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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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Systems Engineering Students Detail Operational Scenarios for UUVs

by Kenneth Stewart, NPS Public Affairs, for additional info contact sea19a@nps.edu

A team of systems engineering analysis students at the Naval Postgraduate School recently completed detailed analyses of various operational scenarios utilizing the latest unmanned undersea vehicles (UUVs), and briefed their preliminary findings during a presentation in mid-April.

"We were tasked to design a system of unmanned undersea vehicles that will provide an operational undersea force available for tasking over a range of missions by 2024," said NPS student and project manager LT J.P. Kish of Houston, Texas.

"We were originally tasked to see if we could contribute to undersea dominance," continued Kish. "We were given 11 missions to evaluate, but we scaled them down to four that we felt held the most promise of being influenced by unmanned technologies by the year 2024."

According to project members, the Navy is investing considerable intellectual capital into utilizing UUV technology.

"UUVs are a major focus of the Chief of Naval Operations," said LT Chris Caraway of San Diego, Calif. "We, and the [CNO's] Strategic Studies Group are essentially working on the same project with different time frames."

Preliminary findings suggest that UUVs may be both cost and operationally effective in several key naval mission sets, especially in high-risk areas where traditional naval platforms may fall victim to anti-access area denial warfare. Team members found that UUV operations were particularly well suited to intelligence, anti-mine warfare, and both information and offensive operations.

Within each of the four defined mission areas, students evaluated the ability of UUV platforms to complete their assigned missions, determined optimal sensor and weapons packages, and considered logistical restraints.

"Using UUVs in mine countermeasures (MCM) operations is the most promising," said LT Sam Fromille. "MCM operations leverage work that is already being done by private industry … Commercial enterprises have developed a robust capability."

In order to evaluate each undersea system and its associated mission set, students employed a series of complex mathematical models. Each system was run through hundreds of simulations utilizing a strident series of constraints designed to demonstrate UUV capabilities and limitations in highly challenging undersea environments.

"We also conducted site visits to Panama City's Naval Surface Warfare Center and to the Penn State Applied Research Laboratory where students met with operators and industry professionals responsible for the advancement of UUV technologies," said LT Kris Blandin of Boise, Idaho.

Students demonstrated that UUVs, when used in conjunction with traditional platforms, were a significant "force multiplier." Student analysis also revealed that UUVs are a viable replacement for legacy equipment and that they can increase the capabilities of more modest naval platforms. Still, challenges were identified in the areas of endurance, data transfer and mine neutralization.

In the area of information operations, UUVs were shown to be effective in military deception and enhance the effectiveness of submarines to conduct other operations. Challenges included object avoidance, particularly in cluttered littoral areas, and the ability of the systems to conduct autonomous operations.

"Military deception is an area where UUVs can provide an immediate impact with current technology. It opens up new mission capabilities that we don't currently have," said Fromille

The use of UUVs in offensive operations showed promise as well, particularly in shallow areas of operations where the UUVs stealth abilities were an advantage. The risk to conducting combat operations with UUVs was also found to be significantly less than the risk associated with manned platforms. Still, analysis team members insist that the submarine remains the most potent combat platform.

"UUVs may be effective in an attack role in large numbers, but the submarine remains the most effective offensive weapon" said LT Jamie Cook of Montgomery County, Md.

In conjunction with their analyses of proposed and extant systems, team members evaluated optimal sensing packages and demonstrated the value added by mixing shipboard and sensor equipped UUVs. These sensing packages became particularly beneficial when evaluating the role of UUVs as pathfinders. UUVs were show to be an effective means of traversing heavily mined areas and were shown to be able to create safe passages for manned systems in high threat areas.

Finally, members concluded that a greater number of less capable, and therefore less expensive UUVs, were more effective than fewer numbers of highly capable systems. They also found that when equipped with a "sprint" capability, UUVs were more likely to survive enemy contact, and that their use significantly enhances the effectiveness of intelligence collection.

"In the future, we will employ UUVs," said Fromille. "It will be interesting to see if the future matches what we have demonstrated here."

Their final progress review (FPR) will be held Thurs 23 May at 0900 (PDT) in the ME Auditorium on NPS. Dial-in is available at 831-656-6692 or e-mail VTC@nps.edu to attend via VTC.

Director's Corner

Over two years ago Dr. Buettner worked personally with Undersecretary of the Navy Work to lay the foundation for the CRUSER community. On 1 May I happily turned over the CRUSER Directorship to him and will now assume a position on the NPS CRUSER advisory board. By any measure CRUSER is a success. We have an active community of over 1000 and growing weekly. Our monthly NPS meetings are well attended by faculty, students, and off-campus members via VTC. We have an active cross-campus research program under the aegis of two Innovation threads which take concepts generated by our students to experimentation by our students. In addition, we have many NPS students participating in diverse unmanned systems research through thesis work and capstone projects with other CRUSER community members. CRUSER is shaping the next generation of America's warriors by having them participate in the birth of the robotics age. This is all due to the following people: Dr. Timothy H. Chung, CRUSER Director for Education and Research; CAPT Carol O'Neal, USN (ret), CRUSER Director for Innovation and Concept Generation; Lisa Trawick, CRUSER Operations Manager; and Lyla Englehorn, CRUSER Program Manager. Each has other NPS responsibilities and shares those with their CRUSER job, yet each has given a full time effort to Undersecretary Work's and Dr. Buettner's vision. I thank them for their efforts.

CAPT Jeff Kline, USN (ret)
CRUSER Advisory Board Member

ScanEagle Survivability Assessment

by LT Jacob King, jeking@nps.edu and LT Jared Wolcott, jmwolcot@nps.edu, NPS Systems Engineering – Test Pilot School Co-Op students

The discipline of combat survivability is well defined for manned aircraft. Other physical combat systems like ships and ground vehicles have been explored, but not to the breadth and depth of aircraft. To date, there has not been an in-depth analysis of the survivability of an unmanned aerial system (UAS). This ScanEagle survivability assessment seeks to adapt the well-defined manned aircraft survivability discipline into concepts applicable to an unmanned aerial vehicle (UAV).

As unmanned aerial systems become more prevalent over battlefields, a survivability analysis and enhancement program must occur in order to ensure operational readiness and mission success in the future. In 2010, when analyzing the increased demand on unmanned systems by the combatant commanders, Air Force Chief of Operations Lt. Gen. Philip Breedlove stated, "We need to look at bridging from the permissive environment (to) contested airspace." The increased dependence of the combatant commanders on unmanned aerial systems as intelligence, surveillance, and reconnaissance gatherers in a heavier threat environment increases the need for a survivability enhancement program for all unmanned aerial systems. Although the loss of a small UAV does not incur any loss of life or a large cost, the potential loss of the ISR mission it performs is becoming increasingly important to the combatant commanders. The survivability discipline must be applied to UAVs to ensure that these assets become more survivable and can complete their assigned missions in a higher threat environment.

Our work outlines the survivability approach, applies it to the ScanEagle UAV in the context of small arms threats, and provides some initial findings. We determine that the ScanEagle, while highly vulnerable to gunfire can be made less susceptible to small arms. Our analysis shows that the overall probability of kill in a given scenario may exceed 50% against a 12.7 mm weapon, and that the greatest driving factor in the UAV's survivability is its slant range to the threat. We suggest that upgrades, especially to optics modules, will allow the aircraft to operate at higher altitudes which will reduce the probability of detection, increase the aiming error and ballistic dispersion, and possibly eliminate small arms threats altogether by flying above and outside of their maximum effective range. In short, a relatively inexpensive upgrade to onboard sensors may prevent the loss of aircraft or mission.

The primary methods for this analysis are taught in the Survivability and Weaponeering courses offered by the Mechanical Engineering department at NPS and are drawn from the following books written by NPS professors:

Ball, Robert E. The Fundamentals of Aircraft Combat Survivability Analysis and Design. 2nd. Reston, VA: AIAA, 2003.
Driels, Morris R. Weaponeering: Conventional Weapon System Effectiveness. 2nd. Reston, VA: AIAA, 2013.

Full report available at http://libguides.nps.edu/loader.php?type=d&id=748302

NPS ME4822 class (summer 2013)

Do you want to learn advanced Guidance Navigation and Control (GNC) techniques along with some basic Operations Research (OR) concepts in the most convenient and fun way. You will learn about intelligent autonomy (IA=GNC+OR) and have fun in competing among themselves. Moreover, the most successful algorithms will have a chance participate in an online competition with professional thermal soaring human pilots.

While the key objective of the ME4822 is the design of advanced control algorithms for autonomous robots, and the key "for credit" audience is the ME/EE students, the class might be of interest to a wide spectrum of OR/CS/SE students ("not for credit") looking for an application of the Search Theory, Computer Science, Artificial Intelligence knowledge. If so, the model of thermal soaring glider will be given as a complete Simulink model and the student will be asked to design an intelligent thermal search and soaring algorithm in MatLab/Simulink and integrate it with the Condor API provided.

Sign for ME4822 in Python or contact Prof. Vlad Dobrokhodov (vldobr@nps.edu) for more information.

March 2013 NPS Graduates' CRUSER-related theses are now available at: http://bit.ly/18wMyrE

Robotics Takes Center Stage During Annual Campus Research Fair

by MCSN Danica M. Sirmans, NPS Public Affairs

Robots of every shape, size and purpose dotted the academic quad as the Naval Postgraduate School's Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) once again hosted their annual Robots in the Roses Research Fair, Apr. 11.

The annual event brings the campus community together to spotlight existing research projects throughout every department, encouraging maximum collaboration across the university.

"Robots in the Roses is wonderful because you get a chance to meet interested students and show them some interesting devices," said Steven Jacobs of the physics department. "It's great exposure to the community … It helps put our department out there and really helps to showcase what we've been working on."

Researchers displayed robotics platforms large and small – everything from bird-like bots that seek out and ride upon thermals, to small-unmanned watercraft capable of sensing threats in harbors.

"Robots in the Roses is an annual event that allows faculty and students to showcase their research in unmanned systems … and present them to the broader community," said CRUSER Director, retired Navy Capt. Jeff Kline. "It's on one-hand very useful for the students to come out and see the variety of the things that are going on, but it's also very good for the faculty to see what other faculty members are doing in order to find opportunities for collaboration."

CRUSER Director for Research and Education Dr. Timothy Chung was recently awarded the prestigious Hamming Award for his interdisciplinary work in robotics and technology. He too sees the annual event as an opportunity for collaboration and exploration.

"While CRUSER stands for Consortium for Robotics and Unmanned Systems Education and Research, in general terms, it's an environment or forum for us foster collaboration in the areas of unmanned systems and robotics," said Chung.

Dr. Kevin D. Jones, a Research Associate Professor in the mechanical and aerospace engineering department, a third-year participant, noted he appreciates the opportunity to network with his colleagues. He sees the value in sharing research amongst fellow faculty and students.

"Robots are a lot like living creatures in the sense that they are all made up of the same primary building blocks," Jones said. "Living organisms have more similar DNA components than they do those that differ. The same can be said for robots.

"Robots in the Roses is a great way to get us all together from all our respective types of robotics to appreciate our similarities along with our differences," he added.

NPS' Consortium for Robotics and Unmanned Systems Education and Research provides a collaborative environment and community of interest for the advancement of unmanned systems education and research endeavors across the Navy, Marine Corps and Department of Defense. Along with Robots in the Roses, the group coordinates several innovation workshops in addition to regular campus meetings and consistent communications to a broad community of interested stakeholders.

Unmanned systems research at NPS/Multi-University recognized with 2012 SAGE Best Paper Award by the Journal of Systems and Control Engineering

A reflexive vehicle control architecture based on a neural model of the cockroach escape response by Ravi Vaidyanathan, Chun-Ta Chen, Chan-Doo Jeong, Charles Williams, Yochiro Endo, Roy E Ritzmann and Roger D Quinn

Part I: Journal of Systems and Control Engineering 2012; 226(5) 699–718
http://pii.sagepub.com/content/226/5/699.full.pdf+html

Joint Interagency Field Exploration (JIFX)

by Tristan Allan, NPS Research Associate, jifx@nps.edu

The Naval Postgraduate School's field experimentation team is pleased to announce a call for papers for the 13-4 Joint Interagency Field Exploration (JIFX) event. The event will be held 5-8 August 2013 at Camp Roberts, CA.

Please visit our website (http://www.nps.edu/Academics/Schools/GSOIS/Departments/IS/Research/FX/JIFX/JIFX.html) to review the Request for Information (RFI), submit a whitepaper, and apply for attendance. Everyone is encouraged to apply, but attendance is by invitation only.

The deadline for whitepaper submissions is June 7, 2013.

Event Information:
Held twice a year, JIFX is a multi-institutional, semi-structured event that pairs areas of interest identified by the DoD and DHS with new and innovative research from private industry, academia, and government research labs. The venue is characterized by a mix of technical and field environments and a focus on collaborative solutions to complex problems. This is not a sales event, ideal participants are professors, students, engineers, developers, technicians and other domain experts within your organization.

Research & Experimentation for Local & International Emergency First Responders (RELIEF):
This announcement serves as a call for papers on behalf of the RELIEF series of experimentation as well. If you are interested in participating in RELIEF 13-4 (which will be held as a subset of experiments at JIFX during the 13-4 event) please apply through the JIFX application process.

Upcoming CRUSER Monthly Meetings

Wed 15 May 2013, 1200-1250 (PDT)
Root 242, VTC, or dial-in 831-656-6681
Wed 19 June 2013, 1200-1250 (PDT)
Root 272, VTC, or dial-in 831-656-6685

Short articles of 300-500 words for CRUSER News are always welcome - cruser@nps.edu

- Unmanned Systems/Robotics research
- New Program/Systems/Projects
- Other aspect of Unmanned Systems/Robotics

STUDENT CORNER

Student: LT J.B. Zorn, USCG

Title: A Systems Engineering Analysis of Unmanned Maritime Systems for U.S. Coast Guard Missions

Curriculum: Systems Engineering

Abstract: The U.S. Coast Guard is uniquely suited to utilize multi-mission unmanned maritime systems (UMS) to maintain its leading role in maritime safety, security and stewardship. Current UMS technological capabilities coupled with USCG mission needs motivate an analysis of proposed USCG UMS through a systems engineering methodology. This work begins by decomposing the capability needs for USCG UMS by developing a series of concepts of operations (CONOPS) in a "solution neutral" context. Following capabilities analysis, multi-mission commonalities help derive three USCG UMS alternatives:(1) Cutter-Based Tactical UUV, (2) Shore-Based Harbor/Coastal UUV/USV, and (3) Operational Offshore USV. These alternatives and their respective system architectures provide a design concept for near- to mid-term (5-10 year) acquisition. Finally, feasibility analysis reviews key system enablers (such as technology, capability, policy, and supportability and manpower) for the alternatives to justify a realistic integration time line. Recommendations for technology investments, enhanced UMS partnerships, USCG unmanned system policies and organizational knowledge are provided to reduce delays and to accelerate delivery of needed capabilities to the field. This study lays the foundation for future strategic planning of USCG UMS (i.e., a USCG UMS Roadmap) while providing additional motivation for USCG unmanned systems in general.

Does your DoD Organization have a potential thesis topic for NPS Students? Contact us at CRUSER@nps.edu

COBRA head to Quebec for National Competition

by Cherise Letson, Prof Howard Li, Department of Electrical and Computer Engineering, University of New Brunswick, howard@unb.ca

Two UNB graduate students headed to Alma Quebec for the 2013 Student UAV competition from May 3-5. Amr Nagaty and Carl Thibault put their unmanned Quad Copter to the ultimate test by flying it in a pre-planned air space, and aiming to specific targets.

The Quad Copter is a fairly old project in the UNB COBRA program; however, new additions and tune-ups have been made to rise to the challenge. These updates include a new camera that beams video back the ground station. It is also able to identify targets with littler user intervention. The students have also improved the copter's flight time and range.

Earlier this year, the COBRA team entered the competition. The competition is divided into two phases. The submissions by all teams are evaluated by a committee of academic and industrial experts and COBRA is named the first place winner for Phase 1. The second phase is the operational phase. The team is the third place winner for this phase. Nagty said the competition is a great opportunity to see what other students across the country are doing with the latest technology.

"It's very interesting," said Nagty. "We go and we meet a lot of people who are working in the same field. [There's] a lot of students like ourselves, many company representatives, sponsors of the event. It's just a big event for people who are working in the same field."

"It's a really big networking opportunity," said Thibault. "You get to catch up on with some people you might not have seen for several years. It feels rather small, so you get to know a lot of people. It's also nice to see how your work compares to everybody else's." Thibault said competition involves advancing what they've already been working on this year. "It's a very natural extension of what we've been doing," he said. "In a sense, we haven't been exclusively working on the competition, but to continue to build what we've been working on."

That being said, the duo are pushing themselves to go further. "There's always that sense of excitement, 'can we do better than the last time?' 'Can we do better than everybody else?' So there's kind of an excitement edge on the preparations," said Thibault.

Thibault and Nagty are sponsored by Forest Protection Ltd. and The Moncton Flight College (MFC), who are partners with COBRA. Chief executive director officer of MCF, Mike Tilley, said they support COBRA because it's the future flight.

"We see what they're [UNB COBRA] doing as innovative and is the next generation of what's going to happen in pilot training," said Tilley. Tilley said since the beginning of flight, much of the training has stayed the same. However, he said MFC wants to get involved in the new innovations happening in the field. He said unmanned aircraft are in the future.

"Traditional pilots will still exist, but we're going to see an opportunity for unmanned pilots in the future, which will also require training. We see the type of work they're doing is interesting and innovative." said Tilley. Tilley said MFC partners with the best, and with UAV growing in popularity, he believes COBRA has potential for helping break UAV into the commercial market.

"Everything we've seen and heard from COBRA, makes us feel they are on the right track, and they got a very solid team and really good technology. We're just excited to be a part of the mix, and hope that's going to turn into some nice commercial activity for more organizations," he said. David Davies of Forest Protection Ltd, also believes the UAV industry is ready to take-off in many different fields. "In my opinion the development and use of UAV technology for commercial purposes is obviously ready to "boom" in many industries," said Davies. "Technology that currently is or will soon be available will allow this in a safe and regulated manner to ensure the safety of all unmanned and piloted aircraft sharing the same airspace."

COBRA was founded at the University of New Brunswick by Dr. Howard Li and a team of graduate students. The group encourages collaboration and teamwork. The group researches and develops prototypes of unmanned air, ground, and underwater vehicles.

"We are pleased with the accomplishment of our students. Although we conduct research at a small university, our ideas, collaboration, and hard work helped us to become successful at what we do," said Dr. Li.