



NAVAL POSTGRADUATE SCHOOL

# IN REVIEW

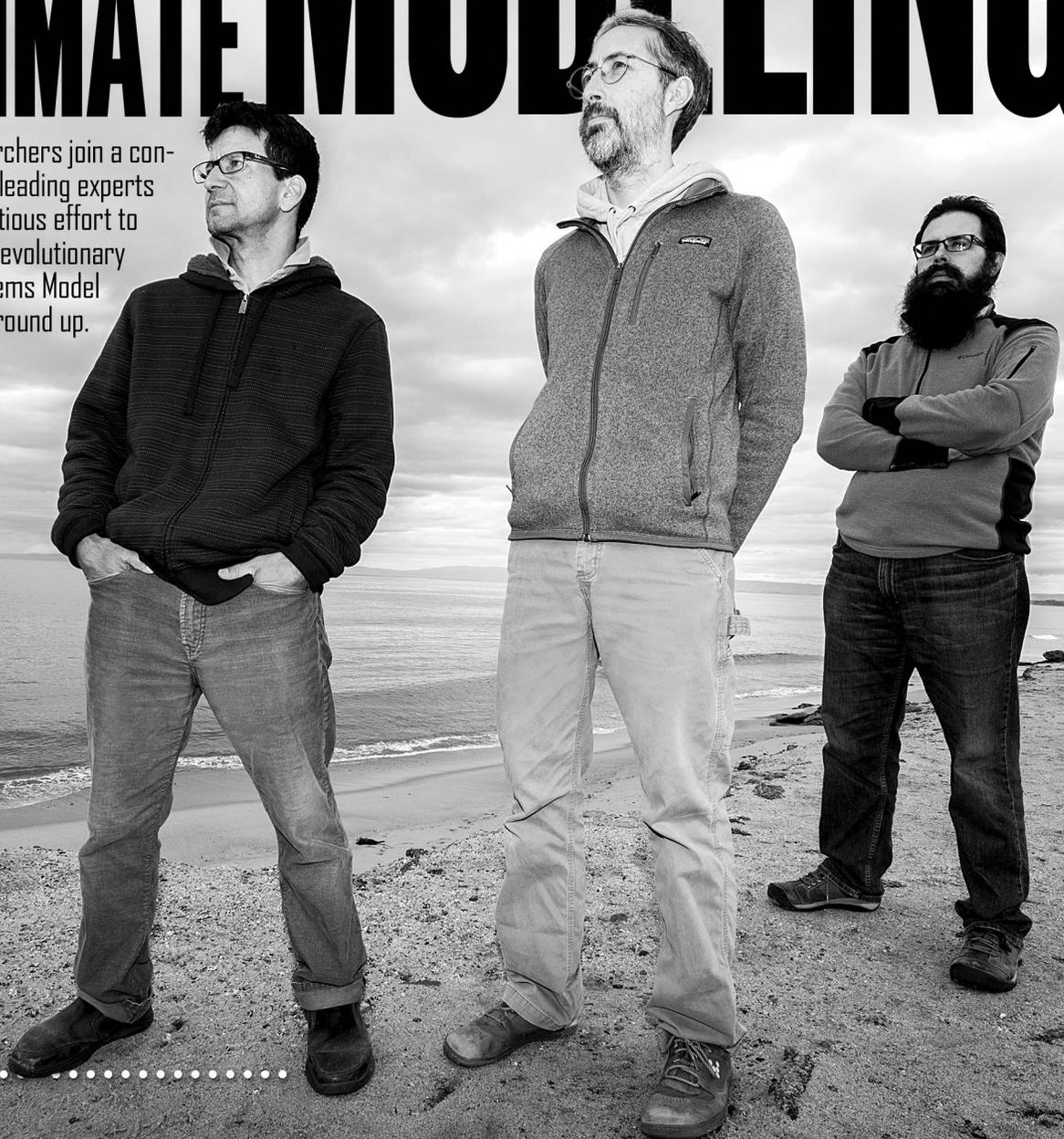
MAGAZINE

SPRING 2019

RESEARCH  REVIEW

# NEXT-GEN CLIMATE MODELING

NPS researchers join a consortium of leading experts on an ambitious effort to develop a revolutionary Earth Systems Model from the ground up.



**INSIDE:**

SECNAV Offers Winter Quarter Commencement  
JIFX Accelerates Solutions Through Partnerships  
CNAF Turns to NPS to Take On Readiness

# PRESIDENT'S MESSAGE

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**Dr. Ann Elisabeth Rondeau**  
Vice Adm., U.S. Navy (Ret.)  
President, Naval Postgraduate School

*“As I reflect upon my own participation on the Education for Seapower board, I am immensely thankful to our senior Navy leaders for exerting such a powerful vision for Naval education.”*

When Under Secretary of the Navy Thomas B. Modly released the Education for Seapower (E4S) study, a powerful statement was referenced on the opening pages of the full report. The comment, originally penned by 29th Commandant of Marine Corps General Al Gray, retired, illuminated the efficacy of military leadership and, especially, its interdependence on intellect.

“A leader without either interest in or knowledge of the history and theory — the intellectual content of his profession — is a leader in appearance only,” Gray wrote. “This is particularly true among officers; after all, an officer’s principal weapon is his mind.”

One would be challenged to find a sentiment more relevant to the Naval Postgraduate School, where our mission of graduate education both relies on, and re-enforces, this very principle. Emphasized several times throughout the E4S report, and embodied in everything we do here on our campus in Monterey, education presents a value proposition that cannot be understated or overvalued.

As I reflect upon my own participation on the Education for Seapower board, I am immensely thankful to our senior Navy leaders for exerting such a powerful vision for Naval education. As president of this esteemed university, I am equally thankful to the students, faculty and staff who walk these halls and bring life to these classrooms and laboratories. They are the leaders who will bring this vision to bear.

Evidence of the power our professionals and experts yield lies throughout this latest edition of our “In Review” magazine. For example, our Center for Executive Education (CEE) has a reputation second to none in the realm of professional education for senior leaders. CEE’s portfolio of seminars and symposia is broadly respected ... However, there is always an opportunity to improve.

With this in mind, Commander, Naval Air Forces Vice Admiral DeWolfe Miller III came to CEE with a challenge, a critical one although not wholly dissimilar from challenges faced by our senior leaders every day. At stake for the Air Boss is Naval Aviation readiness, and an urgency to make significant advancements in aircraft ready to fly and fight at a moment’s notice.

The role of NPS, and the expertise of its executive education team, was to help Vice Admiral Miller and his circle of senior Naval Aviation leaders, to rapidly align under a common vision and culture through CEE’s Commander + Strategically Aligned Leadership Team, or C+SALT, program. Once aligned, the broader Naval Aviation enterprise as a whole needed to charge forward as a unified team and execute their plan. Vice Admiral Miller and a larger cross-section of Naval Aviation leaders returned to NPS for CEE’s Strategic Planning for Execution: Assessment and Risk (SPEAR) program.

In the end, the university has served as a powerful enabling force in supporting this critical warfighting capability. While exemplary, each of the efforts highlighted here in “In Review” could make the same essential claim. From our academic partnerships with the National University of Singapore and the Middlebury Institute of International Studies to our research endeavors in game-changing climatological models and predictive machine learning; from our partnerships with industry to advance tech to the warfighter through JIFX to our annual Naval Research Working Group, each of these programs applies the rigor of a robust graduate education to the effectiveness of the force.

It is a solemn responsibility, an honor without equal, and a mission we are proud to serve, for as General Gray recognized, the weapon we perfect here at NPS is the most powerful weapon our officers can wield — our intellectual capacity to think, create, innovate, and bring solutions to any problem and challenge in support of national security. Indeed, our intellectual capital is our nation’s and our military’s greatest strategic asset.

A handwritten signature in black ink that reads "Ann E. Rondeau". The signature is fluid and cursive, with a large initial "A" and "R".



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### On The Cover

This issue of "In Review" magazine welcomes a new addition to the publication, keenly focused on the efforts of discovery by the university's cutting-edge faculty. Titled Research In Review, this now regular addition to the publication takes an in-depth, detailed approach to reporting the science behind some of the institution's most impactful research. Our first installment details the efforts of Drs. Frank Giraldo, Jeremy Kozdon and Lucas Wilcox as they embark on what has the opportunity to be a game-changing approach to climate prediction through the Climate Modeling Alliance.

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## Deputy USSTRATCOM shares latest in strategic deterrence

Vice Adm. David Kriete, Deputy Commander, United States Strategic Command (USSTRATCOM), addressed NPS students, faculty and staff about the command's strategic deterrence mission, and their latest endeavors to advance that mission through education, during a Secretary of the Navy Guest Lecture (SGL), Mar. 5.

Kriete has almost half a decade of service at USSTRATCOM, and played an integral role in the two most recent Nuclear Posture Reviews, determining the role of nuclear weapons in U.S. policy and strategy.

"Strategic deterrence is the number one mission of USSTRATCOM, however, today's security threats are multi-domain, multi-regional and multi-adversary," said Kriete. "This is an extremely complex environment that militaries around the world have to navigate, and we have to partner with other nations and with other U.S. government departments if we are going to be successful."

Before taking to the podium during his first NPS visit, Kriete toured several laboratories learning about the unique research conducted by faculty and students in the areas of undersea warfare (USW), satellite design and others.



*Vice Adm. David Kriete, Deputy Commander, U.S. Strategic Command speaks to NPS students, faculty and staff during the university's latest Secretary of the Navy Guest Lecture, Mar. 5.*

"The real value of the Naval Postgraduate School is that you're developing ideas here that you will bring back to the fleet or community you work in," said Kriete. "One of the favorite parts of my job at USSTRATCOM is engaging with the young professionals who are going to lead our nuclear enterprise well into the future."

Kriete expressed that the education of all military officers is a force multiplier for both USSTRATCOM and the joint force.

"One of our biggest success stories of late at USSTRATCOM is the establishment of what we call the Deterrence and Assurance Academic Alliance," said Kriete. "The alliance today consists of over 40 prestigious universities and institutions, including NPS, that are all working together to advance deterrence far beyond the old Cold War narrative."

"By promoting collaboration between both the academic and military communities, the alliance encourages the development of security professionals that can meet our future security needs for research, analytics, policy and decision-making," continued Kriete. "We use all those things at USSTRATCOM every single day."

### Annual TechCon Examines Government, Industry Partnerships

NPS' Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) held its eighth annual Technical Continuum (TechCon), April 17, offering a series of panel discussions illuminating the diverse perspectives involved with partnerships between DOD, industry and academia.

"This year, our focus on engaging with industry is really a complement to everything that is going on campus," said Dr. Brian Bingham, Director of CRUSER. "Since NPS is situated half in the DOD and half in academia, CRUSER in particular can be very agile and able to respond and deliver on the goals

that leadership present. Many of our colleagues and external NPS partners connected at this event show that NPS is able to create forums for exchanges of ideas between academia, the DOD and industry."

The continuum's three panels included subject matter experts discussing partnerships from the perspectives of both the government and industry entrepreneurs, as well as a panel focused on how NPS has facilitated relationships between DOD and the private sector.

Speaking to some of the already well established and successful relationships between NPS and industry, Dr. Don Brutzman, professor in the NPS Department of Information Sciences,

described how NPS has traditionally been a channel for the DOD and industry to collaborate on the needs of the United States.

"Why would companies want to work with NPS?" Brutzman asked. "Part of it is to have NPS faculty review their technology, and then have students look at operational applications. If you study the history of NPS all the way back to World War II, it took a combination of young officers, scientists and industry to work together to pull everything off and win.

"Amazing things have continued to happen here," continued Brutzman. "When you bring all of that together ... It becomes an opportunity for NPS, industry, academia, the Department of the Navy and the Department of De-

fense, to all come together and think of things in innovative and collaborative ways."

### Navy Announces New Grad Ed Requirements

The Navy released an administrative instruction in late 2018 that could bring with it considerable impact on graduate education in the service, and on the Naval Postgraduate School.

NAVADMIN 263/18 states that officers in unrestricted line (URL) communities must now be screened by administrative boards in order to attend in-residence graduate education programs, which they must complete to be eligible for taking major command starting with officers in year group 2015.

“I think there are advantages to being an in-resident graduate because you’re taken out of your operational environment for a specified period of time and you can just focus on your studies,” said Cmdr. Doug Jones, NPS Director of Programs. “You also have that time to develop those critical thinking skills and that will pay benefits when you’re in a major command because you’ll know how to analyze, access, critically think, and will develop characteristics that I think are

desired at the major command level.”

The NAVADMIN makes a point to emphasize in-resident graduate education, as opposed to distance learning and hybrid programs, placing a high priority on critical thinking skills developed as a full-time graduate student in a dedicated academic environment.

## Senior Air Force Alumna Honored with Prestigious AACSB, NPS Awards

U.S. Air Force Brig. Gen. Alice Trevino received dual honors during a ceremony on the NPS campus, Feb. 7, when the Association to Advance Collegiate Schools of Business (AACSB) inducted her into its 2019 Class of Influential Leaders, in addition to the university designating her as a distinguished alumna.



Air Force Brig. Gen. Alice Trevino is recognized by Graduate School of Business and Public Policy Dean Dr. Bill Gates, Feb. 7.

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## NRWG leverages NPS expertise for research and innovation

NPS held its annual Naval Research Working Group (NRWG) on the university’s campus April 9-11, providing a forum for Navy and Marine Corps organizations to communicate, review, validate and recommend topics for NPS research over the coming fiscal year.

Now in its sixth year, the annual NRWG connects faculty and students with Department of Defense (DOD) organizations seeking to leverage NPS’ expertise and operational experience to overcome warfighter challenges through research. In total, representatives from 20 different organizations from throughout the Navy and Marine Corps team attended the conference.

“This is really a win-win for everyone,” said NRP Deputy Program Manager Lt. Col David Forbell. “For the Navy and Marine Corps representatives this provides an opportunity for them to get their research needs met at a minimal cost, and it allows NPS faculty and students to work on relevant real-world problems while meeting academic requirements.

“Most of the problems that we face today are interdisciplinary in nature,” added Marine Corps Col. Todd Lyons, Senior Marine Corps Representative and Associate Dean of Research. “Problems will not be solved purely by a computer scientist or an analyst working in isolation, they will be solved by a blend of unique talents from different schools of thought. There is where you find amazing value, and that is what NPS provides.”

New to NRWG-19, subject matter experts from the university held panel discussions on key issues — such as cyber, human-machine teaming and artificial intelligence — to demonstrate current NPS research in these areas.

For Cmdr. John Montinola, a sponsor representative from the office of Deputy Chief of Naval Operations for Fleet Readiness and Logistics (OPNAV N4), these capabilities offer a great avenue to interact with other members of the analytic community in pursuit of new partnerships and opportunities.

“This has been a great way to look at real-world problems and collaborate,” he said. “Many students have expressed interest in the topics and challenges we are facing.”

From the student’s point of view, the NRWG provided an invaluable opportunity to explore potential thesis topics that are directly relevant to service needs and issues.

“Since I have yet to declare my thesis, I was looking for ideas from different members of the Marine Corps community on problems they were looking to solve to see if any of them would align with my current curriculum,” said Marine Corps Maj. Andrew Nelson. “I received a lot of good information on possible thesis topics from new and emerging issues from around the fleet.”

Since the inception of NRWG, more than 2,000 topics have been submitted through the Navy Research Program, including 293 in the last fiscal year. More than 350 research projects have been completed or are in progress.



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“AACSB is honored to recognize Brig. Gen. Alice Trevino and congratulates NPS for its role in preparing alumni who are leading examples of business education as a force for good in the world,” said Thomas R. Robinson, president and CEO of AACSB.

Graduating from NPS’ MBA class of 2007, Trevino has served in several key DOD contracting positions, leveraging her education and experience to the benefit of the warfighter. As a senior contracting official in Afghanistan, she infused \$3.5 billion into the Afghan economy to increase local industrial growth. And while commanding the Defense Contract Management Agency’s western region, she saved more than \$300 million in taxpayer money through a process re-engineering effort.

“Trevino is a leader who has been doing great things in the world of accountability for the financial and contract health of the Air Force. We are delighted to be able to say she’s one of us and comes from the NPS family,” said NPS President retired Vice Adm. Ann Rondeau, who noted the two had worked together at the U.S. Transportation Command years prior. “You don’t make a mark all of a sudden when you make general. You make a mark prior to that because promotion is about investment in the future more than it is about rewarding the past.”

“I’m very humbled to even be considered for the nomination and to represent NPS, because I had such a wonderful time here,” said Trevino in accepting the honors. “Staying in touch with what they teach here, and with the curriculum, is vital to the students and faculty to help them get the recognition they deserve for the business school.”

## East Asia Expert Analyzes Chinese Sea Power During SGL

Naval Postgraduate School students, faculty and staff received an analytical look into the developments of Chinese sea power from Dr. Toshi Yoshihara, Senior Fellow at the Center for Strategic and Budgetary Assessments (CSBA), during a Secretary of the Navy Guest Lecture (SGL), Feb. 26.

“My argument this afternoon is fairly straightforward,” said Yoshihara. “China’s turn to the seas will be a permanent and complicating factor in East Asian politics, and to U.S. maritime strategy for years, if not decades to come.”

Yoshihara explained how the Chinese use the term “maritime consciousness,” meaning a broad understanding of sea power within society, to describe a whole-of-nation approach to sea power. To illustrate China’s recent interest in forming a maritime consciousness, he presented social media posts of Chinese citizens celebrating the launch of a fighter jet off the Liaoning, China’s first aircraft carrier.

“These images attempt to sculpt a new maritime conscious-

ness to condition its citizens to understand sea power as a critical implement in China’s national power,” said Yoshihara. “This highlights the intersection of Chinese society and Chinese strategy. Even for an authoritarian regime like China, the Chinese Communist Party needs to gain the consent of the governed because navies cost a lot of money and require long periods of sustained resources to build.”

Yoshihara referred to a map of the western Pacific and pointed out several island chains that China views as barriers to its maritime ambitions.

“The Chinese have historical evidence for thinking in this way. They go back to the early years of the Cold War when the United States established a series of bases on the island chains to radiate American military power along the eastern seaboard of Eurasia to contain the Soviet Union and communist China,” he said. “When the Chinese look out into the western Pacific, what they see are concentric rings of American military power that stretches from the American homeland right into China’s backyard.”

Yoshihara showed how mari-

time powers could use the choke-points formed by the island chains to cut off China’s access to the seas during war and crisis, thus giving China a claustrophobic world view about the maritime domain. Quoting several of China’s past military leaders, Yoshihara stated that China is obsessed about keeping their economic routes open.

In concluding his presentation, Yoshihara summed up his assessment of Chinese sea power by noting that the nation’s capabilities are finally catching up to its longstanding ambitions to protect its interests at sea. He noted that if the United States is to understand the emerging great power competition with China, then we must understand Chinese sea power in this grand strategic context if we are to compete effectively.

NPS’ Secretary of the Navy Guest Lecture program provides a series of professional lectures by senior leaders throughout defense, government, industry and academia designed to help the university’s students and faculty link their studies, teaching and research efforts to the defense needs of the nation.



Dr. Toshi Yoshihara addresses NPS students, faculty and staff on recent developments and motivations of Chinese sea power during the latest Secretary of the Navy Guest Lecture (SGL) in King Auditorium, Feb. 26.

## Distinguished faculty awarded top spot in prestigious essay contest

Announced April 19, Distinguished Professors Peter Denning and John Arquilla, chairs of NPS' Computer Science and Defense Analysis departments respectively, were selected as the winners of this year's NPS Foundation/U.S. Naval Institute (NPSF/USNI) Essay Contest for their submittal, "Sea Power and Automation," a co-authored article challenging the Navy to fully lean into the coming ascendancy — and risks — of automation and artificial intelligence (AI).

"Our view is that automation will have as profound an effect on naval affairs over the next 80 years — that is, the rest of the 21st Century — as the aircraft carrier has had over the past 80 years," Arquilla said.

"From the NPS Foundation's standpoint, having Dr. Denning and Dr. Arquilla receive this award is another indication of the tremendous talent that the faculty of NPS has," added Richard Patterson, NPS Foundation CEO. "The Foundation is very pleased to have them recognized this way."

As some of the world's foremost authorities in their fields, Denning and Arquilla bring a wealth of understanding to the question of integrating automation into the U.S. Navy. Virtually every facet of the service will soon be profoundly influenced by the introduction of AI, they observe, not only at the tactical level but systemically: organization, doctrine, policy and operations. The Navy will experience this

with no less salience than the transition from sail to steam, from solid shot to exploding shell, or to the submarine and aircraft carrier.

"The rapid rise of digitization and networking signal the beginning of a new era that may, one day, take us beyond the carrier's primacy," Denning and Arquilla state. "Indeed, by our reckoning, when that change comes the next capital ship is likely to be virtual: a swarm of platforms, including carriers, plus countless digitally controlled entities — some remotely controlled, others fully autonomous."

Successfully embracing this sea change means navigating its inherent challenges, according to Denning and Arquilla. While AI opens new horizons for the future of sea power, neural networks are fraught with risks, including reliability, trustworthiness, inscrutability and fragility.



NPS Distinguished Professors John Arquilla and Peter Denning

"One of my biggest concerns is that AI has become so hyped that most people don't understand the limits of the technology and whether it can be trusted in critical situations," Denning noted. "I am glad that we struck a resonant chord when offering to illuminate this question."

The award-winning essay will appear in the June edition of USNI's "Proceedings" journal.

### Susan Sanchez Celebrated as a Pioneer in Operations Research

NPS Department of Operations Research Professor Susan Sanchez was featured as one of ten pioneering women in the field of operations research (OR) in the latest edition of the respected professional magazine "ORMS Today," fresh off her selection as the winner of the Award for the Advancement of Women in Operations Research and Management Science (ORMS) from INFORMS.



Dr. Susan Sanchez

Sanchez has been an active participant in the growth of women in OR, thanks to her participation in an INFORMS forum supporting women in this growing and competitive field.

"The forums helped raise the visibility of women in our profession, and that in turn has helped make ORMS one of the top STEM fields for women," said Sanchez. "The first ones started with a dozen chairs and some women sitting on the floor. We have come a long way ... We now have a professional network and the opportunity for service and leadership that prepare us for other things down the road."

Another member of the INFORMS forum, NPS Research Associate Professor Dashi Sing-

ham, decided to study and work in the ORMS field at NPS because of Sanchez's reputation.

"Senior members of my research community were extremely supportive of my decision to come here because of Susan's reputation as a great mentor to women in our field," said Singham. "As a new professor, I feel very fortunate that I was able to take advantage of the opportunity to learn from her."

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## Human Systems Integration Lab shares research with NPS President

Faculty and students of the Human Systems Integration (HSI) Lab at NPS presented research findings and current projects to university President retired Vice Adm. Ann Rondeau as she toured the lab inside Glasgow Hall, Feb. 21.

The HSI program studies the science surrounding how humans interact with machines, a discipline NPS has been teaching for more than 10 years. Most recently, the HSI program developed shipboard watchbills that match a human's natural circadian rhythm leading to an optimized watchbill program implemented fleetwide to help improve crew performance.

"I wanted President Rondeau to meet the students and see their work, and its importance firsthand," said NPS Professor Nita Shattuck, as she guided Rondeau through the tour. "Having senior leadership interested in our work is a terrific encouragement both for our faculty and the students."



*NPS President retired Vice Adm. Ann Rondeau speaks with Faculty Associate and Human Systems Integration (HSI) researcher Dr. Heather Clifton during a tour of the HSI's Crew Endurance & Stress Lab, Feb. 21.*

Students presented projects ranging from further sleep studies, effects of interior lighting, shipboard habitability and operational stress. Rondeau gave feedback on each presentation and talked to the students about how HSI can bring about changes to Navy procedures.

"You are now knowledgeable about HSI and this knowledge now obligates you to do something with it," said Rondeau. "Take this knowledge with you and be brave and smart about it. You now have information in your hands that you can take to the fleet and become extraordinary difference makers." In addition to acknowledging the potential benefits of the students' work, Rondeau advised the stu-

dents on how to bring their work to fruition once they return to the fleet.

"There is a tremendous amount of obligation that you have to the fleet," said Rondeau. "You need to become the missionaries for HSI because this should be part of our leadership thinking every day. Not everybody is going to be an expert on it, but you can make them better by being leaders and training them on it."

NPS student Lt. Megan Mittleider, who presented research on improving habitability aboard U.S. Navy ships, expressed how important it is for leaders like Rondeau to be aware of these studies in order to help make a difference out in the fleet.

"The more awareness of what we're doing at the HSI Lab, the more findings that will be promulgated out," said Mittleider. "It helps when someone like NPS President Rondeau is being made

aware of our work, for she can help get our message to the Navy and to people who can make a difference at the deckplate level. We want to see that improvement in the fleet on a day-to-day basis and our Sailors' ability to perform at the very best that they can."

After learning about all the research being conducted, Rondeau gave the HSI faculty and students some final encouragement.

"I'm honored and privileged that you would give me this time to learn," said Rondeau. "I'm smarter and better and inspired. You are absolutely exemplifying what this school stands for."

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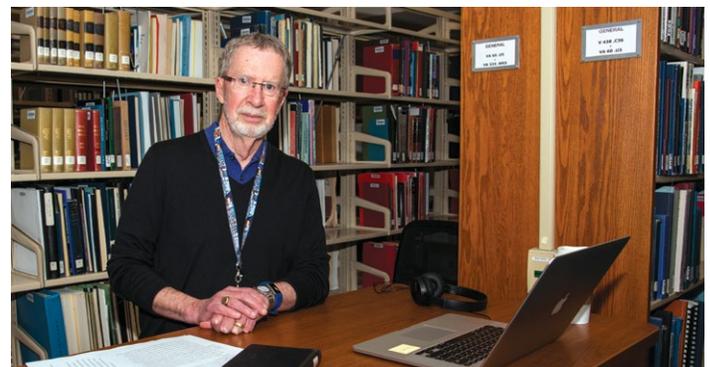
### Ethics Professor Honored Through Namesake Lecture Series

Retired NPS Senior Lecturer George W. Lober has the honor of being the namesake for a new lecture series developed by the Department of Defense Analysis. Focused on the field of ethics, the department debuted the George W. Lober Lecture Series, March 7,

in what will be an annual offering focused on the topic.

Lober retired in 2018 after 21 years serving as a senior lecturer, teaching technical writing and ethical decision-making. He won the annual Schieffelin Award in 2006, which recognizes the best in teaching at the university.

"Having this lecture series named for me is an extremely high



*Retired Senior Lecturer George Lober*

honor,” said Lober. “In my experience, students want a venue where they could actually think about some of the ethical issues that they are confronted with in their careers, and engage in some sort of conversation that would help them work through some of these issues. So, I hope the series grows to be something that people look forward to and come away enlightened.”

Dr. Bradley Strawser and DA department chair Dr. John Arquilla launched the lecture series with hopes that it become a staple at the university for years to come.

“He’s a master teacher,” said Strawser. “I’ve always looked up to him as a mentor, a friend and a model of what a good teacher should be. When he retired last year, we thought there was no better way to honor him than naming a lecture series after him, for he was the guy who brought ethics to our department.

## Professor to Receive Prestigious ASME Award

The American Society of Mechanical Engineers (ASME) selected Dr. Young W. Kwon, a Distinguished Professor in the Mechanical and Aerospace Engineering Department, for the annual S. Y. Zamrik Pressure Vessels and Piping Medal for his significant contributions to the pressure vessel and piping field.

“I really feel honored to be nominated for this award, and I



Distinguished Professor Young Kwon  
NAVAL POSTGRADUATE SCHOOL

am happy that my contribution has been recognized by my peers and others in the community,” said Kwon, who will be presented with the award in July at the ASME Pressure Vessels and Piping symposium in San Antonio, Texas.

“This is the collection of my work,” said Kwon. “Rather than just looking at one project or work, this is a collection of everything, and how it has contributed to the technical field and society throughout my career. They recognized my research program in the field, as well as my education at NPS.”

Since arriving at NPS in 1990, Kwon has built a very impressive resume that includes a Certificate of Recognition for Outstanding Research, the Menneken Award for Excellence in Scientific Research, and a Commendation for Excellence in Teaching. He also received the Cedric K. Ferguson Medal from the Society of Petroleum Engineers while working at the Missouri University of Science and Engineering.

In spite of the individual recognition these awards highlight, Kwon is quick to place his own highlight on the students he has been able to work with and mentor over the years.

“The students I work with are ingenious and hard working,” he said. “They are very fun to work with and because of that, we are very productive and produce great outcomes which are not only used for the Navy, but also other technical communities. I have to give credit to my former and current students, and hopefully to the future students too.”

The S. Y. Zamrik Pressure Vessels and Piping Medal was established in 1980 and is awarded for outstanding contributions in the field of pressure vessel and pip-

ing technology including, but not limited to, research, development, teaching and significant state-of-the-art advancements.

## NPS Oceanographer Receives Navy Meritorious Service Award

For 30 years of service to the NPS Department of Oceanography, Marla Stone was presented with the Meritorious Civilian Service Award, March 3. As an oceanographer at the university, Stone was instrumental in establishing and operating the Oceanography Moored Equipment Lab from April 1989 until her retirement in Dec. 2018.

“I am very honored and surprised that I was selected to receive the award,” said Stone. “I knew a nomination was submitted, but I didn’t think I would be selected. I retired and never heard a word until recently. What a fantastic surprise! It is a special award and I am extremely grateful. It shows me that my hard work was appreciated and acknowledged.”

As noted on her award citation, Stone’s “exceptional abilities and attention to detail has enabled NPS participation in both national and international experimental efforts throughout the Northern hemi-

sphere during her employment.

“She has been singularly responsible for successful design, procurement, programming and deployment of many oceanographic moorings, whose success is demonstrated by the success of the oceanography faculty’s seagoing program of the last 30 years,” the citation read.

Looking back over her three decades of service, Stone reflected on some of her favorite memories from the work and travel that she was involved in during her tenure at NPS.

“From the tropical waters of Dongsha Island in the South China Sea aboard a Taiwanese research vessel, to the crystal blue ice of the Arctic on a Coast Guard Icebreaker, to the fjords of Norway on a Navy research ship, to the Arches off the tip of Baja California aboard a Mexican research vessel, I feel I have seen it all,” said Stone.

“Through it all, my Oceanography Department co-workers have been there to support me with our mutual goals and that has been the best part of my job, working with great people,” she added. “My work could not have been completed without the wonderful assistance I received from them.” **IR**



NPS Oceanographer Marla Stone



Secretary of the Navy Richard V. Spencer offers the commencement address for the Naval Postgraduate School's 2019 Winter Quarter Graduation ceremony in the university's King Auditorium, March 29, welcoming 212 new NPS alumni back to the fleet and force.

## SECNAV presides over Winter Quarter Graduation

By MC2 Patrick Dionne

Secretary of the Navy Richard V. Spencer presided over the Naval Postgraduate School 2019 Winter Quarter Graduation ceremony as the school bid farewell to 212 graduates, including 11 international students, in King Auditorium, March 29.

University president retired Vice Adm. Ann Rondeau conferred the 212 advanced degrees upon the graduates, and then reminded the new NPS alumni of the higher calling ahead.

"This event is a celebration of individual commitment, perseverance and accomplishment," said Rondeau. "You should all be very proud of what you have accomplished here and we look forward to seeing great things of you in the future. Today we celebrate you, but tomorrow our investment in you is what matters."

Rondeau went on to thank the faculty, staff and loved ones that contributed to the students' successes, while also recognizing the NPS Alumni Association and Foundation for providing the university with an important "margin of excellence."

*"One of the things that I truly love about NPS ... is that it is about ready, relevant research. You come in from the fleet, you do your studies, but most importantly, you are now acolytes that go back to the fleet to impart your knowledge of how to do our jobs better."*

The Honorable Richard V. Spencer  
Secretary of the Navy

She then turned the podium over to Spencer, who began his speech with a special recognition of the university, and the graduates' accomplishments.

"To the graduating winter class of 2019, a hearty congratulations," exclaimed Spencer. "One of the things that I truly love about NPS, that I have been excited to see continue, is that it is about ready, relevant research. You come in from the fleet, you do your studies, but most importantly, you are now acolytes that go back to the fleet to impart your knowledge of how to do our jobs better."

"I look forward to the impact you have on the fleet, but I would be remiss to give you all the credit," Spencer added. "Each one of you has benefited from the support of family and friends along the way. I call them, the PSUs, the primary support units. They make you who you are, so today hug and thank the family and spouses that got you here. They are all part of our national defense strategy."

Spencer, who himself served as a Marine Corps aviator from 1976-1981, imparted the wisdom behind maintaining relationships with friends, colleagues and mentors.

"From this day forward, you will share a bond of achievement with your classmates," stated Spencer. "Hold these relationships dear, because if a 65-year-old person standing on a stage can impart one thing on you, it is that a rolodex of friendships will enrich your life."

Spencer then turned his attention to the importance of innovation, and a return on investment that the American people deserve.

"What I am more concerned about, and what I am more pleased about when I come here, is our cognitive gap," he continued. "We can have the best airplanes, the best ships, the best guns, the best weapons in the world, but without that grey matter to fight that ship, to fight that platform, we are going to be handicapped. It is up to you to apply your knowledge and increase that cognitive gap."

Spencer then highlighted experiences both during his time in the Marine Corps and working in the private sector, stressing that the people who face the problem are the ones who often have the best solutions to that problem.

"I can move big boulders when it comes to money, policy and law, but you all have the direct ability to solve the problems that you are facing at your level," said Spencer. "The education that you received and the research you have conducted, as well as the partnerships that you have forged here, will only enhance your ability to do that down the line."

In concluding his speech, Spencer left the graduating class with a message of urgency, and a promise he made to the late Sen. John McCain.

"I will break glass, I will not break laws," Spencer recalled of his testimony to McCain and the Senate Armed Forces Committee. "I will come before you with skinned knees, and if I do not, that means I am not pedaling the bike fast enough. When asked what I learned when I skinned my knees, I should be able to tell you of the learning curve I had and the corrective actions I am going to take.

"That is the kind of organization we must be working in," he concluded. "I look forward to seeing the impressions you make on your services." **IR**

## SECNAV honors NPS leaders during Investiture Ceremony

Secretary of the Navy Richard V. Spencer presided over NPS' change of charge and investiture ceremony, where retired Vice Adm. Ann E. Rondeau officially relieved retired Vice Adm. Ronald A. Route to become the 49th president of the university.

"The Naval Postgraduate School is a pre-eminent education and research institution. But to meet our strategic needs, it must continue to grow and evolve to meet the ever-changing demand signal of a changing world," said Spencer. "If the Navy/Marine Corps team is to continue its migration to a true continual learning enterprise, NPS must lead that migration as the primary educational and research-based enterprise for partnering with the private sector, government and academia."

During the ceremony, Spencer thanked Route for his strong and steady leadership and for setting the foundation for the next phase of growth for NPS.

"Under Admiral Route's leadership, we've expanded our view and reach," said Spencer. "From the moment he set foot on campus as president, Admiral Route has been a major driving force in the evolution of the Naval Postgraduate School as an educational and research enterprise."

As Route departs the university following his five-year term, he expressed a deep appreciation for the institution and its faculty, staff and students, past and present.

"It has been a privilege to be a part of a team that fosters unique, transformational experiences for our students through education and research," Route said. "Education is so pivotal in our profession of arms. Thanks to all of you, NPS faculty and staff, our graduates are propelled to think creatively and critically, to innovate, and to be the agents of change our Navy and the Department of Defense need."

Following Route's remarks, Spencer presided over an honored academic tradition known as the investiture, formally transferring the authority of the school's president from Route to Rondeau. With esteemed tradition and fanfare, he then proudly announced the university's next president to the packed auditorium.

"The opportunity to help lead NPS is a true privilege," Rondeau said. "This is an exceptional institution, with a resident faculty expertise that remains unmatched across the DOD. These gifted faculty, endowed with a sense of service to this university's calling, lead to an educational experience for our students that has no equal."





Air Force Maj. Caitlin Diffley, right, and Marine Corps Capt. Jason Hotalen, both enrolled in the NPS National Security Affairs curriculum, are part of the initial cohort of NPS students attending master's level courses at nearby Middlebury Institute of International Studies, as part of a re-energized exchange program supporting NPS' partnerships with regional civilian institutions.

## NPS relaunches partnership with Middlebury Institute of International Studies

By MC2 Patrick Dionne

For the first time in eight years, Naval Postgraduate School students have returned to the Middlebury Institute of International Studies (MIIS) campus in Monterey, Calif. as part of an exchange program that supports NPS' ongoing effort to enhance partnerships with civilian institutions and academia to the benefit of its students.

According to National Security Affairs (NSA) Program Officer Cmdr. Paul Rasmussen, the exchange program was revitalized after the Secretary of the Navy Richard V. Spencer stressed the importance of expanding NPS' partnerships with academia during a visit to NPS in 2018.

"With the positive trajectory that NPS has right now on partnering with other institutions, it was the right time to breathe some new life into this program," said Rasmussen. "The biggest benefit is that it is going to open up future possibilities for partnership, collaboration and innovation between the faculty, staff and students of NPS and MIIS."

MIIS and NPS share similarities within their curricula in that they teach contemporary international politics, history and strategic stud-

ies. However, the MIIS courses in which the NPS students are enrolled come with the twist of being taught completely in a foreign language.

"Being taught master's level courses in a foreign language adds a whole new dynamic of complexity to their studies," said Rasmussen. "In many ways, it is similar to our international students here at NPS, who have to engage with their classmates and material in a foreign language."

NPS Associate Professor Erik Dahl believes the partnership with MIIS helps NPS maximize its capabilities and provide a better education to students.

"We want our students to not only leave Monterey with an NPS education, but with a broader education," said Dahl. "Interacting with a diverse group of students and faculty at MIIS translates into our students becoming more effective, better educated officers."

Due to the foreign language aspect of the course, NPS students

already fluent in a language, or officers slated to become Foreign Area Officers (FAO), are strong candidates to take part in the program.

When the opportunity for the program was advertised to NPS' NSA students, the advertisement included a variety of potential courses, from nuclear proliferation to Russian cinema. For Air Force Maj. Caitlin Diffley and Marine Corps Capt. Jason Hotalen, both prospective Foreign Area Officers, this was a perfect fit for them to refine and diversify their expertise.

FAOs are commissioned officers from any of the four branches of the United States Armed Forces who are regionally-focused experts in political-military operations, possessing a unique combination of strategic focus and regional expertise in the areas they are assigned.

"My class focuses on Russian through culture, so it is all conversational and all in high-level Russian," said Diffley, who had studied the Russian language for 47-weeks at the Defense Language Institute Foreign Language Center (DLIFLC) in Monterey. "I am gaining access to a Russian cultural mentality that I would not have had otherwise. This really opens the door for me to a lot of cultural discussions that are very new to me.

"From what I've learned so far, Russia makes choices very differently than we do," Diffley continued. "Since FAOs are charged with being regional experts, being able to recognize the motivation, strategy and thought process of either an adversary or an ally is really important."

The program was equally fitting for Hotalen, who is fluent in French and grew up in Sub-Saharan Africa.

"When the opportunity presented itself to take classes at MIIS entirely in French, it was exactly what I was looking for to operate at a higher level than I ever have," said Hotalen. "It has been a broadening and challenging experience. Everything is completely in French, all the reading, writings and classwork is completely in French."

Hotalen, whose parents were missionaries, grew up in the Democratic Republic of the Congo until he was 12 years old, and then moved to Pointe-Norie, Republic of the Congo, until he was 17.

"I have always been interested in leveraging my very unique experiences to help the Marine Corps," said Hotalen. "MIIS is going to make me a better communicator for sure. In today's environment, the military is not operating in a vacuum and there is a real possibility of working with people like you meet at MIIS in the future.

"A knowledge of language and cultures opens up doors and unique opportunities," he continued. "This also helps by presenting a new view of the world's problems because, being a warfighter, my experience of the world and the violence in it is very different from the other students that you interact with there, and that helps expand your point of view."

Given the valued experiences by this initial cohort of students participating in the exchange, Rasmussen says the collaboration is still only beginning to take shape.

"I think as we deepen this partnership, we can not only increase the number of students we send there, but they also can begin to send their students here, which will bring that fresh perspective to our own campus," said Rasmussen. **IR**

## NSA curricula review leans into Great Power Competition

NPS just completed its latest curricula review for the National Security Affairs (NSA) department, adjusting course to meet the new challenges of increasing Great Power Competition.

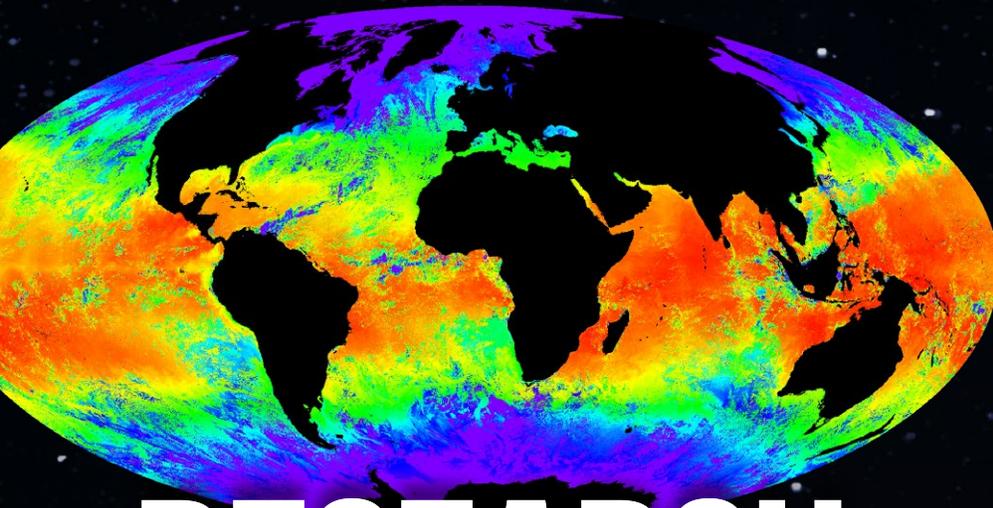
NSA leadership presented the review to Rear Adm. Will Pennington, director of the Office of the Chief of Naval Operations (OPNAV) N-51 Strategy and Policy Division, as well as representatives of the Defense Security Cooperation Agency (DSCA), through an in-depth, day-long tour of the department's capabilities and priorities, March 5.

"As a result of the 2019 NSA curricula review with OPNAV and DSCA, the NSA department will be updating the Educational Skills Requirements (ESRs) across all nine of our programs to reflect changes in the strategic environment and recent strategy and policy documents," noted Cmdr. Paul Rasmussen, NSA program officer. "We are confident that the NSA curricula will continue to produce graduates with the crucial strategic and critical thinking skills needed as we shift from two decades of fighting in the Middle East to an era of Great Power Competition."

Biennial curricular reviews are commonplace at NPS, providing an opportunity to refine academic requirements of degree-granting programs to ensure the university continues to provide relevant and unique advanced education to the nation's military officers, and the timing of the 2019 NSA review was impeccable.

"The officers that come to NPS have come away with an understanding of the various regions of the world and how to interact in those regions," Moltz said. "Not only do they understand the adversaries that they're going to be facing — whether great power adversaries or smaller combatants — but they also learn to work with allies and friends in those regions to build coalitions to create a more effective fighting force around the world."





# RESEARCH IN REVIEW



## NPS Researchers Partner on Next Generation Climate Model

By Dr. Jessica Neasbitt

A team of professors from the Naval Postgraduate School's Department of Applied Mathematics has joined a consortium of leading researchers seeking to revolutionize the world of climate modeling with the construction of a novel and considerably more accurate Earth Systems Model (ESM).

Launched officially in late 2018, the Climate Modeling Alliance (CLiMA) — a coalition of scientists, engineers and applied mathematicians from Caltech, Massachusetts Institute of Technology (MIT) and NPS — announced that they had secured funding to build a new and improved climate model (dubbed "CLiMA") from the ground up. Working with NASA's Jet Propulsion Laboratory (JPL) towards the bold goal of creating a model that "projects future changes in critical variables such as cloud cover, rainfall, and sea ice extent with uncertainties at least two times smaller than existing models" in five years' time, the group stands at the beginning of a daunting and potentially game-changing project.

Principal investigator (PI) Tapio Schneider (Caltech) and colleagues propose to reach their goal with the use of several pioneering features, including a combination of increased resolution in select parts of the model (thus decreasing errors in computable parameters) and adding real-world data in the form of satellite observations.

The latter has the potential to increase the accuracy of non-computable parameters, such as low-lying clouds, which have long been an aspect of climate modeling prone to error. CLiMA, then, will be a model that combines several unique features, including the use of over a decade of data culled via satellite observation to help get a handle on these non-computable parameters. This data will come courtesy of JPL and the A-train, a group of several satellites that follow each other closely along the same orbital track and cross the equator at about 13:30 local solar time every day, taking various instrument readings.

Schneider and colleagues plan to develop CLiMA in such a way that, over time, it will be able to use

“data-assimilation and machine learning tools to ‘teach’ the model to improve itself in real time, harnessing both Earth observations as well as the nested high-resolution simulations” with help from a machine learning component, which will be created by a team at Caltech. Accessing data from the A-train satellite formation will give CLIMA over a decade of “nearly simultaneous measurements” of variables including cloud and sea ice cover, humidity, and temperature. The CLIMA team feels that this data has much to offer when it comes to teaching current parameterization schemes; additionally, it can be supplemented and validated with detailed local observations from the ground and from field studies utilized in testing the accuracy of parameterizations within the ESM.

In order to achieve such a bold undertaking in five years, Schneider and his colleagues knew they would need experts capable of working within a large consortium of international researchers on a project spanning several major research institutions. Knowing that it would take a uniquely talented group to accomplish this, Schneider assembled a hand-picked, multi-campus team that included NPS professor of Applied Mathematics Frank Giraldo as the PI for the group tasked with the development of the CLIMA atmospheric component.

Aware that he would need elite numerical analysts to accomplish this, Giraldo approached fellow NPS professors of Applied Mathematics Jeremy Kozdon and Lucas Wilcox. The timing was fortuitous, as the three had been looking to collaborate on “something special,” according to Giraldo. With CLIMA, the three experts in scientific computing are poised to break new ground in the world of ESMs as the architects of the code at the heart of a model that promises a number of firsts.

## ESMs: Current Models and Opportunities for Improvement

In order to understand the groundbreaking nature of both CLIMA and the NPS team’s contribution to the model, it is useful to know how most ESMs work. Current climate models work by dividing the globe into a grid and computing processes that occur in each of these sectors and how these sectors interact with one another. The accuracy of these models is highly dependent on the size of the grid’s sectors, as these determine the resolution at which the model is able to view the Earth. Generally, these sectors cannot be any smaller than tens of kilometers per side, due to the limitations of currently available computer processing power. An unfortunate result of these limitations is that existing models have grid sectors too large – and thus resolutions too low – to accurately capture some small-scale features that ultimately have large-scale impacts on the various systems that make up the model.

In order to represent these subgrid-scale (SGS) processes (such as clouds and turbulence), ESMs rely on parameterization schemes. A key component of ESMs, the parameterization of physical processes within the model helps account for atmospheric processes that cannot be directly represented within the ESM. Reasons for parameterization include in-

stances where computational expense is too high (due to the complexity or small scale of various processes) and cases wherein scientists lack sufficient knowledge of how a particular process works to represent it mathematically in the explicit manner the model requires. Common parameterizations in numerical weather and climate prediction include cloud microphysics, convection, turbulence/boundary-layer, radiation, stochastic, and cloud-cover/cloudiness parameterizations.

These schemes are generally developed independently of the ESM into which they will be integrated, tested utilizing observations (conducted at limited locations), and then manually adjusted in a process commonly referred to as “tuning.” Since this tuning is conducted utilizing only a portion of available data, it can lead to inefficiency and compensating errors in the components of the model in which it is used. Consequently, current parameterization schemes often contain large uncertainties when it comes to SGS processes, as do any parts of the ESM that rely upon the data provided or affected by these schemes.



**We know how to make our algorithms work on any kind of computer architecture. Those [other] climate models can’t do that; they only run on a certain kind of hardware, and that hardware might be obsolete in five years.”**

– Frank Giraldo, Professor of Applied Mathematics

Since various parameterizations are typically developed independently from each other (and from the ESM they will be integrated into), their interaction within the overall ESM opens up further potential problems when it comes to the accuracy of these models. For instance, the longer time periods that characterize ESMs (these can range from hundreds to thousands of years) are more drastically affected by small errors that occur in the representation of these processes than are numerical weather prediction models, which need only be run for shorter periods of time (typically seven to ten days).

While tuning may address this issue to some degree, this process is not consistent or uniformly practiced, and often varies between practitioners and models.

Among these parameterizations is one of the aspects of ESMs that introduces some of the greatest uncertainty into current models: the parameterization of clouds. Key to this parameterization (and to the equations of ESMs in general) are the Navier-Stokes equations of fluid motion, a set of equations that capture the temperature, pressure, speed, and density of the water in the ocean and the gases in the atmosphere. As an additional set of forcing that must be added to the ESM, yet are not ruled by the Navier-Stokes equations that govern so many of the models’ other dynamics, clouds introduce several layers of difficulty when it comes time to program computer climate models. NPS team leader Frank Giraldo estimates that current models produce clouds at a factor of two less than what exists in reality. This discrepancy has obvious implications when it comes to a model’s accuracy, and – as those charged with CLIMA’s atmospheric component – the NPS team aims to improve this and will help create a model with an accuracy unmatched by existing ESMs.

## A Move Toward More Accurate Modeling

As experts in scientific computing, Giraldo, Kozdon and Wilcox bring the bene-

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fits of their unique training and skill sets to the table as they work to design CLIMA's atmospheric component. Coming from varied backgrounds, including training and work in finite difference methods and discontinuous Galerkin methods, these three applied mathematicians cite their diverse training as a key to their success, both in their work at NPS and as they design the code that will drive CLIMA's atmospheric component. The way they will approach the equations at the heart of these codes is one of the aspects of CLIMA that will be wholly unique, as the NPS team plans to use a new numerical scheme for their component—one that, while it has been used on other flow problems—has not been used working with weather and atmospheric problems (with the exception of the Nonhydrostatic Unified Model of the Atmosphere [NUMA], a weather prediction model designed for the U.S. Navy by Giraldo).

While most current ESMs use low order finite volume or high order spectral methods to help solve the partial differential equations at the heart of the models' parameterizations, the NPS team will use cutting edge numerics in the form of discontinuous Galerkin (DG) methods. This use of DG methods will allow for the introduction of higher order polynomials into CLIMA's atmospheric component, which in turn will offer better accuracy. In addition to DG methods, the team's use of entropy stability will allow them to not have to add artificial viscosity to the equations, a practice done solely to stabilize the model and known as "regularization." According to Giraldo, regularization is currently used by all weather and climate centers, regardless of what mathematical methods their models employ, making the NPS team the first team to find a way to stabilize these equations without using it within their component of the ESM.

Taken together with their use of state-of-the-art numerics, this puts Giraldo, Kozdon and Wilcox at the cutting edge of work being done across all areas of numerical methods, not just weather and climate. It also positions the parameterizations that drive their atmospheric component to be dramatically more accurate without sacrificing stability in the model, a frequent concern cited regarding the introduction of higher order polynomials into ESMs. By utilizing entropy stable high order discontinuous Galerkin methods Giraldo estimates that even a "modest order in the increase in polynomial order (say 4th order)" will give CLIMA a boost in accuracy in comparison with existing ESMs.

The math behind the code, however, is only one portion of NPS' contribution to CLIMA. The code that Giraldo, Kozdon and Wilcox are working on will be a lynchpin of CLIMA, as the teams at MIT and Caltech have expressed interest in the possibility of using the code developed at NPS as a basis for their own portions of CLIMA. In the case of MIT, this will be CLIMA's ocean component, while Caltech is working on a component for atmospheric processes. According to Giraldo, the idea is that the NPS team will build their portion of CLIMA – the atmospheric component – in such a way that it can run on any hardware. The MIT team could then leverage this software, using it to build a new ocean component on top of the NPS atmospheric component, and the Caltech team could build its physical parameterizations based on the NPS component as well. As such, the various components of the overall model would have the same numerics, and use the same computer repositories and code throughout. This would make the model both extremely consistent and extremely rare, according to Giraldo, as most ESMs are written by many different designers using



various computer languages and assembled after the fact.

Since most current ESMs have been around for decades, many are written in Fortran, a programming language developed by IBM in the 1950s. As such, the code is written more like a human language and must be translated into machine language in order to more efficiently run climate models programmed using this language. Current ESMs typically use Fortran and C in order to accomplish this, as well as to run models quickly on the supercomputers required for this task.

A high-level programming language newer than Fortran and more widely used by today's programmers, Python might appear the obvious choice for a new climate model. Coding in "pure Python," however, yields results too slow to be considered efficient, and Wilcox understood that this would mean writing CLIMA's code in Python plus something else — C, CUDA or OpenCL — with the critical performance aspects crafted in the additional (non-Python) code in order to achieve faster run times. With CLIMA's accelerated timeline for completion and new information introduced by Kozdon's recent teaching experiences on their minds, Wilcox and Kozdon contemplated alternatives for the task at hand.

Seeing an opportunity to streamline the project, Wilcox and Kozdon suggested using Julia, an up-and-coming programming language developed by a team at MIT. Julia eliminates the two-language problem in computing, meaning that the NPS team is able to prototype and run their code utilizing one programming language. This saves both time and expense when compared to previous ESMs, which were prototyped in one language and then run in a faster one.

Giraldo agreed with Wilcox and Kozdon, noting that despite its ease of use and ability to handle a variety of applications, Python is not the best choice for industrial applications like the ones that he and the NPS team are designing for CLIMA. In his estimation, Julia promises an elegance and speed for these large systems that Python simply cannot match. Giraldo finds added benefit in how Julia's design reflects its designers' knowledge of the fact that computer languages and hardware are changing in significant ways, and he sees Julia as a language that can both run smoothly on existing systems and still adapt to the changing hardware needs of the components that make up CLIMA, which the group hopes to run on the next iteration of supercomputers — the so-called exascale computers (capable of at least one exaflops, or a billion billion [i.e. a quintillion] calculations per second).

"That's been our goal for a long time, and we know how to make our algorithms work on any kind of computer architecture," Giraldo stressed. "Those [other] climate models can't do that; they only run on a certain kind of hardware, and that hardware might be obsolete in five years."

In October, the NPS team brought sample portions of their code (written in Julia) to the rest of the CLIMA group as part of a "bake-off," so that the group could weigh in on what language the model's code would be writ-

ten in. For their demonstration, Giraldo, Kozdon and Wilcox created “a small number of lines of code” with which they were able to run Navier-Stokes equations in a 3D box on both central processing units (CPUs) and graphics processing units (GPUs). After showcasing how Julia gave them the ability to program these notoriously complex equations (equations integral to the operation of all ESMs) while using cutting edge numerics and eliminating the two-language problem, the NPS team received the go-ahead to proceed with Wilcox and Kozdon’s recommendation and began programming the model’s atmospheric component using Julia.

Julia’s success at the bake-off, however, was not limited to its selection for use in CLiMA. After the NPS team’s demonstration, they were contacted by members of the Julia Lab at MIT who saw an opportunity for collaboration: While the NPS team’s demonstration code was accurate and fast, the lab’s researchers saw the possibility for changes that might make Julia’s code even more intuitive to use for scientists and mathematicians. As a result of the CLiMA team’s proposed use of Julia, the Julia Lab was inspired to begin research on how modifications could be made so that math could be directly written, and Julia would perform the work behind the scenes to make the math run efficiently on the computer. This would allow for a performant code that could be written in ways that scientists who are not programmers could both read and edit, ultimately contributing to Wilcox and Kozdon’s goal of producing code that is both a useful tool and accessible to diverse communities of researchers.

For Kozdon and Wilcox, Julia offers additional benefits for the larger NPS community they interact with — especially their students. As an open source language designed for high-performance computing, Julia can be downloaded and used by the public, free of charge. With access to online communities and tutorials available to all, Julia’s popularity has rapidly increased in the time since its official release in August 2018. The fact that Julia is free to everyone, combined with its ease of use, makes it a valuable option for students who are interested in learning programs that they can afford to access after completing their time at NPS (after which most lose free or reduced-price access to more expensive proprietary languages). Both Kozdon and Wilcox have worked with students interested in the possibilities of Julia, and Wilcox believes that enthusiasm about this new language is one aspect of CLiMA that has the power to attract exciting new collaborations with students and postdoctoral researchers, moving forward.

## Looking Forward at NPS

CLiMA is already creating a lot of buzz for the NPS team, with other campus users of codes similar to those the team is developing for the model — especially those who work in the disciplines of meteorology and oceanography — watching with interest, eager to use the sys-

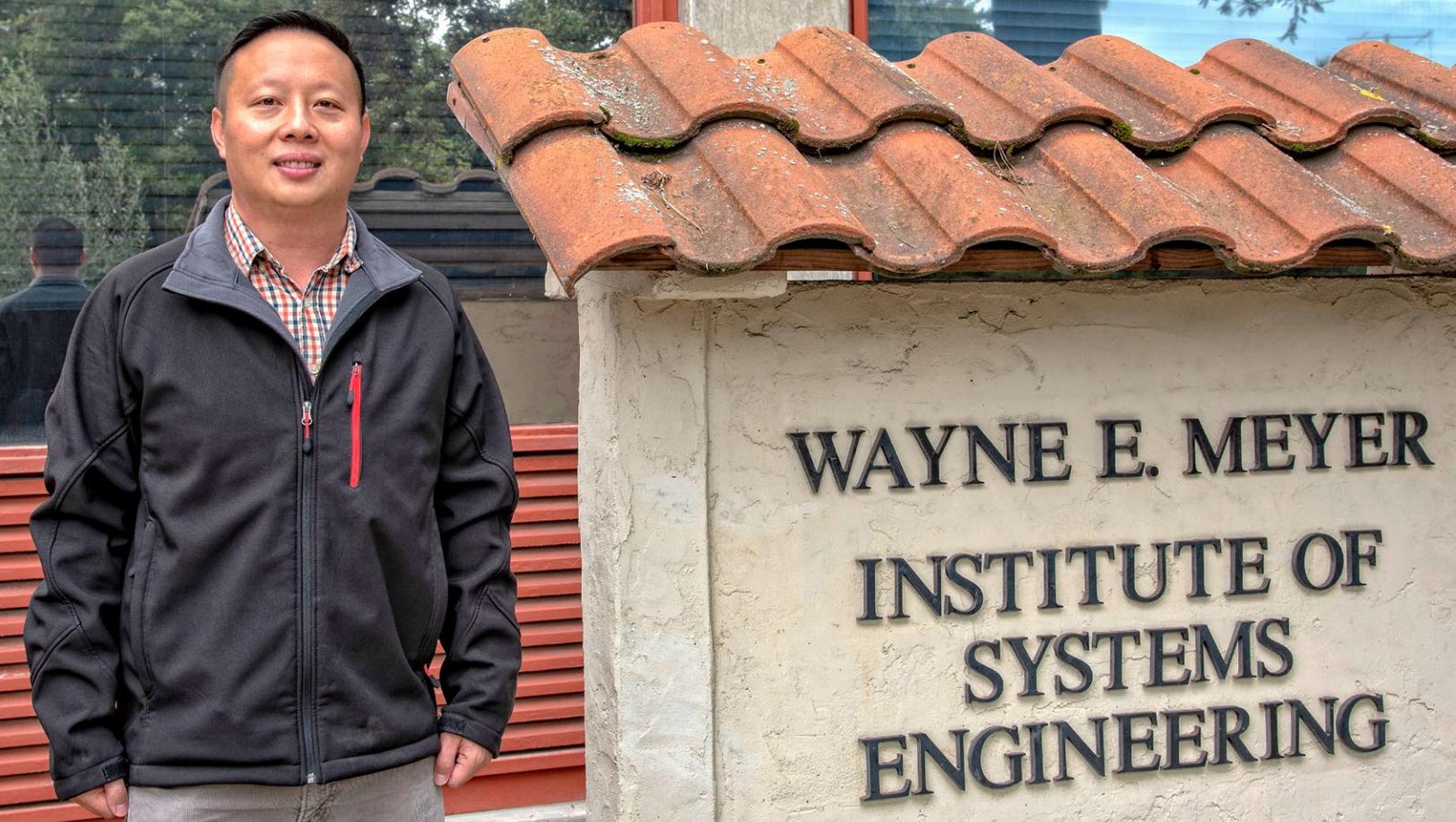
tem the NPS team is helping to design in their own research, once it is up and running. Meanwhile, Giraldo continues to receive daily emails from researchers around the globe interested in joining the NPS arm of the project. Soon, the team will be expanding to include postdoctoral researchers dedicated to the design and implementation of CLiMA’s atmospheric component. These researchers will bring their expertise to NPS for the purposes of idea exchange and technological innovation, working alongside Giraldo, Kozdon, and Wilcox as they design the building blocks of what promises to be a dramatically more accurate climate model than ESMs currently in use.

The NPS team knows that providing an ESM with the vastly improved accuracy projected by CLiMA has potentially profound implications for both the NPS community, and the world at large. More accurate climate modeling is key to preparation and the proactive protection of both naval and other military assets, especially when it comes to the planning and accurate placement of seawall and other protective measures in the face of rising sea levels, and the team is anxious to provide policy makers with the most accurate, up-to-date modeling possible.

Beyond this, the NPS team is contributing to a scientific endeavor that may change the development and workings of ESMs for the foreseeable future—a rare and rewarding opportunity in the practice of science. While their immediate future will be dominated by the daunting challenge of developing a novel atmospheric component for the model in a compressed timeline, Wilcox sees a variety of measures for the team’s success after the close of the project: “[If] this code lives on, beyond us, and beyond our initial funding, and gets used by somebody else . . . if we write code, it’s robust, it gets transferred to the scientists, they find it useful . . . they’re able to get important results, they’re able to get results that are interesting to the policy makers . . . Because, I mean, we can sit around and make codes and new methods, but what’s really cool is when they get used by someone beyond yourself.” ■



*Drs. Frank Giraldo, Lucas Wilcox and Jeremy Kozdon*



Through a longtime partnership between NPS and the National University of Singapore Temasek Defence Systems Institute (TDSI), Singaporean students like Kung Hao Tan and a select few of his U.S. counterparts spend a year at NPS, in addition to six months at TDSI. Upon graduation, students receive degrees from both universities.

## Singapore, NPS continue longtime academic exchange program

By MC2 Tom Tonthat

For nearly two decades, a handful of Naval Postgraduate School students have taken advantage of unique strategic partnership between NPS and the National University of Singapore (NUS). Since 2001, select students from NPS, and their international colleagues from NUS, take part in a rigorous international exchange program leading to two master's degrees, one from each institution.

"I think the most interesting part of why I applied for the program was because of the opportunity to build relationships with the international community and its students," said U.S. Marine Corps Capt. Kevin Wheeler, a member of the latest cohort.

The program has students attending classes on the NUS campus for six months, along with one academic year at NPS.

"The goal of the program is to give students the bird's eye view of current defense technology issues both in Singapore and the United States accompanied by a specialization in their fields of study," said Associate Professor and NPS-NUS program director Dr. Fotis Papoulias.

"The program incorporates two institutions from across the globe with common goals and interests."

Papoulias says that students participate in projects with faculty from both institutions, covering a range of subjects and topics. From the U.S. student perspective, the opportunity to hear about Singapore's defense program was enlightening.

"The schoolwork and classwork that we did in Singapore was focused on defense systems," said Wheeler. "A lot of the curriculum was based on classroom instruction, but we had a lot of guest lectures from industry, and on Singapore technologies."

"The NUS TDSI program offered me the opportunity to learn from experts and practitioners on a wide span of defense-related subject matters," added Kung Hao Tan, a Singaporean participant of the program now studying at NPS.

"Equally important was the opportunity to forge professional net-

works across communities and countries,” he added. “It’s a privilege to learn alongside international and American counterparts and to exchange ideas and glean insights ... And I think it’s also important on a person to person level to build friendships to bring back to Singapore.”

Leaders from both institutions say this is a key component to the program ... In addition to improving the education of its participants, the NPS-NUS program also helps solidify international relationships.

“We have this program in hopes that students from the defense community in Singapore can work hand in hand with counterparts in the

U.S. and the friendship will go a long way, forging a collaboration between the two countries,” said TDSI Director Loon Ching Tan during a visit to NPS. “The U.S. and Singapore have long been strategic partners for many ages. Educating the defense communities in Singapore is a long-term goal. Given that NPS is one of the top schools in defense, we felt that we couldn’t do without such a collaboration.”

“For the U.S., Singapore is one of the most significant geo-political allies in Southeast Asia and the Pacific,” added Papoulias “For NPS, the National University of Singapore is a natural partner. Academically, it’s one of the top institutions in the world.” **IR**

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## Systems Engineering professor earns 2019 Hamming Interdisciplinary Award

By Javier Chagoya

Dr. Oleg Yakimenko, Professor in the NPS Department of Systems Engineering and founding director of the Aerodynamic Decelerator Systems Center (ADSC) and the Autonomous Systems Engineering and Integration Laboratory (ASEIL), has earned the 2019 Richard W. Hamming Faculty Award for Interdisciplinary Achievement.

“I am honored to have been selected for the Hamming Award and I owe a lot of that to the talented students that I have worked with at NPS,” said Yakimenko. “For my 31-year career in graduate and doctoral teaching, I have been very fortunate with having great students who have become cosmonauts, test directors, professors, software and hardware developers, researchers and businesspersons.”

Yakimenko came to NPS in 1998, first as a National Research Council Senior Researcher in the Department of Aeronautics and Astronautics, then joining the Department of Mechanical and Aerospace Engineering (MAE). He was tenured by the Department of Systems Engineering in 2011, and now holds a joint appointment with MAE.

Yakimenko’s cutting-edge research, experience and dedication to student success makes him in high demand as a thesis advisor. During his teaching career, which includes his 21-year tenure at NPS, Yakimenko has advised more than 100 master’s and doctoral students. In the past five years alone, he was the primary advisor for 35 master’s and four doctoral students.

“I think my role is to show my students the current state-of-the-art, both theoretical and technological, and get them interested and involved into real-world projects that will impact the Navy, Army, Air Force and NASA,” said Yakimenko. “I am also trying to work with faculty and students from other departments, schools and universities allowing students to benefit from a multi-disciplinary and multi-university environment.”

Systems Engineering professor and chair Dr. Ronald Giachetti echoes the Hamming Interdisciplinary Award selection committee’s high praise for Yakimenko’s rigorous teaching methods, and especially the concrete results his students have attained.

“Oleg and his students have been especially prolific in the development of unmanned systems,” said Giachetti. “What makes Oleg’s contribution especially valuable is all of his students build actual systems and test them in the field. He has led student teams who built rockets that were launched in the Mojave Desert, ground and aerial robots tested at Impossible City in Fort Ord, as well as countless unmanned aerial vehicles tested at Camp Roberts.”

The Richard W. Hamming Faculty Award for Interdisciplinary Achievement, named after NPS professor emeritus Dr. Richard W. Hamming, highlights one faculty member annually that demonstrates a commitment to interdisciplinary scholarship and exceptional teaching skills. Hamming’s dedication to teaching and research are well known, specifically in the mathematics, computer science and telecommunications fields of study. Hamming taught at NPS as an adjunct Professor from 1976 to 1997. **IR**



Dr. Oleg Yakimenko, Professor in the NPS Department of Systems Engineering is the winner of the 2019 Richard W. Hamming Faculty Award for Interdisciplinary Achievement.



In a surprise to Lt. Allison Hogarth, left, following her question to Chief of Naval Operations Adm. John Richardson, he brought her up to the stage to emphasize the importance of perspective. Solving the Navy's most vexing issues, he noted, will require leaders at all levels to work side by side, facing the challenge head on.

## Chief of Naval Operations shares vision of maritime superiority with NPS

By MC2 Patrick Dionne

Chief of Naval Operations Adm. John Richardson returned to the Naval Postgraduate School to impart his vision of overcoming the biggest challenges facing today's Navy during a Secretary of the Navy Guest Lecture (SGL), Feb. 13.

Newly-appointed NPS President retired Vice Adm. Ann Rondeau introduced Richardson, who then detailed the service's way forward to a packed auditorium of NPS students, faculty and staff.

"What a pleasure it is to be back here ... We scoured the entire planet for the right person to lead this institution and I am confident we made the right choice. I very much look forward to your tenure," Richardson said to Rondeau.

Richardson addressed the recently-released second version of his "Design for Maintaining Maritime Superiority," coined Version 2.0, a 20-page document which reaffirms the growing presence of great power competition and seeks to align the U.S. Navy's strategic guidance with

both the National Security Strategy and the National Defense Strategy.

"One of the reasons that we put out Version 2.0 is that so much has happened since we put out the first version in 2016," said Richardson. "I say 'we' very deliberately, because even though I had the privilege of signing this document as the Chief of Naval Operations, it really represents the collective input from all of Navy leadership.

"The thought driving the publication of the first version is that, even in 2016, we were getting the sense that things were changing," he continued. "We were entering an era of great power competition and we laid out a number of tasks for ourselves ... As we had achieved many of those goals, it was time to come up with the next set of objectives so we could continue to make progress down this track."

Version 2.0 maintains that it has been decades since the U.S. last competed for sea control, sea lines of communication, access to world markets, and diplomatic partnerships. Richardson asserts that U.S. Naval

forces must adapt to this change and respond with urgency in order to aggressively compete in a modern security environment.

“The last time we dealt with great power competition was about 28 years ago, and a lot has changed since then,” said Richardson. “The rivals have changed. The rise of China has presented us with a lot of unique obstacles, and even though Russia is still around and some things are reminiscent of the Cold War, most are different.

“The rules of the game have also changed,” he added. “The pace of change is quicker now than ever before in the 10,000 or more years that human beings have tackled the seas. In fact, since the end of the Cold War, maritime traffic has multiplied by four and carries 90 percent of the world’s GDP, which has doubled in the past 25 years. All while, the maritime domain continues to grow and new challenges have presented themselves such as Information Warfare.”

Richardson noted that the rapid growth and adoption of information technologies have opened a new frontier in warfare, as well as engendered particular interest on such issues as technological superiority and space. Correlating with these issues, the goals of Version 2.0 encapsulate a way ahead for the Navy to become a more agile force that operates at different levels of intensity in different domains at the same time.

“If we want to take on the challenges that we face, then we have to restore agility, and there are multiple dimensions to doing that,” Richardson said. “One is conceptual agility. We have to become more creative and start thinking outside of the box, and it is places like NPS that help us do that.

“There is technological agility. We need to be able to move our technological capabilities into the hands of the warfighter at a relevant speed, because in the modern information age it matters to be first. That means we need to have a way to prototype, produce and deliver our systems before our adversaries.”

Richardson noted that the Navy must transform into a giant, learning engine to achieve faster innovation.

“The Navy has to return to the rate of innovation and development we saw during World War II, and that includes

our schools like this very special place, as well as our exercises and experiments,” he said.

In closing, Richardson brought up the history of the U.S. Navy and how our decisiveness and our values of honor, courage and commitment have yielded the greatest Navy in the world. Moving ahead, he indicated that NPS plays a critical role in the Navy’s future.

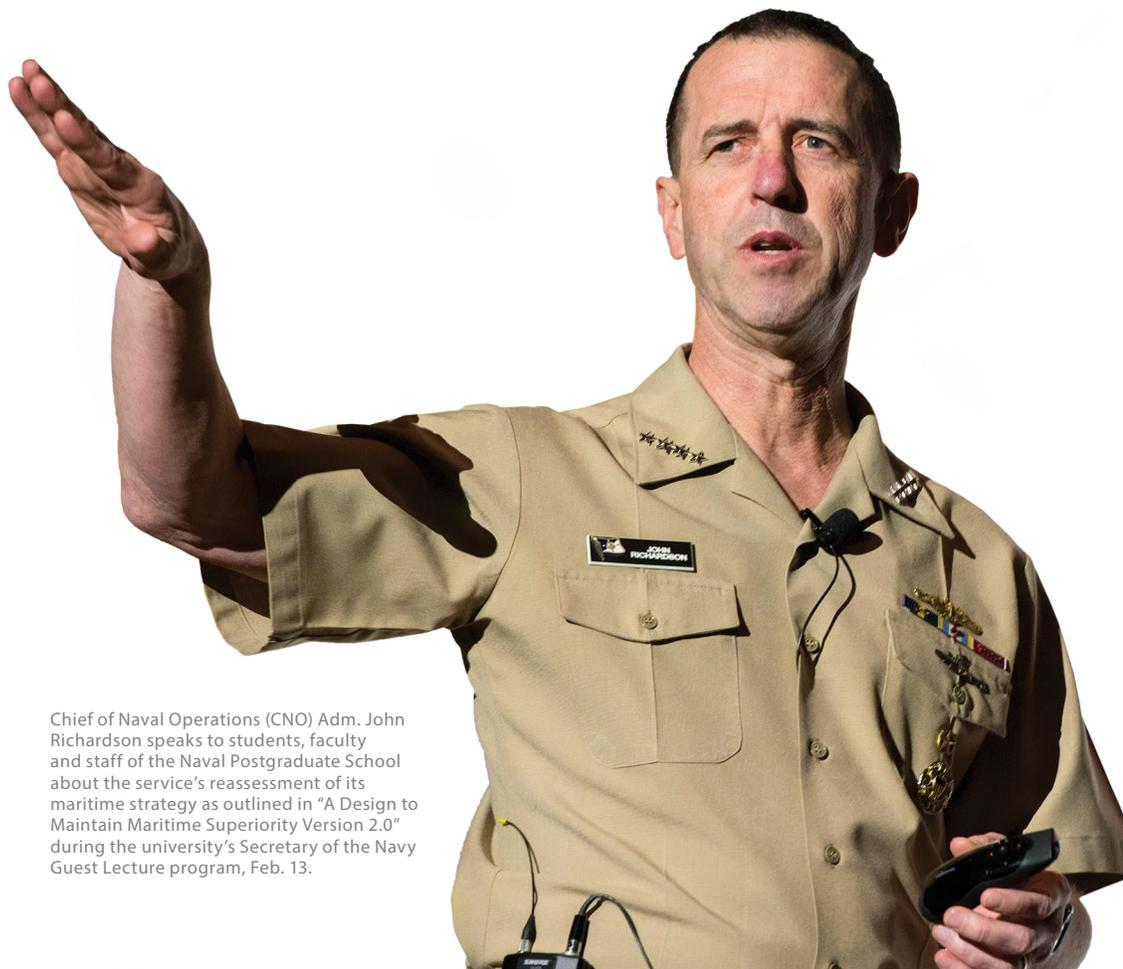
“There are many universities in the world and they are all solving problems,” Richardson stated, “But this university is solving our Navy’s, and our nation’s, problems.

“This is what is unique about this place. Because of your work here, we will continue to be the Navy that is the safest for our Sailors, the best partner for our allies and the worst nightmare for our adversaries,” he concluded. Before closing his presentation, Richardson fielded several questions from the students in the audience.

NPS’ Secretary of the Navy Guest Lecture program provides a series of professional lectures by senior leaders throughout defense, government, industry and academia designed to help the university’s students and faculty link their studies, teaching and research efforts to the defense needs of the nation.” ■

*“Because of your work here, we will continue to be the Navy that is the safest for our Sailors, the best partner for our allies, and the worst nightmare for our adversaries.”*

Adm. John M. Richardson  
Chief of Naval Operations



Chief of Naval Operations (CNO) Adm. John Richardson speaks to students, faculty and staff of the Naval Postgraduate School about the service’s reassessment of its maritime strategy as outlined in “A Design to Maintain Maritime Superiority Version 2.0” during the university’s Secretary of the Navy Guest Lecture program, Feb. 13.



A recent addition to NPS' Department of Mechanical and Aerospace Engineering, Dr. Emre Gunduz continues his research into cutting-edge, direct-write 3D printing with extremely viscous materials.

## NPS researcher explores 3D printing with extremely viscous materials

*By Dr. Jessica Neasbitt*

Dr. Emre Gunduz arrived at NPS in 2018, ready to continue his cutting-edge work with the 3D printing of extremely viscous materials. This work is the culmination of two years of research and testing completed by Gunduz and his colleagues at Purdue University, where they set out to find a way to improve the flow of extremely viscous materials (for comparison, think the consistency of cookie dough) in direct-write 3D printing.

Generally, direct-write 3D printing uses either pliable materials — such as clay — which are then pushed through a syringe via piston or compressed air, or works via thermoplastic extrusion, in which melt-able polymers (such as polylactic acid) are pushed through a heated nozzle in order to form pre-programmed shapes.

As such, both types of direct-write 3D printing depend on the ability to get the materials through the printer's nozzle — and to get them through at a regulated rate in order to produce an accurate, consistent end product. This can be problematic in projects that require finer noz-

zle sizes, since smaller sizes mean more restriction when it comes to the flow of printing material. The increased pressure required to remedy this causes friction, which causes excessive heat. This, in turn, alters the flow, often negatively affecting the precision with which one can operate the printer. As a result, achieving high resolution products becomes difficult, and using these systems on materials that are sensitive to heat or friction is extremely problematic.

The latter issue is one with dire implications for military organizations looking to capitalize on the convenience and potential cost-savings that 3D printing can offer. In defense industries, this is especially true in the case of one of the viscous materials that Gunduz's method was designed for and tested on: solid propellants (such as those used in missiles and the booster rockets for the space shuttle).

In order to avoid the heat (and consequent thermal excursions) that would be produced by increased friction during the 3D printing of the viscous materials that make up these propellants, Gunduz devised a method

to apply ultrasonic vibrations to the nozzles of 3D printing devices, using transducers to resonate in such a way that it separates the viscous materials from the nozzle walls and allows it to flow, unobstructed, through the nozzle.

According to Gunduz, “Everything is arranged so that the resonating frequency of the system is matched, to get the optimum amount of vibrations.”

These high-frequency, ultrasonic vibrations (about 30 kilohertz or 30,000 times per second) push on the inner walls of the nozzle. By using this technique, Gunduz can apply an acceleration of about 60,000 Gs in the nozzle, which creates a force great enough to pull the printing material off the surface of the nozzle walls. The detached materials then move around the nozzle in a step-wise motion, exiting it without necessitating increased pressure and the resultant friction and heat that accompany it.

Gunduz’s method is a game-changer in several ways. It will allow for the printing of viscous materials in existing high-performance systems that previously lacked the ability to print these materials. Additionally, the control and accuracy that are now available when printing these materials allow for the printing of arbitrary shapes — an especially advantageous function in the case of solid propellants, which can now be geometrically designed in ways that produce a more directed and controlled burn.

Similarly, Gunduz proposes that other applications have much to offer in the customization and optimization of military uses of the technique. For example, in the case of missile use, it would allow personnel to print the exact amount of propellant needed for mission requirements, thus eradicating waste and stretching often strained budgets even further. On a Navy vessel, where everything is at a premium, use of the system could increase efficiency by eliminating the need for the storage of propellant in excess of what is specifically required for a particular mission. On long deployments, the printer’s other potential capabilities — such as the printing of biomedical devices, food, and personalized pharmaceuticals — could also contribute to improvements in operations and streamlining of current systems.

As one of the newest members of NPS’ Department of Mechanical and Aerospace Engineering, Gunduz will be continuing to develop materials that are most suitable to this approach to 3D printing. He is currently planning on offering courses focused on this type of manufacturing, with the possibility of developing a certificate program at NPS. Gunduz believes this will be an important addition to NPS’ educational offerings — especially as 3D printers become more commonly used within the military. As such, he is looking forward to working and collaborating with the greater NPS community: “My goal is to train the students on these so they know what’s going on, how they can use these systems, and how they can improve them through research work.” **IR**

# CHDS grads examine wicked problems through innovative HSx program

By MC2 Patrick Dionne

A cohort of top graduates from the Naval Postgraduate School Center for Homeland Defense and Security (CHDS) returned to their alma mater to participate in an innovative program to examine wicked problems across the homeland security space. Coined Advanced Thinking in Homeland Security, or HSx, the program is an 18-month effort designed to build knowledge and create new paradigms for some of the most complex homeland security challenges facing the nation and global community.

“The mission of CHDS is to develop a cadre of critical thinking leaders at the local, state, tribal and federal levels,” said CHDS Director of Strategic Communications Heather Issvoran. “What HSx does is take some of the best and brightest from our graduates to tackle the ‘wicked issues’ in their agencies. The goal was to be able to bring them together and look at national level projects in an innovative way and really think about complexity.”

The program’s students represented a wide range of participants from the Department of Homeland Security — the U.S. Coast Guard, Immigration and Customs Enforcement, local law enforcement and more. Each student was a CHDS graduate, through either the center’s master’s degree program or the Executive Leaders Program.

“The big question that HSx answers is, what if we took the highest graduates and put them through another 18 months of discovery with three general areas to expand knowledge in,” said CHDS Director Glen Woodbury. “What are the wicked problems that we want to look at, and how do we tackle them?”

Throughout the 18-month period, the cohort returned to NPS for six different in-residence periods held once a quarter, with the program separated into three parts. The first dealt with idea generation, determining what problem areas to look at. The second focused on ways to tackle big problems. And finally, the third section put the information and knowledge throughout the course together, and applied it to large scale problems in all sections of government and society.





**JIFX**  
Joint Interagency Field Experimentation



## JIFX accelerates solutions through partnerships with academia, industry

By Matthew Schehl

NPS FIELD LABORATORY, CAMP ROBERTS, Calif. - The Naval Postgraduate School just took another step forward in deepening the creative bonds between the military, academia and the private sector necessary to meet the heady challenges of the 21st Century.

More than 300 leading technology experts from private industry, top universities, military and government agencies converged at NPS' Joint Interagency Field Experimentation 19-2 (JIFX), Feb. 4-8, to explore new ways to adapt rapidly changing technologies to a host of DOD-relevant domains, including defense support to civil authorities, autonomous systems, geospatial intelligence and cybersecurity.

"JIFX is another example of how NPS is responding to the Secretary of the Navy's strategic vision for our institution," noted NPS' president, retired Vice Adm. Ann Rondeau, who made it a priority to observe JIFX during her first full week at the university's helm. "These events, based on our successful legacy of field experimentation, bring together a diverse group of industry, academic and government participants to explore not only emerging technologies, but also new and better ways to share knowledge across these broad institutions."

Over the week-long event held at the California National Guard's Camp Roberts, these participants conducted dozens of hands-on experiments in austere field conditions to sandbox ways both nascent and existing technologies might be adapted to military requirements.

The key to JIFX, coordinated by the Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) in partnership with research centers across campus, is that the event is not about immediate acquisition, but rather, helping to identify commercial and laboratory capabilities that may be transitioned to military applications, according to Dr. Ray Buettner, JIFX director and NPS associate professor of Information Sciences.

"It really is a collaborative learning environment with minimal rules: people come out, interact and share information, and it's done with only enough structure to be safe, secure and legal," he said. "JIFX is, to restate the SECNAV on a recent visit, open to those organizations, both public and private, who want to come to NPS to build, innovate, develop, test and improve ideas, products, and solutions alongside us."

JIFX exemplifies how NPS is leading the charge to facilitate exchange between technology developers and the U.S. military.

In his *Design for Maintaining Maritime Superiority 2.0*, published in December 2018, Chief of Naval Operations Adm. John Richardson specifically called on the university to leverage its unique capabilities to deepen this relationship to inform rapid capability and concepts development.

“If the Navy-Marine Corps Team is to continue its migration to a true continual learning enterprise, NPS must lead that migration as the primary educational and research-based enterprise for partnering with the private sector, government and academia,” Secretary of the Navy Richard V. Spencer recently told the NPS community.

In this, JIFX 19-2 marks a milestone in enabling such partnering.

The February event is the first under primary sponsorship of the Secretary of Defense’s Rapid Reaction Technology Office, further expanding NPS’ mandate to enhance and increase the impact on the joint and naval warfighter.

Along with sponsorship from Naval Special Warfare expeditionary warfare (OPNAV N951) and Special Operations Command (SOCOM)’s PEO-Fixed Wing (EOTACS program), JIFX has evolved over the last decade from a SOCOM testing event to a primary locus for truly joint field experimentation.

“All four services were present, with special operations community and Combatant Commander representatives from Southern Command, SOCOM, North American Air Defense/Northern Command, Transportation Command, and Strategic Command all actively engaged,” Buettner said. “Additionally, interagency participation included folks from the Department of State, Department of Energy, the National Geospatial-Intelligence Agency and the National Guard Bureau.”

“NPS faculty and students were joined by participants from the University of Hawaii’s Applied Research Laboratory, Carnegie Mellon University, and the University of Missouri - Kansas City,” he added.

Crossing the aisle were a range of private-sector entities, who were keen to hone their technologies’ relevance to the military. These included not only defense contractors, such as Lockheed Martin’s “skunk works” division, but also several non-traditional companies from technology giant Nvidia to start-ups like Drones4Hire.

Planet Labs is a prime example of such technology fusion in action.

Recently featured on CBS News’ 60 Minutes, the small private company — working out of a nondescript warehouse in downtown San Francisco, Calif. — operates the largest fleet of satellites in human history.

With an active armada of more than 300 satellites circumnavigating the entirety of the planet every 90 minutes, Planet Labs is poised to revolutionize ‘Big Data’ digital imagery of the earth.

“With our ‘doves,’ we take a three-meter resolution image of the whole world every day, and our SkySat constellation is capable of sub-

meter resolution,” explained Ricky Rios, Planet’s U.S. government programs manager. “We came to support JIFX with our data and see what we can do with it.

“JIFX is a great, hands-on place for this,” he continued. “Here, you’re actually trying to work together and experiment how our data can be ingested into a capability to provide greater value, and the ‘workshopy’ environment provides great value for us.”

In the event of an environmental disaster, for example — such as the wildfires which recently devastated Paradise, California — timely satellite imagery may prove critical in providing humanitarian aid and event relief.

First responders are often limited by the equipment they can carry into a disaster zone, and such imagery can provide crucial intelligence in identifying optimal response requirements.

“Is it going to be worth the extra pounds of kit that you bring in with you, or can you leave a particular piece of equipment back?” mused Danielle Capezzuto, GEOINT Visualization Services Systems Integration Engineer with the National Geospatial-Intelligence Agency (NGA), the DOD agency responsible for such imagery intelligence.

JIFX presents NGA a golden opportunity to prototype new platforms to meet its mission set and plug in data sets like that offered by Planet to find new ways to provide Defense Support of Civil Authorities (JP 3-28).

“We’re really involved in seeing how we can apply some of the capabilities we have for humanitarian assistance efforts, so we brought a portable version of our flagship visualization tool Map of the World,” Capezzuto said. “We’re exploring how it can help our first responders use tablets or laptops to communicate better, get better situational awareness of an affected area, and ‘mashup’ different overlays of terrain data.

“As Ray [Buettner] said, ‘failure is learning,’ so coming here is a way to try different things,” she added. “This is a learning environment, so it doesn’t matter if we fail or succeed: we’ve gotten a lot of feedback for our tools, found some things that work, and some things that don’t.”

The myriad interactions at JIFX also afford NPS students a first-hand glimpse of new technologies and their potential implications for everything from space systems to defense analysis, from data information sciences to cybersecurity.

The experimentation between Planet Labs and NGA, for example, raise foundational questions on the future of imagery intelligence in a big data-driven world.

“How will we be able to pre-position military forces when the entire surface of the planet is being imaged every day?” Buettner observed. “Will new change detection algorithms render many older [operations security] techniques useless?”

“At JIFX, we’re able to ask these questions and take care of the men and women in uniform,” he continued. “That’s why we’re all here.” **IR**



Commander, Naval Air Forces, Vice Adm. DeWolfe Miller III, front row, second from right, brought a cross section of Naval Aviation leaders to NPS for the Center for Executive Education (CEE) SPEAR workshop this past March. Since assuming command in early 2018, Miller has leveraged multiple CEE workshops to help align his leadership team, and resolve readiness challenges within the aviation enterprise.

## CNAF turns to NPS to take on Naval Aviation readiness

By Matthew Schehl

In the fall of 2017, U.S. Navy aviation faced a daunting challenge. The preceding five years had seen a surge in aviation mishaps, and aircraft readiness levels across the Fleet had reached unacceptable levels. Incidents involving F/A-18 E/F Super Hornets, for example, had more than doubled over this time, and the Navy testified to Congress that only 31 percent—170 aircraft—of the Navy’s 542 Super Hornets were ready to “fight tonight.”

When Vice Adm. DeWolfe “Chip” Miller III took the helm in January 2018 as the nation’s 8th “Air Boss” — Commander, Naval Air Forces (CNAF) — he was tasked to turn this around. It was a daunting challenge, indeed, but not unlike the pressing challenges many senior military leaders face when stepping into a large command.

“We needed to make sure that those staffs were aligned not just with the way we communicated between ourselves, but aligned with respect to mission functions, tasks and sense of purpose,” Miller recalled. “I knew up front how challenging it is to walk into a large command that you’ve not been part of, so I knew that I needed to learn an awful lot ... That’s when I reached out to the Naval Postgraduate School (NPS).”

Miller and his command team have since worked closely with NPS’ Center for Executive Education (CEE) to successfully take on these leadership challenges. Through a series of customized workshops tailored to CNAF’s needs, the CEE team helped Miller and his staff refine their capabilities across a range of critical skills: strategically-aligned thinking, enhanced innovation and decision making, effective communication, risk management, and many others.

“We aim to foster enterprise-level change in the organizations’ effectiveness,” noted CEE director Winli McAnally. “If leaders are too busy working on the details, and the execution pieces, and trying to understand the inner workings of the organization, they don’t have time to think strategically.”

“They need to be able to let their leadership team do what they do well, but it takes that speed of trust to accelerate that alignment and allow the commander to really be inspirational for the organization,” she added.

Miller realized this ahead of officially assuming his new role as CNAF and began working with CEE in the fall of 2017. The center had an es-

tablished program, the Tailored Support Course (TSC), to work one-on-one with flag officers like Miller to ensure a seamless transition as they stepped into their new command.

“CEE conducted more than 200 of these programs over the years and the feedback we received was phenomenal, but we also heard commanders say that where they struggled when they arrived at their new command was that it took time for their teams to synchronize with them and for them to learn the organizational culture,” McAnally said.

With so much on the line, Miller and McAnally explored new ways to accelerate CNAF’s strategic alignment pieces and foster unit cohesion. In doing so, they broke new ground for the U.S. Navy.

They pioneered a new CEE workshop, the Commander + Strategically Aligned Leadership Team (C+SALT) program, which would be tailored to the CNAF leadership team so they could hit the ground running from day one.

At the beginning of January 2018, nine key CNAF leaders from across the country converged at the NPS campus in Monterey for two days to develop a common vision of their mission. They established strategic priorities, conducted internal and external strategic assessments as well as identified a strategic communication plan.

When Miller assumed command less than one week later on January 11, 2018, the CNAF team was ready.

“The commander plus a strategically aligned leadership team: that’s exactly what C+SALT was; CEE absolutely provided that for us,” Miller recalled. “Typically, anytime a commander takes over a new command, there’s a timeframe when the staff feels out how he or she thinks, and where the commander is just trying to get their feet on the ground.”

“However, this time here at NPS and being able to have the discussions that we had at the depth that we were able to have them really accelerated that learning process,” Miller continued. “On day one, the staff already knew who I was, what my beliefs were, and the vision we had set up for the command.”

CNAF set out to work with this solid foundation. Under the banner of what would be termed the Navy Sustainment System (NSS), CNAF implemented an aggressive program to reform the provision of spare parts and aviation engineering, as well as increase maintenance and logistics support and performance.

“What really matters is our ability to sustain aircraft such that they’re there when we need them,” Miller emphasized, calling the program a “total reform” of everything from maintenance, to supply, to engineering.

And the results have been stunning. On April 4, 2019, Rear Adm. Scott Conn, Commander of the Naval Strike and Air Warfare Center, told the House Armed Services tactical air and land forces subcommittee that between 63 and 76 percent of Super Hornets are currently mission capable, an incredible increase over a relatively short period of time.

Driving this starkly positive trend was the insight gained at the C+SALT workshop to break down traditional stovepipes, Miller explained. Looking back since he officially took the reins of CNAF, he said

he is proud of what his team has accomplished ... But, he aims to continue this trajectory.

“I look at 2018 as a year of discovery, and it really was for us to truly understand the challenges that we had throughout Naval Aviation,” he said. “2019 is going to be a year of results.”

Miller intends to not only move over the goal line but far beyond it, and one of his first actions was to return to NPS. This past March, the Air Boss brought an expanded CNAF leadership team back to Monterey to attend CEE’s Strategic Planning for Execution: Assessment and Risk (SPEAR) workshop. A long-standing program at NPS, SPEAR assists commanders and their executive teams with shaping specific planning initiatives.

“SPEAR is a three-day workshop for commands to work on a specific strategic challenge that they have,” explained Dr. Paul Stames, program manager for the SPEAR and C+SALT programs. “We walk them through a strategy framework and they learn how to develop an effective strategy.”

“The goal is really to help commands not just put together a set of actions that will achieve their outcome but to really design a strategy that’s based on results [...] so they can achieve measurable performance,” he added.

For CNAF, this meant bringing in a larger team stretching across the entirety of the Naval Aviation enterprise, including leadership from repair facilities, Naval Air Systems Command and strategic communications.

“What reinvigorated my sense to renew and come back out here again was the great success we had as a result of [C+SALT], so this is adding onto that success” Miller stated. “We’re taking what we started last year, building on it and incorporating a larger aspect of naval aviation.”

“Our challenges remain, and so [SPEAR] is an opportunity to renew that focus amongst a larger crowd,” he added.

In doing so, the SPEAR workshop enabled the CNAF team to take NSS to the next level. In synchronizing to the same sheet of music, the entirety of the naval aviation enterprise is now poised to succeed in its challenge of aircraft readiness recovery, noted Capt. James “J.J.” Johnston, special assistant to CNAF.

“We brought the team of experts in our enterprise together to make sure that we all understood exactly the issues we’re facing,” he said. “[SPEAR] basically raised up the collective knowledge of everyone to come up with plans to measure success, and then challenge ourselves to get after it and hold each other accountable.”

Reflecting on the last year and a half, Miller credits NPS for enabling him and the CNAF team to successfully take on the monumental challenge of turning naval aviation readiness around.

“NPS is the United States Navy’s institution of higher learning ... We are warrior scholars and the scholar piece is honed here; there’s just not a finer institution in the world,” he said. “I appreciate the opportunity to be at NPS and I hope that this inspires others to take advantage of the great resource that’s here.” **IR**



NPS Defense Analysis assistant professor Camber Warren, left, and Information Sciences lecturer Buddy Barreto, right, have been awarded a grant by the Defense Intelligence Innovation Office (DI2O) to advance their Artificial Neural Networks for Automated Detection of Hostile Information Campaigns project, an effort made possible by the university's Coalition for Open-Source Defense Analysis lab.

## NPS team turns to Machine Learning to predict social unrest

By Matthew Schehl

The balloon of cyber warfare has gone up, and the Naval Postgraduate School remains at the forefront of developing vital technologies to win the fight in this very gray domain.

The Defense Intelligence Innovation Office (DI2O) recently awarded NPS' Coalition for Open-Source Defense Analysis (CODA) lab a nine-month, \$500,000 grant to proceed with development of a creative way to rapidly detect hostile information campaigns and emerging radicalization or violence anywhere in the world.

The CODA project — “Artificial Neural Networks for Automated Detection of Hostile Information Campaigns” (ANN-ADHIC) — employs machine learning to glean data from literally billions of online social media and mass media sources from more than 200 countries and 100 languages. Detecting even the subtlest changes in linguistic patterns, the platform can predict and map out new threats in real-time, explained T. Camber Warren, the NPS Defense Analysis (DA) assistant professor who co-founded the project.

“What if we train a neural network to learn what kinds of discourse are associated with radicalization and violence?” asked Warren. “Then, even in a corner of a country that we didn't know we were supposed to be concerned about, if the discourse shifts – becomes more radicalized, more fearful, or more angry – this neural network could send up a red flag and tell us there's something happening there.”

The potential applications for this technology are wide-ranging, from global strategic monitoring of hostile activity to vastly improved situational awareness of the human terrain at a tactical level.

The world is engaged in a new era of hybrid conflict, and ANN-ADHIC offers the U.S. military a competitive advantage as opponents increasingly weaponize social media to disrupt discourse and galvanize entire populations towards hostility.

The gravity of such disinformation campaigns hit home beyond Russia's dedicated effort to sway public opinion during the 2016 presidential

election. It has been seen time and time again over the last decade: savvy media campaigns by the Islamic State, Boko Haram's radicalization efforts in Nigeria, and China's influence campaigns throughout the world.

"States are the principal actors on the global stage, but non-state actors also threaten the security environment with increasingly sophisticated capabilities," warns the 2018 National Defense Strategy, which explicitly identifies cyberspace as a warfighting domain. "Terrorists, trans-national criminal organizations, cyber hackers and other malicious non-state actors have transformed global affairs with increased capabilities of mass disruption."

Providing operationally-relevant solutions to lean into such challenges is what NPS does best.

In 2014, Information Sciences lecturer Buddy Barreto was chatting in the hallway with a colleague about new ways to use their servers to provide "big data" support to the DA department, when Warren's research interests came up.

After a few informal interactions, Barreto and Warren immediately set to work on the project which would eventually evolve into ANN-ADHIC. The CODA lab grew from a single server to well over 70 machines of various architectures to handle the copious quantity of data streaming in.

"We realized that we actually had a lot of shared interests and ideas that first day," Warren said. "We started to realize it wasn't just about putting some Twitter data on a server; there was potentially so much more that we could do."

Warren and Barreto fine-tuned this capability over the next four years, analyzing massive incoming data streams through software they developed to sense changing patterns through advanced machine learning architectures — the 'artificial neural networks' of ANN-ADHIC.

The data is all open source large media feeds, ranging from Twitter to fan pages on Facebook, online news, and blog sites, meaning it is publicly available and "scrapeable" for key information such as geolocation. ANN-ADHIC observes this data to create a dynamic analysis of changes over time in how people talk with each other, including the subtle differences in new kinds of slang and shifts in discourse.

"For example, it can learn that this letter often follows this letter, this word follows this word, the people in a given town are more likely to use the word for 'fear' than the people in that town, who are more likely to use the word for 'hope,'" Warren explained. "We can now train machine learning models to sense what kinds of patterns are associated with violence and forms of political radicalization."

The sheer volume of data is sourced from virtually every corner of the globe. The profusion of social media has extended even to rural areas in Africa and Asia once assumed to lay beyond the analytic gaze.

"Even if they're not high-tech smartphones, almost any cell phone can send messages, which means you can tweet," Warren said. "You have cell phone towers and smartphones even in low developed areas like Yemen, Iraq, and Nigeria, where there's enough information coming out to get a [statistically viable] sense of the population."

For a test case, Warren and Barreto applied ANN-ADHIC to successive radicalization campaigns by Boko Haram in northeastern Nigeria targeting the ethnic minority Hausa population. Using initial efforts by the jihadist militant organization as a baseline, the team was able to accurately predict social unrest and violence as the campaign unfolded.

"We were able to show that in social media you could see increasing references to these in-group and out-group names as a result of the polarization that was occurring through this radicalization, and we could map that out over space and time to predict where we're going to subsequently see violence," Warren recounted. "These political campaigns necessarily precede the kinetic campaigns: you have to get people ginned up in certain ways to get them fighting the way you want."

With analytical success looking at Boko Haram, Warren and Barreto aim to generalize this capability to a global reach. What makes ANN-ADHIC so advanced is that it uses artificial neural networks to figure out what statistical correlations to look for in changing linguistic patterns.

That potentially becomes a game-changing way of approaching indications and warnings for all kinds of irregular warfare.

"We want it to be able to tell us, 'Hey, there's something weird happening over in this corner of the country; all of a sudden, discourse has shifted,'" Barreto said. "It could be a new group that we have no previous knowledge of that is revealed by the noise."

Additionally, ANN-ADHIC offers a valuable second-order effect: it can provide metrics to validate the effectiveness of our own information operations. In Afghanistan, for example, much blood and treasure have been poured into providing positive messaging to promote Afghan loyalty and unity.

"Are they working? Are they not? Are they actually turning people against us or towards us? We don't know," Warren said. "But with these sorts of tools, we're aiming to build some of the first systematic measures of effectiveness for these information operations."

The DI2O funding will enable the CODA lab to move forward from a notional, tested concept to a specific tool put in the hands of operators in the field for testing.

"We're building fundamentally new science," Warren said. "We've developed new approaches to these computer learning problems which are able to solve these problems better, and once we've scientifically demonstrated this in a verifiable way that works, the next round will be to build this up to the next level where we can be producing these things in a way that they can actually be put in the hands of the force en masse."

Only at NPS would something like this be possible, he continued.

"The school provides a unique combination of cutting-edge scientific expertise and real-world practitioner knowledge, folks coming back from the field who've experienced these problems first-hand," Warren said. "NPS is one of the only places where you can bring those two communities together and build things that are not only cutting-edge data science but operationally relevant." ■



In addition to the Bowman scholarship, two new programs — the Shoemaker scholarship and an opportunity for delayed aviators — have made the current cohort of Ensigns on campus, most of which are set to graduate this June, one of the largest ever.

## Large cohort of Navy Ensigns preps for graduation

By MC2 Patrick Dionne

Each year, there are typically a handful of Navy Ensigns assigned to the Naval Postgraduate School through the Bowman Scholar program, but this has been no ordinary year. In fact, a total of 40 Navy Ensigns have been roaming the halls of NPS over the past several months, wide-eyed and well on their way to earning graduate degrees early in their Navy careers.

Included in the cohort, of course, are the recipients of the distinguished Bowman scholarship, which recognizes excellence in highly-competitive future Nuclear Officers from the Naval Academy.

This year included the addition of the new Shoemaker scholarship, which seeks to replicate the success of the Bowman Scholarship in the Naval Aviation community. Additionally, several students were able to take advantage of gaps in the aviation training pipeline, and were offered a competitive opportunity to pursue graduate education while waiting to begin flight school.

“The biggest benefit to having these Ensigns here is that it allows them to start their career with a deeper academic background than an undergraduate,” said NPS Dean of Students Navy Capt. Markus Gudmundsson. “Additionally, this instills in these young junior officers the value of education while exposing them to NPS ... The more junior officers that we have exposed to what we as a campus have to offer, the more likely they will be throughout their career to recommend others to come here.”

Take Ens. Brianna Kaufmann of the Mechanical Engineering and Undersea Warfare program, and Ens. Joshua Ten Eyck from the Space Systems Operations program, for example. The road to a graduate education at NPS began a couple of years ago with a series of essays and research conducted in their senior year at the academy to qualify for the Bowman Scholar program.

“What made this program so appealing to me is I wanted to be a submariner but I was also really interested in pursuing my own goals in higher education,” said Kaufmann. “This was the perfect match, it comes with its challenges because it is a pretty rigorous course of study

but doing this before going to the Naval Nuclear Power School in Goose Creek, South Carolina, the school makes it worth it to be able to get a master’s degree early which frees up my time in the future.”

With the intention of replicating the success of the Bowman Scholarship, former Commander, Naval Air Forces retired Vice Adm. Michael Shoemaker helped spearhead a similar program now dubbed the Shoemaker Scholarship. Completing its first cohort are five Ensigns nearing graduation in the Aerospace Engineering program.

“There is a renewed emphasis in the value of education and an acknowledgement that Naval Aviation was not giving education, particularly graduate level education, its due,” said NPS Air Warfare Chair Navy Capt. Edward McCabe. “So, we are now making an effort to try to correct that.

“These kids are highly motivated and it is refreshing for NPS,” he continued. “They are brand new to the Navy so everything for them is new and exciting and they bring that energy to the campus.”

While the Bowman and Shoemaker scholarships represent persistent opportunities, an additional 15 Ensigns are completing their studies due to a recognized delay in aviation training leading to delayed flight school. In an effort to use their time as effectively as possible, high-performing ROTC students from top programs around the country were competitively selected to join their Shoemaker scholar counterparts at NPS.

“This is a completely different experience coming directly from a college where the military presence was the 10 other ROTC students per class at Yale,” said Ensign Richard Hicks. “Here I am surrounded by a super diverse range of senior military officers which is nothing like Yale, where most of your classmates come from similar backgrounds.”

“I wanted to get a master’s degree at some point and when I saw the opportunity to not only achieve that goal but also come back home to California, it was just too good of a deal to pass up,” he said. “Being a student in operations research has given me a lot of difficult tasks that I am enjoying taking head on.” **IR**

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# As Iron Sharpens Iron

U.S. Army Col. Ian Rice, a military faculty member in the NPS Department of Defense Analysis, cited Proverb 27:17 in honoring Army Maj. Sean Maples, a December 2018 graduate of NPS who tragically passed away following a long battle with cancer just before the Fall commencement ceremony.

Rice was serving as a keynote speaker during an intimate gathering recognizing Maples' close friend and fellow Soldier, Maj. Peter Arendt, who had been nominated by his peers for the NPS Foundation's 2018 Pat Tillman Leadership Award.

Arendt has an impeccable record, with combat and operational deployments in the PACOM and CENTCOM theaters, and a stellar performance as a student at NPS. His recognition on this day, however, was for his unyielding support of Maples and his family over the six years of their friendship, beginning with their assignment together with 1st Special Forces Group at Joint Base Lewis-McChord.

But Arendt will be the first to tell you that it was Maples' spirit, determination and character that was the truly unyielding force.

"Sean is the one who embodies this award," Arendt said, pictured here with a portrait of his lifelong friend. Maples was on his third cancer diagnosis while at NPS, beating the illness while "becoming a Green Beret, summiting Mt. Rainier, deploying to combat and finally, receiving his master's degree from NPS," consistently perched at the top of every class, Arendt noted.

In its entirety, Proverb 27:17 makes a powerful statement, not just about the caliber of these two men, but about all of the men and women who serve their nations as students on this university campus.

"As iron sharpens iron, so one man sharpens another."

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