



INFRASTRUCTURE: STUDENT COMPETITION

TUESDAY: SESSION 1 TRACK 3 AND RECEPTION

SESSION CHAIRS

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SESSION ABSTRACT

Resilience Week is pleased to announce its fifth annual Student Competition. Student competitors will present a “TED”– type talk of between 8 and 10 minutes, and address 3 – 5 minutes of follow up questions from judges and audience members. A panel of judges—representing industry, government, and academia—will determine a best presentation award to be given at the symposium.

- Part 1: 8 – 10 minute live presentation, delivered virtually, on October 20, 2020.
- Part 2: Poster — Students will submit an electronic depiction of a poster representing their topic.

Committee on National Security Systems (CNSS) Overlay Use for Context-Sensitive Critical Infrastructure Dynamic Classes (CS-CIDC)

Aleksandra Scalco, Colorado State University

There is an operational need for National Security System (NSS) cyber defense capabilities to defend mission-critical infrastructure from cyber attack. Critical infrastructure systems in themselves affect the physical environment, such as power, water, wastewater, facilities, and safety controls. These systems traditionally rely on physical security such as physical access control. For example, the Department of Defense (DoD) mission-critical systems are those systems that perform functions essential to the continuation of operations, and the failure or disruption of which will result in mission failure. The introduction of the Industrial Internet of Things (IIOT) to traditional Operational Technology (OT) systems evolved critical infrastructure systems into cyber-physical systems, making these systems susceptible to cyber attacks such as malware and ransomware. Further, OT and Information Technology (IT) experts have varying contextual approaches to their respective domains. Adding to this complexity, these system interfaces traverse both U.S. Government-owned assets, and commercially- owned systems. The complexity, which is introduced by this evolution of traditional OT into IIOT, calls for a reference model of Context-Sensitive Critical Infrastructure Dynamic Classes (CS-IDC) for identifying requirements, engineering and developing security solutions, and managing mission-critical systems, given the new system boundaries and interfaces. The Committee on National Security Systems (CNSS) provides technical and implementation guidelines applicable to cybersecurity for all U.S. Government departments and agencies. A CS- CIDC reference model adds clarity for new cyber-physical system design and makes the retrofit process for mature operational systems manageable. This paper examines CS-CIDC and its impact on the system owner decision-making when applying CNSS Security Control Overlays, identifying security requirements, providing security solutions, and managing information system security activities related to mission-critical infrastructure.



Resilience on the Periphery: Understanding the Impacts of Population Displacement on Infrastructure Systems beyond the Disaster Zone

Glenn Voelz, University of Washington

In 2018, the United States accounted for around ten percent of all disaster-related displacements world-wide. While many of these movements were short-term phenomena due to pre-emptive evacuation, there has been a trend toward more complex, disruptive, and prolonged dislocations. These events often generate a significant, yet overlooked, impact on the infrastructure systems of host communities receiving evacuees.

This research applied a comparative case study methodology, examining the infrastructure impacts of three major displacement events: Hurricanes Katrina and Maria, and the Camp Fire in Paradise, California. The project applied a mixed-method research approach, analyzing the effects of displacement on a variety of infrastructure systems, using data such as water and sewer use, traffic loads, public safety statistics, housing availability, and demands on public health systems, schools, and social services.

The analysis revealed several factors determining how well a community's infrastructure systems respond to the pressures of displacement. First was whether the triggering event created conditions for long-term displacement. A second factor concerned whether the effects of displacement were concentrated in time and space. A third variable concerned the pre-disaster levels of social vulnerability among the affected population. Other external factors include a community's relative size and resources compared to the scale of displacement, as well as measures relating to infrastructure system resilience.

A common theme among the case studies was how displacement events accelerate the planning process when additional system capacity and services are needed to meet a new baseline level of demand. The hard infrastructure systems showed a relatively fixed capacity and limited flexibility but generally had sufficient underutilized capacity to handle a temporary surge of demand. Soft infrastructure systems were often able to add capacity quickly; however, only through leveraging finite human capital resources. However, in nearly all examples, planning and financing the expansion of infrastructure and services lagged far behind the immediate needs of the community.

A final point of significance was the link between displacement and social vulnerability. Factors such as socioeconomic status, race, age, and infirmity tended to increase the likelihood and duration of displacement. Members of vulnerable groups were far more likely to suffer adverse long-term impacts from displacement, thus exacerbating the infrastructure and resource demands placed on host communities.



Overhead versus Underground: Designing Power Lines for Resilient, Cost-Effective Power Systems under Windstorms

Laiz Souto, Universitat de Girona

This research assesses the costs and risks associated with underground and overhead power lines for a resilient, cost-effective planning and operation under windstorms. Windstorms represent a particular class of high-impact, low-probability events that is highly likely to damage distribution poles and pull down overhead lines in vulnerable areas. As a result, when a windstorm occurs, the cost associated with the energy not supplied may be too high. Conversely, the costs associated with the installation of underground lines are expensive in comparison to overhead lines and may not compensate for the penalties avoided for the loads lost. In this scenario, this research evaluates the costs and risks associated with installation, operation, and repair of underground and overhead power lines, as well as the penalties for the energy not supplied, to determine which power line setting is the most appropriate in terms of resilience and costs for a resilient, cost-effective power system planning and operation under windstorms. To this extent, the choice between overhead and underground power lines is formulated as a long-term cost minimization function, considering the costs associated with the installation, operation, and repair of individual components together with their probability of failure. In turn, the impact of windstorms on the system resilience is assessed through fragility modeling of individual towers or poles and lines, whenever applicable. Furthermore, the methodology is demonstrated in different case studies using a real-based power distribution network. Overall, the results indicate that there is a trade-off between resilience and costs, as the installation costs are the highest for underground lines, whereas the value of lost load is the highest for overhead lines without hardening in most cases.

Modeling Assertions for Expanding Complexity in Infrastructure Resilience Simulation

Craig Poulin and Michael Kane, Northeastern University

Resilience curves illustrate and quantify infrastructure system performance in response to a hazard. Analysis using resilience curves often includes three assumptions: summary metrics and performance measures consistently represent stakeholder objectives; performance targets and thresholds are static; and parameter variation is a sufficient method to discover emergent behavior. These assumptions are not appropriate for all systems, and their adoption can hinder effective resilience analysis. To move beyond these assumptions, this work establishes three modeling assertions to guide simulation-based resilience assessment using resilience curves. These assertions are proved through contradiction with a simple agent based network model that includes generic interactions between an electrical distribution system and the organizations it serves.



Using Python's *pywr* package to Increase AHA's Resilience Modeling Capabilities

Chase Christen, Boise State University

Idaho National Lab's (INL) All Hazard Analysis Framework (AHA) tool allows analysts and decision makers to study the interdependencies of critical infrastructure. The current AHA program allows users to simulate how infrastructure reacts to multiple scenarios including the addition of new infrastructure or the failure of existing infrastructure. There is a demand to add water resilience modeling to AHA to increase the amount of detail decision makers receive from a potential system failure. For example, the freshwater storage levels of a water district could be known following a week-long power outage that impacted a local water treatment plant. This level of detail would help justify the need for critical infrastructure investments or demand restriction policies to reduce the impact from an extended drought. This addition would also allow emergency responders to provide relief to areas of need faster since the interdependencies of a system are already known. The following paper proposes adding water resilience modeling to the AHA tool by incorporating the Python Water Resource (*pywr*) package.

RMDT: Resiliency Monitoring and Decision-Support Tool for Distribution During a Pandemic

Gowtham Kandaperumal, LNU Anshuman, and Sanjeev Pannala, Washington State University

Power system operators and planners rely on decision support tools to provide service to critical loads and reduce the impact of severe weather events. Resiliency definition is evolving and requires a focus on extreme events and critical loads. The tools to quantify, assess, and visualize distribution grid resiliency allows operators to make effective operational decisions and control actions to minimize discontinuity of service to critical loads. The coronavirus disease 2019 (COVID-19) pandemic introduces a significant impediment to the system resilience by affecting the health of utility workers and in-person interaction dealing with restoration and maintenance procedures. The social influences of the pandemic that directly impact system resilience require a set of tools to supplement operator decision-making. In this extended abstract, we describe and demonstrate resiliency monitoring and decision-support tool (RMDT) that monitors resilience indicators, computes multi-stage resilience scores, supports operator decision-making to schedule restoration of distribution grid assets based on the COVID-19 hotspot information, and visualize data-driven and model-based analytics. A 45-node distribution network is analyzed to test the developed architecture, algorithms, and tools.