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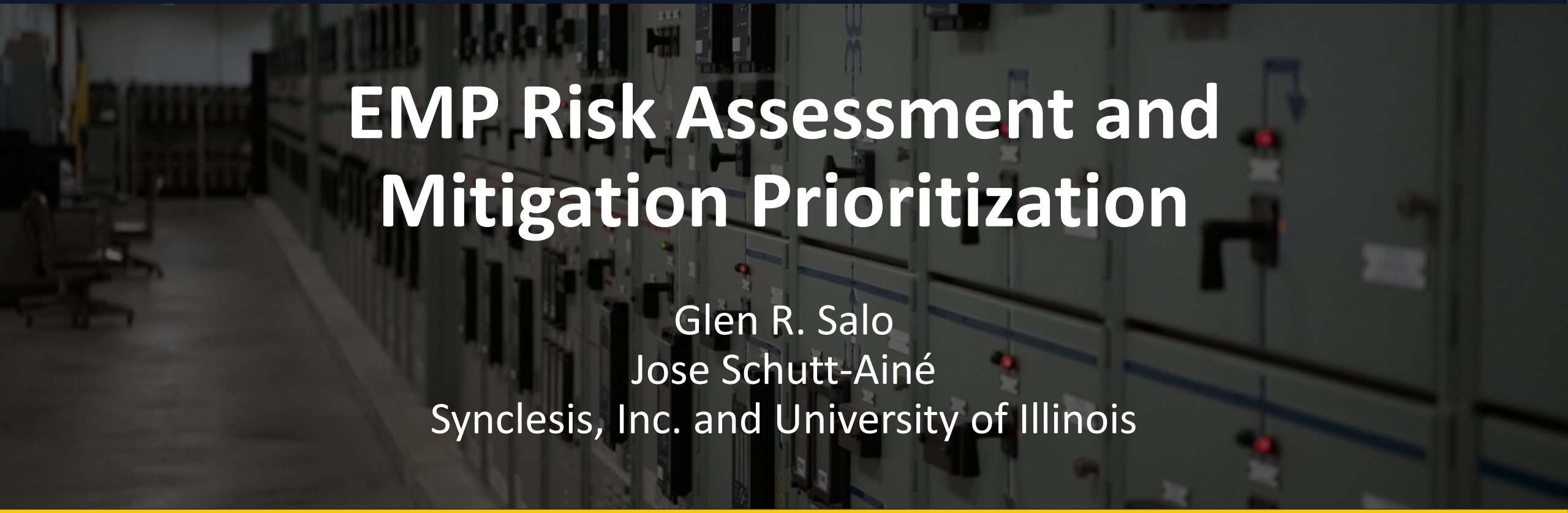

EMP Risk Assessment and Mitigation Prioritization

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Project Overview

- Abstract
  - Develop an **EMP risk assessment capability** that accounts for system, operational, and component variabilities
  - **Conduct assessments** on critical infrastructures
- Objectives
  - R&D: Enhance the proposed stochastic collocation modeling approach
    - Research and implement computational approaches tailored to EMP EM events
    - Integrate fast stochastic circuit solvers
    - Research and implement promising statistical modeling approaches
  - R&D: Research design optimization techniques for EMP mitigation
    - Incorporate transient analysis computational methods and performance metrics into our framework
  - Assessments: Conduct an EMP assessment on a ~~power substation~~ communication system

Milestones and Accomplishments

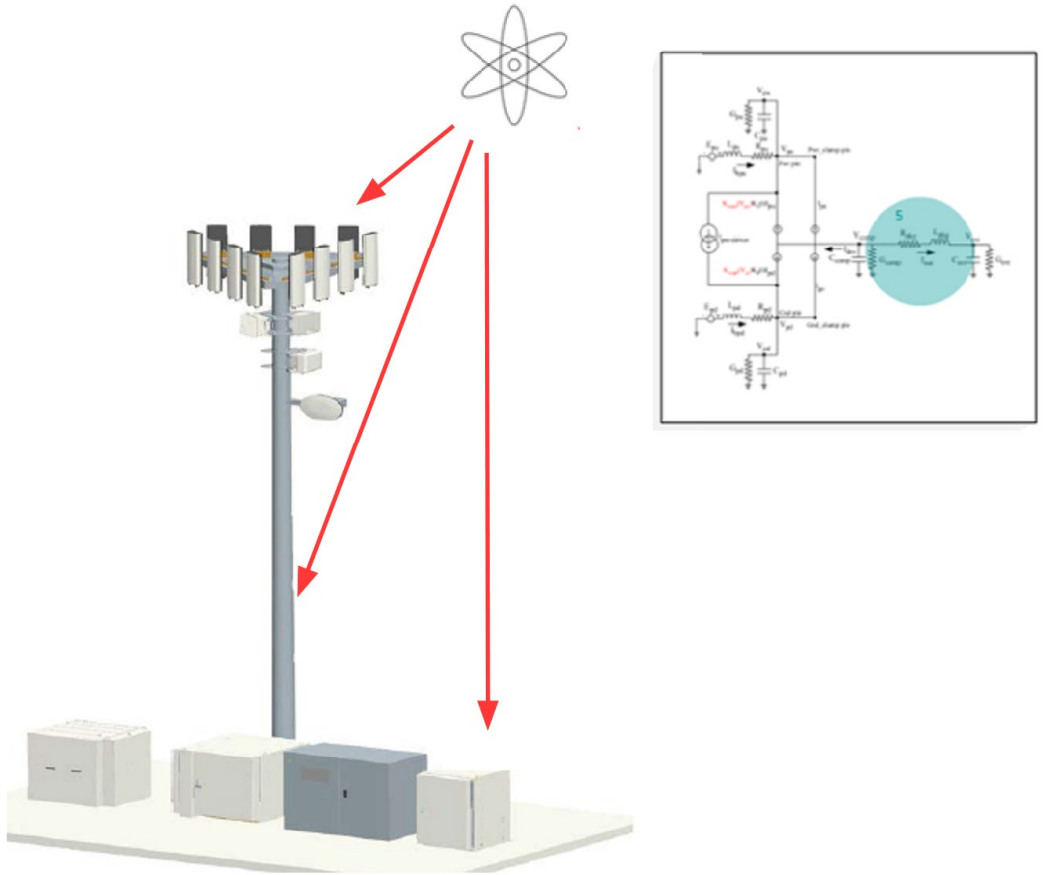
- Collected detailed information about the power substations and their equipment
- Acquired electronic systems used by the power industry (future testing purposes)
- Developed a baseline electromagnetic computational model of the power substation that include electromagnetic coupling of the EMP signal to the power lines and the electronic equipment housed within the substation
- Developed a baseline circuit model of the power substation that models the propagation of the EMP signal through the substation and into the susceptible electronic systems
- Added support for Monte Carlo LIM to the MEAD framework
- Developed the general theory and approach to calculate EMP coupling to power lines and initiated its development

Milestones and Accomplishments (cont'd)

- Project redirection
  - DHS NPPD originally requested assessment of a power substation
    - Focused research on coupling to power lines
    - Focused models on a power substation
  - After discussions with DOE, DHS CISA has requested a change in focus to our nation's communication infrastructure
    - Project assessment is now focused on the impact EMP will have on a mobile communication tower

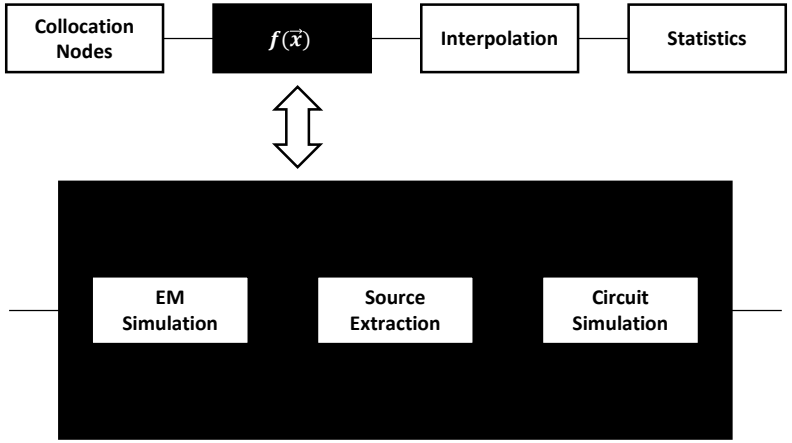
Approach

- Primary Challenges
  - The computational complexity is far too great for brute force application of state-of-the-art electromagnetic and circuit solvers
  - System variabilities and uncertainties can dominant the response
  - Impractical to test all configurations



Approach (cont'd)

- Proposed Solution
  - Break the problem into a cascade of hierarchical components (leverages existing codes)
  - Employ a sparse statistical approach (stochastic collocation) to develop a function response for the system
  - Use the functional response to quickly determine a statistical response
  - Employ same method to explore design options
  - Use statistical response to identify configurations and conditions that require testing



Testing, Evaluation, and Validation

- Individual hierarchical components
  - Compare with exact solutions
  - Quantify with established numerical accuracy studies
  - Validate with canonical and experimental data (when available)
- Hierarchical model
  - Validate process with small models that are computationally feasible for brute force application
- Stochastic methodology
  - Validate with Monte Carlo approaches using small models

Testing, Evaluation, and Validation (cont'd)

- Framework
  - All software is maintain using modern source control methods
  - All development is tracked in an issue tracking system
  - Unit and regression testing will be integrated throughout the development process

Project Impact

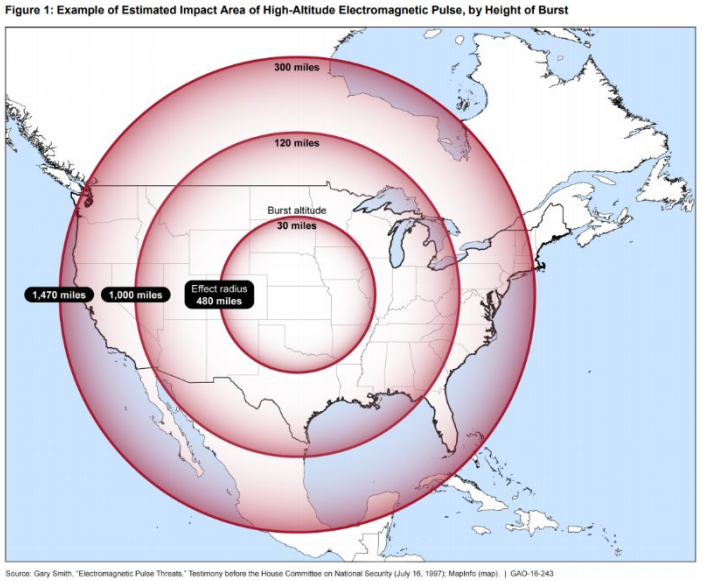


Figure 1: Example of Estimated Impact Area of High-Altitude Electromagnetic Pulse, by Height of Burst

Source: Gary Smith, "Electromagnetic Pulse Threats," Testimony before the House Committee on National Security (July 16, 1997); MapInfo (map). | GAO-16-243

- The threat of EMP is a national security risk
  - President Donald J. Trump's executive order on March 26, 2019 for "Coordinating National Resilience to Electromagnetic Pulses."
  - DHS "Strategy for Protecting and Preparing the Homeland against Threats from Electromagnetic Pulse (EMP) and Geomagnetic Disturbance (GMD)", October 9, 2018
- Low probability/**high consequence** scenario
  - Assessments are intrinsically difficult
  - Proper planning can mitigate effects

Project Impact (cont'd)

- Addressing what has been an intractable problem
  - System, operational, and device uncertainties
  - Multi-scale computational limitation
  - Limited testing options
- Benefits
  - Predict **EMP effects** using **detailed electrical system models** while accounting for **uncertainties**
  - **Prioritize tests**
  - **Improved** electrical system **designs**
  - **Enhanced** critical infrastructure **resiliency**

Transition Plans

- Under an STTR, Synclesis is commercializing EMI modeling approaches developed at UIUC
- This project extends our modeling framework capabilities to EMP applications
- Commercialization of this capability will occur in conjunction with the STTR commercialization effort
  - I-CORP project participation
  - LIM simulator
  - MEAD framework

Transition Plans (cont'd)

- End Users (letters of support)
  - Electronic Design Industry (signal integrity)
    - Intel, XPEEDIC
  - Computer Aided Design
    - ANSYS
  - Aerospace/DoD
    - AFRL, HPCMO CREATE-RF, Lockheed Martin