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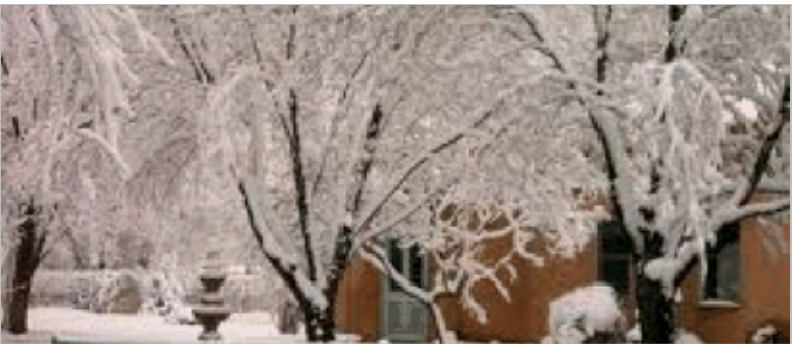

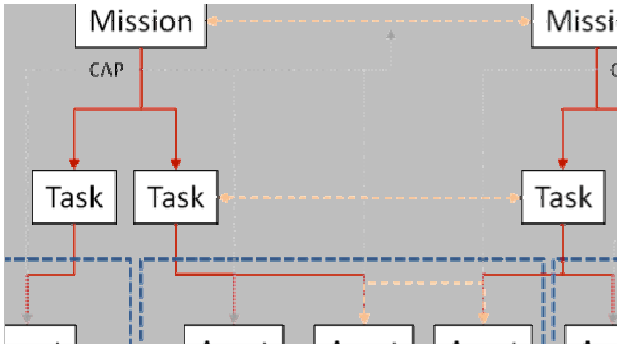

A Mission Resilience Assessment Methodology for Infrastructure Disruptions

Eric Vugrin, Kevin Stamber, Michael Baca, Rick Ramirez, Gio Kao, Michael Mitchell, Hai Le, and Kim Welch

U.S. DEPARTMENT OF ENERGY | NNSA

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A Motivating Example

- February 10, 2011
  - Natural gas shut-off to Kirtland AFB for 5.5 hours
  - Consequence of EP disruptions in Texas
- Impacts at Kirtland AFB include:
  - $4M+ in damage
  - 48 hours to restore all heat
  - 125 water damaged buildings
  - 200+ damaged homes, 150+ displaced residents
  - $3.5M damage for Sandia tenant
  - Mission impacts????

Water Damage Resulting from Burst Pipes

This damage (and potentially mission interruptions) was caused by off-base infrastructure disruption.

Mission Assurance (MA)

- Definition
  - Ensuring the ability to conduct critical military missions for their entire duration
- Requirements
  - Manpower/Materiel/Equipment (M/M/E)
  - Critical infrastructure (CI) services
  - Functionality of contingent missions

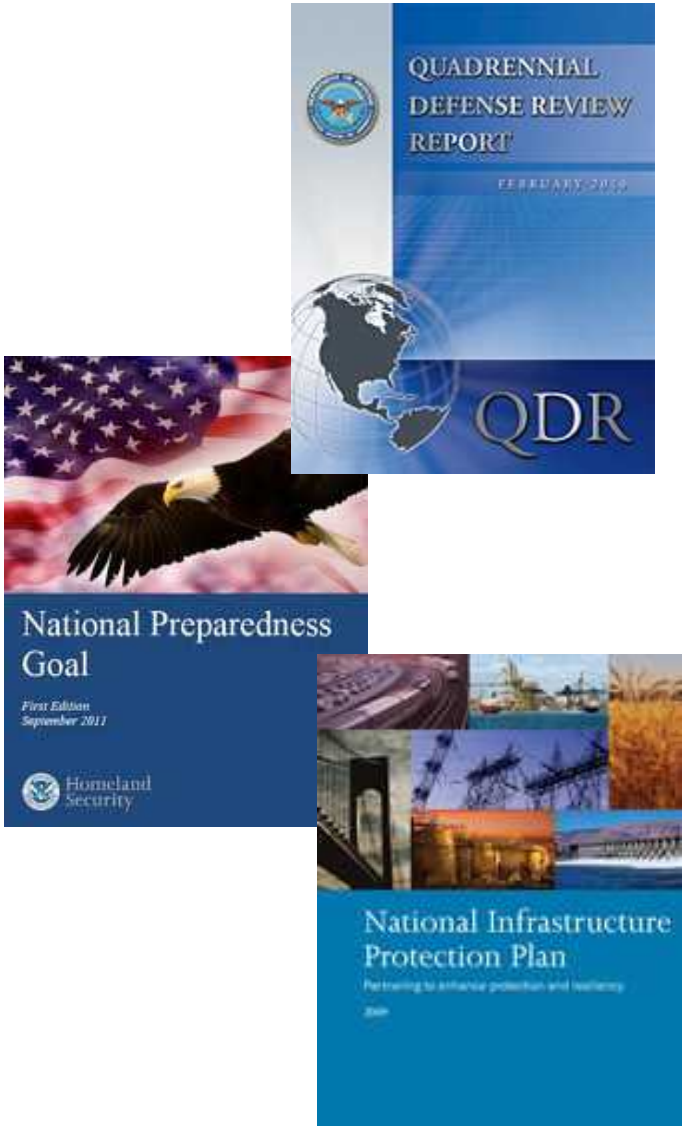
Assessment Limitations

- Assessment methods generally
  - Focus on individual assets
  - Do not consider mission connectivity
  - Rely solely on protection principles
  - At best, consider dependencies on civilian CI in a limited fashion
- These limitations may result in
  - Failure to identify **system** vulnerabilities
  - Misallocated resources during response and recovery activities

Sandia is researching and developing modeling and simulation capabilities to address these limitations.

Resilience

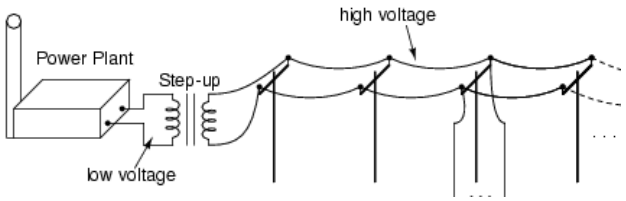
- Emerging as a security objective to complement protection activities
  - For examples, see PPD-8, 2010 QDR and QHSR, NIPP, SSPs
- Fundamental question: what actions can/should be taken to restore system functionality rapidly and efficiently?



Conceptual Approach

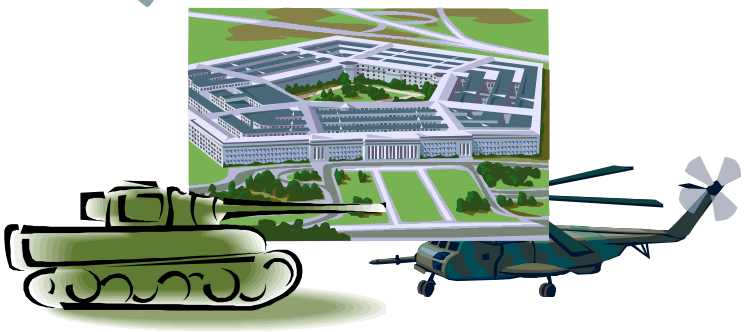
Bridge the Gap

Supply



- Model generation & distribution system (physical & cyber)
- Dynamics of response & recovery to multiple threat types
- Recovery resource constraints & temporal factors

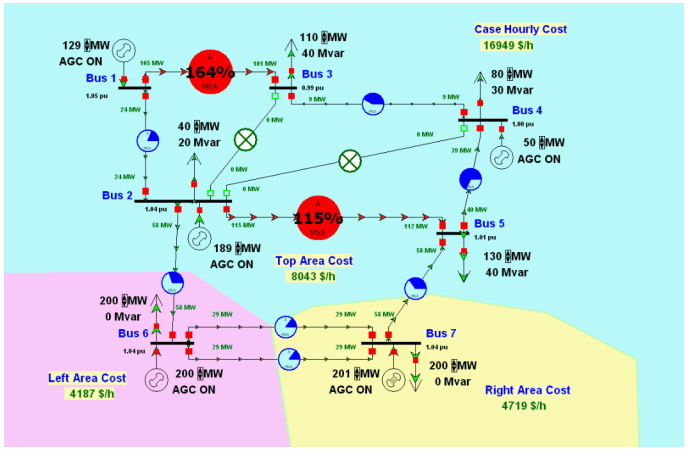
Demand

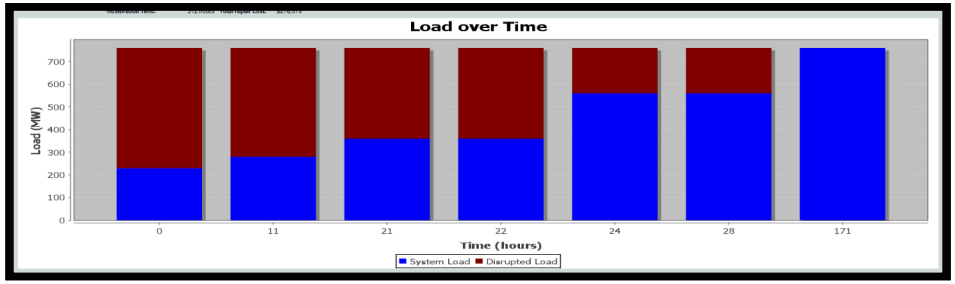


- Asset → task → mission → war plan mapping
- Dynamics of response & recovery to multiple threat types
- Recovery resource constraints & temporal factors

Power Restoration Model

- Evaluates impacts of restoration activities and constraints
  - Inputs: priorities and constraints
  - Model: establish restoration activity sequence that honors constraints and priorities
  - Output: dynamic load restoration and costs of disruption
  - Begun to vet restoration with an electric power utility

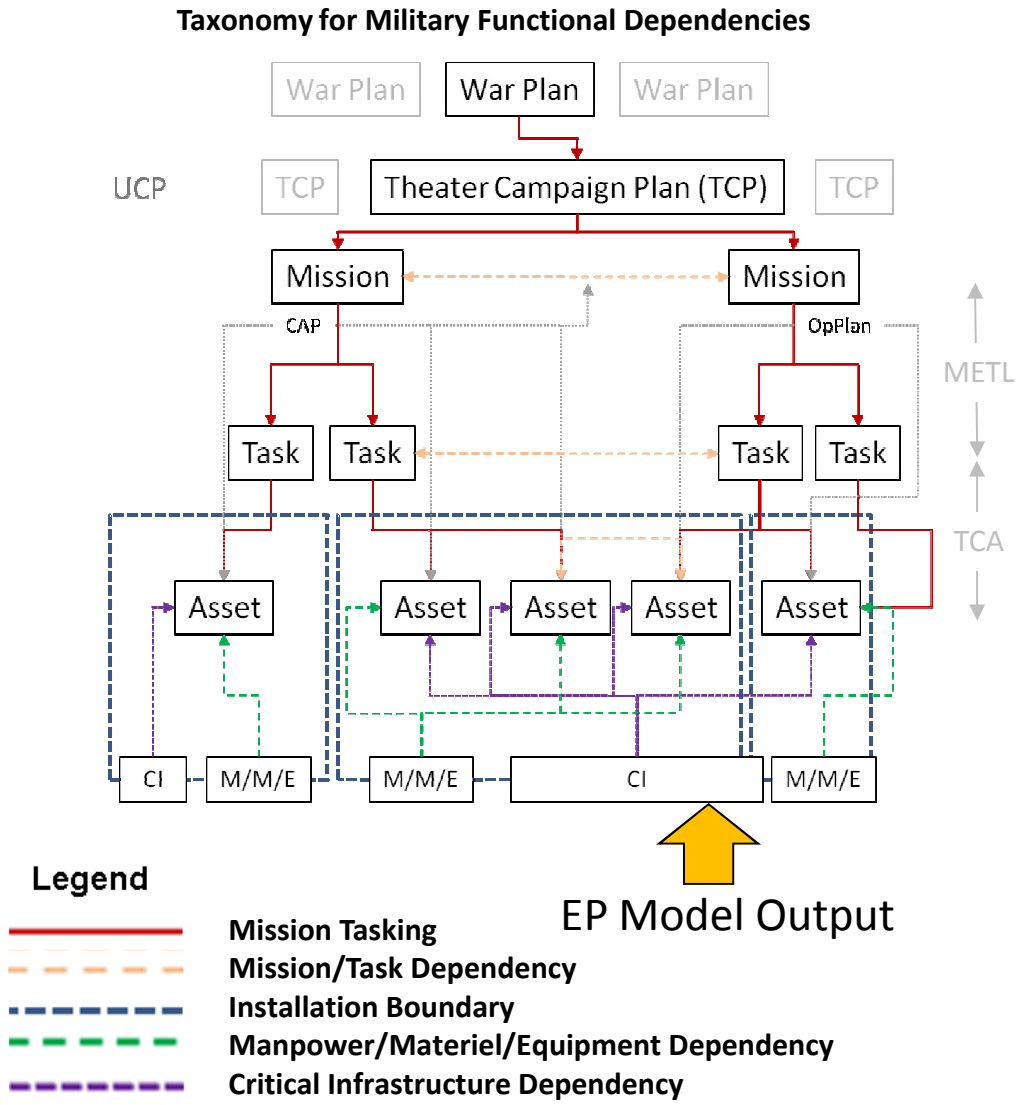




The software establishes sequential recovery states and then uses PowerWorld to predict EP delivery to loads.

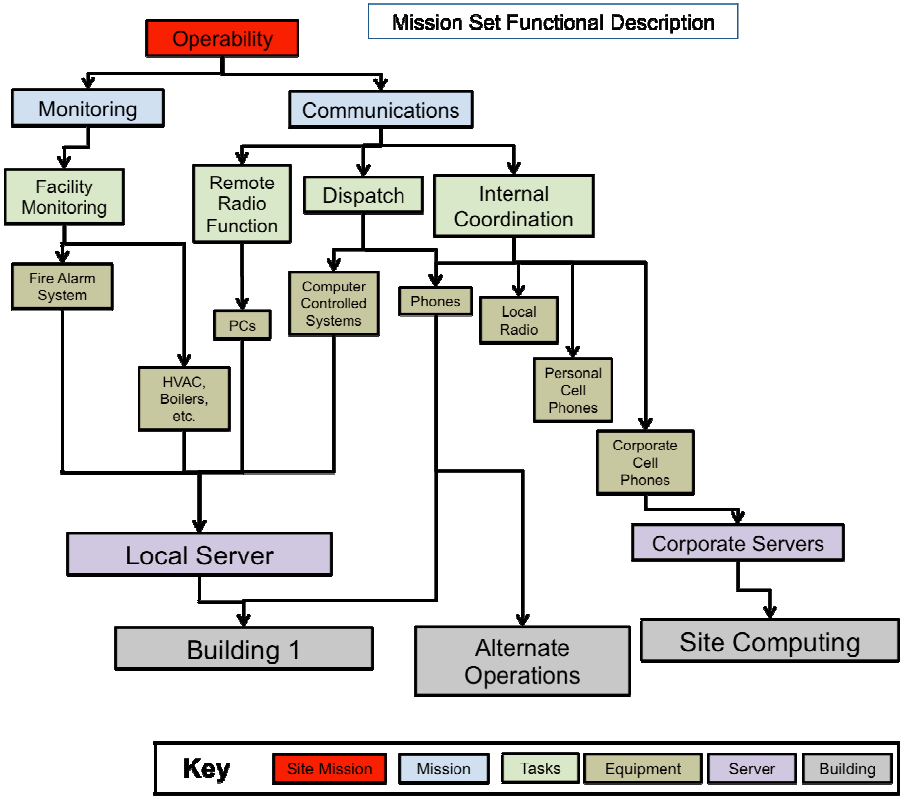
Mission Connectivity Model Development

- Model represents military planning hierarchy
  - War Plans at top of hierarchy
  - CI, M/M/E dependencies
  - Redundancy and mission switch-over capabilities
- Electric Power (EP) model feeds mission model
  - EP disruption impacts propagated through model
  - Mission assurance metrics quantify mission impacts
- Approach can be generalized to other CI systems



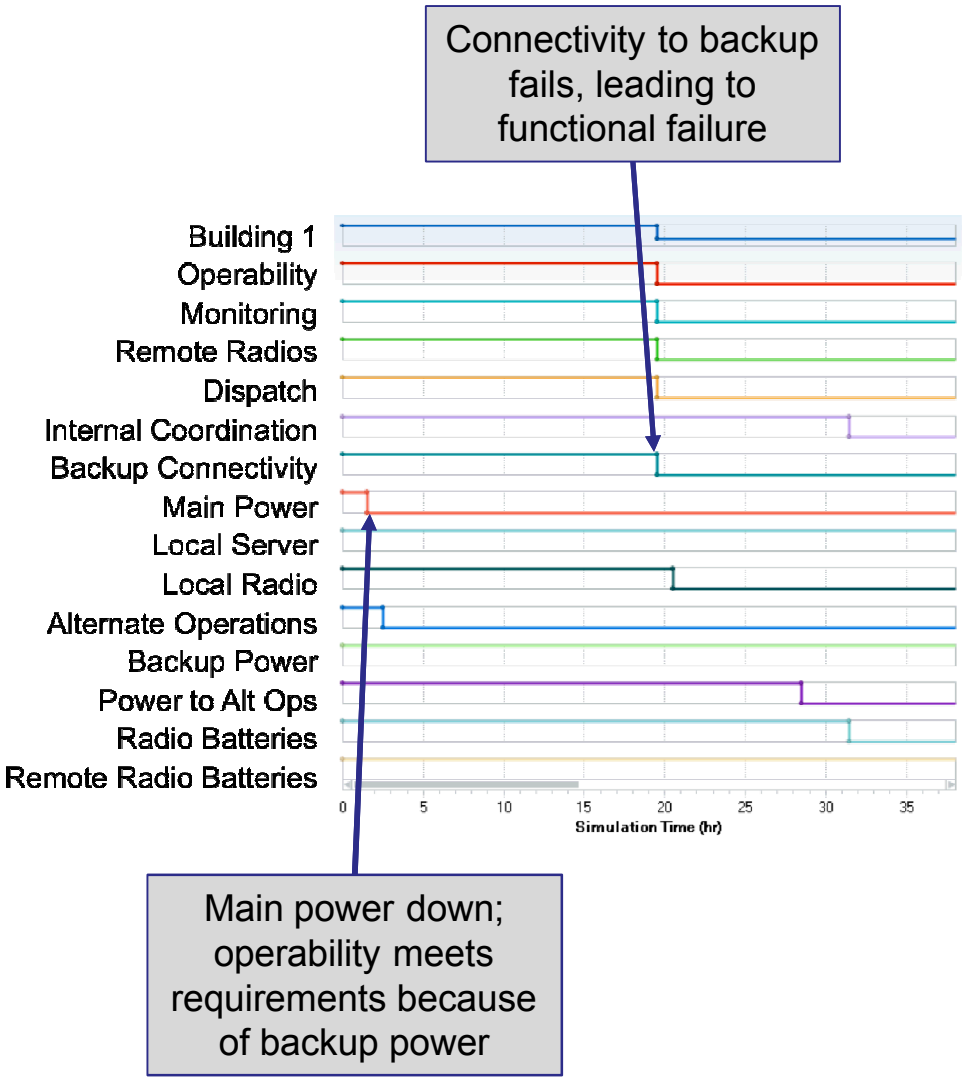
Mission Connectivity Model

- Conducted surveys of range of Sandia missions
  - Power outage after initial round prompted second analyses to determine issues



Mission Connectivity Model

- Conducted surveys of range of Sandia missions
  - Power outage after initial round prompted second analyses to determine issues
- Defined missions using System of Systems Analysis Tool (SoSAT)
  - Software system developed and used for examining Department of Defense systems
  - Used PowerWorld simulation runs output as input driver



Summary and Path Forward

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- Identification of system vulnerabilities and effective resilience strategies requires a new set of approaches
- This project represents a step in the right direction
- The models capture
  - Complex dependencies
  - Consequences of decisions
  - New approaches for improving resilience
- While the focus of these models are electric power dependencies, approaches can be expanded to other/multiple infrastructures