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# CRUSER • NEWS

Consortium for Robotics and Unmanned Systems Education and Research

## From Technical to Ethical...From Concept Generation to Experimentation

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#### NPS ALUMNI AWARD

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### Heterogeneous Autonomous Mobile Maritime Expeditionary Robots – Maritime Information Dominance

by Dr Vladimir Djapic, Kathleen Gately, SPAWAR Systems Center Pacific, [kathleen.gately@navy.mil](mailto:kathleen.gately@navy.mil), Frank Bogart, Keanu Gututala, Christopher Prijic, Julia Roche, Brittany Swigert, Wenjie Dong

The Navy aims to create cross-domain unmanned vehicle systems comprised of Unmanned Surface Vehicles (USVs), Unmanned Aerial Vehicles (UAVs), and Unmanned Underwater Vehicles (UUVs) for search, identification, and intervention missions at sea. Until recent developments in technology, integrating these systems had only been a vision for the future, rather than a reality. Now, due to technological advancements, various research groups are making the connections needed for the successful implementation of the idea around the world. SPAWAR Systems Center Pacific's (SSC Pacific) Center for Innovative Naval Technologies-Information Dominance (CINT-ID) Heterogeneous Autonomous Mobile Maritime Expeditionary Robots (HAMMER) team is working to successfully integrate autonomous Unmanned Systems (UxVs) across multiple domains for future missions at sea.



WAM-V USV on a test mission

#### CINT-ID HAMMER Project

In the summer of 2014, SSC Pacific selected five Naval Research Enterprise Internship Program (NREIP) participants and one Summer Faculty Research Program (SFRP) fellow to collaborate and address important command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) considerations for operationalizing a combination of UxVs, using a system-of-systems approach. The team used a Wave Adaptive Modular Vessel (WAM-V) 16 foot catamaran USV as the central node and main transport mechanism, and designed it to carry UAVs and UUVs across distances greater than 100 miles and operate for months at a time. Over the next three to five years, the CINT-ID HAMMER project, funded by Office of Naval Research (ONR), aims to successfully integrate unmanned surface, aerial, and underwater vehicles.

#### System Components and USV Sensors

The WAM-V's unique stability system of "springs, shock absorbers, and ball joints" allows the vessel to glide over waves while the payload tray (up to 300 pounds) remains relatively level. The WAM-V was provided as a basic structure without any propulsion system, power, or sensor attachments.

- Propulsion: Two "pod-like" cylindrical cases were designed and manufactured in order to extend the hulls' shape and serve as an attachment location for the motors, as well as a storage container for batteries, electronics, etc. While the pods were designed to hold up to 155 pounds of payload and still float, an adjustable hinge plate attaches the pods to the WAM-V to enhance the unique, inherent stability of WAM-V.
- Range Extender: In order for the WAM-V to serve as an energy source for the multi-platform system, a Range Extender was implemented as the central basis of power. The concept behind a Range Extender can be expressed as a hybrid power system in which multiple sources of power are jointly used rather than one independently. In the WAM-V's particular system, Lithium-Ion batteries inside each propulsion pod (chosen in order to maximize energy density and safety) will be integrated with a diesel generator, solar panels and, in future, with alternative energy harvesters.

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<http://CRUSER.nps.edu>

## Director's Corner

Dr Timothy H Chung, CRUSER Deputy Director



As this 2014 comes to a close and we have a chance to reflect upon the past year, it is once again impressive to see how far various facets of unmanned systems and robotics has come, ranging from increased discourse on legal, policy, and ethical implications of robots in warfare; to advances in new enabling technologies that continue to transform and create new robotic applications; to multiple field demonstrations of unmanned systems in all domains. With new developments across the robotics spectrum, from new rules expected from the FAA on civilian UAS usage to an explosion in robotics-related STEM outreach efforts around the globe, we can be sure that 2015 will be yet another exciting year for CRUSER and its ever-growing community of interest! Happy Holidays and Happy New Year!

**Cont from page 1** • Sensors: Some sensors are crucial to basic USV functionality while others can be attached or removed to accommodate a specific mission. Sensors are either installed directly to the payload platform of the WAM-V or attached to a gimbal-pole system that can lower into the water. An Inertial Measurement Unit (IMU) and Global Positioning System (GPS) are crucial sensors needed for most robotic platforms. A LIDAR is another crucial sensor used in mobile robotics platforms, both as payload and navigation sensor, in for example, GPS-denied environments.

- User Interface: Using pre-existing software and prototyping programs, a framework is developed to integrate, collaborate, control, and interact with this project. This incorporates a publish-subscribe framework for communications and control, as well as a Mission Control graphical user interface (GUI) that allows users to report and interact with the HAMMER system.
- UAV: The Unmanned Aerial System (UAS) is comprised of an UAV, a payload, and the necessary onboard sensors and computer equipment. The current design of the UAS involves a helicopter vehicle with onboard autopilot and power system, as well as available space for 10 pounds of payload. Currently, research is focused on core tasks for the UAS, such as takeoff and landing on the USV.
- UUVs: Future developments to the project will include the integration of UUVs.

### Conclusion

With the propulsion, power management, and sensor systems of the USV, the landing and takeoff algorithms of the UAV, the future integration of a UUV, and overarching communications framework, the HAMMER project is soon to achieve heterogeneous system autonomy. Several sub-systems working together as one will minimize operator requirements and reduce the manpower necessary for system success in order to achieve true information dominance in a maritime domain.

### Student Authors, all NREIP 2014 participants:

- Frank Bogart, University of California San Diego
- Keanu Gututala, University of San Diego
- Christopher Prijic University of California Irvine
- Julia Roche, California Polytechnic State University-San Luis Obispo
- Brittany Swigert, Embry Riddle Aeronautical University-Daytona Beach

### Faculty Author, SFRP 2014 participant:

- Wenjie Dong, PhD, University of Texas – Pan American

### SSC Pacific Mentors:

- Vladimir Djapic, PhD
- Kathleen Gately
- George Galdorisi

## Joint Interagency Field Experimentation (JIFX) 15-2 Proposals due by 5 Jan 2015

The Naval Postgraduate School's Joint Interagency Field Experimentation (JIFX) program is now accepting Experiment Proposals for its 15-2 event. The 15-2 event will be held 9-13 February 2015 at the Department of Transportation's Maritime Administration Facility on Alameda Island, CA. This event will be hosted in a maritime port facility setting and aboard a large military cargo ship. Please refer all questions to [jifx@nps.edu](mailto:jifx@nps.edu)

Interested parties are encouraged to visit the JIFX website to review the event's Request for Information (RFI) document and submit an Experiment Proposal by the 5 Jan 2015 deadline. The RFI document outlines the parameters for participation and lists the areas of interest for the event.

<http://my.nps.edu/web/fx/propose>

**Short articles (up to 500 words) for  
CRUSER News are  
always welcome  
submit to: [cruser@nps.edu](mailto:cruser@nps.edu)**

### CRUSER Monthly Meetings

Mon 9 Feb, 1200-1250 (PST)

Mon 9 Mar, 1200-1250 (PST)

details at: <http://CRUSER.nps.edu>

JIFX

9-13 Feb 2015 at Alameda, CA

Consortium for Robotics and Unmanned Systems Education and Research

## MIT/Olin College Wins Top Honour At World's First Maritime RobotX Challenge

by Daryl Davidson, AUVSI Foundation Executive Director, davidson@auvsifoundation.org

Students from MIT/OLIN College have emerged as the Overall Champion for the inaugural Maritime RobotX Challenge, after impressing the judges with their innovative unmanned surface vehicle (USV) which was outfitted to complete a gruelling course of obstacles fashioned after real-life issues. The team received a cash prize of S\$20,000. Teams from Korea Advanced Institute of Science and Technology (KAIST) and Queensland University of Technology (QUT) clinched the second and third prize respectively.

The biennial Challenge, which made its international debut in Singapore, was organised by the National University of Singapore (NUS) Faculty of Engineering, Science Centre Singapore (SCS) and the Association for Unmanned Vehicle Systems International (AUVSI) Foundation.

Professor Chan Eng Soon, Co-Chair of Maritime RobotX Challenge 2014 and Vice Provost (Special Duties) at NUS said, "It has been an exhilarating week, with excellent show of teamwork, skills and knowledge. It was heartening to see the tremendous amount of enthusiasm and dedication that participants have put into their efforts. The Maritime RobotX Challenge takes participants beyond competition as we have witnessed camaraderie developing between teams, with open sharing of knowledge and tactics."

### International University Maritime Robotics Competition

More than 175 students representing over 15 universities from Singapore, Japan, South Korea, Australia and the United States took part in the Maritime RobotX Challenge, which was held from 24 to 26 October at The Float @ Marina Bay.

The student teams were required to outfit a standard maritime platform – a 16' WAM-V® (Wave Adaptive Modular Vessel) – with sensors, computers and software, to complete a variety of maritime surface vehicle missions.

### Science & Technology Showcase

Over the three days, visitors who passed through the doors of Maritime RobotX Challenge were also treated to fascinating demonstrations and workshops, as part of the Science & Technology Showcase.

Combat robot and LEGO robot experts, a scrap metal artist, a cardboard sculptor, and various other experts hosted more than 80 demonstrations and workshops that introduced the fun and excitement of science and engineering through engaging activities like combat robot battles, LEGO robot showcases and tinkering workshops.

Members of the public also tried their hands at building an underwater Remotely Operated Vehicle as part of SeaPerch, an underwater robotics programme. Additionally, they had a chance to witness one of Singapore's latest robotics sensors that can be deployed for quick, in-situation water-quality surveillance. This technology was developed by PUB, NUS and the Singapore-MIT Alliance for Research and Technology (Smart).

Associate Professor Lim Tit Meng, Chief Executive, SCS said, "We are heartened to see many visitors being enthused by the various activities at the Science & Technology Showcase, and we certainly hope that they have gained some science and engineering knowledge. SCS is committed to nurturing a love for science, and we will continue to look into hosting more engaging and fun activities to spread the love for science and grow Singapore's love for the subject."

### Maritime RobotX Challenge 2016

The next edition of the Maritime RobotX Challenge is scheduled for 2016, and organisers expect the next edition to feature even more difficult tasks which will challenge the students to develop more sophisticated systems.

Mr. Daryl Davidson, Executive Director of the AUVSI Foundation said, "Based on the capabilities that the students have demonstrated during the first Maritime RobotX Challenge, we will likely incorporate more difficult challenges for the next competition. Those new challenges may present an opportunity for students to develop an aircraft or an underwater component to their robotic system. Being able to merge together robotic aircraft, boat and underwater systems would be a tremendous achievement for any student team."

Maritime RobotX Challenge 2014 is supported by the Office of Naval Research of the United States (USA) and Future Systems and Technology Directorate of the Ministry of Defence, (Singapore). For more information, please visit [http://www.eng.nus.edu.sg/ero/Maritime\\_RobotX\\_Challenge\\_2014.html](http://www.eng.nus.edu.sg/ero/Maritime_RobotX_Challenge_2014.html).

### About Maritime RobotX Challenge

Maritime RobotX Challenge, comprising of an international university maritime robotics competition and science and technology showcase, is a biennial experiential learning platform that leverages STEM education, promotes the love for and highlight the importance of Science and Engineering in the area of defence technology R&D.

The Challenge was held in Singapore at The Float @ Marina Bay from 24 to 26 October 2014. Visitors will witness the innovativeness and creativity of local and international university students as their specially designed Unmanned Surface Vehicle compete against each other, and experience the fun and excitement of Science and Engineering through the Science and Technology showcase.

The event is organised by the National University of Singapore (NUS) Faculty of Engineering, Science Centre Singapore (SCS), as well as the Association for Unmanned Vehicle Systems International (AUVSI) Foundation.

For more information, please visit [http://www.eng.nus.edu.sg/ero/Maritime\\_RobotX\\_Challenge\\_2014.html](http://www.eng.nus.edu.sg/ero/Maritime_RobotX_Challenge_2014.html)

## STUDENT CORNER

**STUDENT:** CAPT SEAMUS B. CAREY, USMC

**TITLE:** Increasing the Endurance and Payload Capacity of Unmanned Aerial Vehicles with Thin-Film Photovoltaics

**CURRICULUM:** ELECTRICAL ENGINEERING

**LINK TO COMPLETED THESIS:** [HTTP://HDL.HANDLE.NET/10945/42594](http://hdl.handle.net/10945/42594)

### ABSTRACT:

Prior research has shown that the endurance of small unmanned aerial vehicles (UAV) can be significantly extended using thin film photovoltaic cells. The different power requirements of the RQ-11B Raven variants are explored in this thesis, and it is demonstrated that a CuInGaS<sub>2</sub> (CIGS) solar array adhered to the wing of an RQ-11B not only extends the flight time but also expands the payload capacity of the platform. Power requirements and existing endurance of the digital variant of the RQ-11B were measured to establish a baseline of the platform's performance and validate previous research. A modular wing with an integrated CIGS array was then designed and constructed to be incorporated with the existing power circuitry of the platform. The baseline tests were repeated to determine the power generated by the array and supplied to the digital RQ-11B. It was shown that a solar integrated RQ-11B has a larger payload capacity and extended endurance, while still maintaining the modular and expeditionary nature of the existing platform. The concept of this research may be applied to all unmanned aerial platforms in order to expand their power generation to operate simultaneous or demanding payloads without stressing the existing power supply.

## CRUSER Librarian Corner

**Hogan, Hank. "Small Unmanned Aircraft Deliver: The March of SUAS is Changing Military Reconnaissance." *Special Operations Technology* 12, no. 8 (September 2014) 24-26**

<http://www.kmimediagroup.com/sotech/magazines/437-magazines-sotech/sotech-2014-volume-12-issue-8-september>

**The June 2014 of the Air Land Sea Bulletin is entirely focused on Unmanned Aircraft Systems**

<http://www.alsa.mil/library/alsb/ALSB%202014-2.pdf>

## NPS Alumni Receives Best Paper Award in the Annual Mexican Symposium on Unmanned Aerial Vehicles

The Second Mexican Symposium on Unmanned Aerial Vehicles held on September 29-30th in Veracruz, Mexico invited researchers from federal organizations, academia, and private industry. The forum addressed most critical issues associated with the design, production, application and integration of UAVs in civilian airspace; issues which are also critical around the world. The symposium was hosted by "Instituto de Investigación y Desarrollo Tecnológico de la Armada de México (INIDETAM)" which is the premier authority for R&D in the Mexican Navy, it was a forum where every year a growing community of aerial researchers present, discuss, and demonstrate in flight their latest advances and achievements in UAV technologies and applications.

Besides the presenters of INIDETAM UAV lab, led by an NPS alumnus (Capt. Mariano Lizarraga, 2003), the forum included a number of federal organizations like Mexican Dirección General de Aeronáutica Civil (Mexican FAA); universities including CINVESTAV-IPN, UNAM, and UANL; private companies like Itzamna Aeo, Aerovantech, Tecnavix, and Quetzal Aeroespacial, all representing their expertise in various areas of Guidance Navigation and Control of autonomous aerial vehicles. After 2 days of panel discussions and flight demonstrations the presentation of a recent NPS graduate, LT Nahum Camacho (2014), entitled "IMPROVING OPERATIONAL EFFECTIVENESS OF TACTICAL LONG ENDURANCE UNMANNED AERIAL SYSTEMS BY UTILIZING SOLAR POWER," was anonymously selected for the Best Paper award.

NPS alumni receiving awards of this magnitude and holding leadership roles in national programs are a vivid reminder of the quality and international recognition of research and education programs at NPS.

