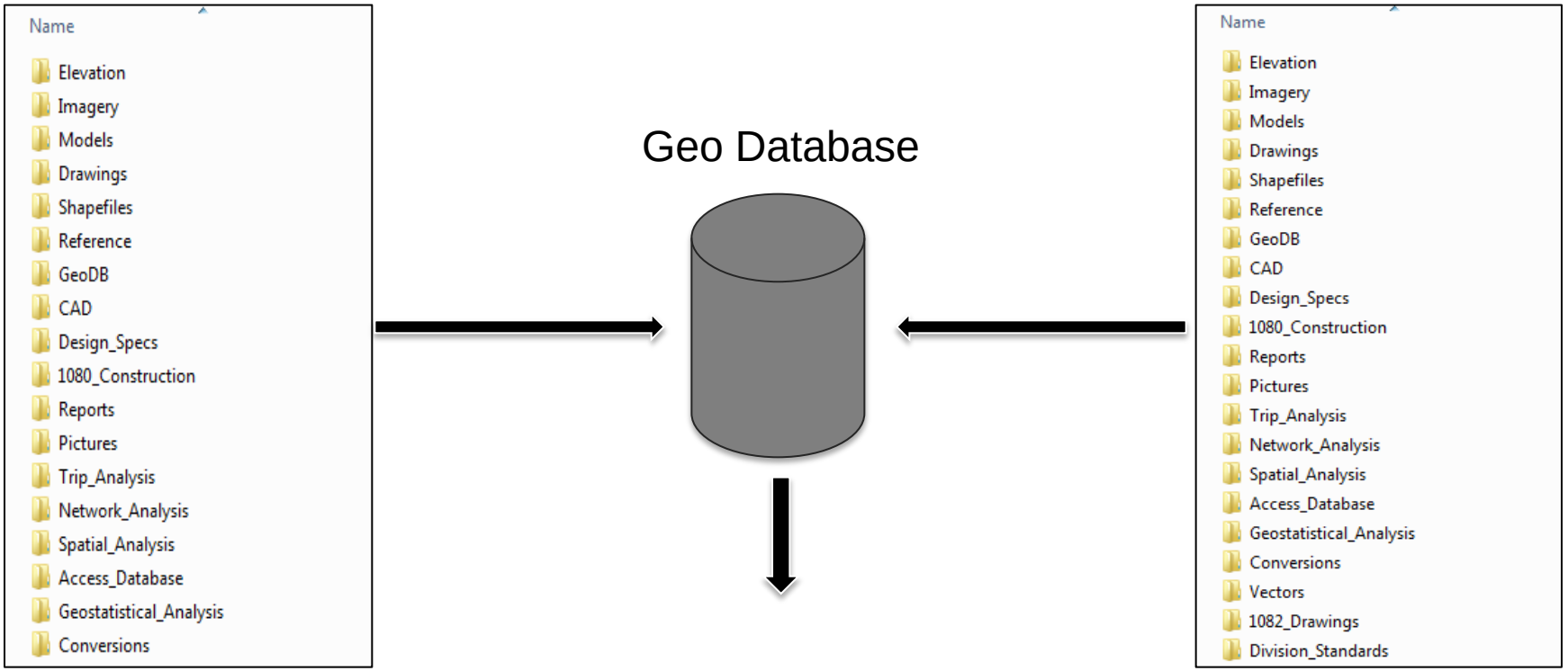


An upstream trace selects key meters from an outage call back to the substation. It then queries (pings) each selected meter and returns a value of green (has power) or red (does not have power).

Using this GIS viewer, employees can perform geographic analysis. All the points of interest are visible in the viewer, and all network features are available. By using this kind of web solution, data and knowledge can be distributed throughout the organization.

Data Organization

- Organize one project into a container that can serve data whenever requested.



Multiple users utilizing multiple formats

3D Analysis and Planning

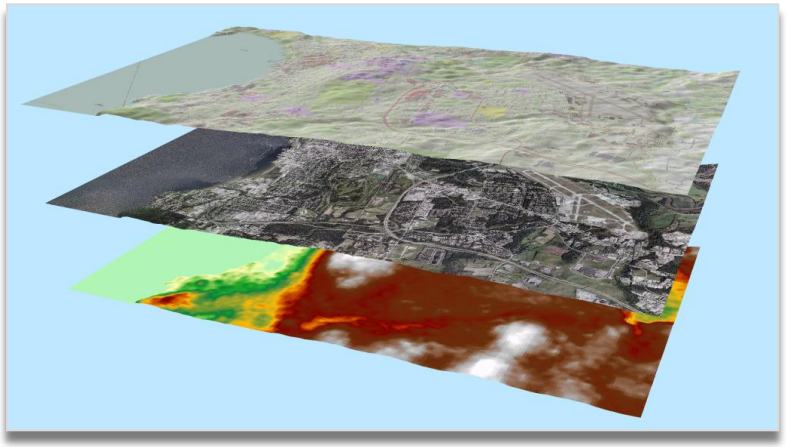
Sandia National Laboratories

3D Analysis of Surfaces and Features

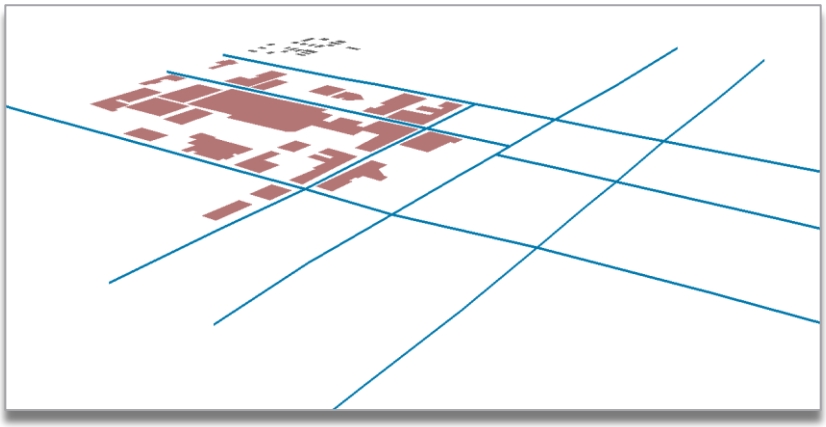
- Wind Analysis
  - Surface Analysis of wind patterns at 30m, 50m and 80m.
  - 3D Analysis of turbine placement and effect on surrounding environments.
- Volumetric and Slope Analysis
  - Determine volume of water flows from origination to power source.
  - Analyze water body values to determine sustainability.
- Hillshade Rasters and Aspect
  - Analysis on raster depicting sun/surface angles for optimal placement of renewable energy resources.
- Modeling unknown values based on sample data
  - Point sampling to used to analyze spatial patterns over a significant study area.
- Terrain Model Generation to portray realistic study area
  - Place 3D rendered features in accurately placed positions on a terrain derived from elevation, imagery, and vector sources.

3D Data Set Development

Sandia National Laboratories



Raster Data



Plan Data

Raster Overlay

Extrusion of features given specified attribute

Network Analysis and Planning

Sandia National Laboratories

Produce base maps for specific analysis and studies

- Pattern Analysis
  - Use average nearest neighbor to predict possibility something will/ will not happen
- Site Location
  - Mapping trends and buffering distances to determine optimal placement of power sources
  - Analyze current distribution of power network and determine the optimal direction for efficient management
- Geocoding
  - Ability to track customer locations dynamically
  - Utilization of database to query all customer information and output information real time

Importance of GIS to Implement Smart Grid

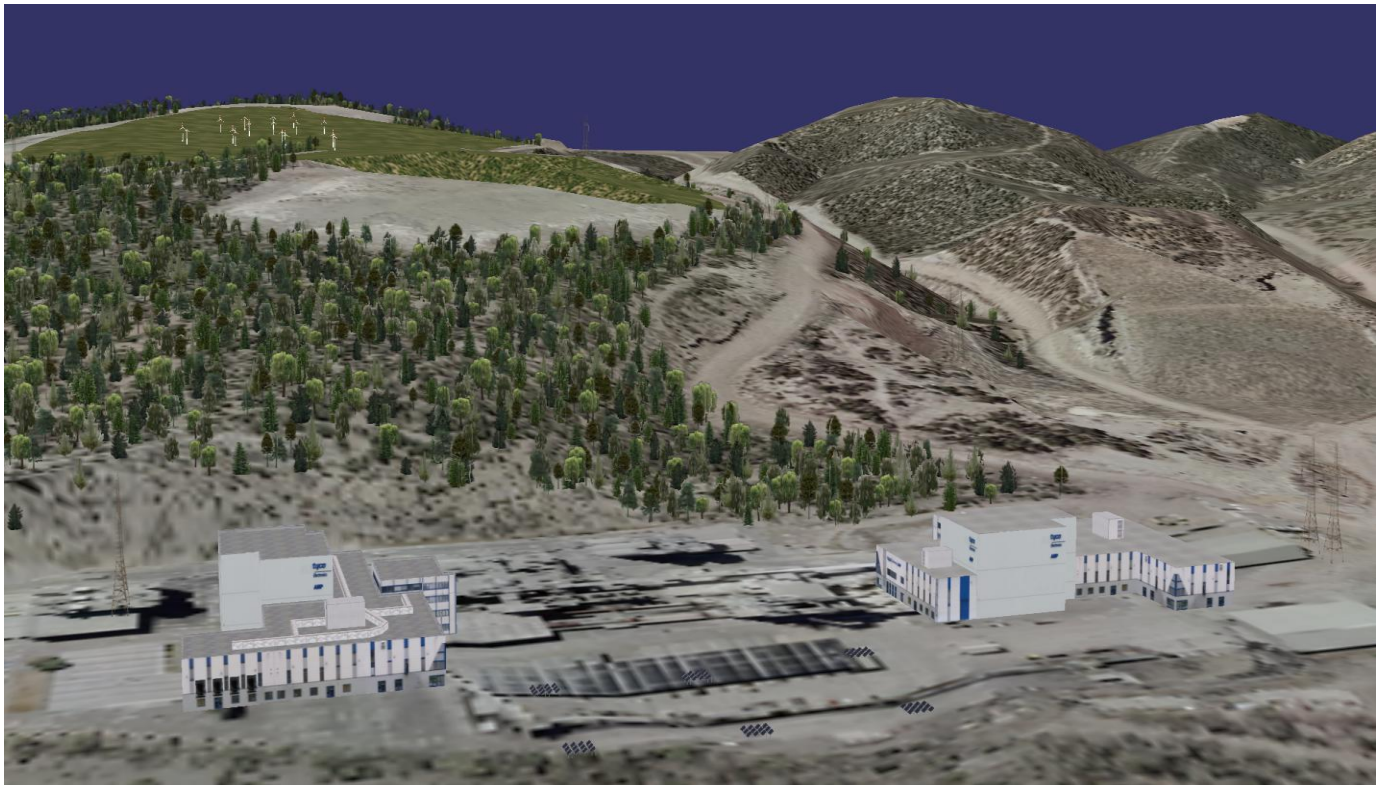
Sandia National Laboratories

- Utilities need sturdy foundation of healthy enterprise GIS for
  - Data management
  - Planning and analysis
  - Situational awareness
- Utility operators require GIS-based view of their utility to make the best decisions about key issues such as:
  - Managing meters and customers
  - Incorporating renewable energy
- Field crews will depend more heavily on GIS for implementing an advanced metering infrastructure (AMI) and keeping current with data collection.

3D Terrain Model Development

Sandia National Laboratories

- Design model utilized for research and marketing
- Models designed to represent any area with realistic texturing
- Analysis can be performed from terrain model using Sandia developed applications



Applications

- ESRI ArcGIS Suite
  - ArcEditor
  - 3D Analyst
  - Network Analyst
  - Geostatistical Analyst
  - Spatial Analyst
- Global Mapper
- Sandia Developed
  - Dante 2.0
  - OpShed
- GAutoDesk Suite
  - AutoCAD 2012
  - AutoCAD Civil 3D 2012
  - Autodesk 3ds Max
- Adobe Photoshop CS5
- Presagis Terra Vista

Equipment Utilized

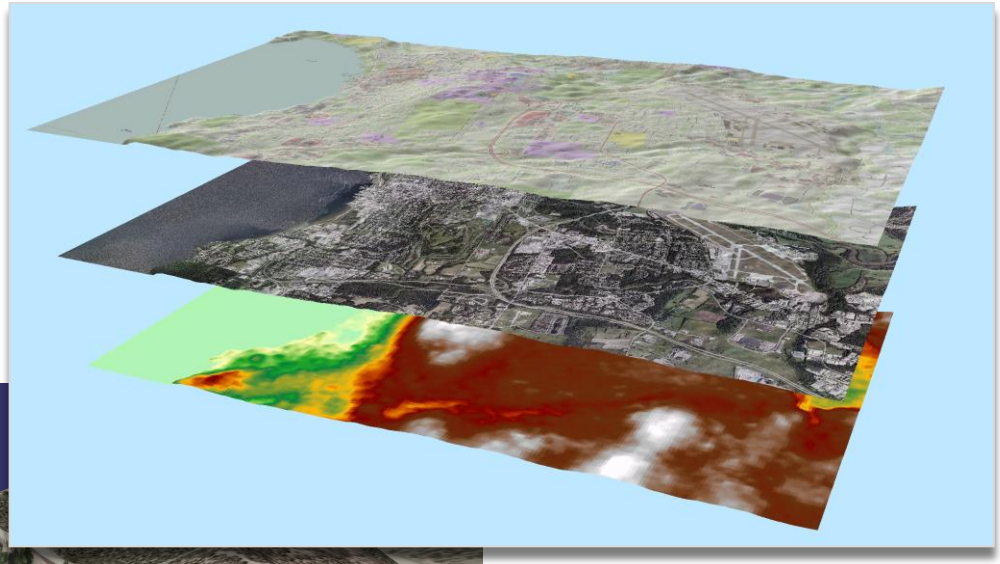
Topcon GPS

Top of the line equipment at our disposal to meet geospatial needs.

FARO Scanners

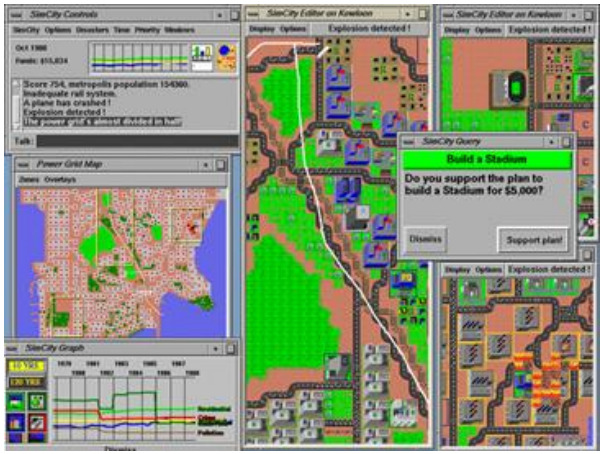
Sandia National Laboratories

QUESTIONS?



Serious Gaming and Gamification for Smart Grid Integration

A look at existing applications and how they apply to Smart Grid integration



Tam Le

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Focus of Discussion

Sandia National Laboratories

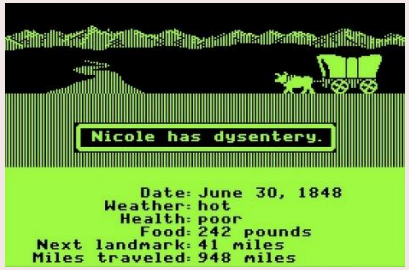
- Overview of Serious Gaming and Gamification
- Look at past and present examples of serious gaming
- Examine how examples apply to Smart Grid Integration
- Brainstorm ideas that apply these concepts

Terminology

- Serious Gaming
  - Game design or technologies applied toward a specific purpose other than pure entertainment in the application of defense, education, scientific exploration, health care, emergency management, city planning, engineering, politics, etc.

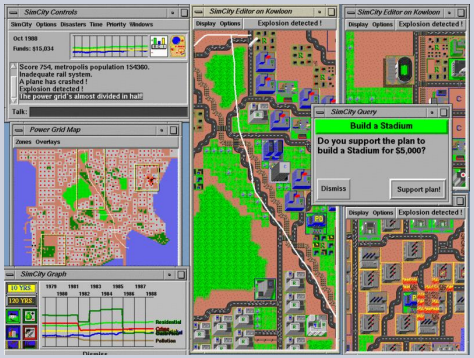
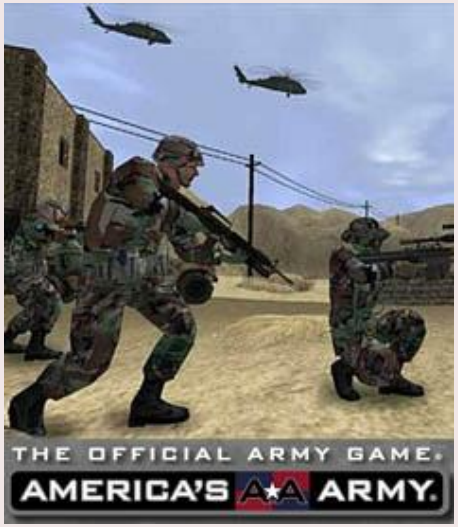
- Gamification
  - Game design techniques and mechanics to solve problems and engage audiences.
    - Encourage desired behaviors
    - Show a path to mastery and autonomy
    - Take advantage of human psychological predisposition
    - Make ordinary or boring chores more interesting and engaging

Serious Gaming Examples

Example	Applicable Solutions
Lemonade Tycoon 	• Pricing based on supply and demand • Resource management • Budgeting
Oregon Trail 	• Personal immersive experience • Informational

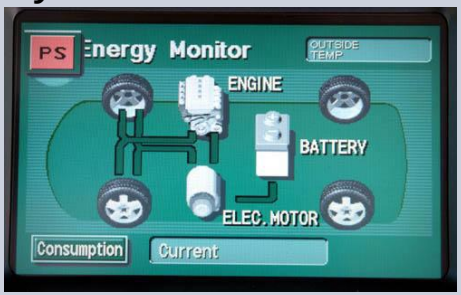
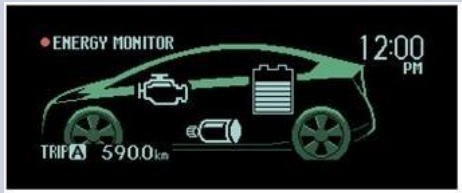
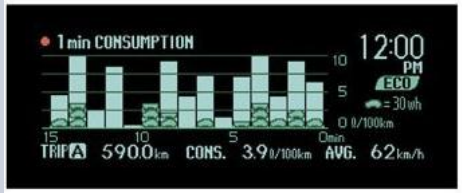
Serious Gaming Examples (Cont'd)

Sandia National Laboratories

Example	Applicable Solutions
SimCity 	• Understanding of large system dynamics • Decision making • Budgeting • Urban planning
America's Army 	Geared Toward Next Generation *** • Marketing and recruiting • Exposure and preparation • Training

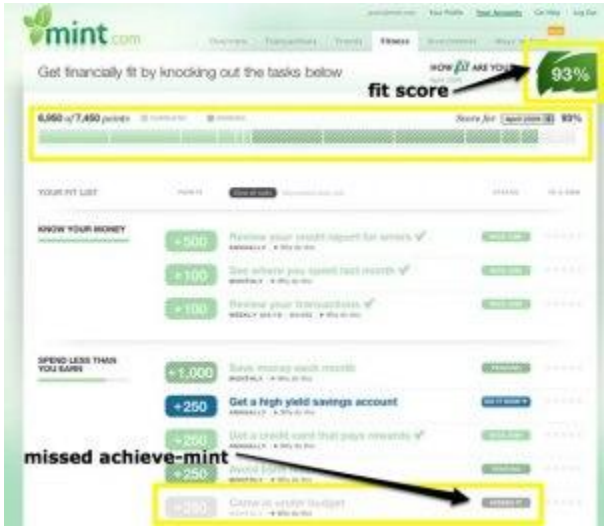
Gamification Examples

Sandia National Laboratories

Example	Applicable Solutions
Hybrid Vehicles    	Real-time monitoring • Encourage desired behaviors • Show path to mastery and autonomy • Human psychological predisposition • Interesting and engaging Visual displays to educate

Gamification Examples (Cont'd)

Example	Applicable Solutions
Banking Marking Health	Real-time monitoring • Encourage desired behaviors • Show a path to mastery and autonomy • Human psychological predisposition • Interesting and engaging



Brainstorming Concepts

- **Virtual Smart Grid City and Home Tour**
  - Create touring application allowing users to view a city, factory, facility, home, charging station, etc. to learn how the smart grid systems work together.
  - Idea is to replace standard video with an interactive and more engaging way to learn.
  - Users can mouse over areas of interest to see further information including images, videos, links, animation, etc.

Brainstorming Concepts (Cont'd)

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Upgrade Homes With Smart Equipment and Appliances

- Users virtually upgrade their current homes with smart equipment and appliances
- Start by designing\describing their current home (sq ft, rooms, windows, 1 or 2 story, etc)
- Enter their family (members, age, etc.)
- Enter family life styles (work, school, tv time, etc.)
- Based on these statistics, cost and benefits of upgrading their home is given
- Information can be tied directly to venders for statistics and shopping
- Can be used entire time they own their homes to monitor and continue to upgrade their homes

Brainstorming Concepts (Cont'd)

Sandia National Laboratories

Smart Grid SimCity

- Similar to SimCity with a smart grid twist
- Player is given a standard city to work toward improving city's
  - efficiency
  - eco footprint
- **Could also be used as a table top for city planners**

Experience Life Smart Grid

- Users are immersed in a world with smart equipment and smart appliances
- See first hand what life is like and how they will be affected

Brainstorming Concepts (Cont'd)

Sandia National Laboratories

Gamification of Smart Grid Web and Mobile Apps

- Currently web and mobile apps are company or equipment specific
- Standard repository where all companies and equipment report to will enable web and mobile apps to be more effective
- Allow for tie in of all equipment for better real-time, historical, and social applications

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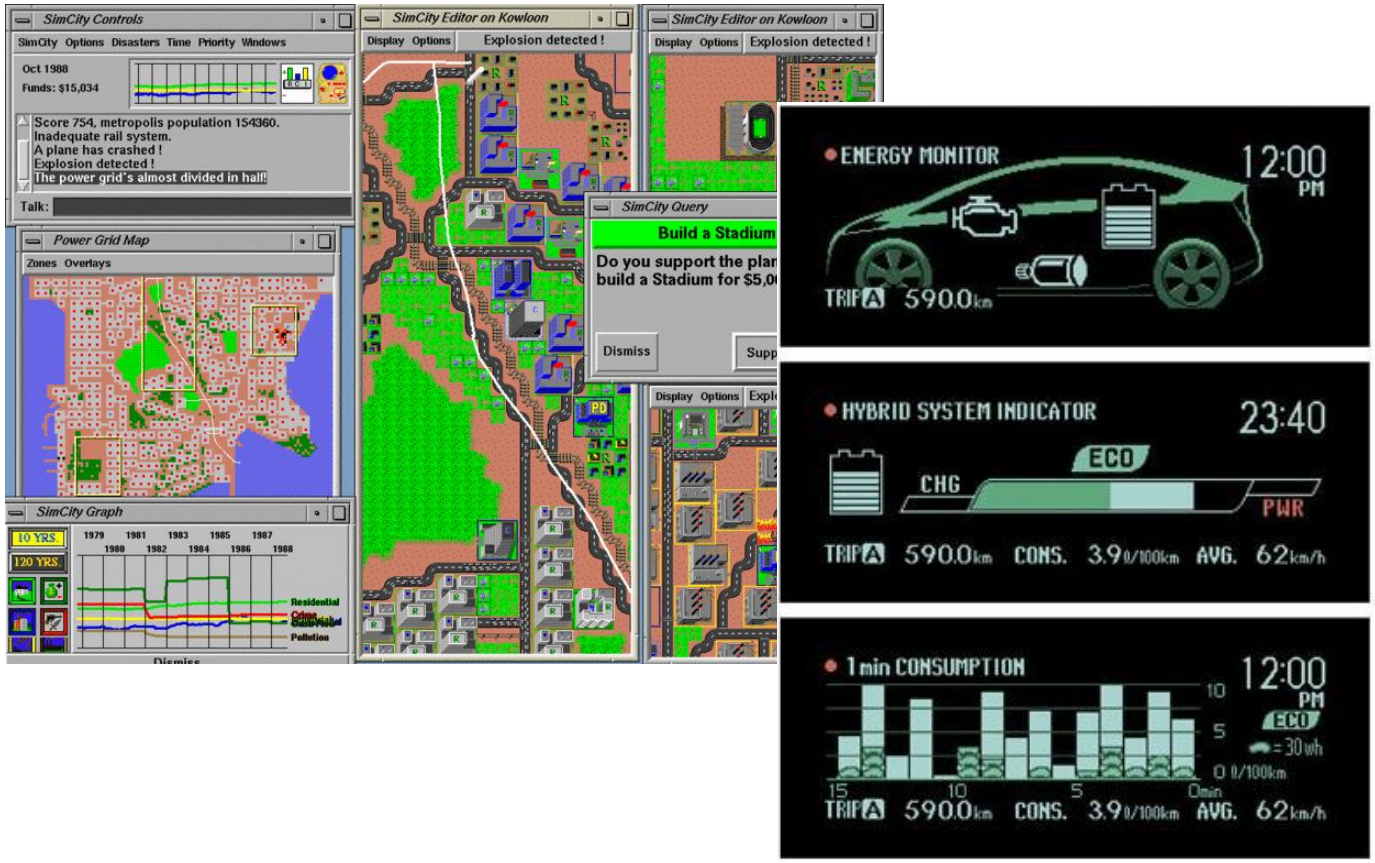
QUESTIONS?



Physical Security for Critical Infrastructure

Defense In Depth Through Systems Engineering

James Rivera

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Sandia & Physical Security History

Sandia National Laboratories

Nuclear Weapons

Integrated, engineered warhead systems

Arming, fuzing, and firing systems

Defense Systems & Assessments

Surveillance & Reconnaissance

Energy
Information
Transportation

Integrated Military Systems

Energy, Climate, & Infrastructure Security

Global Security

Critical Asset Protection

Homeland Security & Defense

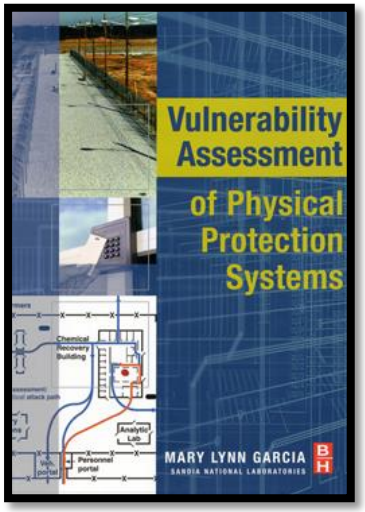
Subject Matter Experts

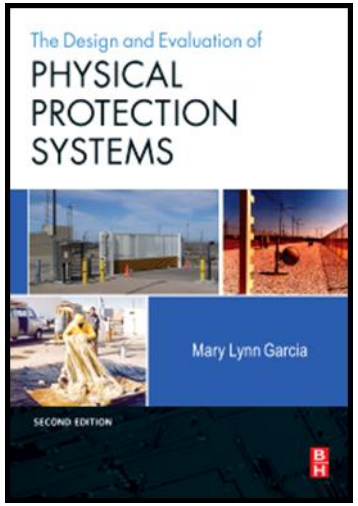
Sandia National Laboratories

- Sandia is strategically positioned to design, evaluate and implement physical security solutions for critical infrastructure
  - Facility Characterization
  - Target ID & Characterization
  - Threat Definition
  - PPS Design
  - Intrusion Detection
  - TIDs & Key Control
  - Alarm Assessment
  - Contraband Detection
  - Entry Control
  - Alarm Communication & Display
  - Access Delay
  - Response
  - Component/System Performance Testing
  - Maintenance & Sustainability
  - Analysis & Evaluation
  - Scenario Development
  - Insider Analysis
  - Upgrade Analysis
  - Cyber Security

Definitions

- Physical Protection System (PPS) - Integrated system of security equipment/hardware/technology, personnel, and procedures designed to protect assets
- Design Basis Threat (DBT) - Attributes and characteristics of potential insider and/or external adversaries
  - PPS is designed and evaluated to protect against
  - Prerequisite to systems engineering
  - Stable requirements basis
  - Long-range resource planning
- We Wrote The Books
  - The Design and Evaluation of Physical Protection Systems (2nd edition)
  - Vulnerability Assessment of Physical Protection Systems





The Risk Landscape

Sandia National Laboratories

- North American Electric Reliability Corporation (NERC)
  - Created Electricity Sub-Sector Coordinating Council (ESCC) to:
    - Coordinate sector-wide policy
    - Improve reliability & resilience of physical & cyber electricity sector infrastructure
  - Adopted "All-hazards/All-threats Approach to Risk Management"
    - Identified 3 Categories
      1. Natural
      2. Human Caused (Intentional/Unintentional)
      3. Technological

Risk Area	Opportunities for Improvement
Naturally Occurring Hazards	
• Geological (e.g. earthquake)	Plans typically in place
• Meteorological	
○ Severe storm	Plans typically in place
○ Extreme water flows (drought, flood)	Plans typically in place
○ Extreme temperature	Plans typically in place
○ Geomagnetic disturbance (GMD), solar magnetic disturbance (SMD)	Requires additional action
• Biological disease (e.g. pandemic)	Plans typically in place
Human-Caused (Unintentional) Hazards	
• Hazardous material spill or release	Plans typically in place
• Explosion, fire	Plans typically in place
• Interdependency (e.g. fuel shortage, telecommunications service disruption)	Plans typically in place
• Human operational error	Plans typically in place
Human-caused (Intentional) Hazards:	
• Local criminal activity or sabotage	Plans typically in place
• Civil disturbance, riot	Plans typically in place
• Strike or labor dispute	Plans typically in place
• Terrorism	Requires additional action
• Physical attack	Requires additional action
• Electro-magnetic pulse (EMP)	Beyond the scope of the industry
• Cyber security breach, coordinated cyber attack	Requires additional action
Technological Hazards:	
• Equipment failure	Plans typically in place
• Local information/control system failure	Plans typically in place
• Local telecommunications system failure	Plans typically in place

Electricity Sub-Sector Risk Priorities

2009 – High Impact Low Frequency Workshop

- Identified 3 scenarios requiring additional action

  - **Physical Attack on Significant Electrical System Equipment**

    "A coordinated physical attack on key nodes of the bulk power system critically disables difficult to replace equipment in multiple generating stations or substations and could have a significant affect on the remainder of the system. A prolonged period of time is required to fully restore the bulk power system to normal operation."

  - **Coordinated Cyber Attack**

    "A coordinated disruption disables or impairs the integrity of multiple control systems, or intruders take operating control of portions of the bulk power system such that generation or transmission equipment is damaged or mis-operated."

  - **Geomagnetic Disturbance**

    "A severe geomagnetic disturbance (GMD) damages difficult to replace generating station and substation equipment, and causes a cascading affect on the remainder of the system. A prolonged period of time is required to fully restore the bulk power system to normal operation."

Risk Assessment Methodology – Energy *(RAM-E)*

Sandia National Laboratories

- **(Likelihood of Attack) ∗ (Consequence) ∗ (1-System Effectiveness) = Risk**
  - Step 1 – Complete threat assessment to determine likelihood
  - Step 2 – Procedure for consequence assessment
  - Step 3 – Process for determining protection system effectiveness
  - Step 4 – Complete risk assessment to determine level of risk
    - High risk = Need for mitigation strategies

Security Framework

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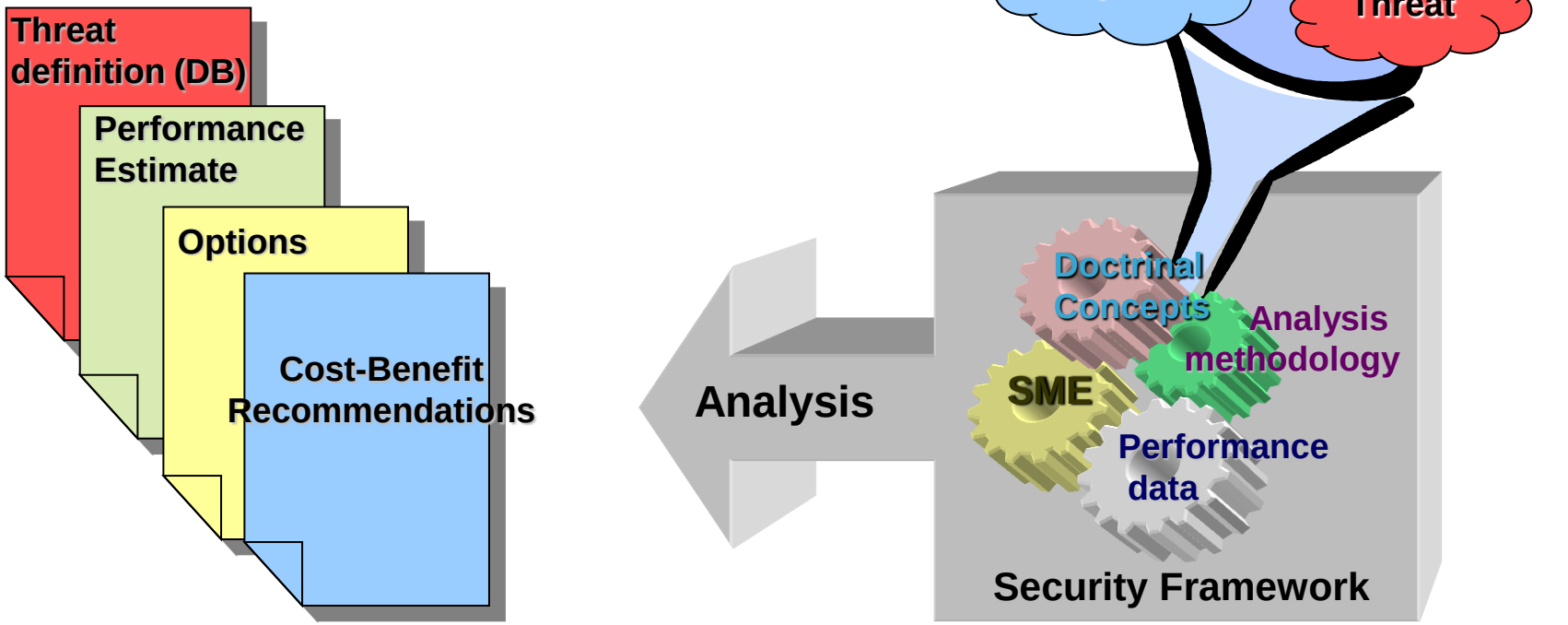
NWS Analysis Environment

Purpose: Support risk management

Problem Statement: DB addresses an unprecedented event

System: Mix of complex & deterministic behavior

Activities: Training, sustainment, acquisition



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QUESTIONS?

Conclusion

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- Covered only a few examples and viewed brainstorming ideas
- Idea was to discuss topic for further brainstorming
- Ideas can be delivered as one big application or several small ones
- Delivery can be standalone, kiosk, web, or mobile.
- SGTT has expertise and experience to implement in house or leverage partnerships with others
- Possible partners
  - University of Vermont
    - Work study program with University
    - Model asset/statistical data from local companies
  - Champlain College
  - Norwich University
  - Local companies

Let's educate and train the next generation for a smarter system!

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Thank You!

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Questions

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