Naval Postgraduate School:
Where Science Meets the Art of Warfare

THEN & NOW

Then

"The technical advances of the past century have brought complexities to naval war which have made mandatory a comprehensive Naval Postgraduate School. In establishing the Postgraduate School at Monterey we have reaffirmed conviction that sea power rests on Science"

—Vice Admiral Thomas L. Sprague, Chief Bureau of Naval Personnel, Letter to S.F.B Morse May 22, 1948

Now

National Security Strategy 2017
"To retain U.S. advantages over our competitors, U.S. Government agencies must improve their understanding of worldwide S&T trends and how they are likely to influence—or undermine—American strategies and programs."

National Defense Strategy 2018
"The security environment is also affected by rapid technological advancements and the changing character of war. The drive to develop new technologies is relentless, expanding to more actors with lower barriers of entry, and moving at accelerating speed. New technologies include advanced computing, "big data" analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology—the very technologies that ensure we will be able to fight and win the wars of the future."

Tri-Service Maritime Strategy 2020
"The Naval Service will develop an integrated all-domain naval force through training and education; capabilities and networks; plans, exercises, and experiments; analysis and wargaming; investments and innovation; and force design." and "Training and education for warfighting advantage in dynamic environments. Investments in education and training will develop skills and experience that generate warfighting advantages. Building upon the Naval Service's centuries-old culture of mission command, we will enhance our warfighters' ability to prevail in complex, contested, and communications denied environments."

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CNO NAVPLAN 2021:

"The Navy's education enterprise must align its curriculum and research to deliver warfighting advantage. Student and faculty research will focus on warfighting concepts and capabilities our fleet needs to compete and win."

Naval Postgraduate School Mission:
Provide defense-focused graduate education, including classified studies and interdisciplinary research, to advance the operational effectiveness, technological leadership and warfighting advantage of the Naval service.

Since its inception, the basic rationale for the Naval Postgraduate School has not changed—to provide officers with advanced education oriented toward the critical thinking and comprehensive technical skills needed to design and deploy emerging technology in the fleet to **fight and win future wars** (NDS 2018).

At NPS we teach officers how to think…how to think about employing technology in situations they have not thought about before. We rarely know the answers, as it is a journey of discovery for both officers and faculty—this is the role and requirement of research with advanced education. **Our graduates are prepared to face unanticipated conflict situations, and then apply their technical and tactical talents to generate and apply innovative ways to meet our country's future challenges** (TMS 2020). That is our niche, that is our uniqueness, and that is our contribution to the nation's future security.

This paper will measure where possible, and provide examples of how NPS is meeting the major elements of its revised mission statement (above) in support the Navy's governing documents.

- What NPS does: *"Provide defense-focused graduate education including classified studies and interdisciplinary research..."*

- Outcomes NPS enables: *"... to advance operational effectiveness, technological leadership and warfighting advantage of the Naval service.*

NPS MISSION MEASURES

"Provides defense focused graduate education…"

In 2021 NPS has 68 distance learning and graduate programs in technical and engineering fields and 32 graduate programs in either defense management or foreign area officer studies. All programs have defense and security focus as demanded by the program's sponsor. Total number of naval officer graduates in FY20 in all NPS graduate programs (resident and distant learning) was 508, each completing a defense-focused thesis or capstone project related to their academic degree. However, NPS faculty also offer 82 continuous learning programs as certificate, short courses, special seminars, and mobile education teams providing enhanced professional, executive, and technical skills. In FY20, a total number of 454 naval officers are expected to complete these programs.

"… including classified and interdisciplinary research…."

In addition to multiple topic-specific centers like the Center for Information Warfare, NPS has three Institutes and three standing Consortia dedicated to inspiring interdisciplinary research related to defense issues and emerging technology. They are the Wayne P. Hughes, Jr. Naval Warfare Studies Institute, the Cebrowski Institute for Military Innovation, the Modeling Virtual Environments and Simulation (MOVES) Institute, the Consortium for Robotics, Education and Research (CRUSER), the Consortium for Intelligent Systems Education and Research, and the Sea Land Air Military Research Initiative. These entities' membership range from 60 to 3000 members from faculty, students, industry, naval and DoD commands and organizations. Leadership in each are provided by teaching NPS faculty.

In 2020 they executed 158 interdisciplinary education, research, and field experimentation programs and activities to enhance the NPS student's experience in dealing with complex challenging operational challenges. Over 30% of all NPS sponsored research is approached with interdisciplinary teams.

In 2020 NPS faculty and students conducted over 120 classified and restricted studies and/or wargames through research, thesis work, and classroom capstone projects. For sponsored research alone, 25% of the 2020 total included classified or restricted work Efforts to increase classified capacity in space and terminals will increase this number.

NPS MISSION METRICS

"…provides defense focused graduate education…"

- **68** graduate resident and distance learning programs in technical and engineering fields (2020 graduates: 305)

- **32** graduate resident and distance learning programs in defense management and security studies (2020 graduates: 203)

- **17,208** total 2021 student engagement (resident, distance, certificate, Exec-Ed)

- **82** continuous learning, certificate, short courses, special seminars, METs (2020 454 participants)

"…including classified and interdisciplinary research…."

- More than **1,000** research thesis and capstone projects delivered every year

- In 2020 over **150** interdisciplinary education, research, and field experimentation programs executed

- In 2020 **30%** of all sponsored research was approached with interdisciplinary teams

- In 2020 over **120** classified/restricted research and education activities were conducted (25% of all sponsored research)

- In 2021 **60%** of NPS Naval Research programs directly support CNO Key Operational Problems

"…to advance the operational effectiveness, technological leadership and warfighting advantage of the Naval service."

NPS is the only command in both the Naval Education Enterprise and the Naval Research Enterprise and Development Establishment. Again, NPS is where science meets the art of warfare. Faculty and students develop and assess emerging technologies' contributions to naval operations and contribute to concept generation and development. **60% of all funded NPS Naval Research programs were related to a CNOG Key Operational Problem.**

These activities are best measured through recent examples of NPS faculty and student education and research activities which met this mission statement goal.

Cyber Warfare System project: NPS faculty and students are directly contributing to the Navy's afloat intermittent cloud-based cyber defense by evaluating alternative architectures, dataflows and workflows. Their efforts support the Cyber Warfighting System project, which aims to improve detection of and response to advanced cyber threats on Navy ships and Marine Corps units in the field. Masters of Applied Cyber Operations students finished this summer an evaluation of a commercial cybersecurity platform operating in connected versus IP-isolated conditions in a specifically constructed NPS lab and shared their observations with the Navy Cyber Defense Operations Command. In cooperation with FLTCYBER and PMW 130, the next CWS phase entails experiments led by faculty in the National Security Affairs Department and Cybersecurity Operations Center, in the Persistent Cyber Training Environment with Naval Red and Blue teams

Replenishment at Sea Planner (RASP) Decision Aid: Developed by students and faculty at the NPS, RASP is currently employed by MSC to CTF 53, 63, and 73 to efficiently plan logistics support to their respective fleets by minimizing the cost of fuel and good delivery while meeting demand. Ongoing improvement by NPS research has added wartime planning functions to best route logistics to avoid high risk areas, including a RASP RED system which provides adversary courses of action. RASP is also being used by OPNAV, CPF N55, and JHU/APL for logistics in contested environment studies. **(NOA, Analytic Decision Tools)**

COVID19 Afloat Risk Mitigation Model for CVNs: This systems dynamic model was developed by faculty and students in the Masters of Systems Analysis distant learning program to advise medical staff in USS THEODORE ROOSEVELT (CVN-71) on the relative impacts of COVID19 prevention methods while deployed. The product is being used by the NPS MSA graduate in the ship to advise the command and medical staff. **(NOA, Analytic Decision Tools)**

Crew Workload: This NPS study examined the impact of increasing admin requirements in the face of declining crew sizes, to include mapping Sailor tasks on SURPAC units back to the modeling allowances in the Naval Availability Factor (NAF) instruction.
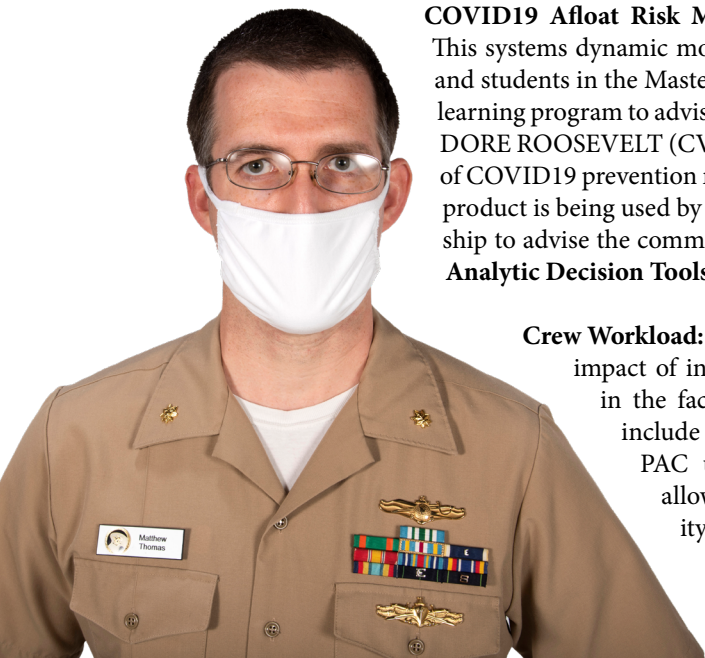
(continued)

"…to advance the operational effectiveness, technological leadership and warfighting advantage of the Naval service…"

In 2020 NPS research and studies impacted fleet operational effectiveness in:

- Logistics
- Cyber operations
- COVID 19 ship board risk mitigation
- Watch rotation
- Maintenance and dock scheduling
- Concept Development
- Support to force structure and operational studies

A compulsory exploration of just a few thesis titles provides a obvious direct relevance to the issues that challenge defense leaders most.

- Special Operations in a 5G World: Can we Still Hide in the Shadows?

- Providing the Joint Special Operations Command with a critical solution to evaluating mixed-reality visualization technologies

- Operations research determined how combat loads impact battlefield effectiveness of the U.S. Marine Corps.

- Effects of Electromagnetic Blow Off of Materials Subject Coated with Carbon Nano Tubes (for Railgun)

- How DoD Can Adopt Commercial-Style Artificial Intelligence for Procurement

- Bringing Hypersonic Missile Capability to the Fleet

This research significantly influenced OPNAV N12 and NAVMAC in their 2018 Navy Workweek study, which culminated in a Jan 19 major revision to the NAF (Navy Standard Workweek) and subsequent revisions to multiple ship-class Ship's Manning Documents.

AI for Small Unit Maneuver (AISUM): This effort, developed within SOCOM S&T, focuses on developing small, autonomous systems to hyper-enable special operations forces at the tactical level. Current student teams are partnered with Naval Special Warfare's "Robotic Autonomous Systems Manned/Unmanned Teaming" (RAS MUM T) initiative to contribute to technology integration, concept development, and the human-centric design of user interface/user experience **(Operation Overmatch)**.

Circadian Watchbills. NPS faculty and student research examined sleep patterns and stress levels of operational crews to determine where circadian watch rotations may help mitigate Sailor fatigue. Data was collected from NIMITZ CSG at commencement of deployment and during return transit using ships employing various watch rotations, both circadian and traditional. Results directly influenced issuance of COMNAVSURFPAC/LANT INST 3120.2, Comprehensive Fatigue and Endurance Management Policy and supported RROC action item M.13/CR54. As well, NPS researchers created "Circadian Roadshow" training syllabus for SWSC which is now part of the core curriculum for Dept Heads and P-XOs. **(21st Century Sea Control)**
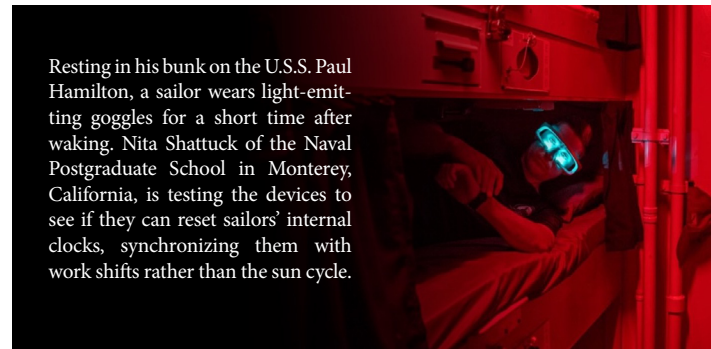

Resting in his bunk on the U.S.S. Paul Hamilton, a sailor wears light-emitting goggles for a short time after waking. Nita Shattuck of the Naval Postgraduate School in Monterey, California, is testing the devices to see if they can reset sailors' internal clocks, synchronizing them with work shifts rather than the sun cycle.

Port Loading/Drydock Availability Optimizer/Decision Tool. Multi-year study and thesis work developed a computerized model to document and predict the depot-level maintenance workload in each Fleet Concentration area by physical facility (drydocks, cranes, etc) and by worker trade (welders, pipefitters, shipfitters, electricians, machinists, etc). These calculations were done essentially by hand – project model includes automation and predictive functions for maintenance planners. Drydock optimization module is now in use by NAVSEA 21 and Regional Maintenance Centers. Other modules remain under development. **(NOA, Analytic Decision Tools)**

M/LUSV CONOPS Development Support. ONR and NIWCPAC have funded multiple years of NPS faculty support for Sea Hunter MUSV concept development, analysis, and wargaming as well as research on USV AI and control system algorithms. Most recently, this included NPS faculty participation in the M/LUSV CONOPS development team, a SURFDEVRON sponsored wargame for one of the CONOPS vignettes, and a comprehensive pre-release review of the current draft CONOP document. **(Operation Overmatch)**

Value of dedicated NPS faculty to support DoD studies, analysis and Concept Development to enhance operational effectiveness, technical leadership, and warfighting advantage.

NPS faculty are frequently called upon to participate in Defense Science Board, Navy Science Board, and other national studies. Their defense oriented view from a specific technical expertise is valued by study directors and enhances report outcomes. Navy specific, NPS education and research has recently supported capability and concept studies, sometimes foreshadowing the need for a more formal development effort. Recent examples of these include:
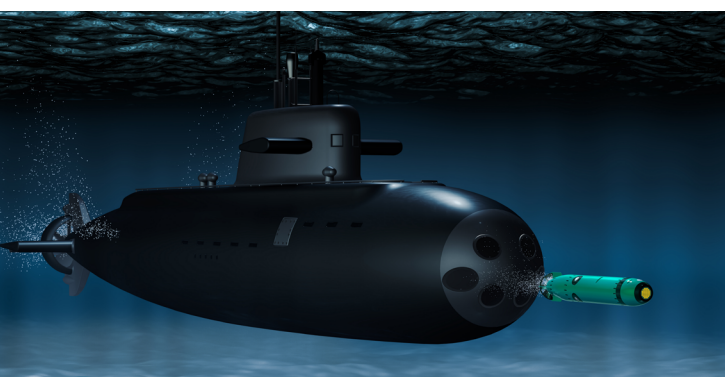
OPNAV N81 In-hour Study on LPD17 Enhancements: NPS OR faculty and students developed the Mission Loadout planner, and optimized decision aid to match ship load out requirements with CONPLAN mission assignment. This program modified and used by NPS faculty in direct support of OPNAV N81 study on LPD-17 strike mission enhancements. **(21st Century Sea Control)**

Advanced Undersea Warfare Systems (AUWS): Originally an OPNAV N8B sponsored NPS Systems Engineering Analysis capstone project, this educational and research effort provided NUWC the functional analysis diagrams and preliminary concept of employment for this now classified emerging program. **(21st Century Sea Control)**

Logistics Network Interdiction: Classified study by NPS faculty to advise OPNAV N81 staff on impact of various logistics network targeting against specific adversaries. **(NOA, Analytic Decision Tools)**

Logistics in Contested Environments: The FY19-FY20 Warfare Innovation Continuum "Logistics in Contested Environments", now a major study project by OPNAV N4, NWDC, and MCWL, provided campaign analysis and warfare analysis started in FY18, including a robust logistics carrier design and combat logistics force architecture and design. All this material was sent to NWDC and MWCL staff for their resourcing. **(21st Century Sea Control)Littoral Operations in Contested Environments (LOCE):** The 2014 CRUSER and WIC Thread "Warfare in the Contested Environments" provided wargaming, campaign analysis, and mission engineering to NWDC and MWCL for the proposed "Littoral Operations in the Contested Environments" concept. **(21st Century Sea Control)**

Value of a Dedicated NPS Faculty to mitigate against future surprise and crisis—or a fleet in being.

What is not frequently recognized is the value of having a diverse set of academicians with deep experience in defense and security related issues to call upon by DoD leadership. This goes beyond analytical and study support to real crisis response. Just five examples of our nation leveraging this capability include NPS faculty providing decision tools to generate air tasking orders and logistic plans in Desert Storm and Iraqi Freedom; generating evacuation routing for DoD civilians during the Japanese Tsunami event, and setting up mobile communication networks post-Katrina and Thailand Tsunami events. These capabilities were established through previous faculty and student research, which were built on the foundation of having a dedicated postgraduate school for mid-grade officers.

Since 1909 the Naval Postgraduate school has been responsive to creating educational and research experiences related to emerging technologies and their impact on national security needs. **Today student and faculty research are oriented to exploring the critical technologies of advanced computing, "big data" analytics, artificial intelligence, autonomy, robotics, directed energy, and hypersonics** (NSS 2017 and Project Overmatch). In doing so, it prepares officers to go beyond training responses to creative innovative solutions in uncertain environments. This is accomplished through the integration of graduate education, relevant advanced research, and a dedicated defense oriented faculty.

"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"

—*VADM DeWolfe "Bullet" Miller, USN 2019*

Appendix

Additional examples of recent NPS applied Research

RASP Red —To use RASP from an adversary's (red) point of view in order to identify key logistical interdiction nodes, logistics capacity and resilience, and links for blue to dispatch. In particular, apply RASP to PRC to estimate upper bounds on PLAN maritime fuels logistics capacities, including power projection capabilities and operational reach in the South China Sea and Indian Ocean, based on logistics assets, supply limitations, and availability of PRC-owned port infrastructure. **(NOA, Analytic Decision Tools)**

Resilient Islands and Installations: This research effort and associated theses focus on assessing and improving the operational resilience of island territories (critical to forward bases) and military installations(both CONUS and OCONUS). This project provides modeling, analysis, and subject matter expertise to the operation of interdependent critical infrastructure systems (e.g., power, water, telecom, transport), as well as support for the recovery and long-term mitigation planning for both non-deliberate hazards (e.g., accidents, failures, disasters caused by extreme weather) and deliberate threats.

Big Data analytics on F/A 18 Fuels Use: Gain insights into FA-18 fuel consumption using big data analytic techniques in support of Naval Air Systems Command's (NAVAIR) Aviation Energy Conservation (AIR ENCON) program. Specific focus is given to operational squadron fuel consumption in order to identify potential areas of fuel conservation. Established techniques and gained insight may be used to scale the AIR ENCON efforts to other aircraft platforms in the Naval Aviation Enterprise (NAE). (NOA, data base architecture, analytical tools).

(continued)

Modeling Compound Threats to Interdependent Infrastructure Systems on Military Installations: This project is developing methods that measure worst-case disruptions across interdependent infrastructure systems on Navy and DOD military installations and to support infrastructure planning and management. Disasters like Hurricane Florence at Marine Corps Base Camp Lejeune have revealed deficiencies in DOD infrastructure planning and recovery. We address these deficiencies by applying modeling methods used to identify worst-case losses in interdependent systems on military installations. Results to date include the development of modeling architectures for interdependent infrastructure systems and novel attack scenarios to identify worst-case disruptions to compound threats. These are being used to design new measures of resilience that are directly tied to mission assurance. **(WPB, infrastructure defense, forward base defense, industrial resiliency).**

Operational Resilience Analysis and Capacity Building (US Virgin Islands): In September 2017, the US Virgin Islands (USVI) were struck by two Category 5 hurricanes in a two-week period of time that collectively devastated the homes, businesses, and infrastructure throughout the Territory. Since then, our team has worked with FEMA, DOE, and other federal and local government to provide an assessment of infrastructure resilience for the Territory, and outline specific projects that can be engaged in the near-term and long-term to promote resilience.

Life Cycle Cost of Microgrid Resilience: This research and associated student thesis quantifies the cost of resilience when applied to a microgrid on a naval installation. Understanding this cost supports decision-makers in making informed decisions when implementing or upgrading the current base energy grid to support mission-critical loads and associated tenant organizations that cannot tolerate significant power disruptions. Improving microgrid resilience supports USN's missions during nominal conditions, during major storms and hurricanes, and in the event of adversary action so that critical loads have electrical power when they need electrical power. (NOA, networks; WPB, infrastructure defense, forward base defense, industrial resiliency).

AI decision aides for directed energy weapon systems: Research on developing AI decision aids to support engagement with directed energy weapons to determine which targets to engage, how to engage, dwell time, and other parameters by taking into consideration weather, other environmental factors, energy available, and target factors.

Logistics in Contested Environments: Various studies provided to OPNAV N4 including augmenting current logistics fleet with commercially available assets, risks associated with Pacific Fleet husbanding service providers, and in-theater ship repair and submarine replenishment.

Faculty and students from NPS' Physics Department recover autonomous gliders for environmental monitoring. Acoustic data from autonomous underwater gliders in the Monterey Bay area communicate acoustically through autonomous surface systems. Post-processing of the data yielded acoustical signatures to track ships and marine mammals in real time.
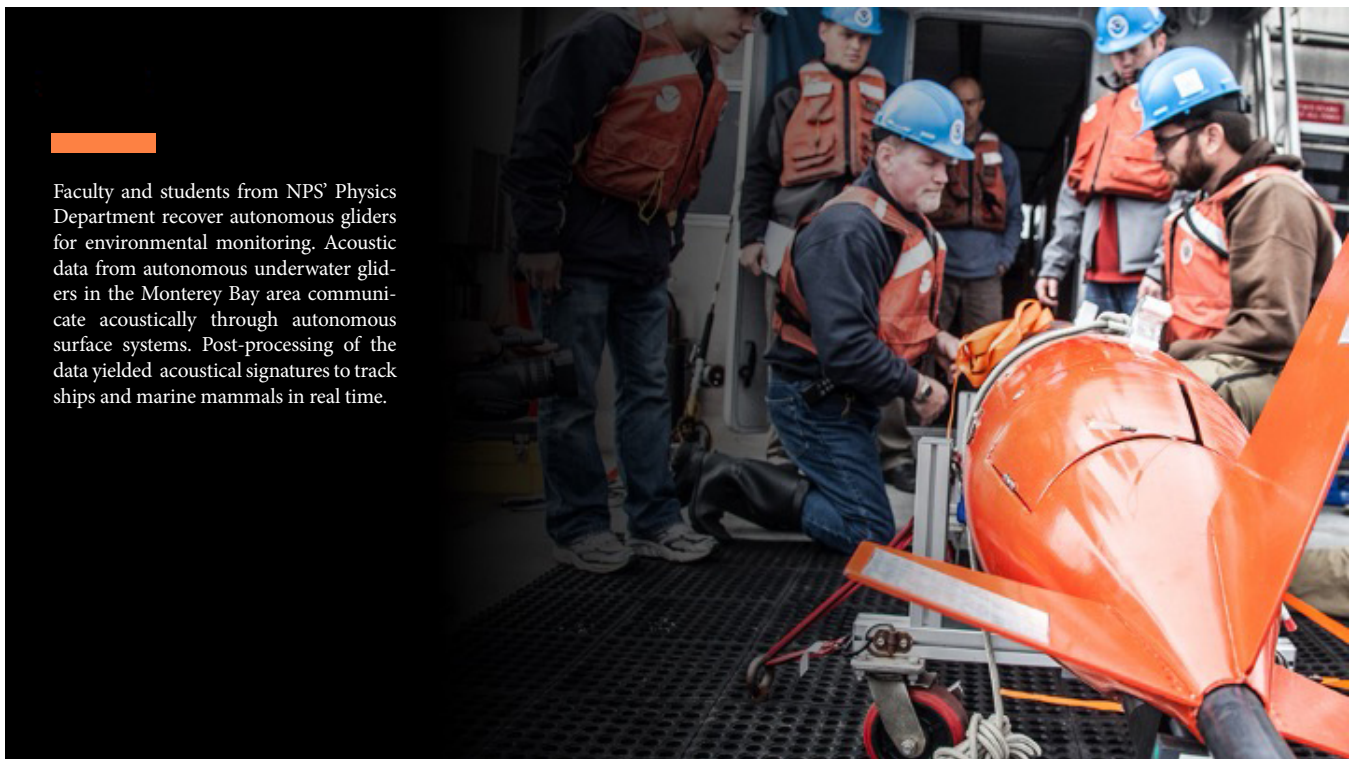
Mission Measures
Naval Postgraduate School

Current Leadership

President: Dr. Ann E. Rondeau, Vice Admiral, USN (Ret.)
Provost: Dr. Scott Gartner
Chief of Staff: CAPT Philip Old, USN
Vice Provost: Dr. Michael Freeman
Dean of Students: CAPT Brandon Bryan, USN
Dean of Research: Dr. Kevin Smith
Assoc. Provost, Graduate Education: Dr. Dennis Lester
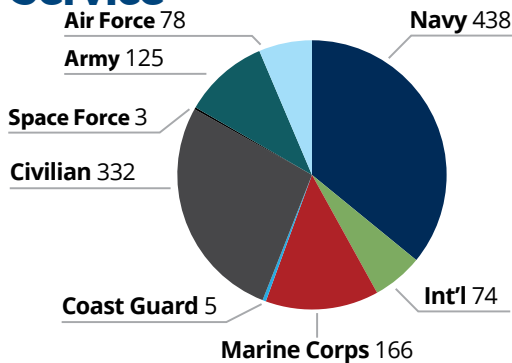**Assoc. Provost, Faculty Affairs:** Dr. Jomana Amara

2021 Student Engagement

1,446 Resident Degree
808 Distance Learning Degree
513 Certificate/Non-Degree
14,441 EE/PD*

17,208 total engagement

2021 Degrees Awarded

1,205 Master's Degrees
16 Doctorates (PhDs)

1,221 total degrees

NPS Graduate Degrees Conferred by Service

Air Force 78
Army 125
Space Force 3
Civilian 332
Coast Guard 5
Marine Corps 166
Int'l 74
Navy 438

* EE/PD = Executive Education/Professional Development

Faculty & Staff

213 Tenure Track Faculty

Non Tenure Track Faculty:
165 Instructional Faculty
174 Research Faculty
17 Administrative Faculty
318 Staff

Student Faculty Ratio

7:1*

* Tenure and non-tenure instructional faculty

Financials

- **$113** million Direct Authorization (w/o military salary)
- Approx **$97** million in sponsored/reimbursable education & research programs
- NPS utilizes a University Operating Model with reimbursable operations
- Delivers high-value leverage in a resource-constrained environment
- Enables responsive, diverse Grad-Ed and research results

Academic Facilities

62 Classrooms that offer media technology
8 Classrooms with Video-Conferencing
4 FLEX Classrooms of the Future
4 Auditoria
48 Labs

Accreditation

- WASC Senior College and University Commission (WSCUC)
- Accreditation Board for Engineering and Technology (ABET)
- Network of Schools of Public Policy, Affairs, and Administration (NASPAA)
- Association to Advance Collegiate Schools of Business (AACSB)

Source: Office of Institutional Research

A Capability to Optimize

Only NPS synchronizes student *operational experience* and *graduate education* with *applied research* and *faculty expertise* to deliver twice the return on investment:

WARFIGHTING SOLUTIONS AND LEADERS EDUCATED TO EMPLOY THEM