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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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Navy Game Changer: QR Code Streaming for Tactical Line-of-Sight Communications

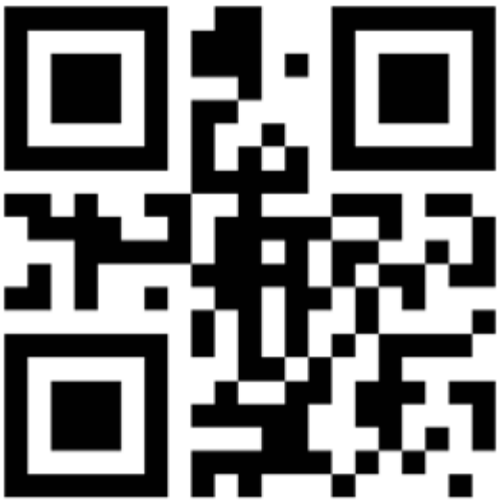
by Phil Richter and Andy Lucas, NPS Students, QR@nps.edu, Dr Don Brutzman brutzman@nps.edu

Over the last several decades, the U.S. Navy's ability to communicate visually has atrophied to the point where it can no longer be relied upon in critical tactical scenarios. Visual communications, such as flag semaphore and flashing light, have been replaced by radio communications and have become the standard for operations today. The drawback to these radio communications is that they can be used to geolocate forces, they can be intercepted and they can be interrupted. QR codes introduce a method for communications that has the potential to reinvigorate visual communications and restore a measure of security to tactical operations.

QR codes are two-dimensional barcodes that have the ability to represent significantly more information than traditional one-dimensional barcodes. Further, they inherently contain an error correction capability of up to 30% of the encoded data.

CRUSER-sponsored research has developed a data flow representing the end-to-end steps required for the transmission of data via QR code from a sender to a recipient. Of the items in the data flow, the most significant barriers to success are the environmental effects associated with large ranges. As range increases, superior technologies are required to overcome environmental effects and capture an image of a QR code with sufficient detail for decoding. To date, the maximum successful range for a QR code transmission has been 750 yards using an Astro 4K studio camera with a 580 mm lens. Potentially readable images were captured in intervals up to 2000 yards, but at these large ranges, optical turbulence and visibility prevented successful scanning without significant image enhancement.

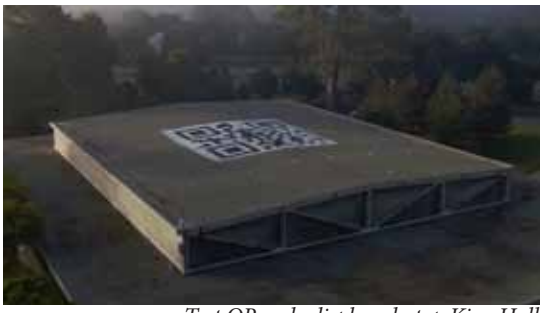
With further research, this technology can have a significant impact on naval communications. Tactical units can establish a secure channel during routine operations, such as formation steaming, well-deck operations, and replenishment at sea, while maintaining radio silence. QR codes can to help the fleet restore its emissions control (EMCON) proficiency in a time when vulnerability to electronic attack is at an all-time high. Improvements with communications when under the restrictions of Hazards of Electromagnetic Radiation to Ordnance (HERO) are also possible. An unexpected area for future work emerged from these studies – the use of a digital flashing light system leveraging existing technologies for visual communication.



http://qr.nps.edu

Key to potential fleet use is NPS implementation of an initial tactical decision aid (TDA) that provides end-users a simple interface for sending and receiving QR code communications. It takes into account all factors end-to-end and is streamlined to be injected directly into traditional communications channels replacing the RF link. Development of this TDA has produced a basic interface using open source QR code libraries and has demonstrated the ability to encode, send, receive, and decode messages. Further development will incorporate optical means for QR code transmission.

The implications of this technology to fleet operations are staggering and must be considered if the U.S. Navy is to adapt to modern warfare threats. Further information on this research can be found by navigating to http://qr.nps.edu.



Test QR code displayed atop King Hall

Director's Corner

In this time of challenging fiscal realities the Department of the Navy's commitment to realizing the operational and economic potential of robotics and unmanned systems is more important than ever. The Naval Postgraduate School, and CRUSER, are important vehicles for realizing these potentials.

Dr Ray Buettner
CRUSER Director

Unmanned Surface Vessel (USV) Concept for Improvised Explosive Device Defeat (IEDD)

by Commander Jeremy Thompson, U.S. Navy/ Johns Hopkins University School of Advanced Int'l Studies, jeremy.thompson@navy.mil

This concept proposal explores a technology solution to the problem of risk to first responders when identifying, neutralizing, and exploiting "surface-floating" maritime improvised explosive devices (SF/MIEDs). When considering the proliferation of technology for use against land-based improvised explosive devices (IEDs), it may be puzzling to many observers why remote IED Defeat (IEDD) technologies (particularly robots) have yet to fully cross over into the maritime domain.

Although some unmanned underwater vehicle programs designed for limpet mine-like object detection on ships are in development , much less attention has been given to countering SF/MIEDs. In general, the purpose of MIEDs is to destroy, incapacitate, harass, divert, or distract targets such as ships, maritime critical infrastructure and key resources (CI/KR), and personnel. MIEDs may also present obstacles (real or perceived) with the purpose of area denial or egress denial.

As a subset of the MIED family, the "surface-floating" MIED operates on the water's surface in environments such as harbors, the littorals, the riparian, and the open ocean. It may be either free floating or self-propelled, with remote control (manual or pre-programmed) or with no control (moves with the current). It is a tempting low-tech, low-cost option for an adversary.

Thankfully, SF/MIED incidents have been rare in recent times, the last significant use occurring during the Vietnam war. Nonetheless, a capability gap is presented by the challenge they present—namely, that a human must unnecessarily expose themselves to the object.

One material solution to a surface-floating IED may be to develop an IED Defeat Unmanned Surface Vessel (USV) around a design philosophy based on IEDD robots used in land warfare. Protection of high-value units and critical infrastructure / key resources would be its primary missions along with counter-area denial. Its most likely operating environment would be CI/KR dense areas such as harbors and seaports as well as the riparian environment since rivers are constricted in the water space available to shipping to maneuver around SF/MIED threats. A key element of design philosophy in an IEDD USV would be to meet the expectations of the customer—the first responder. Military explosive ordnance disposal (EOD) units and civilian bomb squads are much more likely to accept a platform in which the console and all other human interface features are nearly identical in look, placement, feel, and responsiveness as the most popular robots they have been accustomed to operating such as the TALON robot by QinetiQ and Packbot by iRobot. A functional hierarchy could be drawn around major tasks such as re-acquisition of a suspected surface-floating IED, identify/classify, threat removal, neutralization, and recovery of the IED for exploitation. Modularized payload packages to execute these tasks may include a towing package, an attachments package (e.g. hooks, magnets), a neutralization tool package to include both precision and general disruption EOD tools, an explosives, chemical, and radiological detection package, and an electronic counter-measures package.

Figure 1: Surface-floating maritime IEDs used against United States Navy forces in the Mekong Delta, 1969. USS Westchester County assigned to RivFlot 1 was the victim of an attack using bulk explosives buoyed on the surface by inner tubes and initiated by chemical delay pencils. Source: photo courtesy of the Navy and Marine Corps EOD Association.

Numerous trade-offs between weight, power, stability, and the complexity of modular packages would need to be considered and tested, however, variants like a "high-low" combination of a complex and simple USV working together may minimize some of the trade-off risk.
If an IEDD USV were to be developed key recommendations include:

- Official liaison between NAVSEA between PMS-406 (Unmanned Maritime Systems) and PMS-408 (EOD/CREW program) to ensure the transfer of USV expertise between PMS divisions.
- A DOTMLPF assessment to determine whether limpet mines or surface-floating IEDs are more likely and more dangerous to U.S. assets and personnel given the uncertainty of future naval operations.
- Including civilian bomb squads in the design and development process early to increase the potential for demand and cross-over with the law enforcement sector and therefore reduced long term program costs.

[1] Current UUV programs being developed include the Hull UUV Localization System (HULS) and Hovering Autonomous Underwater Vehicle (HAUV).

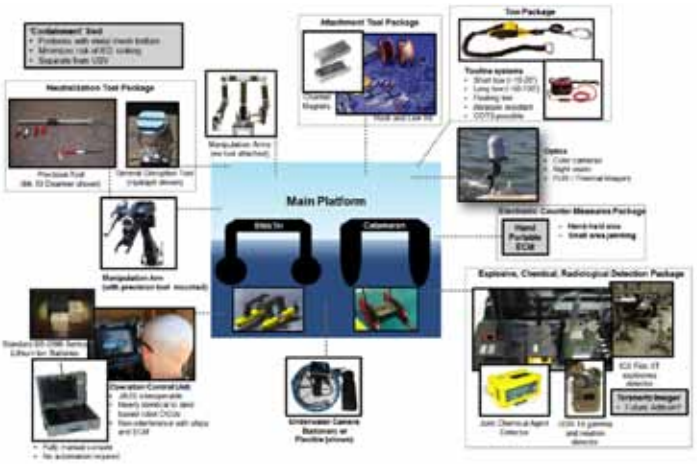


Figure 2: Significant Features of an IED Defeat USV.

Consortium for Kansas Unmanned Systems (CKUS)

by Joel Anderson, Development Director, Kansas State University, Office of Research and Sponsored Programs (ORSP), jdanderson@ksu.edu

The Consortium for Kansas Unmanned Systems is meeting key U.S. and international "Grand Challenges" in autonomous and aviation systems research, development, and integration through focused efforts from Kansas government, academic institutions, and industrial partners.

Kansas brings a rich history of global leadership to the aviation industry. Collaborating across industry, government and academia, we are committed to maintaining U.S. national technical leadership by building on the Wichita "aviation cluster" through engaged involvement in unmanned systems. The Kansas "unmanned systems cluster" includes an expanding technology sector encompassing Overland Park, Olathe, Hiawatha, Lawrence, Manhattan, Fort Riley, Herington, Salina, Neodesha, Augusta and Wichita. We provide a unique opportunity for partners and stakeholders to benefit from Kansaswide capabilities and expertise for:

- Airspace for unmanned systems operations
- Airport support facilities
- Education
- Precision agriculture
- Energy and environment
- University R&D – sensors, airframe, autonomy and control theory
- University flight and operations training and testing
- Data interpretation, analysis, distribution and application
- Technology development and manufacturing

Kansas is home to major aviation manufacturers, industry partners and academic centers of excellence. From the "Air Capital of the World" to "America's Fuel Stop", our industry leaders provide a unique hybrid response to national and international manned and unmanned aviation research, application and technical solution development. Our influence spans a technical landscape bridging aviation and autonomous systems technologies to education, precision agriculture, energy, environment and advanced manufacturing.

Our academic institutions, involved in focused science, technology, engineering and math (STEM) related activities support local, regional, national and international interests and needs.

Examples from Kansas academia include:

➢ Kansas State University Salina-as an outgrowth to its leading collegiate aviation department, the Salina campus established the Unmanned Aerial Systems Program Office in 2008. The program uses a hands-on approach for learning and attaining the skills needed to safely operate and manage unmanned systems. K-State is one of the first universities in the U.S. to offer a bachelor of science in unmanned aircraft systems. K-State Salina's proximity to accessible restricted airspace creates an ideal setting for operational training and testing of unmanned systems.

➢ The University of Kansas is the lead institution for the Center for Remote Sensing of Ice Sheets (CReSIS). The university's aerospace engineering department has developed the 1100 pound, 26-foot wingspan Meridian UAV as the Center's semi-autonomous, ice-sounding flight vehicle. With a range of approximately 1,000 miles and an endurance of up to 12 hours, the UAV is designed to augment crewed flights in the unforgiving Polar Regions in the effort to form a digital elevation map of the bedrock beneath Antarctica and Greenland.

➢ Wichita State University's College of Engineering and National Institute for Aviation Research (NIAR) offer significant research and testing capabilities for a wide range of unmanned systems' related subjects including aerodynamic characteristics, material selection, susceptibility to environmental factors, human factors, network security, computational analysis and advanced coatings. Wichita State has a strong history of supporting aviation research, including unmanned systems, and currently ranks third in the nation for aeronautical research and development expenditures.

Kansas provides vital contributions and synergy for research and development, advanced manufacturing, and technology innovation. Our institutions provide focused and collaborative response in meeting a variety of our nations "Grand Challenges." The aim of the Kansas consortium is to effectively and efficiently support keeping the U.S. at the forefront of cutting-edge technology, manufacturing and innovation in order to drive job creation, economic growth and sustain U.S. international competitive advantage.

For more information, CKUS website: http://www.k-state.edu/ckus/

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

Faculty Position Autonomous Maritime Systems at Naval Postgraduate School, Monterey, CA

The Department of Mechanical and Aerospace Engineering seeks applicants for one tenure-track faculty position at the assistant professor level in Dynamic Systems and Control with emphasis on Autonomous Systems with expertise in surface vehicles, underwater vehicles and robotic systems. Candidates must have an earned Ph.D. in Mechanical/Aerospace engineering or a closely related field. They must have the ability to teach at the graduate level, obtain a security clearance, and create nationally recognized research programs. Full description and application details available at:

http://www.nps.edu/Academics/GSEAS/MAE/docs/Faculty_Position_Ad_UW_2013_050113.pdf

Upcoming CRUSER Monthly Meetings

Wed 19 June 2013, 1200-1250 (PDT)
Root 272, VTC, or dial-in 831-656-6685
Wed 17 July 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: LCDR Eric L. McMullen, USN, MAJ Shane Grass, USA

Title: EFFECTS OF UAV SUPERVISORY CONTROL ON F-18 FORMATION FLIGHT PERFORMANCE IN A SIMULATOR ENVIRONMENT

Curriculum: Modeling, Virtual Environments, And Simulation (MOVES)

Abstract: Continual advances in technology, along with increased cockpit workload particularly the shift from two-seat to single-seat fighters to save money and reduce risk to lifepush the limits of human mental capacity. Additionally, there is interest within the military aviation community to integrate Unmanned Aerial Vehicle (UAV) control into the cockpit in order to expand force projection capability. This study compared the effects on formation flight performance of two different secondary tasks, specifically a traditional secondary task such as target prosecution with an electro-optical Forward Looking Infra-Red (FLIR) pod, and a futuristic secondary task such as UAV supervisory control. A total of 34 military fighter aviators volunteered to fly three five-minuteF-18 simulator sessions in close formation with no secondary task, and then treated with each of the two secondary tasks. Results provided clear indication that the futuristic task was significantly more challenging than the traditional task, and that both secondary tasks significantly increased the average mean following distance and variance compared to the undistracted flying baseline scenario. Additionally, we found no evidence that increased flight experience (total flight hours) significantly improved performance of the prescribed primary task when treated with the futuristic task distraction. Knowledge gained from the results could contribute to improved crew resource management (CRM) and pilot workload management as well as flight safety resulting from the modification of flight procedures based on known effects of distractions in the cockpit.

Graduating Mechanical Engineering students take-off

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

Fredericton, NB - Some graduating UNB mechanical engineering students showed their peers how to fly last week- fly airplanes.

The two groups of three, Devin Hardy, Dylan Gullison, John Matthew Black, and Brad Van Steeg, Christopher Dube and Adam Turner, set up their COBRA (COllaboration Based Robotics and Automations) Unmanned Arial Vehicle (UAV) launchers in the bustling Head Hall, to show students how they made their visions take flight.

The groups have been working on their launchers with electrical engineering faculty and graduate students all year as their senior design project. After a year of hard work, they recently got to see their creations in action.

Gullison said seeing his group's plane in the air was a sign the work finally paid off. "It was one of those moments when you get to see everything you worked so hard on finally come together," he said. "It's been a year, long project with hundreds of hours put in between all of us. And seeing [the launcher] successfully launch a plane is what we deemed as having the project a success."

Though one of the planes had a rough take-off, Brad Van Steeg said when the planes finally took off, the air was full with excitement. "[I felt] Joyful. Arms were in the air, and big smiles were on the faces. It was a good feeling for sure. I couldn't describe any other way," said Van Steeg. "Seven months of hard work paid off. To see that plane actually stay in the air was a happy sight."

The project allowed the students to use the theoretical knowledge they learned in class, and apply it to real situations. Black said building the COBRA UAV launcher helped him gain practical experience he needs for the real-world.

"It's important because for a lot of people, you're not going to stay in school after you graduate…You're going to go to work right away, so you need that practical experience," said Black. "Not just with building stuff…but working with other people and group dynamics and learn how to manage your time, budget, and schedule, all that stuff."

Van Steeg said the communication skills are one of the most important skills gained from the experience. "You have to deal with different classmates as well as advisors, as well as material providers, machinists, different people that give us different information that we need to complete the whole project," he said. "I'd say the biggest thing is dealing with people, which you don't usually get to do in the classroom."

Though building a COBRA UAV launcher was an educational experience, Christopher Dube said it was a fun one too."I enjoyed it. It was a lot of fun. It was a very interesting project and I got to work with some really cool people," he said.

Carl Thibault, whose research interests include unmanned aerial vehicles, worked closely with the undergraduate students during the construction of their project, which began in September 2012. Thibault is a graduate student in the Department of Electrical and Computer Engineering. "Working closely with senior design teams is a very rewarding experience," said Thibault. "As a mentor you see three people take an idea and turn it into reality. Being a mentor also means you learn with them. Working with a team of motivated individuals is all about encouraging inspiration and innovation while making sure the project can be finished and the students will graduate. Going from a concept to a working machine is not an easy task and everyone did exceptionally well. Both teams were determined and worked hard to design a usable and safe system. Their determination in the face of setbacks was rewarded with a sweet victory on the first successful launch," he said.

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 have helped us to become successful at what we do," said Dr. Li. "Because of that, we've been able to form connections with the unmanned industry, both in Canada and beyond. Our research projects also provide excellent training opportunities to the next generation of engineers. We provide students with hands-on career-related experience and training. The University of New Brunswick and the faculty of engineering are playing a large role in providing high quality education to young talent from across the country."