Issue 55 September 2015

CRUSER • NEWS

Consortium for Robotics and Unmanned Systems Education and Research

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

Contents

ARSENL Flies 50 Autonomous UAVs
Lewis Hunsaker

RoboSub
Patric Petrie

What's in a Name
Curtis Blais

Student Corner
Louis Batson
Donald Wimmer

JIFX
Tristan Allen

Librarian Corner
Greta Marlatt

Warfare Innovation Workshop
Lyla Englehorn

JOIN the CRUSER Community of Interest
http:\\CRUSER.nps.edu

ARSENL Reaches Its Ultimate Goal of 50 Autonomous UAVs in Flight

by MC1 Lewis Hunsaker, NPS Public Affairs

Swarm of 50 UAVs in flight

Members of NPS' Advanced Robotic Systems Engineering Laboratory (ARSENL) flew 50 autonomous UAVs breaking their previous record of 30, set just five weeks ago.

"I'm very proud of reaching our goal of successfully flying 50 autonomous UAVs simultaneously," said NPS Assistant Professor Timothy Chung.

The 50 UAVs were launched and flown autonomously in two "sub-swarms" of 25 UAVs each and guided using ARSENL-developed swarm operator interfaces. The UAVs performed basic leader-follower cooperative behaviors and exchanged information amongst themselves via wireless links.

"This project came from the notion that quantity is a quality," said Chung. "It's like trying to play a game of tennis against an entire 5th grade class. If they were are all lobbing tennis balls across the court, it would be very hard to defend against them."

In the past, each aircraft would be operated by a single person, which makes for a very large footprint with many moving parts.

"One of the ways we can mitigate that is transferring autonomy. These robots can make limited decisions … that will alleviate some of the pressure on our human operators," said Chung. "Today, we were able to successfully control 50 UAVs with two operators that managed the aircrafts' behaviors and health."

Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) Director Raymond R. Buettner is hopeful about this technology's future applications. "Twenty years from now when aerial swarms are routinely helping farmers improve their crops, helping rescuers locate lost children, and helping warfighters to win our nation's wars, people will be able to look back at the efforts of NPS faculty and students in the skies over Camp Roberts as one of the seminal events that made such things possible," he said.

ARSENL Team at Camp Roberts

Chung noted that ARSENL's recent successes would not have been possible without the hard work and initiative of its systems engineering and cross-campus team members including NPS professors, Naval reservists, summer interns, NPS students and many more.

All opinions expressed are those of the respective author or authors and do not represent the official policy or positions of the Naval Postgraduate School, the United States Navy, or any other government entity.

Director's Corner

Lyla Englehorn, CRUSER Director of Concept Generation

Our fifth CRUSER Innovation Thread starts next week with the next Warfare Innovation Workshop, "Creating Asymmetric Warfighting Advantages." We have a full roster of six concept generation teams exploring the CNO's concept of electromagnetic maneuver warfare, and leveraging unmanned systems to enhance cross domain operations. Among many important topics on the schedule are briefs to review advances in 3D printing, EMP, and cyberwarfare. Dr. Timothy Chung will also share lessons learned in his recent success with swarming UAVs – a concept that originated in one of our early workshops! Stand by for the results from this year's effort.

RoboSub 2015: SSC Pacific hosts international student robotic submarine competition, July 23–26

by Patric Petrie, lead staff writer, SSC Pacific

SAN DIEGO – More than 30 schools worldwide and 300 students competed under Southern California's famed blue skies during the 18th International RoboSub Competition July 23–26 at the Navy's Space and Naval Warfare Systems Center Pacific (SSC Pacific) TRANSDEC research pool facility on Point Loma.

The goal of the annual competition, sponsored by the Association for Unmanned Vehicles Systems International (AUVSI) and co-sponsored by the Office of Naval Research (ONR), is to advance the development of autonomous underwater vehicles (AUVs) by challenging a new generation of engineers to perform realistic missions in an underwater environment. The winners take home more than $20,000 in prize money.

The event also fosters ties between young engineers and organizations developing AUV technologies. SSC Pacific's TRANSDEC research pool facility, the site of the competition, is a one-of-a-kind Navy facility built in 1964 that simulates an ocean of water and provides ideal conditions for research.

"SSC Pacific continues to be a key innovator for the Navy in unmanned and autonomous systems for the fleet. We are honored to cohost the RoboSub event with the Office of Naval Research to bring together future leaders in robotics: students, engineers, and other experts from around the world," said SSC Pacific's Commanding Officer Capt. Kurt Rothenhaus. "It is exciting to watch the students integrate new technology and see the energy and comradery between teams from around the globe."

One of the most striking aspects of the event was the level of cooperation and support demonstrated by the various teams when solving out a problem. "This group is made up the best and brightest university (and high school) students, who have come to compete against each other," said Daryl Davidson, executive director for the AUVSI Foundation. "But more importantly, they're willing to collaborate to share their approach to solving some very difficult mission challenges using robotic submarines."

An estimated 3,000 visitors attended the free event, which was open to the public. Spectators watched the teams prepare and launch their vehicles for the competition while a large screen broadcast the underwater action live for bystanders.

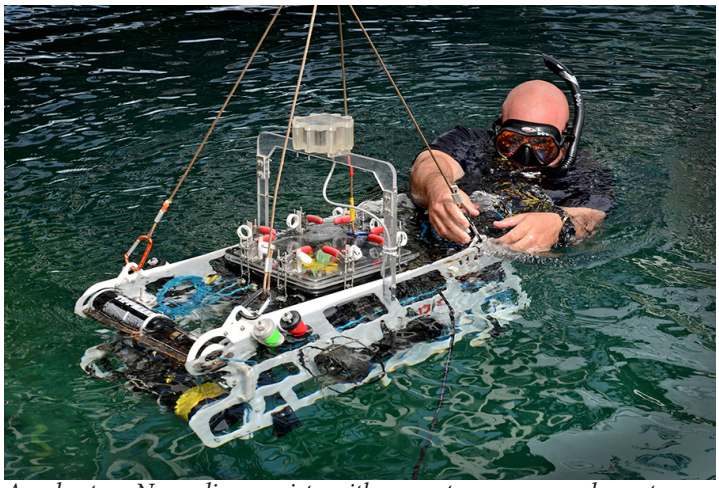
In addition to regional schools such as San Diego City College and the University of Southern California, robotics teams from as far away as Sweden, Russia, Canada, Turkey, India, and China showcased their innovative skills.

This year's winners are as follows:

1. San Diego State University (SDSU)
2. National University of Singapore
3. Maritime State University
4. California Institute of Technology (Cal Tech)

Davidson pointed out that just like San Diego TV anchor legend Ron Burgundy, RoboSub is still "a pretty big deal."

"The number of international teams (attending RoboSub) continues to grow every year," said Davidson. "There are other competitions that have been created as a result of this event in Europe, Asia, and India. We see teams that have won those competitions receive funding to participate in RoboSub. This really is the World Cup of robotic submarine competitions."



A volunteer Navy diver assists with an autonomous underwater vehicle during the 18th International RoboSub Competition, held July 23-26 at SSC Pacific's TRANSDEC. (Photo by Alan Antczak/released)

What is an autonomous system? Are we talking about the same things?

by Curtis Blais, NPS Faculty Associate Research, clblais@nps.edu

I enjoy reading the monthly articles in the CRUSER Newsletter. We are challenged intellectually by new ideas and even by the different terms used in talking about robotic systems. For example, in the January 2015 issue, Paul Scharre ("The Coming Swarm") spoke of human-inhabited and uninhabited systems, with the statement that incorporation of increasing automation in uninhabited systems helps them become "true robotic systems." Such concepts make one wonder how to classify the emerging "driverless" automobiles that transport humans and allow human override, or autonomous medical evacuation aircraft transporting human casualties – are those "true robotic systems"?

Clearly, a challenge in new fields of research and technology is reaching common agreement and use of terminology. In the Department of Defense, the robotics field has emerged rapidly as a revolution in warfighting, potentially reshaping the future battlefield in ways that we are only beginning to discover. In 2008, the National Institute of Standards and Technology issued Special Publication 1011-I-2.0 titled "Autonomy Levels for Unmanned Systems (ALFUS) Framework, Volume 1: Terminology," in an attempt to standardize terminology for this field. In this report, we find the following definitions that can help focus CRUSER concerns:

Unmanned Systems (UMS): A powered physical system, with no human operator aboard the principal components, which acts in the physical world to accomplish assigned tasks. It may be mobile or stationary. It can include any and all associated supporting components such as OCUs [Operator Control Units, the computer(s), accessories, and data link equipment that an operator uses to control, communicate with, receive data and information from, and plan missions for one or more UMSs]. Examples include unmanned ground vehicles (UGV), unmanned aerial vehicles/systems (UAV/UAS), unmanned maritime vehicles (UMV) —whether unmanned underwater vehicles (UUV) or unmanned water surface borne vehicles (USV)—unattended munitions (UM), and unattended ground sensors (UGS). Missiles, rockets, and their submunitions, and artillery are not considered the principal components of UMSs.

Autonomy: A UMS's own ability of integrated sensing, perceiving, analyzing, communicating, planning, decision-making, and acting/executing, to achieve its goals as assigned by its human operator(s) through designed Human-Robot Interface (HRI) or by another system that the UMS communicates with. UMS's Autonomy is characterized into levels from the perspective of Human Independence (HI), the inverse of HRI. Autonomy is further characterized in terms of Contextual Autonomous Capability (CAC). A UMS's CAC is characterized by the missions that the system is capable of performing, the environments within which the missions are performed, and human independence that can be allowed in the performance of the missions.

Autonomous: Operations of a UMS wherein the UMS receives its mission from either the operator who is off the UMS or another system that the UMS interacts with and accomplishes that mission with or without further human-robot interaction.

Fully autonomous: A mode of UMS operation wherein the UMS accomplishes it assigned mission, within a defined scope, without human intervention while adapting to operational and environmental conditions.

Semi-autonomous: A mode of UMS operation wherein the human operator and/or the UMS plan(s) and conduct(s) a mission and requires various levels of HRI. The UMS is capable of autonomous operation in between the human interactions.

Remote control: A mode of UMS operation wherein the human operator controls the UMS on a continuous basis, from a location off the UMS via only her/his direct observation. In this mode, the UMS takes no initiative and relies on continuous or nearly continuous input from the human operator.

Teleoperation: A mode of UMS operation wherein the human operator, using sensory feedback, either directly controls the actuators or assigns incremental goals on a continuous basis, from a location off the UMS.

Under CRUSER auspices, the author of the present article is investigating how behaviors and effects of human and unmanned systems can be distinguished in simulation models (see the January 2015 issue of CRUSER News). From the above definitions, we could ask a fundamental question, "Should human warfighters be considered as fully autonomous or semi-autonomous entities?" We probably are quick to consider human warfighters (soldier, sailor, Marine, airman, etc.) as fully autonomous entities, even though they report to some higher command and their actions can be overridden by modified orders from higher command (and, those orders are subject to interpretation, which may or may not correctly align with the commander's intent, and even so are not guaranteed to be obeyed). Suffice to say, we are in the early stages of a fascinating era of research and development that will bring about greater precision in our concepts and terminology relating to unmanned systems, while possibly redefining our notions of manned systems as well.

CRUSER Calendar

21-24 Sept - Warfare Innovation Workshop
5 Oct (1200 PDT) - Monthly Meeting
2-6 Nov - JIFX

details at http://CRUSER.nps.edu

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

STUDENT CORNER

Student: **Capt Louis T. Batson V, USMC; Capt Donald Wimmer Jr, USMC**

Title: Unmanned Tactical Autonomous Control and Collaboration threat and vulnerability assessment

Curriculum: Information Sciences

Link to Completed Thesis: https://calhoun.nps.edu/handle/10945/45738

Abstract: Information systems designed and developed without considering security and potential threats create avoidable risks to the United States and the Department of Defense (DOD). Unmanned Tactical Autonomous Control and Collaboration (UTACC) is a ground-breaking and original approach to using systems autonomy to augment and improve the intelligence, surveillance, and reconnaissance process. However, UTACC will fail to accomplish that task if the system is not built with security in mind from the outset. To improve the security of UTACC, this thesis conducts an analysis to identify threats and vulnerabilities in the system's concept. The goal of this analysis was to mitigate threats and enable mission success to UTACC-supported missions. During the initial research, a framework for threat and vulnerability analysis was developed based on The National Institute of Standards and Technology's (NIST) Risk Management Framework (RMF) and DOD's Information Assurance Certification and Accreditation Process (DIACAP). This framework was used to create a threat template to analyze each threat facing UTACC and UTACC's inherent vulnerabilities. The templates also include technical and non-technical security control strategies to mitigate each of the vulnerabilities within UTACC.

Joint Interagency Field Experimentation - Call for Experiment Proposals due 25 Sept 2015

The Naval Postgraduate School's Joint Interagency Field Experimentation (JIFX) program is now accepting Experiment Proposals for its 16-1 event. The 16-1 event will be held 2-6 November 2015 at Camp Roberts, CA. This event will be hosted in a field environment to accommodate a wide range of technology experimentation.

Interested parties are encouraged to visit the JIFX website to review the event's Request for Information (RFI) document and submit an Experiment Proposal. The RFI document outlines the parameters for participation and lists the areas of interest for the event. Experiment Proposals are due no later than 25 September 2015.

Applications will be accepted that relate to any of the RFI areas of interest.

Please refer all questions to jifx@nps.edu or see our website: http://my.nps.edu/web/fx ("About Us" page)

Librarian's Corner

How Many UAVs for DOD?, CRS Insights. IN10347
http://www.fas.org/sgp/crs/natsec/IN10347.pdf

Human Factors Considerations in Autonomous Lethal Unmanned Aerial Systems
http://commons.erau.edu/aircon/2015/Friday/22

Cloud-Based Distributed Control of Unmanned Systems
http://www.public.navy.mil/spawar/Pacific/Robotics/Documents/Publications/2015/SPIE_NguyenK_2015.pdf

Observation Modelling for Vision-Based Target Search by Unmanned Aerial Vehicles
http://eprints.soton.ac.uk/374064/1/camera-ready.pdf

Design Methods for Remotely Powered Unmanned Aerial Vehicles
http://digitalcommons.calpoly.edu/theses/1386

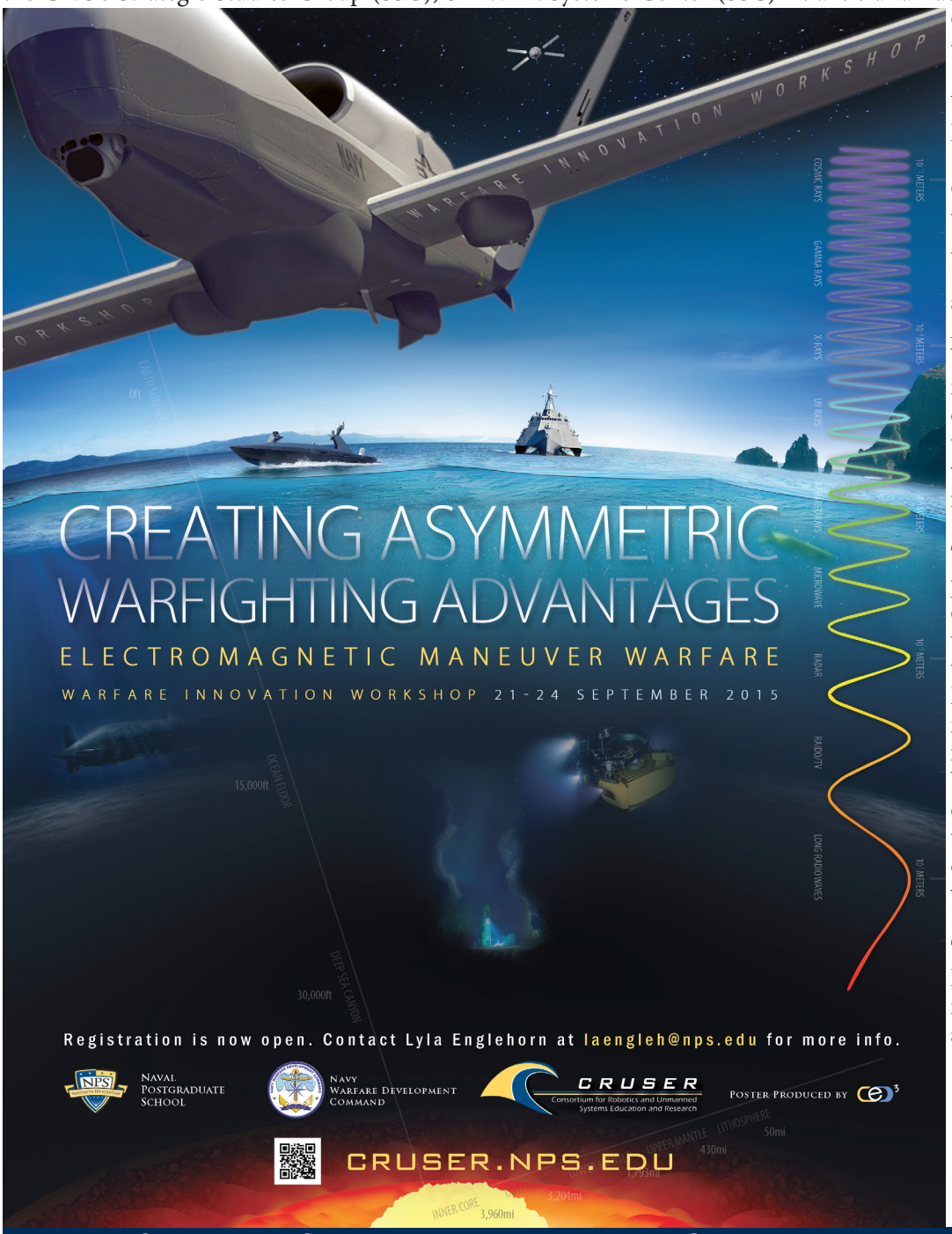
Terrorist and Insurgent Unmanned Aerial Vehicles: Use, Potentials, and Military Implications
http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubID=1287

NWDC/CRUSER Warfare Innovation Workshop: 21-24 September 2015

WANTED: Professionals who want to make a difference. By applying to participate in this September's NPS Warfare Innovation Workshop "Creating Asymmetric Warfighting Advantages," you have the chance to shape the Navy you will command. Held at NPS from during Enrichment Week, 21-24 September 2015, and sponsored by the Navy Warfare Development Command (NWDC) and CRUSER, senior officers and DoD civilians come to hear what NPS officers have to say.

This year's Warfare Innovation Workshop will focus on advancing the CNO's concept of Electromagnetic Warfare and leveraging unmanned systems to enhance cross domain operations.

You will be joined by other officers from across campus, engineers from navy labs and industry, and junior officers from the fleet to propose technologies and employment concepts in a challenging scenario-based seminar. Our 2015 roster includes representatives from the Navy Warfare Development Command (NWDC), the CNO's Rapid Innovation Cell (CRIC), the CNO's Strategic Studies Group (SSG), SPAWAR Systems Center (SSC) Atlantic and Pacific, the Navy Surface Warfare Center (NSWC) Panama City, the Naval Air Warfare Center (NAWC) Patuxent River, NAVAIR China Lake, Lawrence Livermore National Laboratory (LLNL), NASA Ames Research Center, Battelle, Draper Labs, the Johns Hopkins University Applied Physics Laboratory (JHU/APL),Lockheed Martin, and Systems Planning and Analysis, Inc. Each team will brief conclusions to sponsors, industry executives, and senior officers the final morning of the workshop, and these results will then be disseminated to fleet commands.



This is your invitation to participate in this important enrichment week event. For those new to NPS, remember that there are no classes during Enrichment Week – no grades, no other classes to compete for your time and attention. Your tactical and operational experience will be valued in this effort, regardless your NPS curriculum. Come create a vision!

To be placed on a team, contact Lyla Englehorn, CRUSER Director for Concept Generation at laengleh@nps.edu.