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GRADUATE SCHOOL
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A ROBOTICS ENGINEERING CERTIFICATE FOR STUDENTS ACROSS THE NAVY

By Lyla Englehorn, Dr. Brian Bingham, Marianna Jones,
Reid McAllister, and Michael Tall

THE NAVAL POSTGRADUATE SCHOOL OFFERS A CERTIFICATE PROGRAM IN ROBOTICS ENGINEERING THAT AIMS TO GIVE GRADUATE-LEVEL TRAINING IN THIS IMPORTANT CAREER AREA FOR STUDENTS WITHIN THE NAVY, WHEREVER THEY MAY BE.

The Naval Postgraduate School (NPS) provides a graduate education experience that is highly relevant for men and women in uniform, and has had success extending educational opportunities to nonresident communities. Taking advantage of the new COVID digital work environment now accessible to many levels of the Naval Research and Development Establishment (NR&DE) workforce, a new NPS robotics engineering graduate certificate leverages on-campus courses to provide a flexible, distance-learning experience for our civilian colleagues at the Navy's warfare centers. With support from the Consortium for Robotics and Unmanned Systems Education and Research (CRUSER), and developed in cooperation with colleagues at the warfare centers, this graduate-level certificate provides a technical foundation and supplemental credential for practicing engineers across the NR&DE. The certificate gives the workforce a flexible, low-residence learning experience that includes the essential concepts and skills necessary to understand, design, and operate robotic systems. Each course in the robotics engineering certificate is composed of both instruction and hands-on activities to support student learning.

Michael Tall, Naval Information Warfare Center (NIWC) Pacific battlespace awareness portfolio manager, identified a gap in robotics engineering skills in his workforce and started scanning the landscape outside of NIWC for opportunities to get his colleagues the skills they need to move ahead. "I was meeting a lot of talented people in the workforce that didn't know about unmanned systems, but they know about computer programming, embedded hardware," Tall said. "We could teach an introductory class here about unmanned systems, so they could start to make the career switch." Tall reached out to NPS associate professor Brian Bingham, who agreed to prepare a weeklong deep-dive course on robotics engineering to teach at the NIWC Pacific campus in San Diego. There was such a large demand for that initial course that they immediately scheduled more offerings.

Doug Lamb and Gerardo Gamboa of Naval Air Warfare Center China Lake helped bring the new applied trajectory optimization certificate program to China Lake in 2018, but always hoped for additional engineering courses geared toward weapons and weapon platforms. The NPS robotics engineering certificate program fills this need, and will provide a path to a distance learning master's degree for students within Naval Air Systems Command. Through Doug Lamb, Misty West-Bruna helped Bingham share information with employees at both China Lake and Pt. Mugu in advance of the certificate launch.

Chris Egan and Reid McAllister, co-leads of the NR&DE's unmanned vehicle and autonomous systems working group,

also reached out to Bingham at NPS with a similar need. "We had been searching for the right institution and curriculum to advance the naval workforce's understanding and capabilities in the development, testing, fielding, and sustainment of autonomous systems," McAllister said. After Egan and McAllister had several discussions and meetings with NPS staff and faculty, it became clear that NPS was the right place to meet the Navy's need. Once Bingham confirmed that the robotics engineering certificate program was officially part of NPS's offerings, Egan and McAllister reached out across the NR&RE for potential candidates. With a response from more than 70 candidates, it was evident there was a strong demand for this type of advanced curriculum.

Robotics and autonomy are increasingly vital to naval planning and strategies. The 2018 Assistant Secretary of the Navy for Research, Development and Acquisition unmanned systems vision lays out the "strategic imperative to exploit emergent and rapidly developing unmanned and autonomous systems technologies." Concurrently, the size of robotics and autonomy programs is growing exponentially through program offices. It is critical for the NR&DE to be able to educate and retain the expertise to deliver this vision. Bingham noted that the defense focus of NPS academics make it the ideal university to provide this series of courses because warfighters require a robotics engineering education that is different from that offered to the general public.

For example, Naval Surface Warfare Center Carderock Division's primary mission is to design and integrate manned and unmanned ships, boats, craft, submarines, and large undersea vehicles. "For our robotics certificate program, one of the needs we heard from warfare centers is that often they are not just building platforms, but also are responsible for enhancing existing [defense] platforms through the development and integration of innovative payloads and missions," Bingham said. "The development and application challenges of intelligent autonomous systems for warfighting capabilities in the air, on the ground, across the sea's surface and undersea is distinctively different than those developed by companies in support of self-driving cars." McAllister said that a version of the course also will be offered at Carderock, where more than 20 workforce members eagerly await it.

Collaborating with colleagues across the NPS campus, the resulting four-class program is offered to any US military officers (both residential and not) and Department of Defense government civilians with a bachelor of science in engineering, or similar field, and experience in computer programming. To best meet the needs of the students across the NR&DE workforce, Bingham has coordinated with not just NPS faculty members and professionals within CRUSER,

but also experts such as Mark Paulus and David Mortimore from Naval Undersea Warfare Center Keyport Division as well as Egan, McAllister, and Tall, among others. The team designed the program to help practicing engineers refresh their knowledge and skills to orient them toward working efficiently on unmanned systems projects. Tall said that the formal certificate will provide credibility to the skillset, making it easier for job recruiters to know what applicants have learned. There also is work under way to offer the NPS robotics certificate to defense contractors as well.

"We've found that folks with computer science, applied math, and physics degrees are very well prepared for the coursework," Bingham said. The program is structured to be a combination of instruction and hands-on activities, and the four classes cover computational and theoretical foundations of robotics as well as component-based software engineering to build the required skill set. The first half of the curriculum is foundational, covering important software tools (e.g., MATLAB/Simulink, the Robotics Operating System, and OpenCV) and the theoretical foundation for robotics. Applied physics and data collection complete the four-course sequence, with each course taught by a different NPS faculty member, or, in some cases, co-taught by multiple faculty members. For the hands-on portions of the course, students will travel two times to the NPS campus at Monterey, California, for a week of labs—or an alternative designed with the best interest of public health through the COVID-19 crisis.

With this certificate intended as the first step in more intentional educational offerings in robotics and autonomy, additional programs in areas such as robotics operations, machine learning for autonomy, and modeling and simulation for autonomy are currently in consideration. The first cohort

began the NPS robotics certificate in early July 2020. Students nominally finish the program in one year, taking one course per quarter. Applications were due 30 March 2020 for this first offering; the current plan is to offer entry twice a year, in July and January. The July cohort includes students from across the NR&DE: Naval Air Systems Command, Naval Sea Systems Command, various warfare centers, and the Naval Research Laboratory. A cohort sponsored by Carderock Division is slated to begin the program in January 2021. Each single sponsored cohort (of at least ten students) will be tailored to meet the needs of the command and will allow instructors to cover some of the course content at the command's location.

This robotics certificate is designed to contribute to and expand the fledgling "Naval Innovation Ecosystem." As our "new normal" emerges in the COVID-19 learning and work environment, this NPS opportunity is ideally suited to meet the needs of learners throughout the Naval Enterprise. In addition to the distance learning certificate program, NPS also is planning to offer a resident version for registered NPS students in Monterey. The Monterey campus is open only for limited lab work during this COVID-19 environment, but even resident students will be served well by this timely and carefully crafted distance learning certificate.

For more information, please go to our website <https://my.nps.edu/web/mae/robotics> and pay special attention to the brochure and FAQ page, or email robotics.certificate@nps.edu.



About the authors:

Lyla Englehorn has a research faculty appointment at Naval Postgraduate School specializing in rapid concept generation.

Dr. Bingham is an associate professor in the mechanical and aerospace engineering department at the Naval Postgraduate School.

Marianna Jones has a research faculty appointment at the Naval Postgraduate School working with several programs on campus including the Advanced Systems Engineering Robotics Laboratory.

Reid McAllister is the director of the US Navy's Integrated Unmanned Maritime Mobility Systems at the Naval Surface Warfare Center Carderock Division.

Michael Tall serves as the battleship awareness portfolio manager for the Naval Information Warfare Center Pacific.

Photo by Javier Chagoya



NPS students enrolled in the Physics Robotics 533 class deploy their autonomous ground vehicles on Spruance Plaza after weeks of preparation for their final project.