

Using a network science and ArcGIS approach to enhance resilient critical infrastructure governance

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HOMELAND SECURITY CHALLENGE

Interdependent Systems:

- ❖ Societies rely on complex critical infrastructure systems to support the essential needs of their residents, grow economically, and provide safety and security. The Department of Homeland Security has identified **16** critical infrastructure sectors.
 - The majority of infrastructure is owned and operated by the **private sector**.
- ❖ Disruptions in one system can quickly **cascade** to another system.
- ❖ Systems that **span local, state, and national jurisdictions** present complex governance challenges.
- ❖ Many current decision-support tools are **threat-centric**, limiting their usefulness in disasters that deviate from anticipated threats.



Barriers to Resilience:

- 1) **Inadequate understanding of cascading interdependencies** – it often takes a crisis to reveal interdependencies across systems.
- 2) **Lack of adequate designs and tools for embedding resilience** into systems, networks, and infrastructure.

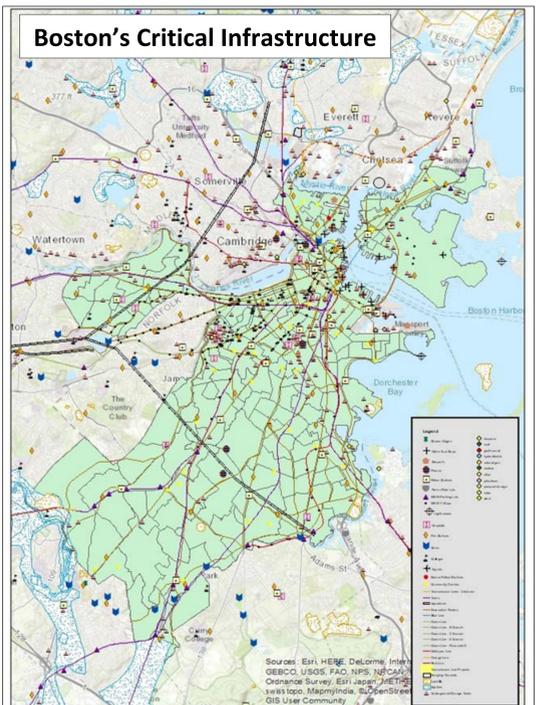
Developing Tools to Build Resilience:

This project focuses on the need for a **comprehensive understanding of interconnectivity across critical infrastructure**, and the **ability to simulate how the loss of functionality in one system will impact other systems**, allowing key stakeholders to **identify counterparts with whom they should engage** before a potential hazard materializes into a crisis.



APPROACH / METHODOLOGY

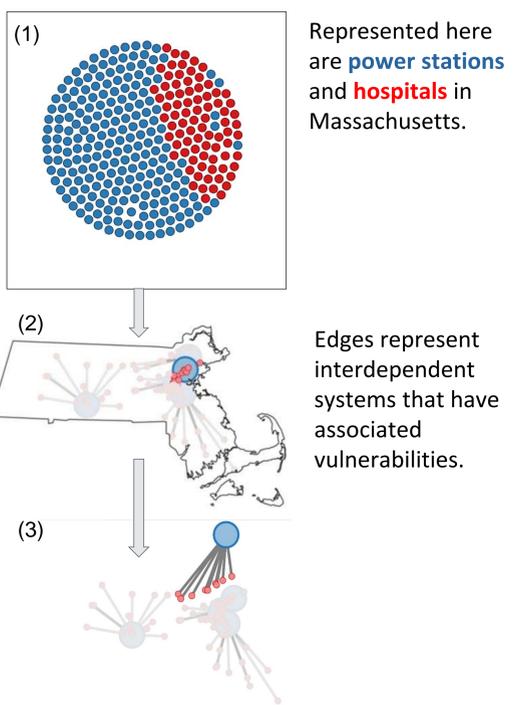
i. Mapping



The project employs a **mixed-methods approach**. In addition to mapping and network analysis techniques, the team has convened and interviewed key stakeholders to identify critical infrastructure interdependencies that are not available in the existing data.

- Boston-region examples include:
- ❖ **Logan airport's** reliance on the **Port of Boston** for 100% of its jet fuel
 - ❖ The **Massachusetts Bay Transportation Authority (MBTA)**'s reliance on a **South Boston Power Station** that is vulnerable to hazards such as flooding

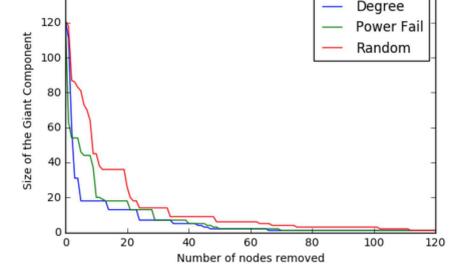
ii. Network Analysis



As a proof of concept, the team has plotted Boston's critical infrastructure in ArcGIS, based on Department of Homeland Security Critical Infrastructure Sectors (PPD-21, 2013).

OUTCOMES / RESULTS

Impact of Power Grid Failure on MBTA Functionality



Outcome: When nodes are removed from the network, or when capacity is reduced for specific assets (e.g. power stations), the **disruption cascades into other systems**, with widespread ramifications for Boston's critical functions.

Result:

This mixed-methods approach, employing mapping, network science, and stakeholder interviews, produces a **threat-agnostic tool to support resilient critical infrastructure governance**.

Sample critical infrastructure assets that can be selected in the tool

CONCLUSION

New Tool Development:

While existing tools allow users to map hazards and anticipate impacts to specific infrastructure, our tool allows for an **all-hazards approach** that focuses on assets. Users can remove a node from the network – simulating the inoperability of an asset – and identify cascading impacts to other critical infrastructure.

Value Proposition:

1. **Informing decisions** by public officials, private corporations, and regional associations
2. Supporting both **preemptive risk analysis** and **emergency response planning**
3. Generating **cross-sectoral and interregional engagement** to facilitate regional recovery



Future Research Agenda:

1. The tool is still under development; the project team will be adding data sets and supplementing the data with practitioner interviews.
2. The current tool focuses on Boston as a proof of concept – our ensuing work will **expand the model to other regions**.



ACKNOWLEDGEMENTS

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