Cyberinfrastructure for Crisis Resilience: Extending Communication Infrastructure Theory in Big Science Organizations

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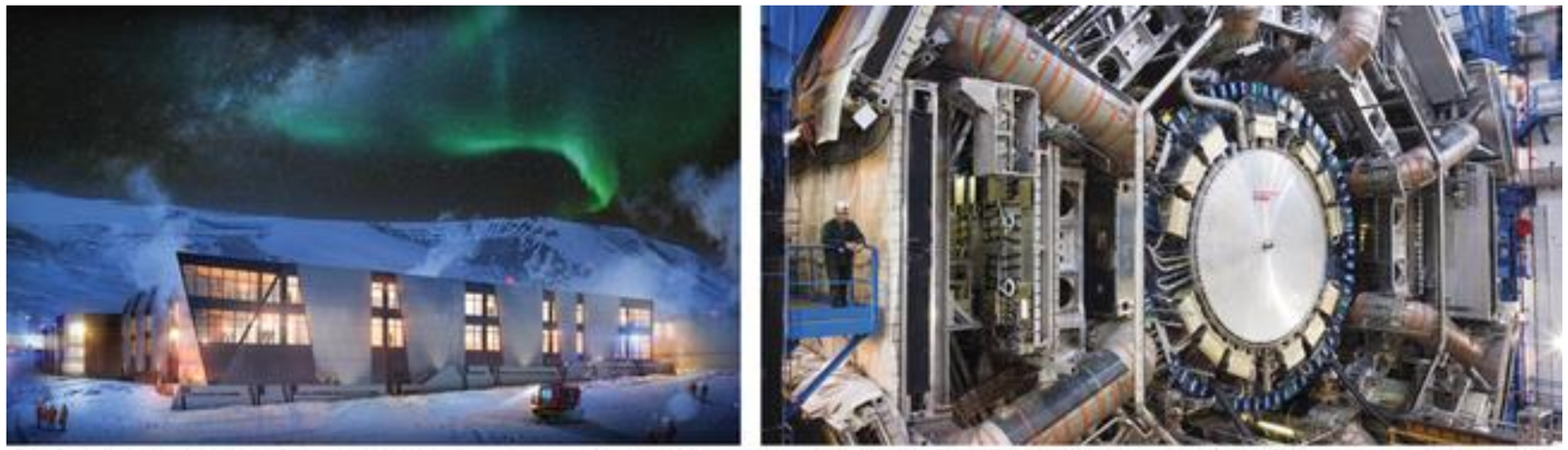
Overview

National Science Foundation (NSF)-funded Research Infrastructure (RI) programs, including Major and Mid-Scale Facilities, are central to advancing U.S. scientific capacity. During the COVID-19 crisis, these organizations rapidly adapted their cyberinfrastructure (CI) to maintain operations, collaboration, and communication.CI refers to the integrated set of technologies used for communication, data transfer, storage, computation, and collaboration—such as secured servers, high-bandwidth networks, communication platforms, and AI tools.

This study investigates how NSF-funded scientific organizations adapted their CI during crisis conditions and identifies what types of CI are now considered critical for building long-term resilience and maintaining scientific missions.



Artist rendering of the Antarctic Infrastructure Modernization for Science project (left) and a picture of the A Toroidal Large Hadron Collider Apparatus Detector (right).

Source: Leidos (artist's rendering, left); 2008 CERN European Organization for Nuclear Research (photograph, right). | GAO-24-106380

Methods: Study Design A three-phase qualitative interview study (2020-2023). Data collected from 56 interviews with professionals from RIs. Purposive sampling targeting leadership, researchers, and staff. Snowball sampling to ensure diverse perspectives.

Participant breakdown:
Phase 1 (2020-2021)(n=13).
Phase 2 (2022-2023) (n=17).
Phase 3 (2023) (n=26).

Data Analysis Grounded Theory Approach (Corbin & Strauss, 1990).

Theoretical Framework
This project extends **Communication Infrastructure Theory (CIT)** (Ball-Rokeach et al., 2001):
• Traditionally, CIT focuses on geographically bounded communities with macro, meso, and micro layers of communication.

Findings: In Phase 3, participants rated the importance of five CI types identified during earlier phases:

CI Type	Avg. Agreement
Secured CI / Cybersecurity	**4.92 / 5**
Integrated communication platforms	**4.71 / 5**
High-bandwidth systems	**4.68 / 5**
CI with social networking features	**3.70 / 5**
Smart CI / Artificial Intelligence tools	**3.39 / 5**

These findings highlight which CI components are perceived as essential versus experimental or emerging.

Theoretical Contribution

- We reconceptualize **Research Infrastructures (RIs)** as **distributed professional communities** with shared missions and risks.
- We extend CIT by incorporating **technical CI systems** (e.g., Slack, Zoom, data dashboards, storage tools) as **active layers** that support storytelling, coordination, and decision-making.

Practical Implications
• CI design should emphasize **security, speed, and collaboration tools** to improve crisis response.
• Research infrastructures should prepare for future crises by integrating communication and networking platforms into their operational core.
• Social and technical CI should be seen as **mutually reinforcing assets** for organizational resilience.

References:

Ball-Rokeach, S. J., Kim, Y. C., & Matei, S. (2001). Storytelling neighborhood: Paths to belonging in diverse urban environments. Communication Research, 28(4), 392–428.

National Science Foundation. (2023). NSF Major Facilities List. https://www.nsf.gov/bfa/lfo/docs/major-facilities-list.pdf

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