Implementation Roadmap for the National Critical Infrastructure Security and Resilience (CISR) Research and Development (R&D) Plan

Strengthening the Security and Resilience of the Nation's Critical Infrastructure

December 2016

Role of R&D in CISR

- The Nation's security depends on uninterrupted provision of critical infrastructure services
- R&D is needed to better ensure that such services continue uninterrupted during normal conditions and infrequent high-impact events
- To identify and coordinate such R&D, the National Science and Technology Council has released this Implementation Roadmap for the National CISR R&D ("the Roadmap")

Policy Driver – PPD-21 (Feb. 2013)

- Tasks DHS to develop a National CISR R&D Plan, in coordination with other Federal stakeholders
  - Account for evolving threats, annual metrics, etc.
  - Reissue every 4 years with interim updates as needed
- Designates 16 critical infrastructure (CI) sectors and sector-specific agencies (SSAs)
- Defines resilience and security
  - Security is reducing the risk to physical or cyber…
  - Resilience is adapt to, withstand, and recover from…

CI Sectors in PPD-21

Critical Infrastructure Sector	Sector-Specific Agency (SSA)	Co-SSA
Chemical	DHS	
Commercial Facilities	DHS	
Communications – LL	DHS	
Critical Manufacturing	DHS	
Dams	DHS	
Defense Industrial Base	DOD	
Emergency Services	DHS	
Energy – LL	DOE	
Financial Services	Treasury	
Food and Agriculture	USDA	HHS
Government Facilities	DHS	GSA
Healthcare and Public Health	HHS	
Information Technology	DHS	
Nuclear Reactors, Materials, and Waste	DHS	
Transportation Systems – LL	DHS	DOT
Water and Wastewater Systems – LL	EPA	

LL = Lifeline Function

National CISR R&D Plan (Nov. 2015)

- Released November 2015 by DHS
- Five priorities areas for CISR R&D:
  - Foundational Understanding of CI Systems and Dynamics
  - Integrated Scalable Risk Assessment and Management
  - Integrated and Proactive Capabilities, Technologies, and Methods to Support Secure and Resilient Infrastructure
  - Data Sciences for Unified Situational Awareness and to Understand Consequences of Action
  - Crosscutting Culture of CISR R&D Collaboration
- Recommends an OSTP & DHS-led NSTC CISR subcommittee develop an Implementation Roadmap

CISR Subcommittee

- Convened in December 2015 under the NSTC Committee on Homeland and National Security

Department of Agriculture
Department of Commerce
Department of Defense
*** Department of Energy
Department of Health and Human Services
*** Department of Homeland Security
Department of State
Department of Transportation
Department of the Treasury
Defense Advanced Research Projects Agency
Environmental Protection Agency
Federal Aviation Administration
Federal Communications Commission
Federal Emergency Management Agency
Federal Energy Regulatory Commission
Federal Highway Administration
Food and Drug Administration
General Services Administration
National Institute of Standards and Technology
National Science Foundation
Nuclear Regulatory Commission
United States Army Corps of Engineers
United States Bureau of Reclamation
National Security Council
Office of Management and Budget
*** Office of Science and Technology Policy

*** Three co-chairs

CISR R&D Implementation Roadmap

- The CISR Subcommittee, with input from industry, identified five Challenge Areas that each addresses a cross-cutting issue or a lifeline function
- The Roadmap describes goals for ongoing Federal R&D associated with each Challenge Area
- The Roadmap identifies activities for Executive departments and agencies to conduct over the short term (1–3 years), midterm (3–10 years), and long term (10 years or more)

Challenge Areas

1. Understanding **Interdependencies in Infrastructure** Vulnerabilities for Improved Decision Making

2. **Position, Navigation, and Timing Support** Functions

3. Resilient, Secure, and Modernized **Water and Wastewater Infrastructure Systems** Capable of Integration with Legacy Systems

4. Next-Generation Building Materials and Applications for **Transportation Infrastructure Systems**

5. Resilient and Secure **Energy Delivery Systems**

Understanding Interdependencies in Infrastructure Vulnerabilities for Improved Decision Making

Vision:

Leverage data-rich repositories, quantitative models, and visualizations to support improved overall risk management and resource allocation processes for the Nation's critical infrastructures; thereby enhancing the resilience and security of interdependent infrastructures

Goals:

1.1 Models of critical infrastructure interdependencies on lifeline functions

1.2 Data to support predictive models and decision making

1.3 Effective and efficient decision processes for resource allocation

Position, Navigation, and Timing (PNT) Support Functions

Vision: Enhance the security and resilience of critical PNT-dependent systems through the development of robust PNT services and equipment that ensure the continuity and integrity of vital services

Goals:

2.1. Technologies to harden PNT receivers

2.2. Technologies to enable more secure and resilient PNT services

2.3. Technologies to enhance the security of current & future PNT systems

Resilient, Modernized Water and Wastewater Infrastructure Systems Capable of Integration with Legacy Systems

Vision:

Create safe, secure, and resilient municipal water infrastructure systems by developing new technologies and integrating them into existing systems

Goals:

3.1. Resilient water and wastewater infrastructure

3.2. Methods and strategies for response to disasters

3.3. Smart water systems for water resilience and security

Next-Generation Building Materials and Applications for Transportation Infrastructure Systems

Vision : Build a resilient, sustainable, adaptable, and durable smart transportation infrastructure that incorporates high-performing materials, optimized structural designs, advanced sensor systems, and fabrication and construction processes that meet mobility and livability challenges

Goals:

4.1. Modernized critical transportation infrastructure

4.2. Transportation infrastructure that withstands extreme events

4.3. More rapid, efficient and cost-effective building and repair

4.4. Diagnostic capabilities for assessing the infrastructure

Resilient and Secure Energy Delivery Systems

Vision Statement: Develop technologies, models, and analytic tools that enable energy owners and operators to design, implement, operate, and maintain secure and resilient energy delivery systems that are capable of sustaining critical functions during and after disruptive events

Goals:

5.1. System design for resilience

5.2. Preparedness and mitigation measures

5.3. System response and recovery

5.4. Characterization and management of energy interdependencies

5.5. Energy systems that withstand high-impact, low-frequency events

5.6. Next-generation cyber-physical security capabilities

Backup Slides on Challenge Areas

Understanding Interdependencies in Infrastructure Vulnerabilities for Improved Decision Making

Vision:

Leverage data-rich repositories, quantitative models, and visualizations to support improved overall risk management and resource allocation processes for the Nation's critical infrastructures; thereby enhancing the resilience and security of interdependent infrastructures

Goals:

1.1 Models of critical infrastructure interdependencies on lifeline functions

1.2 Data to support predictive models and decision making

1.3 Effective and efficient decision processes for resource allocation

Example Activities in the Interdependencies Challenge Areas

1.1.1. Through an interagency process, identify and characterize lifeline function interactions among sectors. Characterization will include identification of key physical, social, and behavioral effects on critical infrastructures to enable model development. Stakeholder agencies for this objective include the National Institute of Standards and Technology (NIST), , DHS, National Science Foundation (NSF) and other relevant agencies.

Deliverables: (1) Requirements for the selection and integration of data and metadata into models of infrastructure interdependence; (2) a taxonomy of social and behavioral influences on mitigation, response, and recovery processes; and (3) a crosswalk of sector interdependencies at the community, industry, regional, and national levels to identify key physical, operational, economic, social, and behavioral relationships necessary to support model development

Timeline: Short term

Example Activities in the Interdependencies Challenge Areas

1.1.2. Link existing models of the effects of interdependencies across critical infrastructure sectors on system service, security, and resilience. DHS will coordinate this activity.

Deliverables: (1) Formats for data exchange that facilitate data use across different infrastructure models; (2) federated models that combine existing analytical tools at various levels of granularity; and (3) a gap analysis of existing data and models

Timeline: Short term

Public Access Infrastructure Data

- Support **holistic perspective**: Common data block?
- Support large-scale **comparison/validation/prediction**
- Support **translation and transition** of research
- Approaches
  - Collect new *or* Fuse existing
  - Simulate from real
  - Mint synthetic
- Build community and address data economics
  - Educate research&practitioner communities
  - Intergovernmental/industry partnerships/collaboration
  - Integrate tools/data into planning process

Position, Navigation, and Timing (PNT) Support Functions

Vision: Enhance the security and resilience of critical PNT-dependent systems through the development of robust PNT services and equipment that ensure the continuity and integrity of vital services

Goals:

2.1. Technologies to harden PNT receivers

2.2. Technologies to enable more secure and resilient PNT services

2.3. Technologies to enhance the security of current & future PNT systems

Example Activities in the PNT Challenge Area

2.1.1. Understand existing and emerging threats to receivers and chipsets from interference, spoofing, jamming, and cyber-attacks, to reduce and possibly eliminate these vulnerabilities, and to improve the integrity, availability, and continuity of PNT receiver components and PNT equipment. DHS, Department of Defense (DOD), and Department of Transportation (DOT) will work with other agencies and the private sector (particularly the manufacturing and user communities), as appropriate, to coordinate this activity. The Federal Communications Commission (FCC) shall be invited to participate.

Deliverable: A report of findings to increase manufacturer and user community awareness of critical PNT-dependent user application system vulnerabilities to improve the resiliency of technologies used within critical application systems

Timeline: Short term

Example Activities in the PNT Challenge Area

2.1.2. Advance PNT receiver and other PNT technologies to be used in and interoperable with new and legacy PNT subsystems. Examples of potential R&D activities may include improved integration of GPS and multi-GNSS with terrestrial radio frequency and autonomous sensors; improved logic and algorithms for receiver components, software assurance, and cyber protections; and improved antenna hardware and processing (e.g., nulling antenna). DHS, DOD, and DOT will work with other agencies and the private sector (particularly the GPS and GNSS manufacturing communities), as appropriate, to coordinate R&D activities.

Deliverable: Pilot-ready prototype PNT receivers and PNT systems that incorporate new advanced elements that will improve the identification and mitigation of existing and anticipated future interference, spoofing, and cyber threats to the extent practical to enable the provision of PNT services to critical user application systems

Timeline: Short to midterm

Resilient, Modernized Water and Wastewater Infrastructure Systems Capable of Integration with Legacy Systems

Vision:

Create safe, secure, and resilient municipal water infrastructure systems by developing new technologies and integrating them into existing systems

Goals:

3.1. Resilient water and wastewater infrastructure

3.2. Methods and strategies for response to disasters

3.3. Smart water systems for water resilience and security

Example Activities in the Water and Wastewater Challenge Area

3.1.1. Develop system-wide approaches for assessment of transformative fit-for-purpose and resource-recovery-based water systems. The Environmental Protection Agency (EPA) plans to coordinate this activity.

Deliverable: An open source database (e.g., a toolkit library) that contains a repository of detailed water-related technical options and perspective papers to serve water professionals and decision makers looking for specific transformative solutions that have been evaluated and assessed

Timeline: Short term

Example Activities in the Water and Wastewater Challenge Area

3.1.2. Provide a system-level assessment of alternative fit-for-purpose water reuse scenarios for urban environments. This involves an integrated assessment approach combining life-cycle costing, life cycle impact assessment, local human health risks, and resilience capable of evaluating the role of scale, type of wastewater, and treatment approach on the sustainability of alternative scenarios. EPA will coordinate this activity.

Deliverables: (1) A new life-cycle assessment tool and database that will be able to quantify location-specific environmental impacts (such as eutrophication and water scarcity) for community water systems; and (2) a novel approach through coupling the system water scarcity with a total water assessment model to assess sustainable solutions for water shortages

Timeline: Short term

Next-Generation Building Materials and Applications for Transportation Infrastructure Systems

Vision : Build a resilient, sustainable, adaptable, and durable smart transportation infrastructure that incorporates high-performing materials, optimized structural designs, advanced sensor systems, and fabrication and construction processes that meet mobility and livability challenges

Goals:

4.1. Modernized critical transportation infrastructure

4.2. Transportation infrastructure that withstands extreme events

4.3. More rapid, efficient and cost-effective building and repair

4.4. Diagnostic capabilities for assessing the infrastructure

Example Activities in the Transportation Challenge Area

4.1.1. Develop, pilot, and support research of next-generation building materials to ensure extended performance by addressing strength, durability, and life-cycle requirements to improve the condition and performance of transportation infrastructure. DOT, DHS, NSF, and USACE will work with other agencies to coordinate these R&D activities.

Deliverables: Stronger, more ductile, and more corrosion-resistant steels; advanced paint systems and coatings; stronger, durable, flexible, and crack-resistant concretes; concrete mixes that use less Portland cement and more crushed limestone; corrosion-resistant reinforcing bars and strands; decay-resistant wood and wood products; more durable asphalts; nanomaterials; and polymers for infrastructure applications

Timeline: Midterm to long term

Example Activities in the Transportation Challenge Area

4.1.2. Develop and adapt building materials for challenging environments, including cold weather or underwater, to improve the integrity of levees, flood walls, bridge piers, and other underwater structures. USACE and DOT will work with other agencies to coordinate this activity.

Deliverable: Faster hardening concretes and cements

Timeline: Midterm

Resilient and Secure Energy Delivery Systems

Vision Statement: Develop technologies, models, and analytic tools that enable energy owners and operators to design, implement, operate, and maintain secure and resilient energy delivery systems that are capable of sustaining critical functions during and after disruptive events

Goals:

5.1. System design for resilience

5.2. Preparedness and mitigation measures

5.3. System response and recovery

5.4. Characterization and management of energy interdependencies

5.5. Energy systems that withstand high-impact, low-frequency events

5.6. Next-generation cyber-physical security capabilities

Example Activities in the Energy Challenge Area

5.1.1. Conduct R&D to improve measurement, sensing, and real-time wide-area visibility of transmission grid behavior using phasor measurement units (PMUs) and synchrophasor data, and develop advanced communications and control systems, next-generation PMUs and software applications, and PMU-based algorithms needed to identify and react to disturbances and enable self-healing systems and automatic islanding. DOE will coordinate this activity.

Deliverable: Advanced communications and control systems, next-generation PMUs and software applications, and PMU-based algorithms that identify and react to disturbances and enable self-healing systems and automatic islanding

Timeline: Midterm

Example Activities in the Energy Challenge Area

5.1.2. Develop innovative grid modeling approaches that improve computational speeds by several orders of magnitude and validate power system models in real-world environments using real-world data. DOE will coordinate this activity**.**

Deliverable: Advanced computational and modeling capabilities, including dynamic operation, real-time analysis, and predictive response, that can be tested to simulate power system behavior in a real-world environment

Timeline: Short term