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CRUSER • NEWS

Consortium for Robotics and Unmanned Systems Education and Research

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

Contents

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Exploring Unmanned System Autonomy in the DoD

by LCDR Nathaniel Spurr, NPS Systems Engineering Student, ncspurr@nps.edu

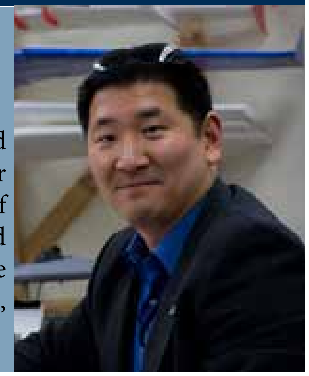
The objective of the Center for Technology and National Security Policy (CTNSP) symposium held on February 24th 2015 at the National Defense University was to foster an open, unclassified discussion regarding the potential that unmanned system autonomy has within the Department of Defense (DoD) in the 2025 timeframe. This topic was of critical importance to the development of SEA-21A's integrated project that seeks to provide a recommended maritime system of systems (SoS) to support over-the-horizon targeting (OTHT) in a contested littoral environment during the same period. The symposium began with a keynote address by General James E. Cartwright, USMC (Ret), former Vice Chairman of the Joint Chiefs of Staff where he emphasized the partnered role of autonomy and human interaction, followed by presentations from various discussion panels comprised of government, military, and industry subject matter experts to address autonomous system limitations, their associated operating environments, and perspectives on current and future military progress.

From the symposium's outset, it was clear that one of the most important points when discussing autonomy (in any capacity) was to first properly define the term. In this day and age of unmanned systems and remotely piloted aircraft (RPA), the word autonomous is often misused. Additionally, it is important to note that there are few (if any) fully autonomous systems currently in use by the DoD. As Paul Scharre of the Center for New American Security (CNAS) defines it in his article "Between a Roomba and a Terminator: What is Autonomy?" "…autonomy is the ability of a machine to perform a task without human input." He continues by defining an autonomous system as "…a machine, whether hardware or software, that, once activated, performs some task or function on its own." This definition implies a certain level of "thinking" or inference by the autonomous machine, thereby suggesting that it is capable of learning. Therefore, describing unmanned systems like Northrop Grumman's MQ-8 Fire Scout, for example, as "autonomous" isn't quite accurate. While some of its tasks such as takeoff and landing have been automated like many of our existing commercial and military aircraft have, they are not truly autonomous in nature because those tasks still require a human to interact with the system through the input of specific waypoints for navigation or defined parameters for takeoff and landing (e.g., desired glideslope, airspeed, and altitude). Additionally, in the performance of these tasks, these systems still require a human "on" the loop (i.e., human supervision), so the tasks, though automated, are not truly autonomous.

With the definitions of and differences between "autonomous" and "automated" established, much of the symposium's discussion focused on the current state of unmanned systems and what progress might be seen in the DoD by 2025. It is important to note that it was of universal agreement by both the panel experts and the audience that implementation of autonomous lethality (or "weaponized autonomy") in the DoD was unlikely for the foreseeable future due to the significant cultural, ethical, and policy concerns surrounding its use. Similarly, there was also mutual agreement across the symposium's attendance that unmanned platforms will always augment manned platforms, with the former unlikely to completely replace the latter in DoD use. This also reinforces Scharre's position that the term "Full Autonomy" (human "out" of the loop) is meaningless and that we should instead focus on "…operationally-relevant autonomy: sufficient autonomy to get the job done." These associated levels of operationally-relevant autonomy will, therefore, continue to have a human either "in" or "on" the loop and keep the current and future DoD unmanned systems focused on the relationship between the human and the machine as autonomy continues to bring the information age into the robotics age.

Director's Corner

Tim Chung, CRUSER Deputy Director



As unmanned and autonomous system capabilities continue to advance and mature, we are further presented with numerous key challenges and opportunities in understanding not just the technologies, but also their tactics, testing and assessment, and even terminology. This edition of CRUSER News highlights some of these key areas, where continued discussion and information exchange continues to help focus, align, and drive progress, while also promoting the introduction of fresh perspectives and innovative approaches. In the face of this rapidly advancing field, such richness and diversity remains essential for addressing, designing, and employing these robotic systems, both in the present and in the future.

Unmanned Underwater Vehicle Independent Test and Evaluation

Authored by William P. Ervin, J. Patrick Madden, and George W. Pollitt in The Johns Hopkins University Applied Physics Laboratory Technical Digest, Volume 32, Number 5 (October 2014) pages 752-761; excerpt reprinted with permission ©The Johns Hopkins University Applied Physics Laboratory. http://www.jhuapl.edu/techdigest/TD/td3205/32_05-Ervin.pdf

The lightweight vehicle class Mk 18 Mod 2 Kingfish unmanned underwater vehicle (UUV) is a larger, extended-range version of the Mk 18 Mod 1 Swordfish man-portable search, classify, and map system currently deployed in several operational theaters. Both systems were developed as Abbreviated Acquisition Programs under the sponsorship of the Staff of the Chief of Naval Operations (OPNAV N957) and guidance of PMS-408 using an informal integrated product team (IPT) organization from requirements development through system development, developmental testing, user evaluation, and operational fielding. The Mk 18 family of systems is based on REMUS vehicles built by Hydroid, Inc., a subsidiary of Kongsberg Maritime.

Figure 1: Mk 18 Mod 1 and Mod 2 UUVs. (Image courtesy of Space and Naval Warfare System Center, Pacific.)

In December 2011, the Office of the Secretary of Defense approved a Fast-Lane initiative to provide Mk 18 Mod 2 Kingfish UUV systems and associated sensors and upgrades to Commander Fifth Fleet on an accelerated basis. Seven months later, in July 2012, wave 1 of the Mk 18 Mod 2 Kingfish UUVs arrived in the C5F area of responsibility to begin search, classify, and map missions as part of a phased incremental-capability rapid-fielding plan that included an extended user operational evaluation system (UOES) period in theater. The purpose of the UOES period was to develop mine countermeasures (MCM) concepts of operations for integration with other MCM platforms in theater and to receive operator feedback that could be used to improve the design. A second wave of Mk 18 Mod 2 UUVs arrived in theater in February 2013. The third wave arrived in October 2013 and included more UUVs and ancillary equipment. Advanced sensors and command and control technologies were demonstrated in theater in November 2013. After undergoing operational testing in February and April 2014, the advanced sensors were provided as operational capabilities. The rapid delivery of these capabilities to meet the commander's operational need was made possible by several factors, including the following:

- A technologically mature system design when the Fast-Lane initiative was approved
- Strong program office leadership of a multi-organizational IPT
- Strict adherence to identified measurable and testable user requirements
- Outstanding testing and feedback support from operational units
- A competitive manufacturer selection process
- A "build a little, test a little, field a little" development process
- Responsive in-service engineering agent support

Figure 2: Civilian crew recovering UUV in 11-m RHIB

In accordance with acquisition policies, OPNAV N957 and PMS-408 have transitioned from an Abbreviated Acquisition Program process to the Joint Capabilities Integration and Development System (JCIDS) process for future development and procurement efforts.

Joint Interagency Field Experimentation
Now Accepting Experiment Proposals

JIFX will be held 11-15 May 2015 at Camp Roberts, CA
Experiment Proposals are due 3 April 2015

JIFX Website: http://my.nps.edu/web/fx

CRUSER Calendar of Events

CRUSER Technical Continuum: 7-8 Apr
CRUSER Robots in the Roses: 14-16 Apr
Monthly Meeting - Mon 4 May, 1200-1250 (PDT)
Monthly Meeting - Mon 1 Jun 1200-1250 (PDT)
details/remote connect at: http://CRUSER.nps.edu

Unmanned Systems in Transition: From War to Peace, From Military to Commercial

by Dr Bill Powers, Research Fellow Potomac Institute for Policy Studies Center for Emerging Threats and Opportunities Futures Assessment Division, Futures Directorate, earl.powers.ctr@usmc.mil

Military procurement and operations are moving from war to peace while unmanned systems research, development, and manufacturing are moving from military to commercial use.

As forces redeploy from operations in the Middle East, the peacetime use of unmanned systems (UMS) by the military will reflect a subsequent decrease. Concurrently, progress is being made to provide access to civil airspace, thus enhancing the potential use of unmanned aerial systems (UAS) by civil authorities and commercial users. As these transitions occur, there will be myriad adjustments required by both manufacturers and users of UMS. This will provide opportunities for UMS to be used in ways that are currently only imagined…or demonstrated via YouTube videos. Commercial use of UMS is poised to become a far larger market than military employment has ever been. Conversely, the advances realized in the commercial sector, especially regarding autonomy, may well be transferable to military employment through the use of commercial off-the-shelf technology.

As of January 2014 there were more than 2400 different unmanned aerial systems available from more than 715 companies; more than 700 unmanned ground systems from 295 companies; and more than 740 unmanned maritime vehicles from 281 companies. The potential exists for unmanned systems to become an integral part of many aspects of our lives in the next few years.

The Association for Unmanned Vehicle Systems International's (AUVSI) economic report projects that expansion of UAS technology alone will create more than 100,000 jobs (70,000 in the first three years) and generate more than $82 billion in economic impact in the U.S. during the first decade following U.S. airspace integration.

UMS are in a commercialization phase and are being used in a variety of civil and commercial applications[1]. Some of the more noteworthy are: aerial and wildfire mapping[2] , agricultural monitoring, disaster management, thermal infrared power line surveys, telecommunication, weather monitoring, television news coverage and sporting events, environmental monitoring, oil and gas exploration, freight transport, law enforcement, commercial photography, advertising, and broadcasting. Academia has recognized the potential and has committed to providing the requisite training and education that will underpin the commercial use of UMS with numerous well-known colleges and universities providing degrees that are UAS and robotics related.

In a recent compendium of future oriented studies focusing on foreseeing, two areas made nearly every list as significant technology areas that will impact the next 30 years: robotics and autonomous systems. There are four primary science and technology (S&T) areas that potentially will radically affect future robotics.

First is neuroscience and artificial intelligence, probably the most contentious. Many scientists claim that advances in neuroscience and artificial intelligence are laying the foundation for giving UMS the ability to reason and decide autonomously. They predict that UMS will become part of the social landscape and that as autonomy and intelligence grows, these systems will raise difficult questions about the role of personal responsibility and "machine rights". The potential dark side to the issue is that systems left to their own devices will enable nearly anyone to employ UMS in a variety of scenarios including as lethal devices.

Second is sensors and control systems that will be necessary to interact safely and effectively with humans. As they become more integrated into society, we will face challenging legal and regulatory issues around how much autonomy robots should be granted. As robotics employment becomes more civil oriented, there will be increasing demand for capable, lightweight, inexpensive payloads that contribute to increased automation and autonomy.

Third is power and energy. Research into advanced power storage and management will enable UMS to operate for hours or days at a time, a necessary step to realizing the full potential of autonomous systems.

Fourth is human-UMS interaction with systems that can partner with humans to perform complex, real-world tasks. In military parlance, this is known as manned-unmanned teaming (MUMT) and in the civilian world, human-robot interaction (HRI). HRI implies a close interaction between the robotic system and the human where robots and humans share the workspace but also share goals in terms of task achievement. This close interaction needs new theoretical models to improve the robot's utility and to evaluate the risks and benefits of HRI for society. In the manufacturing arena, for example, Carnegie-Mellon faculty and students are researching systems where robots and humans can easily swap the initiative in task execution[3]. The demand for commercial systems that are more and more autonomous will increase as users seek to decrease the training required to operate them and decrease the "hands on" nature of systems that are automated but have little autonomy.

The future of UMS is destined to be refined by the transition from military to commercial use but the probable demand for increased capability and autonomy will ultimately present challenges to law enforcement agencies and governments as these technologies are used for activities beyond the peaceful commercial uses for which they are intended. The advances that will almost assuredly occur in autonomy as commercial UMS become more prevalent will make autonomous systems more and more capable and potentially more lethal when used by terrorists or criminals.

1 Market Intel Group (MiG), November, 2010

2 Predators improve wildfire mapping: Tests under way to use unmanned aircraft for civilian purposes, Tribune Business News, August 26, 2007

3 Carnegie-Mellon University Robotics Institute 2005-2010 Research Guide, http://www.ri.cmu.edu/research_guide/human_robot_interaction.html, 10 April 2014.

The Military Operations Research Society (MORS) is soliciting papers for its 83rd Symposium to be held 22-25 June 2015 in Alexandria, VA. Of particular interest is Distributed Working Group 2: Unmanned Systems. This Working Group covers all aspects of unmanned systems in the airborne, ground-based and maritime domains. Topics of interest cover a wide range including platforms and sensors, CONOPS, autonomy, swarming, manned-to-unmanned teaming, modeling, simulation and analysis of unmanned systems, new and novel applications, test results and more. For further information, contacting Larry Bulanda at the Johns Hopkins University Applied Physics Laboratory at: (240) 228-8705.

STUDENT CORNER

Student: LT Ryan Hilger, USN

Title: Acoustic Communications Considerations for Collaborative Simultaneous Localization and Mapping

Curriculum: Mechanical Engineering

Link to Completed Thesis: https://calhoun.nps.edu/handle/10945/44579

Abstract:

This thesis considers the use of acoustic communications in reducing position uncertainty for collaborating autonomous underwater vehicles. The foundation of the work relies on statistical techniques for accurate navigation without access to GPS, known as Simultaneous Localization and Mapping (SLAM). Multiple AUVs permit increased coverage, system redundancy and reduced mission times. Collaboration through acoustic communications can minimize navigational uncertainty by permitting the group to benefit from locally discovered information. However, the propagation of acoustic communications can be used to counter detect the system during naval operations. The thesis gives explicit consideration to tactical security in acoustic communications for a multi-AUV SLAM system. It provides initial techniques and analysis for minimizing communications between AUVs. The reduction is accomplished through a statistical method that allows for the estimation of the updated covariance matrices. Normally, SLAM techniques use expropioceptive (sonar and cameras) sensors and computer vision algorithms for the detection and tracking of navigational references. We propose a novel use of the acoustic modem as another sensor. It leverages the physical characteristics of underwater acoustic transmissions and the information transmitted in the signal to provide an additional measurement. We believe this is the first emphasis on minimizing communications within a multi-vehicle SLAM approach.

Applied Composites Engineering & Unmanned Systems Technology International Partnership

by Kelly Wallace, Applied Composites Engineering

As the UAS industry grows, Applied Composites Engineering (ACE), based in Indianapolis, Ind., has been working to provide composite solutions for the U.S. Department of Defense and private companies.

ACE began working in the UAS industry more than 10 years ago, when the company was contracted to manufacture SAR components for the Predator. ACE also manufactures multiple components for the Fire-X, an unmanned helicopter system with the payload and cargo carrying capabilities of the Bell 407 helicopter, as well as engine shrouds for the TigerShark, a composite UAS with a wingspan of 17.5 feet.

But recently, ACE moved beyond making individual components to collaboratively designing and manufacturing an entire UAS structure - the MX-1.

The MX-1 was initially designed by Unmanned Systems Technology International (USTI), a company based in Monterrey, Mexico that approached ACE at a UAS trade show. At the time, the company had already constructed a prototype out of plywood, foam, and fiberglass, but they were in need of a composites manufacturer who could turn their design into a composites structure and develop tooling for production. They needed the UAS, at 9 feet 8 inches long with a nearly 20-foot wingspan, to be lighter, faster, more durable, and increased endurance.

After obtaining a TAA with the U.S. Department of State, ACE was able to use its composites expertise to design a composite structure in just over seven months, which matched the Outer Mold Line required by USTI while being constructed of advanced composites of high strength and light weight. This process included the use of Finite Element Analysis software to determine whether the number and position of carbon fiber plies would provide the required strength and durability. ACE also designed cost-effective tooling for the project.

ACE delivered the first MX-1 to USTI in March 2014, weighing in at just 65 pounds. A second MX-1 was delivered in November 2014. USTI presented the MX-1 to the Mexican media. In less than 24-hours, USTI was featured in many publications within their state of Nuevo Leon and internationally via social media.

For more information about USTI, contact Jorge Llamas at jllamas@usti.mx or +52 (81) 8122 0304. For more information about ACE, contact Lisa Rybolt at lrybolt@appliedcomposites.com or +1 (317) 243-4225.

Librarian Corner

Remotely Piloted Aircraft: An Integrated Domestic Disaster Relief Plan - http://aupress.au.af.mil/bookinfo.asp?bid=551

Boyle, Michael J. “The Race for Drones.” Orbis 59, no. 1 (2015): 76-94 [http://www.fpri.org/docs/boyle_on_drones.pdf]

Galdorisi, George. “Keeping Humans in the Loop.” US Naval Institute Proceedings 141, no. 2 (February 2015): 36-41. http://www.usni.org/magazines/proceedings/2015-02/keeping-humans-loop

Majumdar, Dave. “The Trouble with High-Tech.” US Naval Institute Proceedings 141, no. 2 (February 2015): 42-47.

Short articles (up to 500 words) for CRUSER News are always welcome
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