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2014

# Defending Interdependent Infrastructure Systems

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<http://hdl.handle.net/10945/43351>

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### DEFENDING INTERDEPENDENT INFRASTRUCTURE SYSTEMS

— RESEARCH PROJECTS —



**Prof Baldick (U. Texas at Austin),  
Prof Alderson, Prof Salmeron, & Prof Wood (NPS)**

Operations Research Department

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#### Objective

Develop new models, theory, and algorithms for design and retrofit of interdependent infrastructure systems to make those systems more resilient to kinetic and other types of weapons of mass destruction (WMD) attacks. The emphasis is on electric power grids and related infrastructure.

#### Relevance

We seek actions that reduce the vulnerability of a system, or improves its resilience to attack, e.g., hardening, adding redundancy, reducing repair times.

#### Approach

To optimally defend a system, we first must be able to identify the worst-case attacks on that system that an intelligent adversary could carry out: "attacker-defender" (AD) or "interdiction" models. Our models combine large-scale optimization and game theory. Modified interdiction models also solve "network-manipulation problems"

#### Defender-Attacker-Defender (DAD) Models

$$\min_{w \in W} \max_{x \in X(w)} \min_{y \in Y(x, w)} f(y)$$

- 3-stage Stackelberg game: (1) **Play**, (2) **observe and play**, (3) **observe and play**. We seek  $w^*$ .
- Broad applicability to the C-WMD mission space
- Interdependent infrastructures require novel DAD modeling
- DAD is not easy to solve (e.g., exhaustive enumeration works in principle but is impractical)

#### Personnel Support

R.Baldick (PI), Univ. of Texas; D.Alderson, J. Salmerón, K. Wood, NPS (Assoc. Investigators); 1 PhD student Univ. of Texas; 1 PhD student NPS; 4 MS students NPS; and advised one military PhD student at Colorado School of Mines.

#### Results update

- Developed new decomposition algorithm for solving AD
- Solving some AD models faster with new, adaptive branch-and-bound algorithm

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- Developed new decomposition algorithm for solving DAD with nonlinear system-operations models
- Developed new taxonomy and mathematics to represent infrastructure interdependence
- Integrated simulation-based cascading-failure model with steady-state AD model: gives interesting new guidance

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