Implementing a Roadmap for Critical Infrastructure Security and Resilience

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The Problem

As critical infrastructure systems become increasingly interdependent, targeted research and development (R&D) is needed to anticipate evolving threats to infrastructure systems and to mitigate potential cascading effects across sectors. As part of a broad effort to achieve these objectives, IDA researchers facilitated the development of a Federal R&D Roadmap and associated performance metrics for interagency R&D priorities associated with key infrastructure topics.

Critical Infrastructure

Federal policy defines 16 critical infrastructure sectors that support the Nation's economy, society, public health, and national security. These sectors must be protected against hazards that threaten to disrupt the services that they provide. Ensuring the security and resilience of these sectors is complex because critical infrastructure systems are increasingly interdependent, and R&D is needed to address emerging threats and mitigate potential cascading effects across sectors. Most critical infrastructure is owned and operated by non-Federal stakeholders, and these stakeholders' ability to carry out critical R&D is impeded by the priority placed on continuity of operations. Federal departments and agencies are uniquely positioned to initiate much of the necessary R&D and are well positioned to work with key industry stakeholders to deploy the R&D output across critical infrastructure systems.

In 2016, the IDA Science and Technology Policy Institute supported the Department of Homeland Security National Protection and Programs Directorate in developing the Implementation Roadmap for the National Critical Infrastructure Security and Resilience (CISR) R&D Plan (National Science and Technology Council 2016) ("the Roadmap"). To meet national policy requirements and track the progress and impact of CISR R&D described in the Roadmap, IDA developed a novel metrics framework to evaluate the maturity and performance of R&D activities.

Policy Drivers

Presidential Policy Directive 21 (PPD-21) (The White House 2013) called for a national effort to strengthen and maintain a secure, functioning, and resilient critical infrastructure. PPD-21 directed the Secretary of DHS, in coordination with other Federal departments and agencies, to develop a National CISR

R&D Plan (Department of Homeland Security 2015) ("the Plan") and annual metrics. The Plan, released in December 2015, identified broad priority areas for critical infrastructure R&D. It called for the creation of an interagency CISR Subcommittee under the National Science and Technology Council (NSTC) to facilitate CISR R&D coordination, develop a Roadmap for implementation of the Plan, and establish annual performance metrics to track the progress of CISR R&D activities. IDA supported these three objectives through its work with DHS.

Identification of Infrastructure Challenge Areas

Given the breadth of risks to national critical infrastructure, areas of focus had to be identified and prioritized. IDA helped facilitate the identification and prioritization of "challenge areas" that address either a cross-cutting multi-sector issue or a lifeline function of national importance; lifeline functions include communications, energy, transportation, and water. We used quantitative (i.e., literature review and content analysis) and qualitative (i.e., expert opinion) approaches to identify potential challenge areas.

Literature Review and Content Analysis

To identify potential challenge area topics, we conducted a literature review of CISR-related documents published between 2010 and 2015. The corpus of publicly available documents included sector-specific strategies, plans, and assessments and sector and government coordinating council charters. IDA performed a content analysis on the most relevant subset of the corpus to identify and compile R&D activities, priorities, and goals. We developed a coding system to assess the relevance of potential R&D topic areas. Using the output from the literature review and content analysis and considering existing Federal CISR R&D efforts, we proposed an initial list of challenge areas for consideration.

Review by CISR Subject Matter Experts and CISR Stakeholders

IDA provided the list of initial challenge areas to CISR Subcommittee subject matter experts (SME) for review. Using a modified Delphi method, the SMEs were asked to propose additional challenge area topics, which lead to a final list of 40 potential priorities.

The final step in the challenge area development process was a CISR stakeholder review, which was facilitated through the Critical Infrastructure Partnership Advisory Council (CIPAC).[1] Potential challenge areas were presented to CIPAC members along with a questionnaire to elicit structured feedback from SMEs. With IDA's facilitation, the CISR Subcommittee used the CIPAC feedback to refine the potential list

[1] CIPAC was established by the Secretary of Homeland Security consistent with Section 201 of the Homeland Security Act of 2002 (6 U.S.C. § 121). It facilitates direct deliberation and development of consensus positions to assist the Federal Government in the coordination of Federal CISR programs. CIPAC develops policy advice and recommendations on CISR topics to DHS and other relevant Federal stakeholders.

into the final five challenge areas—prioritized in the Roadmap as follows:

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.

Developing the Roadmap

After coordinating the identification and selection of challenge areas, IDA facilitated an interagency working group process under the CISR Subcommittee, with each working group focused on a challenge area. The working groups set goals and identified R&D activities, actors, deliverables, and timelines necessary to make progress across each challenge area. The Roadmap was published in December 2016.

The Maturity Scale Framework (MSF) and Measuring Performance to Achieve CISR R&D Goals

The Plan called for DHS to develop annual performance metrics within six months of the release of the Roadmap. Performance metrics allow agencies to track the progress of activities against the challenge areas challenge areas in the Roadmap and priority areas in the Plan. Performance metrics can help inform future Federal CISR R&D program investment by identifying CISR programs that are effectively managed and meeting user needs.

To fulfill the Plan's requirement and accomplish these objectives, IDA developed the MSF. The concept of tracking metrics through a codified framework is not new idea, but existing approaches to evaluating and tracking R&D progress are insufficient for the varied R&D activities in the Roadmap. For example, the Technology Readiness Assessment (TRA) evaluates linear innovation processes for an individual technology but does not assess non-technical processes required for successful R&D. The MSF builds on the TRA by providing a more holistic approach to metrics. It tracks and evaluates technical and non-technical processes associated with R&D and provides stakeholders a standard taxonomy for measuring progress across activities. When used together, technical metrics such as the TRA can complement the MSF's holistic approach to create a more complete set of data to evaluate R&D progress and processes.

The MSF is divided into four phases (see Figure 1). The first phase focuses on identification of R&D challenge areas, goals, activities, and deliverables. The second phase focuses on the development (or refinement) of R&D programs to address and complete the identified goals, activities, and deliverables. The third phase focuses on the implementation of the R&D program. The fourth phase, which focuses on transferring the R&D product to the broader CISR community, includes piloting, confirming, and finalizing R&D results

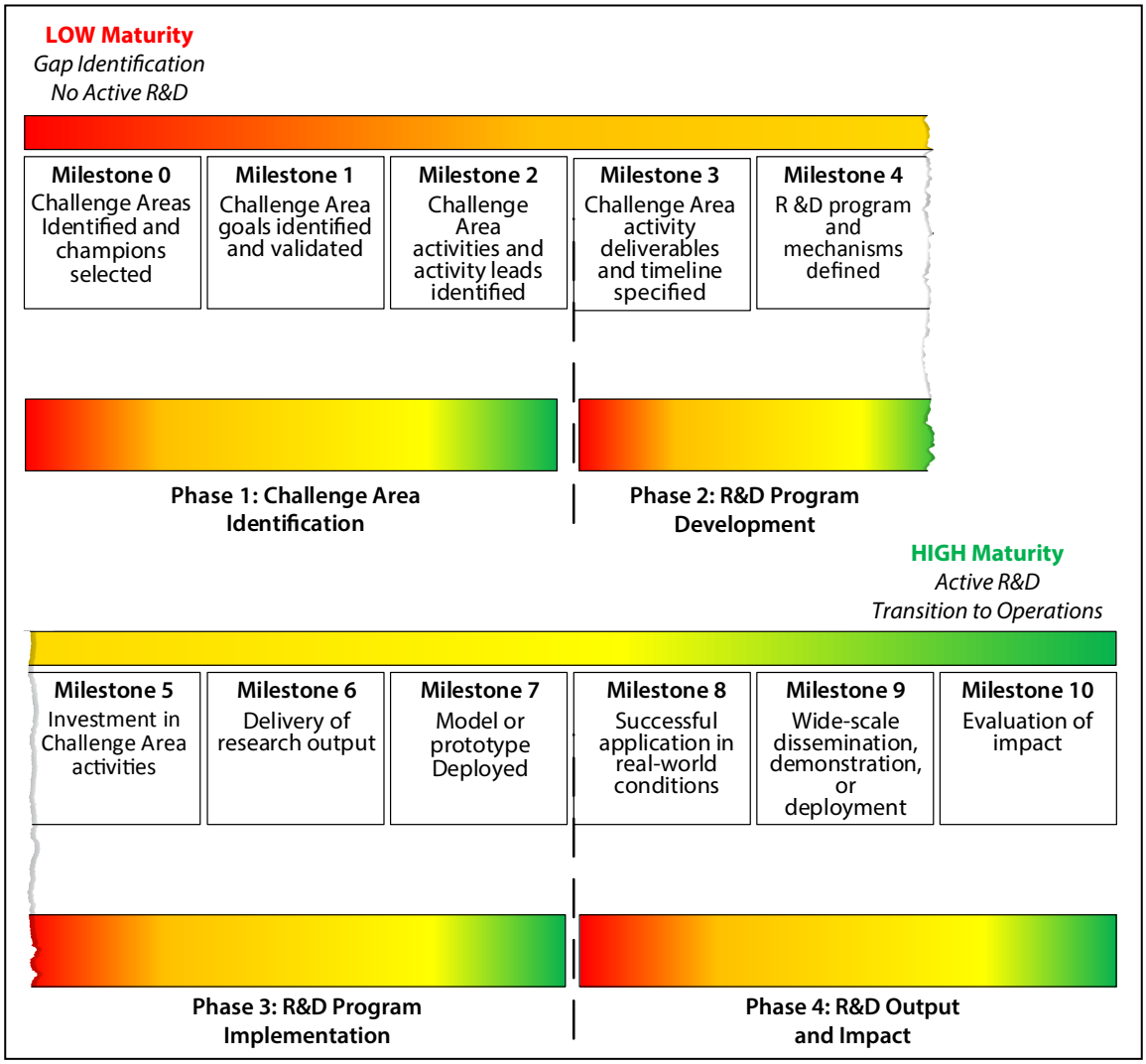

Figure 1. Maturity Scale Framework

and promoting the adoption of the product.

Each phase of the MSF contains milestones that require completion for advancement, with eleven milestones spanning the R&D lifecycle, from priority identification through evaluation of impact. The MSF stratifies the often circular R&D processes into distinct increments, which users can more easily and realistically track.

The MSF can be further stratified into sub-milestones at the activity-level (not shown in Figure 1) to meet more granular needs of the user. STPI proposed the use of the MSF to meet the call for metrics in PPD-21 and the Plan.

Applicability of the MSF

Applications for the MSF framework also extend beyond CISR. The MSF is currently being considered

for use in other efforts, and IDA researchers presented the framework at the 30th Annual American Evaluation Association Conference in October 2016 to highlight its broad applicability to all R&D efforts inside and outside the Federal government.

References

Department of Homeland Security. 2015. *National Critical Infrastructure Security and Resilience Research and Development Plan.* Washington, DC: Department of Homeland Security, November.

National Science and Technology Council. 2016. *Implementation Roadmap for the National Critical Infrastructure Security and Resilience Research and Development Plan.* Washington, DC: Executive Office of the President, December.

The White House. 2013. *Presidential Policy Directive 21 – Critical Infrastructure Security and Resilience.* PPD-21. Washington, DC: The White House, February.

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