SURGE

ENERGY ACADEMIC GROUP QUARTERLY NEWSLETTER WINTER 2020

Highlights

INFRASTRUCTURE RESILIENCE

NPS Researchers Plan Resilient Infrastructure for the Next Disaster in the U.S. Virgin Islands

NOAA's GOES satellite shows Hurricane Irma as it moved toward the Florida Coast in the Caribbean Sea on September 7, 2017.

Is your community prepared to respond to a Category 5 hurricane? Does your community know how to backup electricity and water systems when it is unclear which power lines and pipes will break? Does your community know where to store disaster relief supplies when it is unclear how to access them when roads wash out? Does your community know how to bring communication networks back online when it is unclear who will be unable to access the internet or cellphones? Even if your community has answers to these questions, is your community prepared to handle a second Category 5 hurricane just two weeks after the first? This is exactly the situation that the U.S. Virgin Islands (USVI) faced in September 2017, and a team at the Naval Postgraduate School (NPS) is working with experts across the territory and federal government to answer these questions for the USVI.

In September 2017, Hurricane Irma struck the islands of St. Thomas and St. John in the northern part of USVI Territory and Hurricane Maria struck St. Croix just two weeks later in the south. Together, these storms devastated local infrastructure and communities [1]. Since this catastrophic event, the Federal Emergency Management Agency (FEMA) has funded a team led by Drs. David Alderson and Daniel Eisenberg of the NPS Operations Research Department and the Energy Academic Group to work with colleagues in the USVI Territorial Government, U.S. Department of Energy, U.S. National Labs, University of the Virgin Islands (UVI), and territorial infrastructure providers to ensure communities are resilient to the next big storm. The project consists of three efforts to improve local infrastructure systems and build local capacity to future disasters:

1. Modeling and analysis of interdependent infrastructure in the USVI to improve operational resilience, including electric power, water, transportation, and telecommunications systems;
2. Support the development of a Territorial Hazard Mitigation and Resilience Plan; and,
3. Develop a capacity building and workforce development program for resilient infrastructure.

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From the Chair

Dan Nussbaum, Chair, Energy Academic Group

More often than not when I tell people that I am in the "energy" business, their response is something like "oh, you do climate change, renewable energy, and environmental things, right?" Until now, my response has been that no, we are mainly in the operational energy, energy efficiency, critical energy infrastructure resilience, and energy security ends of the business, rather than on the environmental side. It is true, for those of you who know how all three Service Secretariats are organized, that environment and installations and energy are all grouped under the same assistant secretary in each Service. What that means is that from the Services' perspectives, these topics are closely aligned, and therefore EAG has been missing an important building block by not having somebody working in the environmental space. We are about to fix that, as we are in the final stages of selecting somebody for an environmental position. Our ability to do this is thanks to the support of Provost Lerman and Dean Scandrett. So, in addition to announcing this new capability within EAG, I encourage you to reach out to me if you have work that needs to be addressed in the environmental field. I know, this covers a large body of knowledge, including everything in NEPA, the National Environmental Policy Act. I look forward to this challenge, and I hope you will join me in it.

I want to recognize the fine work of Alan Howard, Lois Hazard, and Nora O'Connor in putting together this quarter's excellent Defense Energy Seminar series. The speakers have been a rich and diverse set of experts, all of whose talks can be seen on https://nps.edu/web/eag/seminars. I encourage you to look at the videos and slides that are there, and to let us know what you like, what you wish we had more of, and whatever suggestions you have.

As always, I look forward to your comments.

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Continued from page 1

Recent developments show the increasing impact of NPS work. The first year of this project focused on reporting the state of USVI electricity, water, roadway, and telecom systems, culminating in a technical report describing systems before and after the storms [2]. Now, NPS researchers have curated enough data, built enough models, and produced enough assessments of USVI infrastructure to inform FEMA disaster planning, mitigation, and response. This hard work recently culminated with NPS researchers playing a critical role at the second USVI Hazard Mitigation and Resilience Planning (HMRP) Workshop held on the 2nd anniversary of the storms.

The HMRP Workshop was led by Drs. Gregory Guannel and Kim Waddel of UVI and prominently featured work by NPS professors and students on infrastructure resilience. Highlighted was a thesis completed by U.S. Navy Lieutenant Commander Jeffery Good and German Army Captain Dominik Wille (students co-advised by Drs. Alderson and Eisenberg) on roadway supply chains [3] and interdependent electric power and water systems [4], respectively. As the outcome of this and future HMRP workshops will be incorporated in the USVI Hazard Mitigation and Resilience Plan, results from NPS experts and students will have a direct impact on future crises response within the territory.

The recent success working across the federal government and local communities now spurs more innovation and research at NPS. Since the HMRP Workshop, the NPS group has grown to include professors in computer science and students working on measuring the vulnerability of telecommunications systems to disasters. Future results produced by NPS students on electricity, water, transportation, and telecommunications systems are already planned to be discussion topics in the next HMRP Workshop in summer 2020.

LEARN MORE
Email Dan Eisenberg at **daniel.eisenberg@nps.edu** or call 831-656-2358

REFERENCES

[1] USVI Hurricane Recovery and Resilience Task Force (2018) Final Report. Technical report, Government of the U.S. Virgin Islands, St. Thomas, USVI, available electronically from https://www.usvihurricanetaskforce.org/, last accessed 8 July 2019.

[2] Alderson DL, Bunn BB, Eisenberg DA, Howard AH, Nussbaum DE, Templeton JC, Interdependent Infrastructure Resilience in the U.S. Virgin Islands: Preliminary Assessment, Technical Report NPS-OR-18-005, NPS, December 2018.

[3] Good, Jeffrey E. An Operational Model of the Critical Supply Chain for the US Virgin Islands. Master's Thesis., Department of Operations Research, Naval Postgraduate School, 2019.

[4] Wille, Dominik. Simulation-Optimization for Operational Resilience of Interdependent Water-Power Systems in the US Virgin Islands. Master's Thesis., Department of Operations Research, Naval Postgraduate School, 2019 (expected).

ENERGY OUTREACH

EAG Represents NPS at PTEC Marketplace

As a member of NATO's Partnership Training and Education Centre (PTEC) community, the Naval Postgraduate School participated at the 2019 PTEC Marketplace at the NATO Headquarters in Brussels, Belgium on 5 November 2019. The marketplace provided a forum where 26 of the community's 33 centres presented and explained education and training offerings to NATO personnel. The Energy Academic Group (EAG) represented NPS at the marketplace. The EAG facilitates and conducts education programs with partner nations related to NATO's identified emerging security challenges. The marketplace was followed by a one-day PTEC workshop and training on NATO's ePRIME, a program with the primary purpose to identify and market courses available to partner nations.

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Email Alan Howard at **arhoward@nps.edu** or call 831-656-2358

EAG Deputy, Mr. Alan Howard, explains NPS education opportunities with PTEC Martketplace attendee (top). EAG's Mr. Lawrence Walzer and LT Jason Morlan, NPS student in the Graduate School of Business & Public Policy, represented NPS at the marketplace (bottom).

ENERGY OUTREACH

EAG Represents NPS at the OE-I Demonstration at the Pentagon

EAG's Alan Howard and Brandon Naylor represented the Naval Postgraduate School at the recent Operational Energy – Innovation (OE-I) Demonstration in the Pentagon. They passed out NPS' In-Review magazine, Naval Research Program brochures, and various EAG materials (EAG's newsletter, *SURGE,* and informational pamphlets) and talked about our work in energy education, research, and outreach.

Over 225 people stopped by the exhibits and discussed the projects. These included SESes, three-star generals, and other military members. The Office of the Under Secretary of Defense, Research and Engineering (OUSD(R&E)) senior leadership was pleased and fascinated by each OE project and initiative. In the words of the senior OUSD(R&E) POC, "This Energy Expo event was a huge win for the DoD OE community."

EAG's Alan Howard and Brandon Naylor represented NPS at the OE-I Demonstration at the Pentagon.

LEARN MORE
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CASE STUDY

Waste Flow, Recycling, and Environmental Impact: A Case Study at the United States Naval Academy

The United States Naval Academy (USNA) in Annapolis, Maryland

United States Naval Academy faculty involved in an interdisciplinary energy security course asked the questions—What happens to the waste at our institution? Are we doing a good job of recycling? Can we do better? When the faculty are from Economics, Mechanical Engineering, Oceanography and Political Science, you get a very thorough answer. The flow of waste, the policy framework that underlies it, and the environmental impacts of the waste stream were modeled for the Naval Academy including the midshipmen dining facility, King Hall, and the adjoining Naval Support Activity Annapolis.

The total municipal solid waste was followed over a twelve-month period from the point of generation and assessed using weight data from hauling trucks, direct observations, and interviews. The recyclable waste streams were evaluated by directly collecting and sorting the waste to determine the recyclable materials that are discarded in the non-recyclable waste stream. Both faculty and midshipmen enrolled in a waste-to-energy engineering elective participated in the collection and sorting. Waste was collected across the midshipman dormitory as well as many locations in academic buildings. In one academic "test building," free standing waste cans were removed for months prior to collection, and the only waste cans available were conjoined with clearly labeled recycling receptacles.

Waste hauling data for the one-year period showed that the institution generated approximately 300 tons of total waste each month and recycled approximately 11–15% of that waste. A large majority of recycled material is cardboard (70%) followed by metal (11%) and various paper products (10%).

Approximately 36% of the non-recycle waste stream contains recyclable materials, mostly plastics and cans that came from academic spaces. The "test building" showed a substantial reduction in recycling infiltrating the non-recycling waste stream.

Current practices result in over 500 metric tons of carbon equivalent savings over the long-term during the one-year measurement period. An economic incentives analysis indicates that waste sorters and transporters outside the institution operate in a relatively efficient market. However, for the primary waste generators (people that throw things away at the institution) and the contractors performing the initial collection and sorting, there is little marginal incentive for minimizing waste production or optimizing waste sorting. Focusing on social behavior carries the greatest promise for increasing levels of recycling, reducing landfilled waste, and reducing net carbon emissions.

CASE STUDY AUTHORS

Patrick Caton, Department of Mechanical Engineering, USNA; Howard Ernst, Department of Political Science, USNA; Karen Flack, Department of Mechanical Engineering, USNA; Joseph Smith, Department of Oceanography, USNA; Kurtis Swope, Department of Economics, USNA

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For more information about this case study, email Karen Flack at **flack@usna.edu**

EAG Faculty Associate Brandon Naylor shown with the microgrid lab midway through construction. The lab is built into a 20-foot shipping container using commercial off-the-shelf components and designed to support a wide variety of energy generation and storage mechanisms.

ENERGY RESEARCH

NPS Microgrid Lab Under Construction

The Energy Academic Group is midway through construction of a microgrid power systems lab that will enable students and faculty to conduct hands-on research in the fields of renewable energy generation, energy storage, and power distribution and management. This microgrid was originally planned as a demonstration for microgrids composed of commercial-off-the-shelf (COTS) components, but it was later realized that the microgrid would have more value as a lab for student and faculty experimentation. The lab is built into a 20-foot shipping container and features solar and wind generation, battery storage equivalent to a typical household's daily energy use, and dual fuel backup generation. Because most of the components are COTS devices intended for residential and industrial applications, they tend to have more robust data collection capabilities built in. In the future, it is also planned to incorporate more military specific hardware so that the microgrid will more closely resemble systems students might later encounter in the field.

Upon completion in Q2 FY20, the microgrid will be available for NPS students and faculty to use in support of their educational labs, sponsored research, and thesis projects.

Upon completion in Q2 FY20, the microgrid will be available for NPS students and faculty to use in support of their educational labs, sponsored research, and thesis projects. The microgrid has been designed to support a wide variety of energy generation and storage mechanisms, so students and faculty pursuing topics such as alternative generation or storage methods are highly encouraged to incorporate their systems into the microgrid. Anyone interested in using the lab is encouraged to reach out to Mr. Brandon Naylor of the Energy Academic Group at blnaylor@nps.edu.

LEARN MORE

Email Brandon Naylor at **blnaylor@nps.edu** or call 831-656-1986

STUDENT ENERGY RESEARCH SPOTLIGHT

Compressed Air Energy Extraction

By LT Michael Johnson

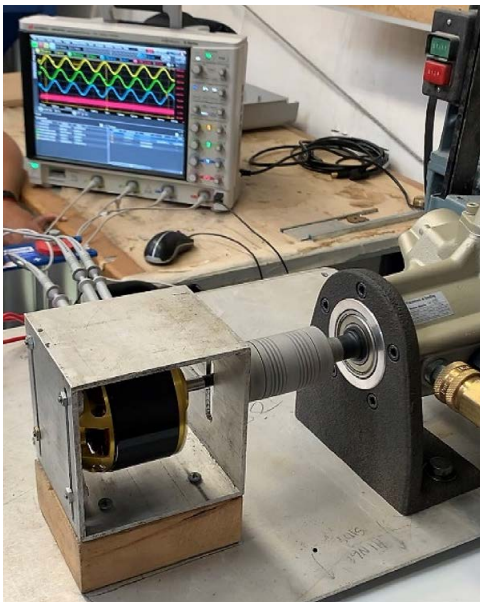
Energy is a hot topic in the world today. Transitioning from fossil fuels to resilient energy sources, such as solar and wind, has become a major focus within the power generation industry and in the Department of Defense. Increased energy independence is of strategic importance due to emerging grid dependence on networks, which are susceptible to cyber-attack.

Wind and solar are great for this movement but have the typical drawbacks associated with these energy sources. When peak power is produced with Solar (noon to mid-afternoon), the demand is the smallest. Wind tends to be the best generator at night, but demand is small then as well. Traditional thinking lends itself to using batteries and by extension, capacitors to store this excess energy. Unfortunately, existing battery technology does not provide large amounts of storage space for the energy required. Large battery banks, the size of buildings, would be required to store the energy required for a small area during high demand. Storage of energy outside of batteries also allows for more options to diversify energy storage.

Compressed air storage and infrastructure is already in place throughout the country. Gas stations have compressed air stations to inflate tires and auto shops have compressed air systems in place for air tools. All ships have compressed air systems on board for a multitude of purposes. Compressed air systems are easy to install and maintain and are very user friendly, typically just plug and play once installed.

The design uses low pressure air to power a small air motor to generate voltage to recharge a super capacitor. Voltage is sensed on the capacitor and the air motor is periodically cycled to maintain. This use could allow for smaller battery or capacitor banks with more intermittent recharging rather than a large bank to hold stored energy over a long period. Further, as this air motor runs on low pressure air, an air reserve at high pressure would be able to last quite a while.

The Navy could put this system to use in many applications, from shore to sea. Ashore, this could be used to help sever the Navy's dependence on the existing power grids around the installations, providing power to buildings or vital equipment. At sea, with emerging weapons such as the rail gun and the directed energy weapons, this system could be used to minimize the impact to the ship's existing electrical system. Using already installed air systems, this could be an addition to offset charging requirements to battery/capacitor banks being used to power loads with high electrical demand. This is scalable and mobile, only weighing about 35 pounds. Using all commercially available and inexpensive materials (the most expensive part is the air motor at $1000), this system is also very cost effective and easily implemented into existing arrangements.



Generator (Left) and Radial Air Motor (Right)

In a world where energy resilience is essential, the Navy is helping to lead the transition into the various options using widely available existing technology.

LT Michael Johnson

About the author

LT Michael Johnson is a Surface Warfare Officer and a student in the Mechanical Engineering Department of the Naval Postgraduate School. Contact Dr. Anthony Gannon at **ajgannon@nps.edu** for more information on this research.

OPERATIONAL ENERGY

Energy Action Month: Air Force Academy Cadets Optimize the Future

By Corrie Poland, Air Force Operational Energy (SAF/IEN)

Members of the cadet Air Force Academy Energy Action Team pose at the U.S. Air Force Academy, Colo., October 04, 2019. Energy Action Month is recognized every October to highlight the critical role energy plays in Air Force operations, and to encourage smart energy use and management for installations, ground vehicles, and aircraft.

Article originally published October 10, 2019. Provided by the U.S. Air Force Air Combat Command and reprinted with permission.

WASHINGTON—With Energy Action Month in full swing, cadets at the Air Force Academy are taking the initiative to learn how energy impacts the mission, and what Airmen can do to improve combat capability through optimized operations. Every October, the Air Force recognizes the national campaign as a way to highlight the importance energy plays in daily operations, and showcases ways to build an energy-smart force through innovative technologies, policies, best practices and data solutions.

Eight cadets stepped forward to collaborate with Air Force Operational Energy (SAF/IEN) and launch their own energy action initiatives at the Academy. Their first goal was to better understand defense energy challenges and research solutions currently underway in the Air Force, and actions they could implement at the Academy

Col. Anne Johnson, SAF/IEN Liaison and an assistant professor of mathematical sciences, is guiding the cadets and informing their initiatives.

"The cadets have been really excited about getting involved in such a critical issue for the Air Force," she said. "They love the opportunity to make an impact locally and globally, and explore ways to increase capability through energy efficiency."

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>
> **– COL. ANNE JOHNSON, SAF/IEN LIAIS**

The cadet Air Force Academy Energy Action Team has organized several initiatives across campus to promote awareness of Air Force energy initiatives and promote a culture of efficiency and environmental responsibility. Through October, the team will host a number of competitions challenging squadrons to collect recycling, reduce energy consumption in dorms and prevent unnecessary waste in Mitchell Hall, the cadet dining facility. They have also scheduled a visit to the waste management recycling plant in Denver to better understand how cadets can reduce their environmental footprint.

On the operational energy front, cadets are meeting with Academy professors and subject matter experts to learn how aerodynamics, lift and propulsion, combustion processes and turbine blade sustainment have an impact on aviation fuel efficiency to better inform other cadets of its significance for the global mission. Additionally, they've visited the Academy Airfield to learn the fundamentals of optimized operations for combat readiness.

"We're working really hard to improve the culture of energy efficiency and sustainability at the Academy and teach cadets better practices for the future," said Energy Action Month team member Cadet 1st Class Santiago Garcia. "We plan on continuing to work on these initiatives throughout the year."

LEARN MORE

For more information about Energy Action Month, visit **www.safie.hq.af.mil/EnergyActionMonth** for resources and follow the hashtag #EnergyAbleMissionCapable at **www.facebook.com/AirForceEnergy** and **www.twitter.com/AFEnergy**

Batteries or Bullets: A Tool to Estimate Dismounted Unit Power Requirements

By Gary W. Parker, Faculty Associate–Research, Systems Engineering Department, NPS

A soldier conducts dismounted maneuvers wearing a photovoltaic solar panel harvester during an energy-harvesting technology demonstration. (Photo: David Kamm, NSRDEC)

Marines and soldiers conducting dismounted operations under logistically austere conditions often have to make hard choices as to what and how much to carry. In the past, operational experience was generally sufficient to make zero-sum tradeoffs among ammunition, water, and food depending on the length of mission, likelihood of enemy contact, and environmental conditions. The increasing integration of electronic technology to increase the connectivity and situational awareness of dismounted units added a new commodity to the mix, namely energy (usually in the form of batteries). Commanders, planners, and materiel developers now needed an easy-to-use tool that would allow them to make energy-informed decisions for dismounted operations.

The USMC Expeditionary Energy Office sponsored the development of just such a tool, called the Intelligent Power Optimization with Environmental Reactivity (IPOWER) simulation model. IPOWER predicts power requirements for dismounted units based on a number of factors that can be varied to assess power consumption. Recently, a Naval Postgraduate School operations research student, LCDR David Medici, completed his thesis titled, "A Sensitivity Analysis of IPOWER: A Small Unit Energy and Mission Planning Tool" in which he describes the development and use of a software wrapper that gives IPOWER users the capability to automatically run efficient experiments consisting of thousands of runs while varying multiple input parameters and mission durations. LCDR Medici used this new capability to perform a sensitivity analysis by conducting over 4,000 simulated missions that varied input parameters such as mission duration (24– and 72–hour durations) and whether energy harvesters (solar panels) were used or not.

In analyzing the results from the 4,000 simulated missions, LCDR Medici discovered that IPOWER delivered intuitive results as long as energy harvesters were not included in the scenario. Once harvesters were included, however, IPOWER began to deliver unexpected results such as missions where harvested energy did not result in batteries being recharged. He also noted that errors and data anomalies occurred when mission durations were extended to 72 hours. It is suspected that the introduction of harvesters results in possible system-level interactions that make the simulation more complex. LCDR Medici concluded that while IPOWER is useful for its intended purpose, further research and investigations are required to account for increased simulation complexity when energy harvesters such as solar panels are included in scenarios.

LEARN MORE

LCDR Medici's thesis is available via the Naval Postgraduate School's Institutional Archive "Calhoun" at **http://hdl.handle.net/10945/63483**

RESILIENCE CORNER

Resilience Is Not About What You *Have*, It Is About What You *Do*

By Dan Eisenberg, PhD, Department of Operations Research, NPS

Resilience is a "new" term creeping into military directives, but what does it mean and how do we use it to guide decisions? In previous Resilience Corners, we discussed how resilience is more like a verb than a noun and that resilient military systems should be designed to handle surprises instead of only pre-defined threat scenarios. But how can one assess and design military systems that successfully adapt to surprise?

The key is to focus less on what your service has and focus more on what people do when faced with stressful events. For example, the resilience of an installation's electric power system is not determined by whether it has backup generators for mission critical systems, but by the actions people take to ensure that the generators turn on and work during a blackout. Often missions are not degraded due to a lack of backup systems, but because the systems did not function as intended and personnel were unable to resolve operational issues. The fundamental question is not, "how many backups do we have," but, "are we capable to respond to surprise?"

Research suggests that improving processes for response is the best way to promote resilience. Military practice already puts a strong emphasis on improving soldier capabilities to respond by speeding up their OODA loop—i.e., their ability to Observe, Orient, Decide, and Act under pressure [1]. Improving the OODA loop enables a soldier's capability to sense their environment (observe/orient) and adapt to changing mission needs (decide/act). However, there is a more nuanced perspective promoted in resilience literature that suggests the OODA loop is insufficient, dubbed SAAL—Sensing, Anticipating, Adapting, and Learning [2]. SAAL expands on OODA to emphasize that resilience also requires an ability to overcome bias and foresee new possibilities (anticipate) and incorporate experience into future action (learn). Encouraging this broader view and implementing policies that improve SAAL may have the force multiplying effect that new military resilience requirements are trying to achieve.

Unfortunately, current resilience policies may not improve SAAL processes. SAAL is demonstrated by the actions people take, making these processes much more difficult to measure than the number of backups, soldiers, or weapon systems we have available. Simply put, *SAAL cannot be counted.* This means that resilience policies that focus on the quantity of an asset may not be effective, e.g., energy resilience plans that require seven days of backup electricity.

Instead, *SAAL can be observed.* Resilience does not ask whether we have backup power, but if we are even capable to use it. This means that resilience policies should promote training, simulations, exercises, and deployments to determine just how well soldiers adapt to new situations. Accordingly, energy resilience requirements should not just promote quantifying whether an installation has electricity for the full seven days after a blackout, but also promote observing the actions people took to make seven days possible.

LEARN MORE

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CITATIONS

[1] Osinga 2007, Routledge; [2] Thomas et al. 2019, JHSEM, 16(2)

EAG Chair Delivers Keynote Address at 2019 Scientific International Conference

Dr. Daniel Nussbaum, Chair of the Energy Academic Group, was the keynote speaker at the 2019 Scientific International Conference "Defense Resources Management in the 21st Century (CoDRM 2019)", organized by the Regional Department of Defense Resources Management Studies, under the auspices of Carol I National Defense University, in Brasov, Romania, 07–08 November 2019.

The theme of the conference was *Complementarity Between NATO and EU in Supporting Security and Stability*, and Dr. Nussbaum spoke on the topic Energy Security—*A new EU-NATO Challenge and a Bridge Between NATO and EU in Supporting Security and Stability.* His talk, attended by approximately 100 people, covered the following topics: What is energy security?; Why do NATO and the EU care about energy security?; Resource Management challenges due to energy security; and some tools for addressing these challenges. The presentation was well received, and there is now an opportunity for a more long-term and strategic relationship between NPS and the Carol I National Defense University.

EAG Chair Dan Nussbaum at CoDRM 2019

ENERGY RESEARCH

Navy Officer to Receive Summer Quarter's MORS/ Tisdale Award

By MC2 Taylor Vencill

Article originally published September 10, 2019. Provided by the Naval Postgraduate School Public Affairs Office and reprinted with permission.

Recent graduates of NPS' operations research program, U.S. Navy LT CMDR Jeff Good, LT Ben Garbacz and LT Nickos Leondaridis-Mena, from left to right, presented their research during the MORS/Tisdale Thesis Award competition, Aug. 29. In the end, Good's evaluation of supply chain management for the Virgin Islands following Hurricanes Irma and Rita was selected as the summer quarter's winning thesis. (Photo: Javier Chagoya)

Three U.S. Navy students from the Naval Postgraduate School (NPS) Department of Operations Research (OR) presented theses examining a variety of operational dynamics such as supply chains, chemical analysis and Sailor workloads to a panel of judges for the summer quarter Military Operations Research Society (MORS) Stephen A. Tisdale Thesis Award, August 29.

Following the detailed presentations and extensive deliberations, the judges awarded LT CMDR Jeff Good with the summer quarter MORS/Tisdale Award citing his research represented the most near-term operational relevance to the service. Titled, "An Operational Model of the Critical Supply Chain for the U.S. Virgin Islands," Good researched how to improve supply lines to people involved in natural disasters in the Caribbean Sea region.

Good's research evaluated the supply chain of the Virgin Islands after Hurricanes Irma and Rita heavily battered the region in September 2017. He studied how aid was delivered and dispersed on the decimated islands of St. John and St. Thomas, as well as how the inhabitants traveled to receive the aid.

"It makes me feel good that our faculty feels that the work that I'm doing is relevant to the Department of Defense and the Navy at large," said Good. "It's nice to see the hard work that goes into writing one of these theses pays off. It's a good vote of confidence from our faculty."

Good's research has already turned heads and is looking to be applied to real world applications and improve the plans currently in place in the Virgin Islands.

"My advisors and I are traveling to the Virgin Islands to brief our results as part of a hazard mitigation plan working group," said Good. "The Virgin Islands are in the middle of rewriting their hazard mitigation plans, so we will actually be a part of informing their decisions."

Good's work not only applies to area that experiences frequent natural disasters, but also applies to the Navy at large.

"Part of the Navy's mission is humanitarian assistance and disaster relief," said U.S. Navy CAPT Brian Morgan, program officer for NPS' OR curriculum. "When you look at other agencies that do humanitarian assistance, you can better understand what it takes to efficiently complete the mission. It helps operations go smoothly and you can get the correct amount of aid to the right people."

Good joins a lengthy roster of students earning the esteemed award dating back to the 1970s.

"The MORS Tisdale competition is a time where we, as a department, get to celebrate the excellent work that our students do," said Dr. Matt Carlyle, Operations Research department chair. "Anytime anyone asks me about examples of the work we do here, I have a long list of examples that I can show to anyone who's interested about the fantastic, relevant work that we do in this department."

Good acknowledged the support and guidance from his advisors, Drs. David Alderson and Dan Eisenberg. "They're very invested in the problem, but they've allowed me to take ownership of it and actually feel like I'm part of a larger team and not just doing a thesis," noted Good. "They've been the most influential from the faculty standpoint."

The MORS/Tisdale award is named in honor of LT CMDR Stephen A. Tisdale, a dual-degree graduate of NPS in 1989 who perished in a military aircraft accident on March 21, 1991, while serving with Patrol Squadron 50 off the coast of California. Tisdale's outstanding and influential thesis, "Assessing Optimal Utilization of Potential Anti-Satellite Architectures," won the MORS prize for his graduating class, and was also recognized as the top Space Systems Operations student as well.

Seats Available for Defense Energy Certificate Program

There are still seats available to enroll in the Defense Energy Certificate program that begins 30 March 2020. The certificate program is free to all students, but applications must be submitted, transcripts received, and a Participation Agreement signed as soon as possible. The DL Defense Energy Certificate program is a graduate-level and accredited certificate program. It consists of four courses, offered one per quarter for four consecutive quarters. The program is open to all federal civilian employees who are U.S. citizens and qualified uniformed officers. The Energy Certificate is designed to support the Office of the Secretary of Defense and the Secretary of the Navy's energy goals. The DL Energy Certificate provides those working military and civilian employees of the Department of Defense the opportunity to understand the complex issues facing the Operational and Installation Energy segments of DoD and how they impact Operational Capability issues as well as military requirements. The certificate program is designed to expose students to the technical, operational, and security aspects of DoD's energy needs. Students who successfully complete the program will earn an accredited Certificate in Defense Energy. The Western Association of Schools and Colleges (WASC) confers accreditation.

FOR MORE INFORMATION OR TO APPLY:
Email Kevin Maher at **kjmaher@nps.edu** or call 831-656-2691

ENERGY RESEARCH

Business Case for Non-Intrusive Load Monitoring

Non-Intrusive Load Monitoring (NILM) is the practice of putting power measuring sensors on a facility's electrical hookup to collect information relating to the power consumption of the facility's major loads. This power consumption data can then be examined to extract information related to the performance of specific devices to inform future investment decisions or maintenance needs. For example, energy use data such as that gained from NILM was used when renovating a building at the Naval Postgraduate School to determine that a building originally designed with three HVAC chiller units for a data center only required two, thus lowering the cost of the renovation.

NILM can be an attractive option for decision support in facilities with a small number of large loads that significantly impact facility design or power consumption. It can be used to assess the health or performance of large systems by determining when certain devices with characteristic power profiles are turning on and off. Installing these NILM systems at the circuit level can be preferable to installing power monitors directly on the devices in question because NILM allows one sensor to collect data on all components sharing a circuit. However, this comes at the cost of a more difficult data analysis. For circuits used by only a few high power devices such as HVAC circuits, it may be sufficient for a knowledgeable operator to draw meaningful conclusions from the data, but circuits shared by more devices will require expensive software packages to extract meaningful information.

LEARN MORE
Email Brandon Naylor at **blnaylor@nps.edu** or call 831-656-1986

Calendar of Events

JAN

January 14, 2020
Defense Energy Seminar Series:
Mr. Blane Wilson, Electrical Engineer, C5ISR Center Combat Capabilities Development Command, U.S. Army Futures Command
Visit nps.edu/web/eag/seminars for topic, guest speaker, and time and location.

January 21, 2020
Defense Energy Seminar Series:
Dr. Jay O. Keller, President, CEO, Zero Carbon Energy Systems
Visit nps.edu/web/eag/seminars for topic, guest speaker, and time and location.

FEB

February 4, 2020
Defense Energy Seminar Series:
Guest Speaker To Be Announced
Visit nps.edu/web/eag/seminars for topic, guest speaker, and time and location.

February 11, 2020
Defense Energy Seminar Series:
Mr. Patrick Balducci, Chief Economist, Pacific Northwest National Laboratory
Visit nps.edu/web/eag/seminars for topic, guest speaker, and time and location.

February 18, 2020
Defense Energy Seminar Series:
Mr. Nikos Tsafos, Senior Fellow, Energy and National Security Program, Center for Strategic and International Studies
Visit nps.edu/web/eag/seminars for topic, guest speaker, and time and location.

February 25, 2020
Defense Energy Seminar Series:
Ms. Amy Conroy, Manager, International Government Affairs for Eurasia (Russia), Chevron Corporation
Visit nps.edu/web/eag/seminars for topic, guest speaker, and time and location.

MAR

March 23–27, 2020
Operational Energy Course, Baltic Defense College, Tartu, Estonia

Interested in Energy-Related Thesis Research?

Since 2013, NPS and the EAG supported a plethora of student thesis research in the area of energy. Publicly viewable student theses can be searched from the Resources page of the EAG website at **nps.edu/web/eag/resources**. The EAG's extensive resources, intellectual capital, and connections with multi-disciplinary faculty and energy professionals provide students enhanced support for energy-related research. If interested in energy research, please reach out to the EAG team!

ENERGY ACADEMIC GROUP
NAVAL POSTGRADUATE SCHOOL

Connect with the Energy Academic Group

The Energy Academic Group is located in Quarters D, Bldg 281 on the NPS campus in Monterey, California. A wide range of NPS faculty are affiliated with the energy program, actively participate in energy graduate education, energy executive education, and energy research. For questions, please contact one of the principal EAG faculty members:

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Contribute to an issue of *Surge*

If you would like to contribute an article or have your research/work published in the *Surge* newsletter, please contact Lois Hazard via email at lkhazard@nps.edu.

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