R&D Needs for Improving Resilience to Electromagnetic Pulses

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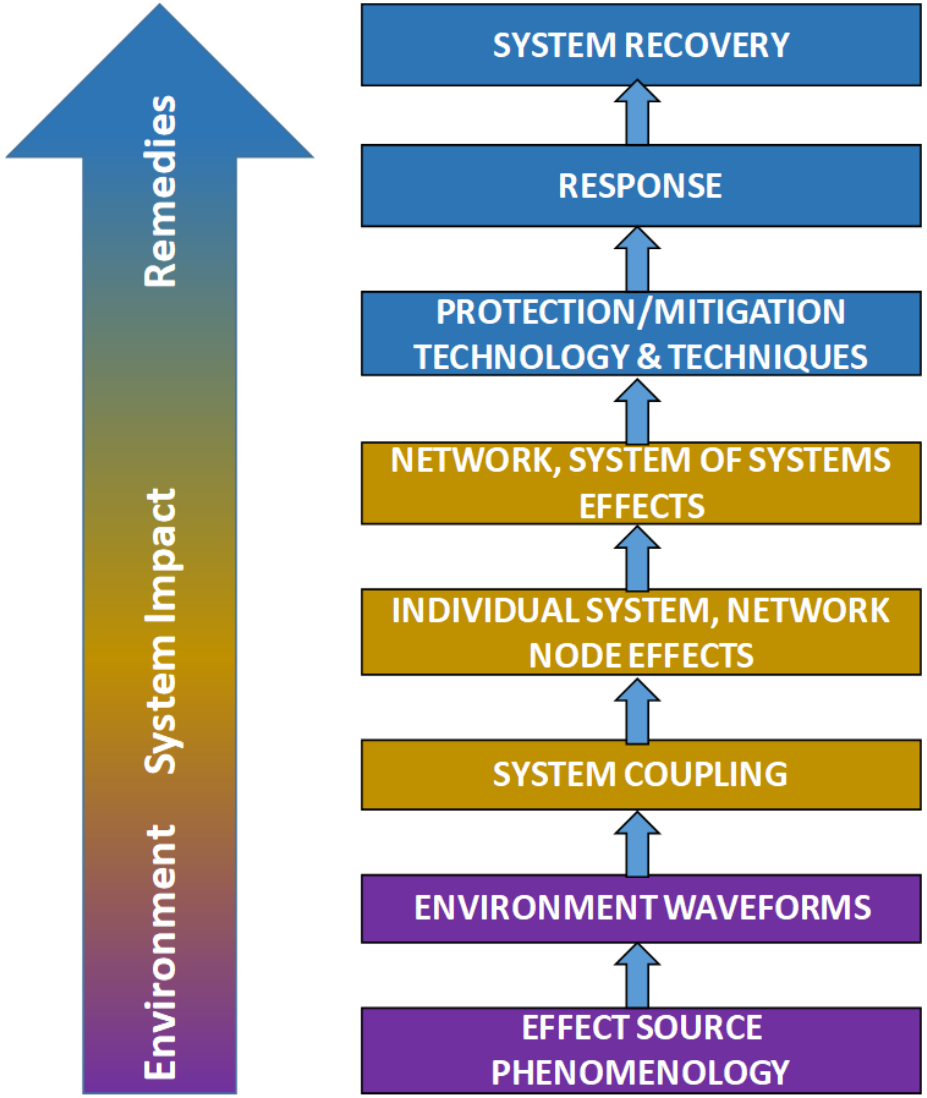
EXECUTIVE ORDER

- Executive Order (EO) 13865 on Coordinating National Resilience to Electromagnetic Pulses (EMPs) issued March 26, 2019
- Improve resilience of critical infrastructure (CI) against natural and man-made EMPs
  - Considers severe space weather and high-altitude nuclear burst generated EMP (HEMP)
  - Objective: minimize disruption to national security, economic prosperity, and stability
- Federal government to foster sustainable, efficient, and cost-effective approaches
  - Coordinated, whole-of-government with risk-informed planning and private sector engagement
  - Promote collaboration among agencies, CI owners/operators, and other stakeholders
- Delineates roles and responsibilities
  - Identifies seven agencies explicitly plus six more as sector specific agencies
  - Assigns responsibility for coordinating implementation to Assistant to the President for National Security Affairs (National Security Advisor)
- Identifies 18 specific tasks with most to be completed in first two years
  - Includes identifying vulnerable critical infrastructure assets, determining mitigation technologies and responses, determining benchmarks, addressing gaps in testing data, and conducting pilot tests to evaluate mitigation approaches
  - Section 4b: OSTP through National Science & Technology Council (NSTC) to review and assess Federal R&D needs to support EO implementation

DEVELOPMENT OF R&D NEEDS

- EMPRAD Interagency Working Group formed under NSTC Subcommittee on Resilience Science & Technology (SRST)
  - Composed of 14 agencies plus NSC staff
- Developed a framework for assessment
- Completed R&D baseline, gaps, and needs using agency inputs
- R&D needs aligned to agency EO responsibilities and core missions
  - Minimizes duplication of effort
  - Encourages collaboration and leveraging of resources
- Recognizes the natural overlap with space weather activities (SWORM)
  - Geomagnetic displacement (GMD) similar to E3 component of HEMP
  - Overlap reduced by concentrating on near-Earth processes ("radiation belts and below")
  - Commonality of some needs underscores their fundamental importance
- Generated "R&D Needs for Improving Resilience to Electromagnetic Pulses" report on an aggressive time schedule; will reassess on an annual basis

ASSESSMENT FRAMEWORK



- Simplified process flow captures the high-level, key areas of knowledge and capabilities needed to improve infrastructure resilience
  - Spans initiating event physics to fully recovered infrastructure operation
- Technical maturity of each area assessed for GMD and HEMP to help identify needs
- Determined 12 topical areas of R&D—half concentrated in System Impact
  - Encompass theory, models, simulation, observational data, experiment, testing, and large-scale pilot studies
  - Interdependence a key characteristic—compounded, cascading effects
- Most needs apply across multiple critical infrastructures; needs concentrated in energy, communications, water, and transportation ("long-line") sectors
- Iterative approach to improvements likely

R&D NEEDS AND ALIGNMENT TO AGENCIES

	Research Need	DHS	DOC	DOD	DOE	DOI	DOS	DOT	EPA	NASA	NRC	NSF
Environment	Monitor, analyze, and understand upper atmosphere and radiation belt dynamics during EMP events (EO §§ 5bi, 5bii, 5di, 5dii)		●	●						●		●
	Improve the accuracy and timeliness of space weather forecasts (EO §§ 5bi, 5bii, 5di, 5dii)		●	●				○		●		●
	Measure and compile geomagnetic data and develop tools to improve EMP impact analyses (EO §§ 5c, 5di, 5e, 5fv, 6biv)	○	●	○	●	●		○				○
System Impact	Improve models for EMP coupling to infrastructure elements (EO §§ 5biii, 5e, 5fv)	●		●	●			○	○			
	Improve models of national-scale infrastructure (EO §§ 5ai, 5biii, 5e, 5fv)	●		●	●		●					
	Utilize improved models and simulation to better assess the impacts to infrastructure (EO §§ 5ai, 5biii, 5e, 5fv, 6aii)	●		●	●		●		○	○		
	Ensure tesbeds have the capabilities to perform fully loaded and connected systems tests (EO §§ 5bv, 5e, 5fv, 6bi, 6bii)	●		●	●			○	●		○	
	Conduct vulnerability assessment testing of representative equipment, systems, and infrastructure (EO §§ 5biii, 5e, 5fv, 6aii, 6bi, 6bii, 6eiii)	●		●	●			○	●	○	○	
	Develop and implement instrumentation methods for critical equipment to capture real-time data during geomagnetic disturbances (EO §§ 5e, 6bii)	●			●	○					○	
Remedies	Develop methodologies for effective placement of monitoring and protection/mitigation technologies in fielded networked systems (EO §§ 5biii, 5e, 5fv, 6ci, 6cii)	●		●	●				●			
	Determine and demonstrate viable protection and mitigation technologies and methods (EO §§ 5biii, 5e, 5fv, 5i, 6ci, 6cii, 6di)	●		●	●			○	●	●	○	
	Investigate technologies and techniques to improve response and recovery efforts (EO §§ 5c, 5fii, 5fiii, 5fv, 5i, 6ci, 6eii, 6eiii)	●	●	●	●	●		○	●	○		

● indicates alignment with EO responsibility/core mission ○ indicates area of interest

OBSERVATIONAL R&D NEEDS

- Observational data highlighted in first three needs (Environment)
- Understand and monitor upper atmosphere
  - In-situ experiments/observation using sounding rockets and satellites
  - Use of theory, simulation, observations to understand the magnetosphere-ionosphere-thermosphere coupled system during GMD events
- Improve space weather forecasts
  - Greater data integration and utilization to verify and improve models
  - Data to inform research-to-operations and operations-to-research improvements
- Measure and compile geomagnetic data
  - New magnetic monitors to improve geographic resolution and temporal monitoring
  - Completion of magnetotelluric (MT) survey to improve infrastructure vulnerability assessments