

Naval Postgraduate School

Operational Resilience Analysis and Recovery Support Fed Partners Overview



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September 2020

Presentation Outline

- Who We Are + Project Summary
 - Part of a team of Federal and Non-Federal partners
- Infrastructure Modeling + Analysis
 - Power, Water, Transportation, Telecom + Interdependencies
- Capacity Building + Workforce Development
 - Geospatial data management
 - New Educational Programs at UVI
 - Support for UVI development of Hazard Mitigation Plan

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Naval Postgraduate School (NPS)

America's national security research university

History Highlights

1909 Founded at U.S. Naval Academy

1951 Moved to Monterey, CA
Operations Research Curriculum

- Facilities of a graduate research university
- Faculty who work for the U.S. Navy, with clearances
- Students with fresh operational experience

FY2018/19:

- 65 M.S. and 15 Ph.D. programs
- 644 faculty
- 1459 resident students includes (144 international / 48 countries)
- 853 distributed learning students





Center for Infrastructure Defense

www.nps.edu/cid

Welcome ▾ Research ▾ Education ▾ Students ▾ Projects ▾ Resources ▾



Dr. David Alderson

Professor, OR
Director, NPS Center for
Infrastructure Defense

Ph.D., Stanford University,
2003



Dr. Daniel Eisenberg

Research Assistant Professor,
OR
Deputy Director, NPS CID

Ph.D., Arizona State
University, 2018



We are experts in interdependent infrastructure modeling and analysis.
We support infrastructure system operations, recovery, and planning.



Center for Infrastructure Defense

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USVI Recovery

www.nps.edu/cid/usvi

Operational Resilience Analysis and Capacity Building in the US Virgin Islands

Sponsor: Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA)

Project Abstract: This project builds on preliminary work to provide modeling, analysis, and subject matter expertise to the Infrastructure Systems (IS) Recovery Support Function (RSF) and the Community Planning and Capacity Building RSF following Hurricane Irma and Hurricane Maria in the territory of the US Virgin Islands. Specifically, this project proposes (1) ongoing modeling and analysis of interdependent infrastructure systems within the territory, with emphasis on assessing and improving their operational resilience; (2) support for the development of a next-generation hazard mitigation and resilience plan in the territory; and (3) capacity building efforts via the development of an education and training pipeline for knowledgeable professionals who understand and think about hazard mitigation and operational resilience of the USVI in everything they do. This project explicitly supports several other complementary efforts, particularly those hosted at the University of the Virgin Islands.

Simulation Optimization for Operational Resilience of Interdependent Water-Power Systems in the US Virgin Islands.

Cpt Dominik Wille, German Army | M.S Thesis in Operations Research
(Completed Dec. 2019)

This work studies the water and power distribution systems on the island of St. Croix (STX) to predict the outcome of interdependent water-power failure events and recommend system hardening and protection activities. As the storms revealed, loss of electricity on STX can also lead to loss of pumping stations that distribute water. During these situations operators rely on water storage tanks to serve communities until electricity and pumps return to service. The goal of this thesis is to model how water-power failures happen and recommend ways to prevent them by answering the following questions:



Operational Resilience Analysis and Recovery Support in the USVI

Naval Postgraduate School (NPS)

Executive Summary

- The NPS Research Team conducts **data collection and curation, model development, and analysis and decision support** for Federal and Non-Federal Entities involved in recovery efforts in the USVI.
- In general, NPS work **informs cost effective and efficient execution of FEMA recovery programs** within the Joint Recovery Office, among Federal collaborators (e.g., DOE, DOT), and among Territorial Stakeholders (e.g., VI Water and Power Authority).
- **Our decision support tools create a new capability** for understanding and improving infrastructures in the USVI. These tools promote effective community planning that support the needs of the whole community and contribute to a viable, sustainable and resilient USVI.
- **These tools are being transitioned to create new local capacity** for Virgin Islanders to do this on their own (e.g., VIWAPA, UVI).

POC: Dr. David Alderson, Director, NPS Center for Infrastructure Defense

Operational Resilience Analysis and Recovery Support in the USVI

Naval Postgraduate School (NPS)

Our team is providing **technical analysis and decision support** for:

- **Power:** prioritizing power system hardening;
- **Water:** prioritizing potable water distribution operations and recovery;
- **Transportation:** evaluating efficient and effective ways to recover critical road and supply chain infrastructure;
- **Information & Communication Technology:** wireless cell service and fiber optic internet vulnerabilities and upgrades.

Operational Resilience Analysis and Recovery Support in the USVI

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Our work supports efforts across the Territory:

- **Public Assistance Recovery Decision Making**
404/406 Mitigation & BBA Decisions, Broader Fed Family
- **Infrastructure Operations & Protection**
Helping WAPA, DPW, others make better recovery decisions
Helping UVI implement Territorial Hazard Mitigation Plan
- **Building Long-Term Territorial Capacity**
Supporting local internships and fellowship (UVI)
Developing long-term data mgmt. and modeling for CIP

Broad Alignment of Effort

DOE Efforts



National Renewable
Energy Laboratory



BERKELEY LAB
Lawrence Berkeley National Laboratory



FEMA Efforts



FEMA



Territorial Efforts



Our work supports alignment of effort across a variety of organizations.

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Modeling & Analysis: Power

Key Questions:

- How vulnerable are USVI power distribution systems to hurricanes?
- What are the expected benefits from planned system hardening?

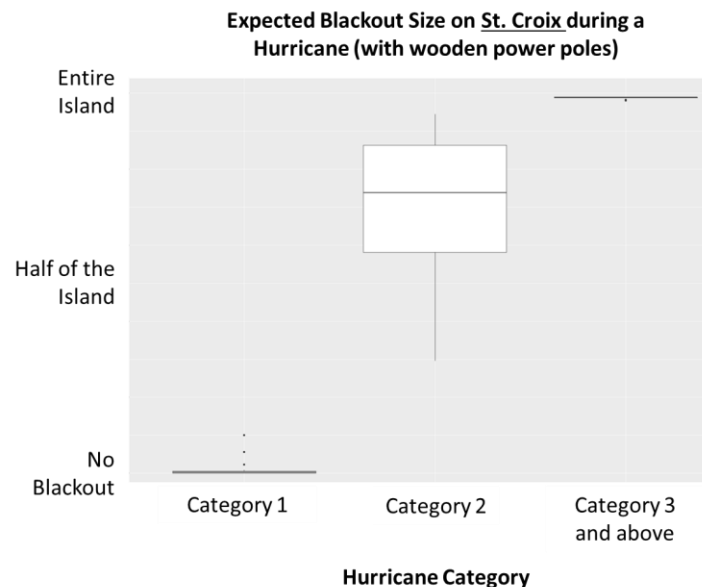
Analysis Supports:

- Identifying most vulnerable power lines.
- Determining optimal mix of undergrounding and composite power poles.
- Identifying who might lose power after hardening.

Products + Reports:

- Wille, D. "Simulation-Optimization for Operational Resilience Of Interdependent Water-power Systems In the US Virgin Islands." 2019.
- Wille, D., Eisenberg, D. "Hurricane vulnerability and Hardening Analysis of Electric Power Distribution Systems in the US Virgin islands," *in preparation*.

Stakeholders Involved:



Modeling & Analysis: Water

Key Questions:

- Can we model water flows and operations for all islands?
- What are the effects of water age and fire flows?

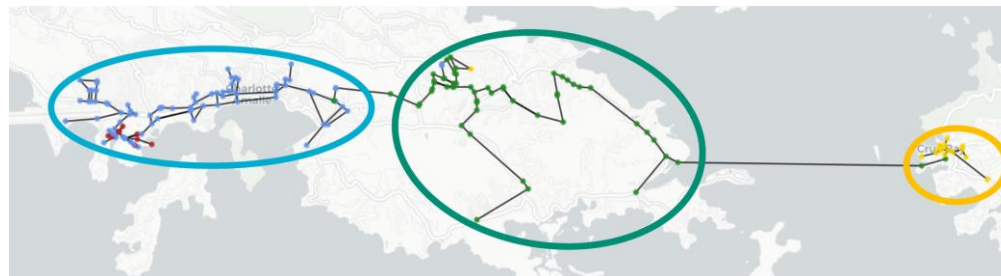
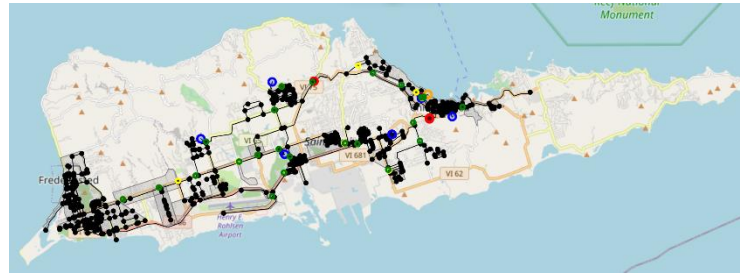
Analysis Supports:

- Planning and operations to improve Master Plan.
- Identifying contaminants and leaks that leave system out of standard.
- Resilience analysis to multiple hazards.

Products + Reports:

- Wille, D. "Simulation-Optimization for Operational Resilience Of Interdependent Water-power Systems In the USVI." 2019.
- Borgdorff, Andrew J. "Measuring and Modeling Potable Water Demand in the USVI." 2020.
- Klise, K., et al. "USVI Water Distribution Resilience." *in preparation*

Stakeholders Involved:



Modeling & Analysis: Transportation

Key Questions:

- How do roadways support supply chain resilience?
- What future road network upgrades should we consider?

Analysis Supports:

- Identifying roadway capacity after disasters and during curfews.
- Assessing the efficiency-resilience tradeoffs for new road infrastructure (e.g., roundabouts).

Products + Reports:

- Good, J.E. "An Operational Model of Critical Supply Chain for the US Virgin Islands." 2019.
- Routley, R. "An Operational Model of the Critical Supply Chain for St. Thomas and St. John." *in preparation*
- Bengigi, E. "Efficiency vs. Resilience Trade-off in Intersection Design in the USVI." *in preparation*

Stakeholders Involved:



Modeling & Analysis: Telecommunications

Key Questions:

- Who will lose cell phone reception if a tower fails?
- How vulnerable is the internet to fiber cuts along roads?

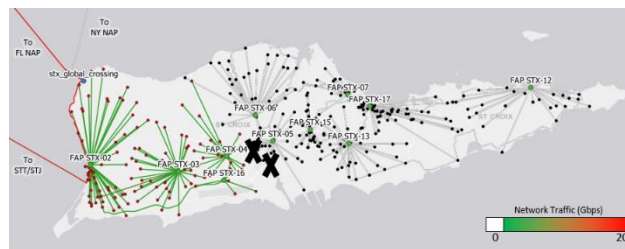
Analysis Supports:

- Identifying which critical facilities lose cellphone services after disaster.
- Measuring what communities are affected by internet outages.

Products + Reports:

- Wine, W. "Analyzing Cell Phone Network Resilience in the US Virgin Islands." 2020
- Moeller, B. "Synthetic Network Generation and Vulnerability Analysis of Internet Infrastructure Systems in the United States Virgin Islands." 2020.

Stakeholders Involved:



Modeling & Analysis: Interdependencies

Key Questions:

- What are various interdependency issues across the territory?
- How long can water systems survive without electricity?

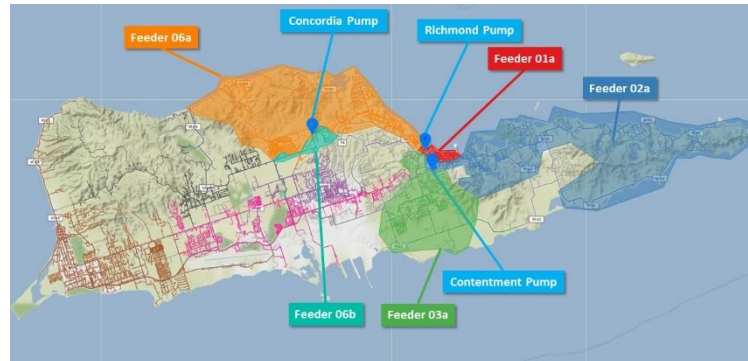
Analysis Supports:

- Identifying ways to improve resilience across multiple systems.
- Example: Identifying ways to harden the power system that supports water operations and resilience.

Products + Reports:

- Alderson, D. L. et al. "Interdependent Infrastructure Resilience in the US Virgin Islands: Preliminary Assessment." *NPS-OR-18-005* (2018).
- Bunn, B., "An operational model of interdependent water and power distribution infrastructure systems." 2018.
- Wille, D. "Simulation-Optimization for Operational Resilience Of Interdependent Water-power Systems In the USVI." 2019.

Stakeholders Involved:



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Capacity Building: Geospatial Data GitLab

Key Issues:

- Lots of disorganized and unknown geospatial data sets.
- Difficulties with sharing and developing new data sets.

Stakeholders Involved:



New Capacities:

- Data storage, sharing, version control, and issues, and collaboration system.
- New data and metadata standards developed for geospatial data.
- Data pipeline and transfer to USVI stakeholders.

Products + Reports:

- Held 20 Training and Coordination Calls.
- 313 uploads of data across 53 users and 15 organizations since April 2020.
- Over 2 gigs of data with multiple versions and views.



NPS GitLab Activity by Day: Tue May 26 - Mon Jun 1



Capacity Building: UVI Fellowship

Key Issues:

- Territorial resilience depends on a workforce with resilience education
- Best students leave the territory

Stakeholders Involved:



FEMA

New Capacities:

- Developing year-long fellowship program that includes a summer internship and two courses on territorial resilience
- Flagship program for the UVI Center for Sustainability and Resilience.



Dr. Kim Waddell
UVI



Dr. Greg Guannel
UVI

Products + Reports:

- Fellowship Program and Course submission to UVI Faculty Council

I am
INQUISITIVE.

I am
INVOLVED.

I am
INNOVATIVE.

I am
READY.

Capacity Building: HMRP

Key Issues:

- How do infrastructure systems work and what are their vulnerabilities?
- How to measure and improve resilience?

Stakeholders Involved:



FEMA

New Capacities:

- Developing online material to support HMRP.
- Establishing content + web development to enable future HMRP updates.
- Research to practice for resilient infrastructure and communities.

Products + Reports:

usvihazardmitigationplan.org



A HAZARD MITIGATION AND RESILIENCE PLAN FOR
THE U.S. VIRGIN ISLANDS

Background

It became very clear after hurricanes Irma and Maria just how vulnerable we are in the Virgin Islands. Thousands of buildings and dozens of critical facilities were damaged, and our natural resources didn't escape



The United States military established a command center in Cruz Bay, St.

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We Welcome Questions and Discussion!

Contact Information

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