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Overview of Infrastructure Science and Analysis for Homeland Security

Los Alamos National Laboratory

Scott Backhaus
Manager for DHS Critical Infrastructure Programs

and DOE Office of Electricity

LANL Infrastructure—Who Are We?

advanced network science initiative (ansi)

- **DHS and other Federal sponsors come to LANL to solve and/or provide insight into "complex, interdisciplinary, multi-physics problems"**
- **LANL's goals**
  - **Provide third-party, independent, science-based input into complex problems of national concern**
  - **Use scientific analysis to "turn down the noise" around complex problems**
- **Interdisciplinary team with expertise in: physics, statistical physics, applied math, statistics, optimization, computer science, geospatial analysis, software development, and cloud computing**
- **Extensive reach back to other science-based capabilities**
  - Weapons physics/weapons effects
  - Space science/Space weather
  - Chem/Bio
  - Geoscience
  - Fluid mechanics
  - …….

LANL Infrastructure Team—Integrated at the Program Level

advanced network science initiative (ansi)

NISAC

Russell Bent (A Division)

Operations Research, Discrete and Continuous Optimization, Heuristics Design, Stochastic/Robust Network Design, Infrastructure Expansion, Resilient Design

Scott Backhaus
DOE and DHS Program Management
Experimental Physics, Systems Design

Michael Chertkov (T Division)

Mathematical Physics, Statistical Physics, Applied Probability, Machine Learning, Graphical Models, Network Design, Stochastic Networks and Dynamics, Optimization

New Scientific Staff

Harsha Nagarajan

Carleton Coffrin

Critical Infrastructure Analysis Team

J. Ambrosiano	R. Boero	M. Ewers	S. Linger
J. Arnold	C. Coffrin	D. Frank	D. Pasqualini
A. Barnes	T. Crawford	L. Inkret	M. Rivera
R. Bent	B. Edwards	H. Khalsa	R. Roberts
			B. Tasseff

New Scientific Staff

Anatoly Zlotnik

Sidhant Misra

Marc Vuffray

Current/Recent Postdocs and Students

Kaarthik Sundar

Conrado Borraz-Sanchez

Emre Yamangil

Sreenath Madathil

Mowen Lu

Current Postdocs

Line Roald

Andrey Lokhov

Deep Deka

Se-Young Yun

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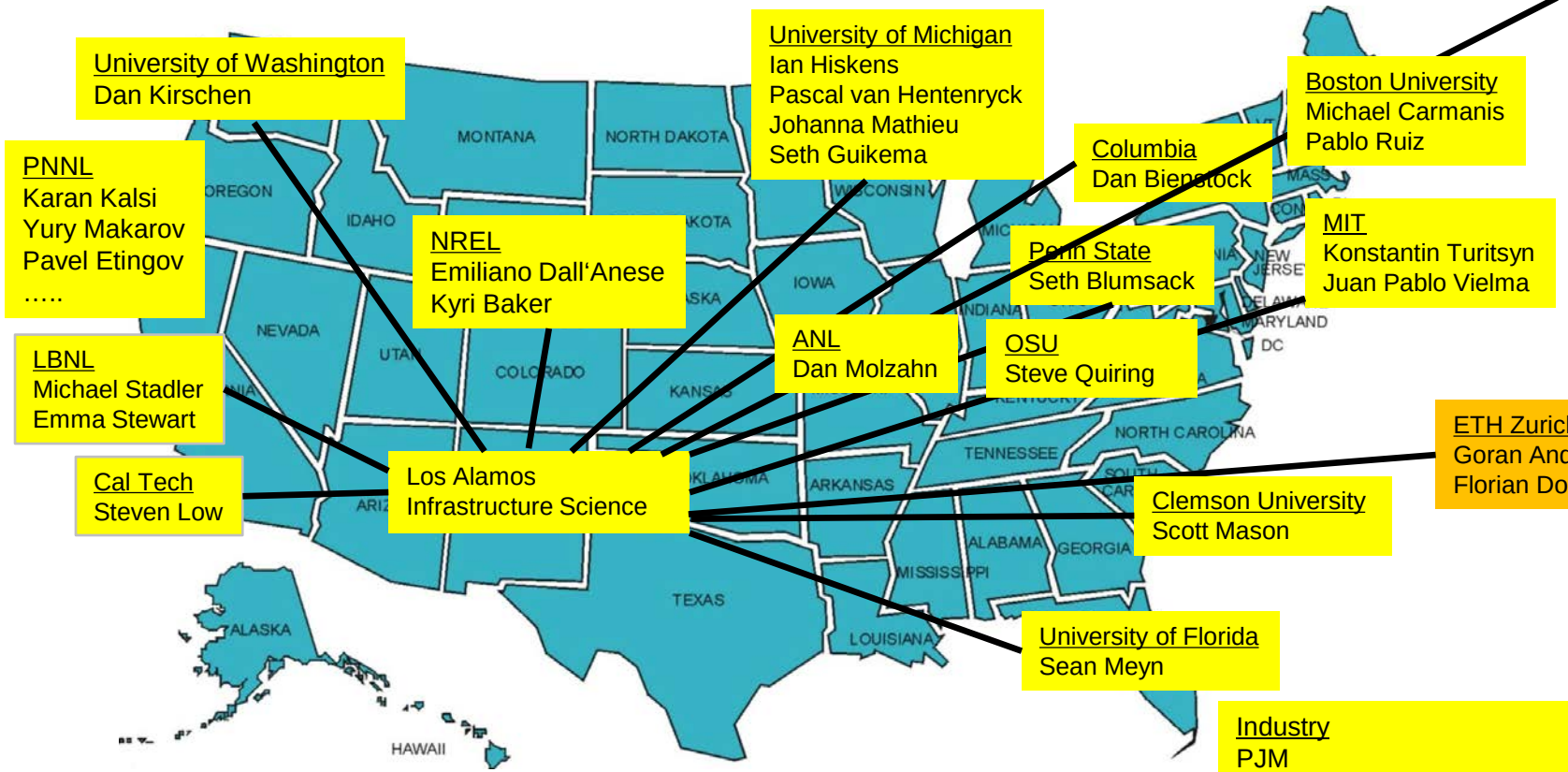
UNCLASSIFIED

National and International Collaborations/Connections

advanced network science initiative (ansi)



Landau Institute
Vladimir Lebedev
Igor Kolohov

University of Michigan
Ian Hiskens
Pascal van Hentenryck
Johanna Mathieu
Seth Guikema

University of Washington
Dan Kirschen

Boston University
Michael Carmanis
Pablo Ruiz

Columbia
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PNNL
Karan Kalsi
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Pavel Etingov
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NREL
Emiliano Dall'Anese
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Juan Pablo Vielma

Penn State
Seth Blumsack

ANL
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OSU
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Clemson University
Scott Mason

University of Florida
Sean Meyn

Industry
PJM
NYISO
ISO-NE
NRECA
Kinder Morgan
Newton Energy Group
General Electric
Burns Engineering
Alaska Center for Energy and Power

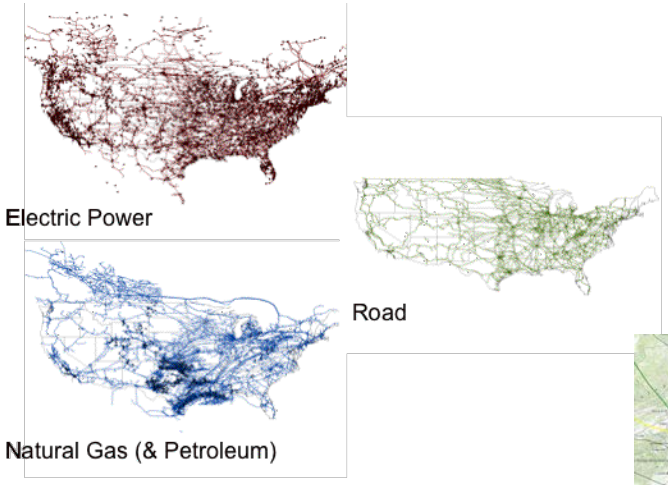
NISAC Team—Domains of Expertise

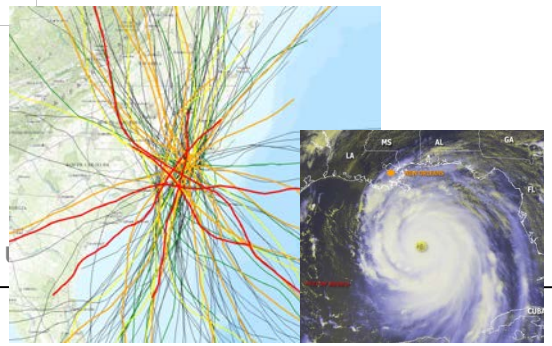
Infrastructure Systems

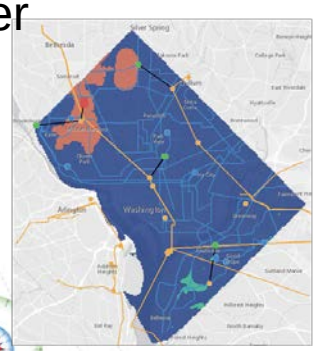
- –Roads
- –Water and wastewater
- –Healthcare/public health
- –Energy (electric power, gas)
- –Population
- –Economics

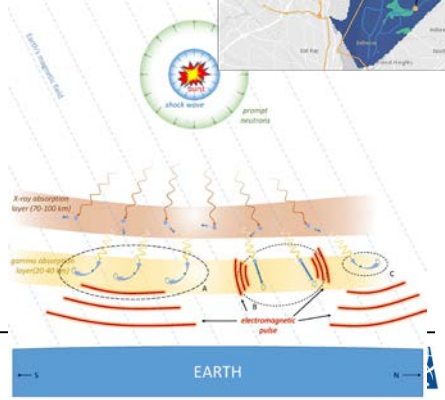
Complex Threat Scenarios

- – Hurricane
- – Drought
- – Earthquake
- – Flood
- – Heat Wave
- – Ice Storm
- – Landslide
- – Pandemic
- – Tsunami
- – Volcano
- – Wildfire
- – Biological
- – Chemical
- – Explosive
- – Radiological
- – Nuclear
- – Physical Assault
- – Insider
- – Cyber









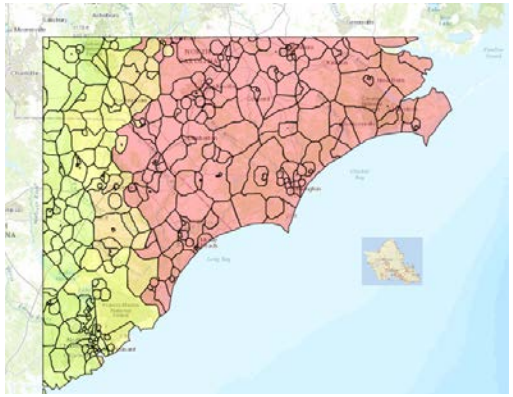
LANL Infrastructure—Who Are We?

- **LANL's goals**
  - **Provide third-party, independent, science-based input into complex problems of national concern**
  - **Use scientific analysis to "turn down the noise"**

EXAMPLES

Computing and Communicating Risk

High-resolution Probabilistic Risk Analysis



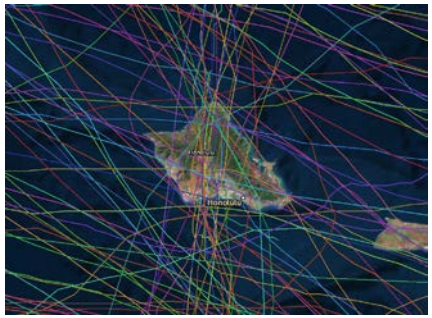
Previous methods
- Low spatial resolution
- Single “worst case” analysis

Typical outcome
- “Worst Case” → Stakeholder inaction
- Mitigation too costly

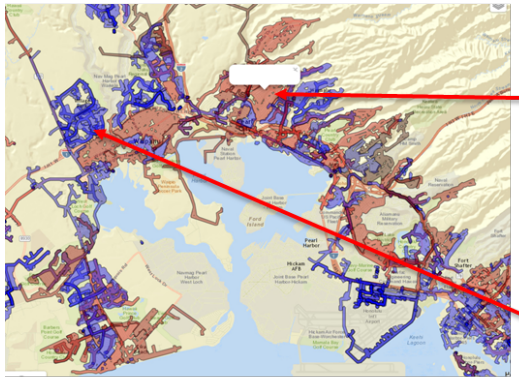
Innovation
- Integrated simulation
- Cloud computing
- Statistical threat modeling
- Probabilistic risk analysis

New methods

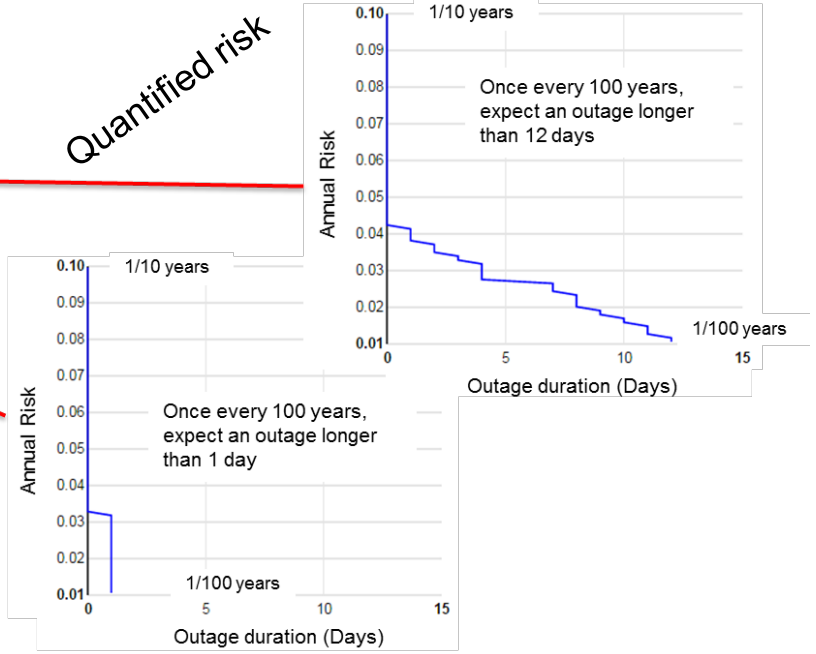
Historically consistent threat



High spatial resolution



Quantified risk



GeoMagnetic Disturbance

Science-Based Threat Analysis

Los Alamos called out 17 times in FERC 830

156 FERC ¶ 61,215
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 40

[Docket No. RM15-11-000; Order No. 830]

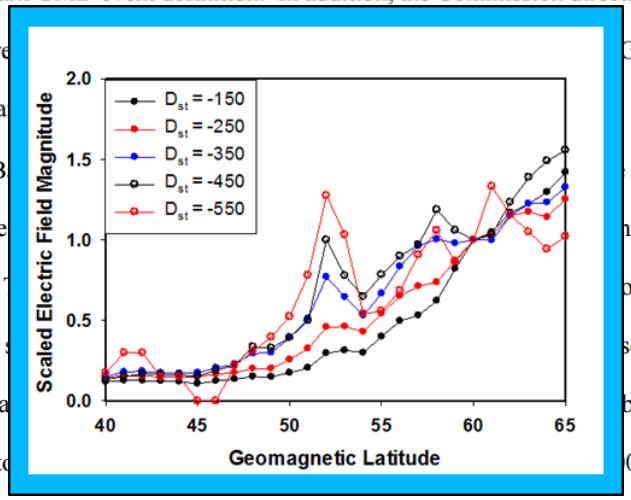
Reliability Standard for Transmission System Planned Performance for Geomagnetic Disturbance Events

(Issued September 22, 2016)

Commission Determination

55. The Commission approves the geomagnetic latitude scaling factor in the benchmark GMD event definition. In addition, the Commission directs NERC to conduct further re GMD research work pla

56. B to conclude that lower ge he effects of GMD events. ocused on the specific some analyses and anecdota be impacted by GMDs t 07-1.



57. The geomagnetic latitude scaling factor in Reliability Standard TPL-007-1 is supported by some of the available research.[80] In addition, with the exception of the Los Alamos Paper, commenters did not provide new information on the proposed scaling factor nor did commenters suggest alternative scaling factors. However, the Commission finds that there are enough questions regarding the effects of GMDs at lower geomagnetic latitudes to warrant directing NERC to study this issue further as part of the GMD research work plan. The Los Alamos Paper and the sources cited in the NOPR are suggestive that a 1-in-100 year GMD event could have a greater impact on lower geomagnetic latitudes than NERC's proposed scaling factor assumes. But, as the Los Alamos Paper recognizes, the current absence of historical data on large GMD events precludes a definitive conclusion based on an empirical analysis of historical observations. Moreover, in prepared comments for the March 1, 2016 Technical Conference, Dr. Backhaus, one of the authors of the Los Alamos Paper, recommended that "the current NERC analysis should be adopted and further analysis performed with additional observational data and severe disturbance modeling efforts with the intent of refining the geomagnetic latitude scaling law in future revisions."[81] The Commission directs NERC to reexamine the geomagnetic latitude scaling factors in Reliability Standard TPL-007-1 as part of the GMD research work plan, including using existing models and developing new models to extrapolate from historical data on small to moderate GMD events the impacts of a large, 1-in-100 year GMD event on lower geomagnetic latitudes.

Nuclear ElectroMagnetic Pulse

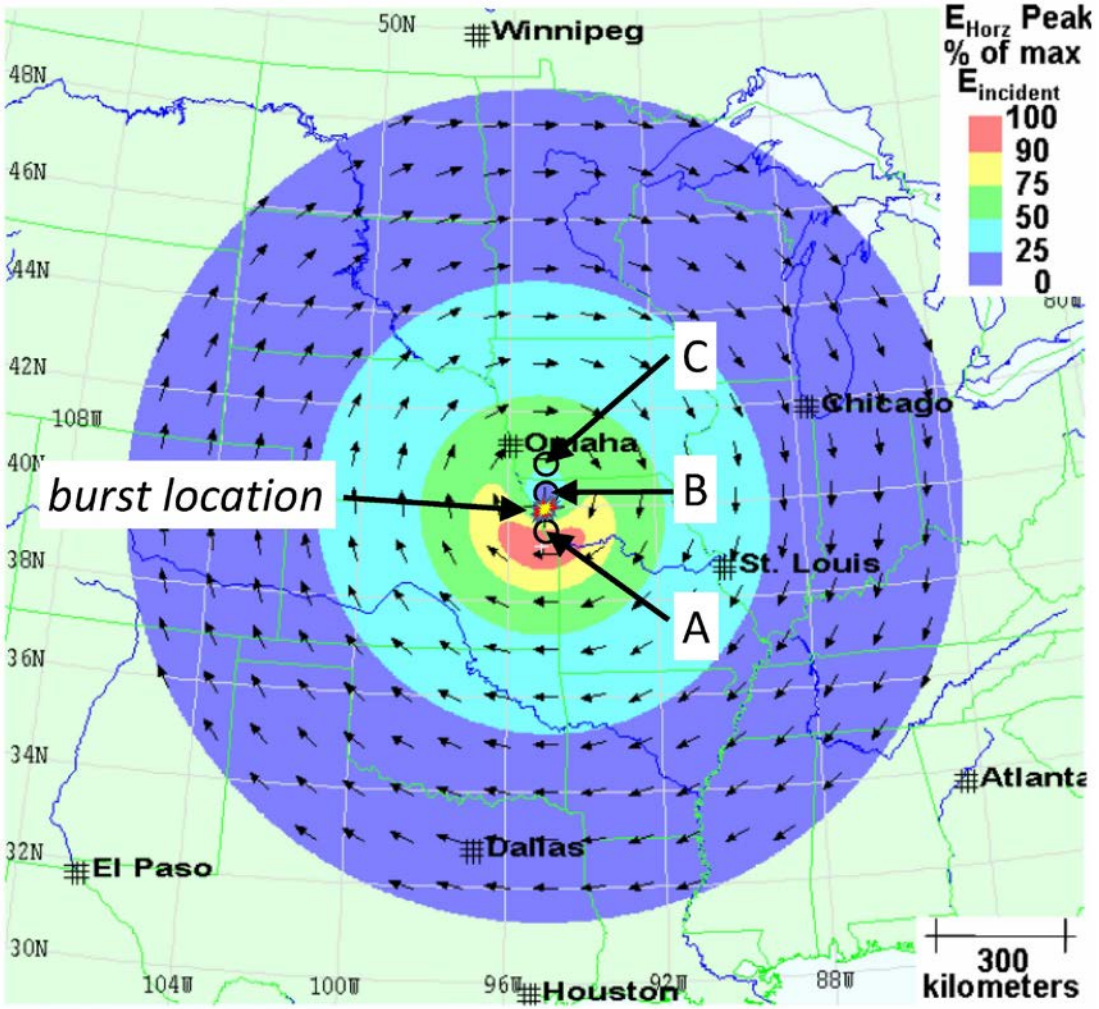
Science-Based Analysis—Determining Threat Basis Events

Without science-based context, the threat of nuclear EMP looks devastating, but:

1. How do we understand the threat space
    1. Country by country?
    2. Location based?
    3. Weapon based?

2. What are the real events of concern?

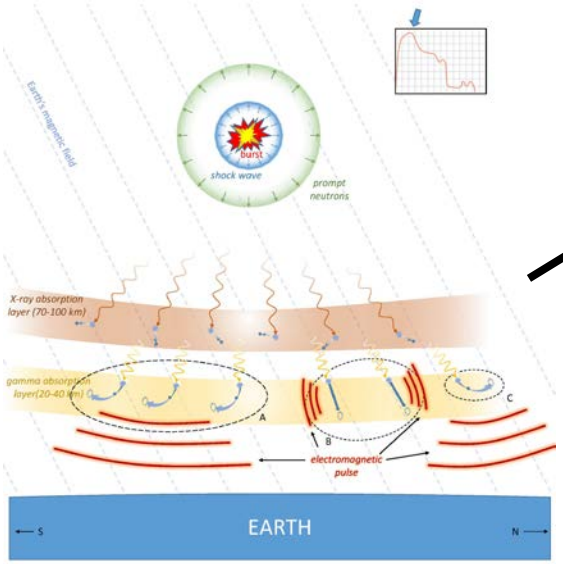
3. How do we use science to determine threat basis events for infrastructure planners?



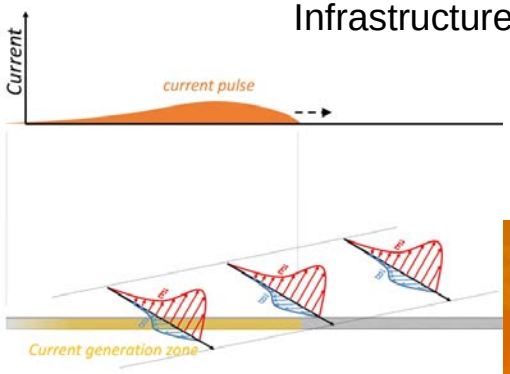
Nuclear ElectroMagnetic Pulse

Science-Based Analysis—Determining Threat Basis Events

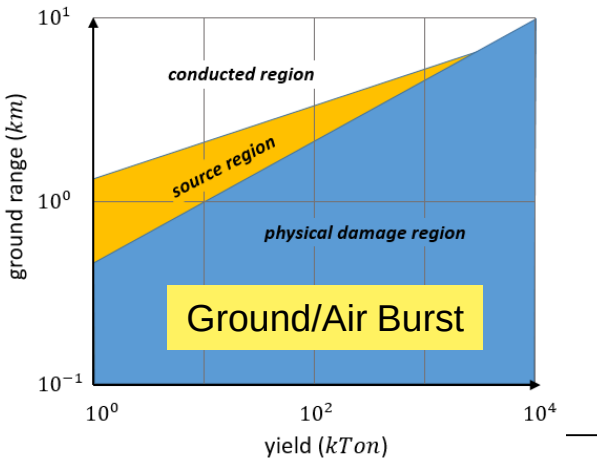
Weapons Effects Physics

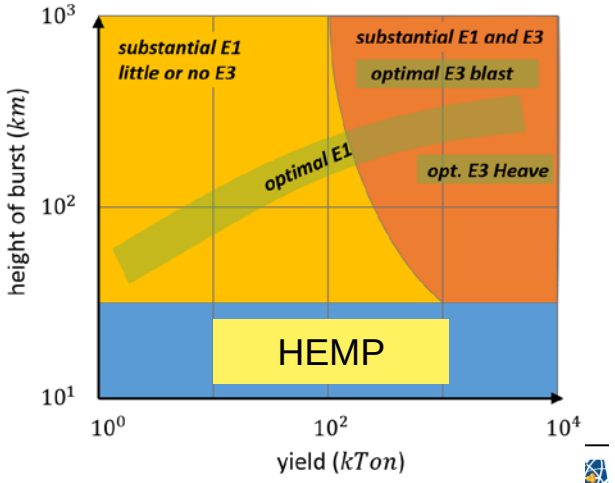


Infrastructure Coupling Physics



Parameterized Events and Hazards

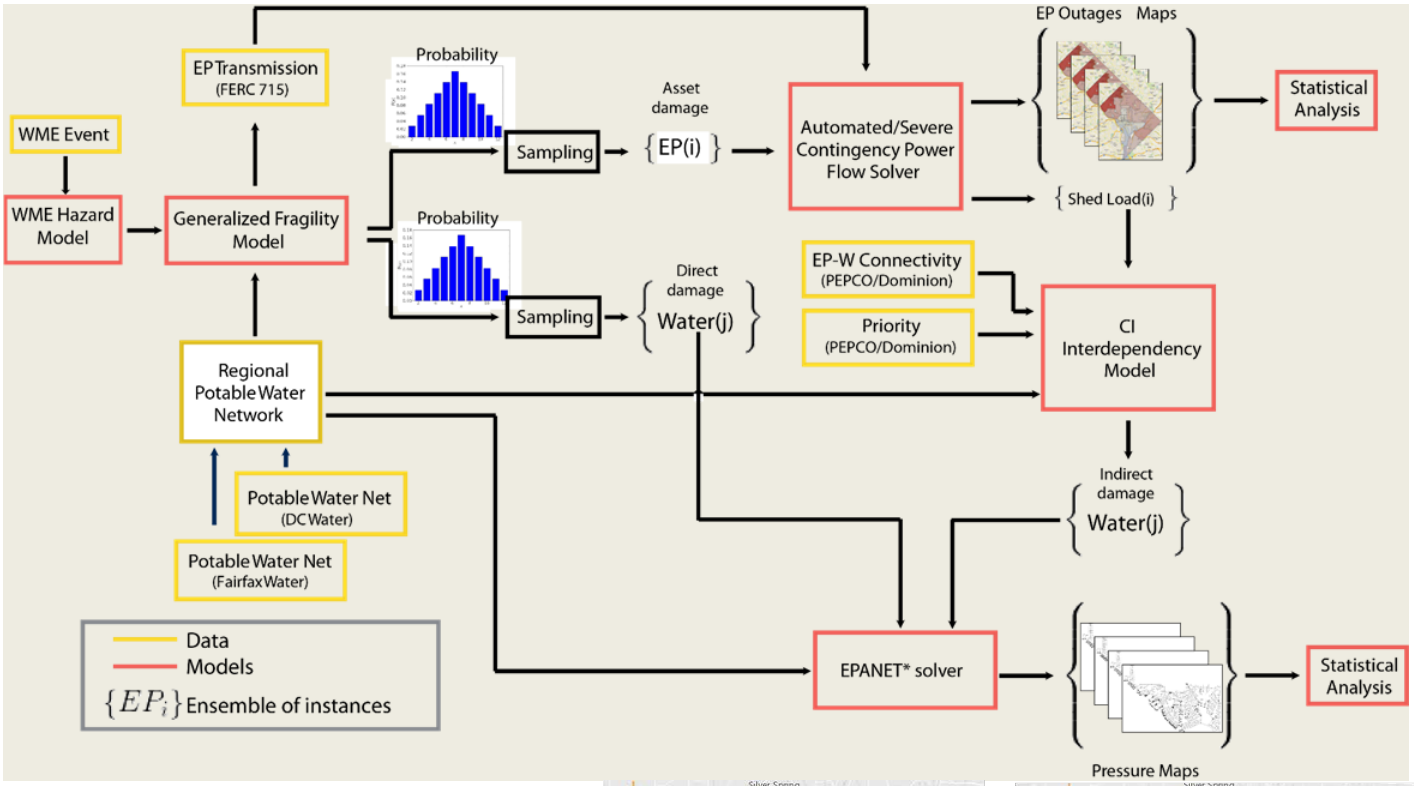




LDRD DR Investments
Developing a better fundamental understanding of space weather an HEMP and impact on infrastructure networks

Cascading Impacts in Dependent Infrastructure

Science-Based Analysis



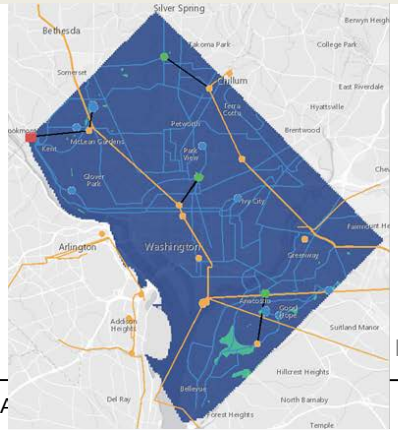
Infrastructure interdependence may lead to complex cascading effects.

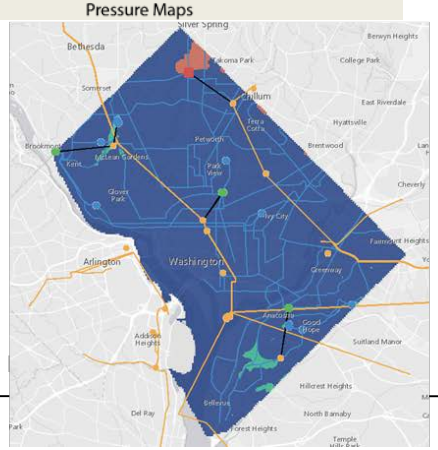
Analysis requires integrated modeling and simulation

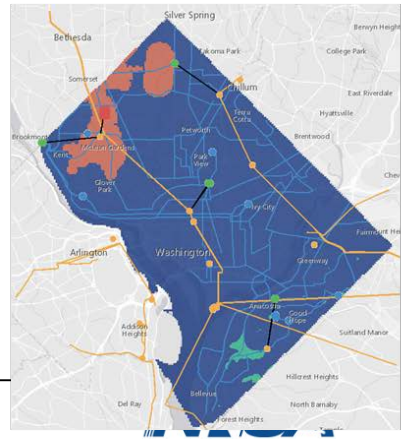
New models are needed to address interdependence for DHS/NISAC data inputs and analysis needs

Water + Electric Power

Communications + Controls integration to address cyber aspects







Cyberphysical Security and Intrusion Detection

Science-Based Analysis—LDRD Investments

Using existing cyber and physical sensing to perform model-free cyberphysical instruction detection