Advanced Robotic Systems Engineering Laboratory Accomplishments in FY13
by Marianna Jones, NPS Research Associate, mjjones@nps.edu

The NPS Advanced Robotic Systems Engineering Laboratory (ARSENL) is developing technologies and capabilities for deployment and employment of large teams of unmanned aerial systems. These low-cost aerial robots may serve as wide-area sensors and communication relays, and serve as an experimental testbed for autonomous coordination and tactical algorithms. FY13 has been a year of exponential growth for ARSENL. We have flown in seven field experiments, including the following NPS hosted experiments: JIFX 13-2, RELIEF 13-3, TNT 13-3, and JIFX 13-4. We were able to conduct 75 Unicorn sorties and 30 Zephyr sorties during these field events. Data collection from these live-fly experiments has enabled the lab, which started flying one Unicorn UAV made by Procerus Technologies (a Lockheed Martin company) in October 2012, to dramatically increase and fly ten Unicorns at one time in May 2013! While flying ten planes at one time was a logistically taxing, especially on the ground control station operators and flight technicians; a lot of research, testing, and energy has been put into rapid development of the Zephyr UAV, which uses open-source and low-cost hardware/software.

Basic UAV swarming missions were also carried out with swarms of size 3. We expect to expand the swarms to larger sizes in the coming year, with custom behaviors for each swarm (e.g., engage target, defend ally, search, survey). Note that ‘engage target’ can have many applications, from agricultural (spray pesticide), to search-and-rescue (deliver survival kit), in addition to various military applications.

Figure 1: Ten-UAV Mission Timeline, including time between launches and recovery

Figure 2: Trajectories of the Ten-UAV Mission (Camp Roberts, Calif., May 2013)

CRUSER Robo-Ethics Continuing Education Series 2013

The next event in Robo-Ethics Continuing Education Series will be a facilitated debate on Monday 23 Sept 2013 in Glasgow 102 from 1300-1500 (PDT). NPS Defense Analysis professor Dr. Bradley J. Strawser will moderate this discussion of the question: Does the future of unmanned and autonomous weapons pose greater potential ethical dangers or greater potential ethical rewards? Panelists include ethicist Dr. Heather Roff and journalist Mr. Joshua Foust. All are welcome to attend in person or via the live video stream.

Coordination Experiments with AUVs and UAVs
by Dr João Sousa, Univ. of Porto, jtasso@fe.up.pt, Dr Kanna Rajan, MBARI, kanna.rajan@mbari.org

In July in engineering/science exercises, off the coast of Portugal in Sesimbra, close to Lisbon a team from the Univ. of Porto’s Underwater Systems and Technology Laboratory (http://lsts.fe.up.pt/) and the Autonomous Systems group at the Monterey Bay Aquarium Research Institute, Moss Landing California (http://www.mbari.org/autonomy/) demonstrated mixed-initiative and fully autonomous modes of interaction between UAVs and AUVs observing the same patch of the coastal ocean. The Rapid Environment Picture (REP) is an yearly exercise conducted by UPorto jointly with the Portuguese Navy.

This years campaign’s ultimate objective is to meld control-theoretic approaches with decision-theoretic methods for autonomous robotic control. The target application (Phase II of REP) that the group is focused on is to track large fish (Mola mola) and to do so fully autonomously with aerial, surface and underwater vehicles working with marine behavioral ecologists. In Phase I in Sesimbra, the combined team working thru the paces of engineering tests and are using joint capabilities with T-REX (MBARI’s AI-based Planning/Execution system which synthesizes and executes plans on an embedded processor) and the UPorto command/control tool chain and assets with mixed MBARI and UPorto teams. An important goal was to enable experimentation inexpensive with assets which are flexible; the unmanned aerial vehicles (UAVs) are put together less than 1300 Euros a piece by UPorto and hooked up with a comprehensive tool set designed, built and deployed by UPorto over the last 4-5 years. T-REX besides running on 2 UPorto AUVs was used to command/control 2 UAVs albeit synthesizing objectives and waypoints from the ground. The goal was to enable coordinated observations with the mixed-use objective of tracking dynamic features in the ocean. Two separate experiments were conducted; one was to track a moving drifter (designed at UPorto for less than 350 Euros) drogued at 2 meter depth and thrown overboard from a RHIB as well as a naval support vessel and tracked continuously by a UPorto AUV contextually recording sensor information in the vicinity of this moving target. This approach tested out the scenario that is expected to be used for Phase II for tracking the Mola’s when on the surface.

A second experiment used a lightweight IR camera deployed by a graduate student of the Norwegian Univ. of Science and Technology (NTNU) on a UAV to look at horizontal thermal gradients in coastal waters. In an event-response scenario and using the situational awareness tool-chain from UPorto, an AUV was deployed when operators noticed a change in coloration from the IR camera. The AUV was then sent high-level goals from the support vessel to observe the water-column in the vicinity of the gradient. The data from these missions are being analyzed for joint publications. The UPorto and MBARI teams are also working towards more joint tests, this time in Monterey Bay, as part of the CANON science field experiments (http://www.mbari.org/canon/).

More info is on the REP exercise in Sesimbra can be found at: http://rep13.lsts.pt/en

Upcoming CRUSER Monthly Meeting
Tues 8 Oct, 1200-1250 (PDT)
Root 242, VTC, or dial-in 831-656-6681
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Short articles of 300-500 words for CRUSER
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https://portal.mmowgli.nps.edu/am
Proteus: A Manned Submersible Also Serves as an Unmanned Underwater Vehicle
by Gregory D. Gregoriades, Principal Research Engineer, Battelle Memorial Institute, gregoriades@battelle.org

Manned submersibles are common around the world. Their construction has been driven by their missions – often the covert delivery and retrieval of personnel and equipment to shore. This mission shows in their size and endurance, which are optimized for short missions carrying teams of people with their gear. Unmanned underwater vehicles (UUVs), in contrast, capitalize on their freedom from the constraints of the human body to conduct lengthier missions such as subsea survey and sampling.

The Proteus Dual Mode Underwater Vehicle (DMUV) has the desirable characteristics of both types of vehicles—the ability to carry out missions autonomously, and the payload of a six passenger wet submersible. Built by Battelle Memorial Institute, its subsidiary Bluefin Robotics, and The Columbia Group (TCG), the hull is a modified version of TCG’s Swimmer Delivery Vehicle, in use by the US and other navies for over 20 years. The autonomy and power elements are adapted from Bluefin’s proven UUV systems. The resulting Proteus vehicle earned a 2013 R&D100 Award from R&D Magazine.

Proteus, almost 26 feet long, weighs 8200 lbs in air. Its Lithium polymer batteries give a maximum speed of 10 knots, with a range of more than 200 nm at 4 knots. In manned mode, it can support six divers for ten hours. It uses GPS, a Doppler velocity log (DVL) and IXSEA Photonic Inertial Navigation to navigate with an accuracy of 0.1% distance traveled with DVL bottom lock. In autonomous mode, operational parameters such as waypoints, depth, altitude above the sea floor and speed are entered into a mission profile. The mission is initiated from a top-side controller and Proteus carries out the programmed activities, including operation or deployment of payload packages such as cameras, sensors, or sample collectors and analyzers. Upon mission completion, Proteus will return to a designated location for recovery. Autonomous behaviors include:

- Waypoint to waypoint with variable depth
- Maintain depth or altitude during transit
- Hover at set altitude or depth
- Deploy payloads at multiple locations
- Ballast and trim
- Masts up and down
- Communicate on surface or at depth
- Ballast down on bottom, communicate or enter sleep mode

The Proteus development was undertaken to fill the predicted need for large autonomous vehicles to undertake the new missions envisioned by Navy and industry. Compared to smaller UUVs, Proteus markedly reduces the need for frequent launch and recovery and can carry and deploy much larger payloads and cover much greater distances than previously possible. A key application will be development and testing—besides its size and range, Proteus has ample electrical power and a readily extensible publish-and-subscribe control system for future payload integration. Manned operation will enable users provide on-site supervision and backup for developmental autonomous payloads.

Dual mode capability also enables Proteus to carry out mixed missions, such as an autonomous transit after delivering personnel to their destination. Other potential missions include sensor deployment, remote array tending, remote teleoperated intervention, and use as a platform for deployment, recovery and replenishment of smaller UUVs.

RS JPO Publishes the Unmanned Ground Vehicle (UGV) Interoperability Profile Version 1.0 (IOP V1)
by Christopher E. Scott, Robotic Systems Joint Project Office, christopher.e.scott16.civ@mail.mil

The RS JPO is pleased to announce the release and publishing of the UGV Interoperability Profile IOP Version 1.0. Version 1.0 is a successor to Version 0, which was published in December 2011. Through the support of Working Integrated Product Teams (WIPTS) across industry, academia, and other government agencies, the IOPs are creating the conditions that will lead to interoperable, modular, and open-system UGVs across the DoD. The UGV IOP activity fully supports both new capabilities for the Warfighter, as well as Better Buying Power (BBP) 2.0 for the taxpayer.

The IOP defines hardware and software interface requirements for UGVs, establishing the baseline for UGV interoperability requirements. Version 1.0 builds upon Version 0 and addresses point to point and multi-robot interoperability and modularity requirements between UGV platforms, payloads (sensors, emitters, actuators), radios and controllers. The IOP software interfaces are primarily based upon the Joint Architecture for Unmanned Systems (JAUS) (SAE AS-4) industry standard. The IOP mandates that if a system is going to include a specific capability, then the corresponding IOP requirements for that capability will be adhered to. It mandates the use of the Ethernet networking protocol, 2 alternative physical connectors, 2 alternative payload power values, common communications link (CCL) design constraints, and Warfighter/Machine Interface (WMI) design practices. For questions regarding the IOP, and to request access to IOP V1, please contact Mark Mazzara, mark.mazzara@us.army.mil
STUDENT CORNER

STUDENT: LT Andrew T. Streenan, USN
TITLE: DIVER RELATIVE UUV NAVIGATION FOR JOINT HUMAN-ROBOT OPERATIONS
CURRICULUM: Undersea Warfare

Abstract: A novel application for Autonomous Underwater Vehicles (AUVs) is considered here: a robotic diver assistant that enables close-quarters robotic operations with human divers. A robotic diver assistant has the potential to improve the efficiency, effectiveness and safety of diver operations. The robot diver assistant must share the operating environment with human divers: the robot must navigate relative to the environment to reach a specified site location (along with moving divers), then maneuver among the mostly static divers as they perform their tasks on location. Strategies for navigating among divers while ensuring diver safety are presented in this paper. A reactive strategy, based on potential fields, is investigated as well as a deliberative approach for path following.

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Autonomous Maritime Vehicle Competition - Applications due 30 Sept 2013
by Kelly Cooper, ONR, Program Sponsor, kelly.cooper1@navy.mil

In 2014 the Office of Naval Research and the Association for Unmanned Vehicle Systems International (AUVSI) Foundation will hold an international competition for autonomous maritime vehicles.

Approximately fifteen teams of students from five Pacific Rim countries – U.S., Singapore, Australia, South Korea and Japan – will use a standardized boat that will be provided by the competition organizers and compete in October of 2014 in Singapore in the first-ever Maritime RobotX Challenge. By providing the teams with a standard platform (boat), the Competition will focus on sensors, software and propulsion.

“RobotX”, sponsored by the U.S. Office of Naval Research and run by the AUVSI Foundation, has two primary objectives: to create a pinnacle STEM student outreach event and promotion of interest among Pacific national partners in the science and technology of autonomous systems.

Consider forming a student team to compete in this inaugural Pacific Rim competition for autonomous surface vessels. Application responses are due to the AUVSI Foundation by 30 September 2013.

Additional details and application details on the website: http://www.robotx.org/

FY14 Joint Interagency Field Exploration (JIFX) Request for White Papers

NPS Field Experimentation will be hosting the first of its FY14 Joint Interagency Field Exploration (JIFX) events 4-7 November at the NPS McMillan Airfield facility located on Camp Roberts, CA. JIFX is a quarterly event that focuses on creating a multi-institutional, semi-structured learning environment where cutting edge research and experimentation from government, academic, private industry, and non-profit organizations occurs simultaneously throughout the week. The focus of each event is determined by stakeholders from the DoD, DHS, and other interagency partners. Experiment focus areas range widely and include such topics as new and emerging C4ISR solutions, social media analysis, communication technologies, computer network security, and alternative power and water solutions, to name a few. For more information please visit the JIFX website: http://www.nps.edu/Academics/Schools/GSOS/Departments/IS/Research/FX/JIFX/JIFX.html