



THE INSTITUTE FOR CIVIL INFRASTRUCTURE SYSTEMS (ICIS) was established in 1998 with initial funding from the National Science Foundation. ICIS engages in research, education, and outreach in infrastructure, including energy, transportation, water, communication and environmental protection, in the context of the quality of life in urban areas. Agencies that have funded current and recent research include the U.S. Environmental Protection Agency, the U.S. Department of Homeland Security (through university centers at NYU, USC, and Dartmouth), the National Science Foundation, the U.S. Department of Transportation Region 2 University Transportation Research Center, the NYS Department of Transportation, and the Fund for Public Health in NY. ICIS researchers have also engaged in research impacts of global climate change on public infrastructure. Contact: Rae Zimmerman, Professor of Planning and Public Administration and Director, Institute for Civil Infrastructure Systems, Wagner Graduate School of Public Service, New York University, 295 Lafayette Street, 2nd floor, New York, NY 10012. Phone: 212 998-7432; Fax: 212 995-4162; rae.zimmerman@nyu.edu. www.nyu.edu/icis

CURRENT RESEARCH PROJECTS

URBAN RESILIENCE TO EXTREME WEATHER RELATED EVENTS

SUSTAINABILITY RESEARCH NETWORK (UREx SRN), Project Sponsor: National Science Foundation through Arizona State University (NSF #1444755). 2015-2020.

<http://wagner.nyu.edu/news/newsStory/prof-rae-zimmerman-chosen-participate-urban-infrastructure-and-extreme-weather>

“The highly interdisciplinary and geographically dispersed Urban Resilience to Extremes Sustainability Research Network (UREx SRN) team will develop a diverse suite of new methods and tools to assess how infrastructure can be more resilient, provide ecosystem services, improve social well being, and exploit new technologies in ways that benefit all segments of urban populations. . . Starting with nine network cities (six continental U.S. and three Latin American, home to over 35 million residents) . . . The extreme events that this project will focus on include urban flooding, coastal storms, regional droughts, and extreme heat waves. . . The UREx team will link SRN scientists, students, local practitioners, planners, industry, NGOs, and other stakeholders across >25 institutions and >70 collaborators to co-produce data, models, images, stories, and on-the-ground projects that show how a new resilient infrastructure can be developed. Infrastructure that is flexible, adaptable, safe-to-fail, socially equitable, and ecologically based will enhance urban resilience in the face of a higher incidence of extreme events, more culturally diverse communities, and continued urbanization pressures. Ultimately, the UREx SRN will help accelerate knowledge generation and application to encourage innovative strategies towards urban sustainability. The Urban Resilience to Extremes Sustainability Research Network (UREx SRN) will develop a novel theoretical framework for integrating social, ecological, and technological system (SETS) dimensions for conceptualizing, analyzing, and supporting urban infrastructure decisions in the face of climatic uncertainty in a more holistic way.” (Abstract from the grant award) The NYU group is part of the NYC Team

and Social-Ecological-Technological (SETS) Integration and City Comparisons Working Groups focusing on infrastructure.

CRITICAL RESILIENT INTERDEPENDENT INFRASTRUCTURE SYSTEMS AND PROCESSES (CRISP) TYPE 1: REDUCTIONIST AND INTEGRATIVE APPROACHES TO IMPROVE THE RESILIENCY OF MULTI-SCALE INTERDEPENDENT

CRITICAL INFRASTRUCTURE, Project Sponsor: the National Science Foundation (NSF #1541164), NYU-Tandon lead. 2015-2018. NSF press release 15-108 September 14, 2015 http://www.nsf.gov/news/news_summ.jsp?cntn_id=136266&org=NSF&from=news

“Critical infrastructures are evolving to be more diverse and increasingly connected. The growing complexity creates convoluted dependencies and interdependencies between infrastructures arising from cyber-physical, geographical, supply-and-demand, and human-in-the-loop relationships between different components of the system. Understanding these interactions requires a reductionist and an integrative approach. The reductionist approach focuses on studying the characteristics of four fundamental classes of dependency links, while the integrative approach uses them as building blocks to establish a holistic network framework to capture the interdependencies of the infrastructure systems. This bottom-up methodology provides a systematic way to generate an integrated and multi-scale view of a system of systems, enabling the identification and quantitative characterization of unanticipated interdependencies through feedback loops. The overarching goal of this project is to improve the resiliency of interdependent infrastructures, enabling them to recover from disruptive events and disturbances within an acceptable amount of time and cost. The proposed research will expand the knowledge base of such interdependencies by adopting both a reductionist and integration approach to create a bottom-up methodology to provide fundamental principles to understand interdependencies. . . The analysis of these relationships will lead to an optimal design of a multi-scale resilience mechanism, which will be applied to case study scenarios . . .” (Abstract from the grant award)

PUBLIC TRANSIT AND MANDATORY EVACUATIONS PRIOR TO EXTREME WEATHER EVENTS IN NEW YORK CITY, Project Sponsor: the U.S. Department of Transportation Region 2 University Transportation Research Center. 2015-2017.

City access to public transit is critical to individuals making decisions about whether to evacuate and go to a shelter or somewhere further away, or to stay in place. The goal of the proposed research is to evaluate public transit services in areas considered to be at high risk for flooding in New York City and to provide a tool that can help transportation planners and city officials improve these services during evacuations. As part of the research the characteristics of public transit in Zone 1 evacuation areas are related to socioeconomic characteristics of the communities that live there. This includes examining proximity to public transit stops, including bus and subway services, multi-modal transportation connectivity, and distance to nearest shelters. A review of the literature on transportation factors that affect decisions to evacuate, statistical analyses and GIS analyses would provide inputs for the development of a transit evacuation vulnerability index that could help planners and agencies identify vulnerable communities or vulnerable clusters within communities. The transit evacuation vulnerability index would include traditional variables for social vulnerability and hazard indexes such as percent poor and percent elderly, and would also include measures of proximity to public transit and consider distance to shelters, vehicle ownership rates, multi-modal transit connectivity and others. The analyses resulting from this research work could provide Region II’s transportation

planners and agencies with valuable inputs to projects and policies aimed at expanding or improving public transit services in support of evacuation efforts or broader policies aimed at making communities more livable and resilient. (Summary from the research proposal)

A META-NETWORK SYSTEM FRAMEWORK FOR RESILIENT ANALYSIS AND DESIGN OF MODERN INTERDEPENDENT CRITICAL INFRASTRUCTURES, Project

Sponsor: National Science Foundation under the Resilient Interdependent Infrastructure Processes and Systems (RIPS) 1 program through NYU-Tandon. 2014-2017. (NSF #1441140)

The interconnected nature of critical infrastructures has been underscored as contributing to the magnification of infrastructure failures. This project provides the establishment of a meta-network system framework that aims to capture physical, cyber and human interconnections within individual infrastructures and across multiple interdependent infrastructures. The framework enables new network structures to be identified that can lead to cascading effects as a basis for improving preparedness and response to improve resilience and safeguard systems against risks. The research adopts a cross-disciplinary approach encompassing policy and engineering. (Summarized from the research proposal)

<http://wagner.nyu.edu/news/newsStory/two-nyu-wagner-professors-explore-disaster-resiliency-and-critical-infrastructures>

RECENTLY COMPLETED AND OTHER SELECTED RESEARCH PROJECTS

SUBURBAN POVERTY, PUBLIC TRANSIT, ECONOMIC OPPORTUNITIES AND SOCIAL MOBILITY, Project Sponsor: the U.S. Department of Transportation Region 2 University Transportation Research Center. 2014-2015.

Recent demographic trends suggest an increasing suburbanization of poor populations where public transit needs are not as easily supported as in urban areas. Insufficient transit can also exacerbate recovery times after extreme weather events for vulnerable populations. The research has two main goals. The first goal is to identify a number of metropolitan areas in UTRC Region II where demographic trends of increasing suburbanization of the poor are taking place and to use them to assess whether current transportation supply is likely to meet the needs of these communities for transit service demand. The second goal addresses risks that vulnerable communities face during extreme weather events due to lack of access to transportation for evacuation or for emergency preparedness and the ability to regain access to jobs. The research will also identify opportunities to diversify public transit alternatives to improve access to the service and meet other public policy goals such as reducing the vulnerability of transit systems to extreme weather events and climate change. (Abstract from the grant award) Final report: <http://www.utrc2.org/sites/default/files/Final-Report-Surburban-Poverty-Public-Trans-Eco-Opportunities.pdf>

NEW YORK STATE RESILIENCY INSTITUTE FOR STORMS AND EMERGENCIES

(NYS RISE), Project Sponsor: The State of New York through NYU-Tandon School of Engineering (formerly Poly) and Stony Brook University. 2013-2014. www.nysrise.org;

<http://www.governor.ny.gov/press/11012013-nys-rise>

<http://wagner.nyu.edu/news/newsStory/nys-rise-storm-preparedness-initiative-taps-prof-rae-zimmerman>, 2013-2014.

ICIS researchers are participating in a collaborative Institute led by New York University and Stony Brook University for research and education on extreme events related to weather and natural hazards. ICIS researchers are focusing on interdependencies among infrastructures, particularly for drinking water, that relate to resiliency and redundancy in the context of extreme events, and monitoring programs that support knowledge of extreme event impacts.

CENTER FOR INTERDISCIPLINARY STUDIES IN SECURITY AND PRIVACY, (CRISSP), Project Sponsor: NYU-Poly (now NYU-Tandon). Project area: critical infrastructure policy and information security. 2009-ongoing. <http://engineering.nyu.edu/crissp/>

Relationships between information technology (IT) and critical infrastructures for energy, transportation and water can increase the vulnerabilities of these critical infrastructure sectors to attack in the information domain. The research identifies areas of IT and critical infrastructure interconnections, the functions of these connections, measures to capture them, and standards and policies that may govern them. Related activities include NSF and NYU funded projects:

- INSPIRE: Integrative Graduate Education and Research Training Program (IGERT) – Information Security and Privacy: An Interdisciplinary, Research and Education Program, (NSF #0966187)
- ASPIRE: A Scholar for Service (SFS) Program for Interdisciplinary Research and Education, <http://engineering.nyu.edu/crissp/projects/aspire> (NSF # 0911982)
- WISSP10 (Workshop on Interdisciplinary Studies in Information Security and Privacy), Abu Dhabi, October 3-4, 2010 <http://crissp.poly.edu/wissp10/>
- Workshop on Collaborative Research in Information Security and Privacy, May 7, 2009

RAPID/COLLABORATIVE RESEARCH: COLLECTION OF PERISHABLE HURRICANE SANDY DATA ON WEATHER-RELATED DAMAGE TO URBAN POWER AND TRANSIT INFRASTRUCTURE, Project Sponsor: the National Science Foundation. 2013-2014. (NSF #1316335)

This Rapid Response Research Grant (RAPID) collects perishable damage data caused by Hurricane Sandy that made landfall on October 29, 2012. It was a very large storm (almost 800 miles in diameter according to National Oceanic and Atmospheric Administration) that affected large areas of coastlines of New York (Long Island and New York Metropolitan area) and New Jersey. The storm was judged to be Category 1 based on its wind speed. However, because of its size and coinciding with high lunar tide, it generated high storm surge. The New York Metropolitan area sustained severe damage to coastal structures due to surge and wave actions. Most of the New York Metropolitan area lost electrical power and the transportation system became inoperable because of flooding of tunnels and loss of power. The overall project with collaborators collects data on weather, storm surge and floods, power outage, transit stoppage, and interdependencies of infrastructures in the New York Metropolitan area, primarily focusing on damage data induced by Hurricane Sandy for power and transit infrastructure. The weather data includes measurements of storm surge, flooding, rainfall and wind speeds. The spatial extent of the data collection is the transit region of New York and damage data is geo-coded and timelines at regular intervals over the duration of infrastructure recovery are established. The research team applies various techniques for data collection including ground-based observations, satellite data, and aerial and water-based survey maps. Interdependencies between transit and power outages are identified in the database. The resulting database will

enhance the research infrastructure of the engineering and urban planning communities in the U.S. (Abstract from the grant award). <http://depts.washington.edu/hursandy/index.html>

PROMOTING TRANSPORTATION FLEXIBILITY IN EXTREME EVENTS

THROUGH MULTI-MODAL CONNECTIVITY, Project Sponsor: the U.S. Department of Transportation Region 2 University Transportation Research Center. 2012-2014.

Extreme events of all kinds are increasing in either number or severity. Transportation provides vital support to people in such circumstances for evacuation and supplies, yet is often disabled in such disasters. Nationwide and in New York and New Jersey record-setting weather disasters have occurred: the December 2010 snowstorm disabling New York City's transportation systems and their emergency capability, January 2011 snowstorms, Hurricane Irene in 2011 disrupting Amtrak, and numerous flash floods bringing local and regional rail and road to a standstill. Impacts are temporary or long-term network closures. Accidents and natural hazards combined often escalate consequences. Transportation is heavily dependent on electric power with increasing dependence on information technology. When disasters affect these systems transportation effects are magnified. Disadvantaged populations are particularly vulnerable to lack of access to vehicles, travel routes, and transportation services. The concentration of infrastructure facilities and usage increases the vulnerability, taking the form of the convergence of roadways at single intersections (the Cross-Bronx Expressway - most heavily congested road segment) or the convergence of rail lines at single transfer points, such as the Long Island Railroad's Jamaica Station. When one concentrated facility is disabled an entire network can be disabled. Though dispersion is needed, it must preserve the density and overall concentration of urban areas. Transportation users need more than one route from origin to destination to reduce the vulnerability posed by concentrated infrastructure. NYC transit and the regional PATH reorganized transit after the 9/11 attacks exemplifying such flexibility. Multi-modal connections provide this flexibility in a more systematic way.

To analyze multi-modal connectivity's role in reducing risks in extreme events, selected multi-modal facilities in the region will be identified for transit using several national transit and road transportation databases. Geographic coverage, capacity, usage, number and type of interconnections, and extreme event experience and capacity for each facility will be defined and statistical summaries provided. A case-based approach will provide analyses of types of multi-modal facilities that have been successful or unsuccessful in emergencies and cover experiences of disadvantaged populations in the UTRC region. Final report:

<http://www.utrc2.org/sites/default/files/pubs/Final-NYU-Extreme-Events-Research-Report.pdf>

MOBILE SOURCE AIR TOXICS (MSATs) MITIGATION MEASURES. Project Sponsor:

University Transportation Research Center Region 2 and NYS Department of Transportation, through the NYU Rudin Center for Transportation Policy and Management. 2010-2013.

The evaluation of mobile source air toxics (MSATs) is part of federal and state environmental impact assessment procedures. The purpose of the project was to tailor MSATs guidance and feasible mitigation strategies (for seven priority MSATs) to New York State's transportation system for the National Environmental Policy Act and the NY State Environmental Quality Review Act.

THE DISCONNECTEDNESS OF THE POOR FROM URBAN PUBLIC SERVICES

funded by the Wagner School Faculty Research Fund. 2013.

This research focused on how policy and planning decisions by public service providers affect the distribution of certain services, particularly public transportation, to outlying portions of urban areas where poorer people tend to live (as distinct from patterns of previous decades where the poor tended to concentrate primarily in inner city areas). Public transportation in turn supports other kinds of services such as the provision of supplies and access to jobs. Census data provides a basis to relate transit access to poverty conditions.

ECONOMICS OF SECURITY – Part of the URBAN COMMERCE AND SECURITY STUDY (UCASS). Project Sponsor: U.S. Department of Homeland Security through the University of Southern California, Center for Risk and Economic Analysis of Terrorism Events (CREATE). 2011-2012.

Security methods take many different forms, and use many different technologies. Given this variation, the economic and social impacts they hypothetically create can also vary considerably. This project explored selected economic and related social impacts of security measures or conditions analogous to them primarily in Manhattan.

WASTE CONTAINERIZATION PROJECT, Project Sponsor: Fund for Public Health in NY for the NYC Department of Health and Mental Hygiene. 2008-2009.

Roll-on roll-off trash compactors compress waste prior to collection and ultimate disposal, and are an alternative waste management approach to curbside pickup of bagged refuse and the use of waste containers. The assessment of the feasibility of Roll-Off Trash Compactor Technology in reducing rat infestations in New York City was conducted for schools and large residential buildings. The assessment covered criteria for technology adoption in terms of site layout and design, capacity to accommodate the operational needs of the facilities, and volume of waste generated. Overall benefits of the technology over other methods were also evaluated.

SOUTH BRONX ENVIRONMENTAL HEALTH AND POLICY STUDY. Project Sponsor: Office of Congressman Jose E. Serrano and the U.S. Environmental Protection Agency. 2000-2009. http://www.icisnyu.org/south_bronx/index_001.html

The main goal of the South Bronx Environmental Health and Policy Study was to evaluate environmental and health issues affecting the South Bronx community, emphasizing relationships among air quality, transportation, waste transfer activity, demographic characteristics and public health. It was a collaborative research project of the NYU School of Medicine's Nelson Institute of Environmental Medicine (NIEM), the NYU Wagner Graduate School of Public Service Institute for Civil Infrastructure Systems (ICIS), and four community groups: The Point Community Development Corporation, We Stay/Nos Quedamos, Inc., The Sports Foundation, Inc., and Youth Ministries for Peace and Justice, Inc. The research included the use and modeling of environmental databases to assess traffic, air quality and other environmental conditions in the South Bronx; green technology reviews; environmental justice analyses; decision tools; and a youth participation and leadership program. See http://www.icisnyu.org/south_bronx/index_001.html.

CRITICAL INFRASTRUCTURE PROTECTION. Project Sponsor: U.S. Department of Homeland Security through the University of Southern California, through the Center for Risk and Economic Analysis of Terrorism Events (CREATE). 2004-2010.

The nation's critical infrastructures have key life-saving and quality of life roles, contribute to the Gross Domestic Product, and have estimated assets of trillions of dollars. Infrastructure systems are vulnerable to disruption since they are large and have centralized production systems. Global terrorist attacks on infrastructure often show catastrophic effects with potential cascading effects exacerbated by interdependencies among infrastructure systems. The U.S. government has placed a very high priority on infrastructure security.

The NYU team focused on the development and application of statistical models and Geographic Information Systems (GIS) to identify associations between causes and consequences (and explore predictions of those consequences) for accidents, natural hazards, and other disruptions of U.S. public services. Risk management areas such as resource allocation policies, cost estimation, and other issues related to infrastructure disruption have been part of the scope. Electricity, transportation and water infrastructure have been application areas, and hazard areas include terrorism (recovery estimates); accidents; and natural hazards. Specific projects have included:

- Using Infrastructure Density for Resource Allocation Policy
- Determinants of Spatial Infrastructure Concentration as Inputs to Resource Allocation; Infrastructure Asset Security
- Resource Allocation Based on Critical Infrastructure; and Risk, Consequences and Economic Analyses for Terrorist Attacks on Electricity.

New York University first conducted an electrical power outage analysis to examine consequences of potential Terrorist attacks, including economic costs. Regression models using non-terrorist outage data estimated outage characteristics such as duration and customers lost used to analyze consequences of potential terrorist attacks on these systems. See <http://create.usc.edu/> for CREATE participants and activities.

RISK COMMUNICATION FOR LARGE SCALE EMERGENCIES, funded as part of the Large Scale Emergency Readiness (LaSER) project: A Public Health Approach. Project Sponsor: U.S. Department of Homeland Security through the NYU Center for Catastrophe Preparedness and Response. 2005-2009.

Understanding risk communication principles is critical to building effective capacity to reduce consequences of terrorism. Under crisis conditions, communication should be planned based on message content, characteristics and needs of message senders and recipients, and technologies to convey messages in order to minimize response delays. These factors differ for pre-disaster, during disaster, and post-disaster conditions. The overall goal of the risk communication task of LaSER was to develop and test critical communication strategies and plans via scenarios for community public health preparedness, response, and mitigation of event consequences before, during and after a large scale, urban terrorist event. An interdisciplinary approach was adopted drawing on social psychology, communication technology, and risk communication for health threats. The project initially targeted a large scale, biological or chemical terrorist act in the NYC Region, scalable to other U.S. cities. This work was a part of and supported other components of LaSER, directed by the NYU School of Medicine. See www.nyu.edu/ccpr for LaSER project information.

PUBLIC INFRASTRUCTURE SUPPORT FOR PROTECTIVE EMERGENCY SERVICES. Project Sponsor: U.S. Department of Homeland Security through the NYU Center for Catastrophe Preparedness and Response. 2004-2009.

Protective emergency services, such as emergency management, health, police and fire protection, routinely depend upon a wide range of traditional infrastructure support services to provide and deploy human resources, goods, and information in times of crisis. These infrastructures include transportation, energy, water, environmental protection, and communication. This project identifies relationships between traditional infrastructure services and emergency services, and vulnerabilities that can occur at interconnection points, creating choke points between these two kinds of services during emergencies. This provides a foundation to prepare managers and operators of traditional infrastructure services and emergency services to coordinate their needs. The project goal was to help develop easily communicated emergency procedures for infrastructure managers that focus on the key interconnections between traditional infrastructure and protective services and the vulnerabilities in these linkages created by emergency conditions.

EMPIRICALLY BASED ANALYSIS OF PROCESS CONTROL SYSTEMS (PCS) AND CRITICAL INFRASTRUCTURES part of the PCS Vulnerabilities and Infrastructure Interdependencies project. Project Sponsor: U.S. Department of Homeland Security, Office of Domestic Preparedness/Office of Justice Programs through the Institute for Information Infrastructure Protection (The I3P) at Dartmouth College. 2005-2008.

Computerized detection and control systems provide both opportunities and risks for the protection and management of critical infrastructures. Recent large-scale accidents exemplify their potential effect on infrastructure. Process Control Systems (PCS) are a type of computerized information technology and process control system. This research was an empirical event-focused statistical analysis of (1) global trends in attacks on oil and gas infrastructure as a context for investigating PCS vulnerability; (2) economic cost and other consequence measures of incidents and accidents in hazardous liquid and natural gas pipelines in the U.S.; and (3) interdependencies between oil and gas and other infrastructures such as water and electricity. Oil and gas infrastructure, a particular target of terrorist attacks internationally, was a key research focus. Users of this work include designers, managers, and operators of PCS and infrastructure. See www.thei3p.org for consortium and project information.

URBAN INFRASTRUCTURE IN A TIME OF CRISIS: Lessons from September 11th. Project Sponsor: National Science Foundation (Small Grant for Exploratory Research) through NYU-Wagner, ICIS. 2001-2005.

Urban infrastructure services such as transportation, electric power, water, waste management, and communications were resilient in the manner and speed with which they rebounded after the September 11th 2001 attacks on the World Trade Center. This resiliency is traced before, during and after the attacks as a basis for future planning of these services.

A list of publications from these projects is available on the ICIS web page; www.nyu.edu/icis. Click on “our publications, presentations and other ICIS information” link or go directly to: <http://www.icisnyu.org/assets/documents/PubsListforICIS2003to0310NYUICIS122010.pdf> and also at <http://wagner.nyu.edu/zimmerman>.