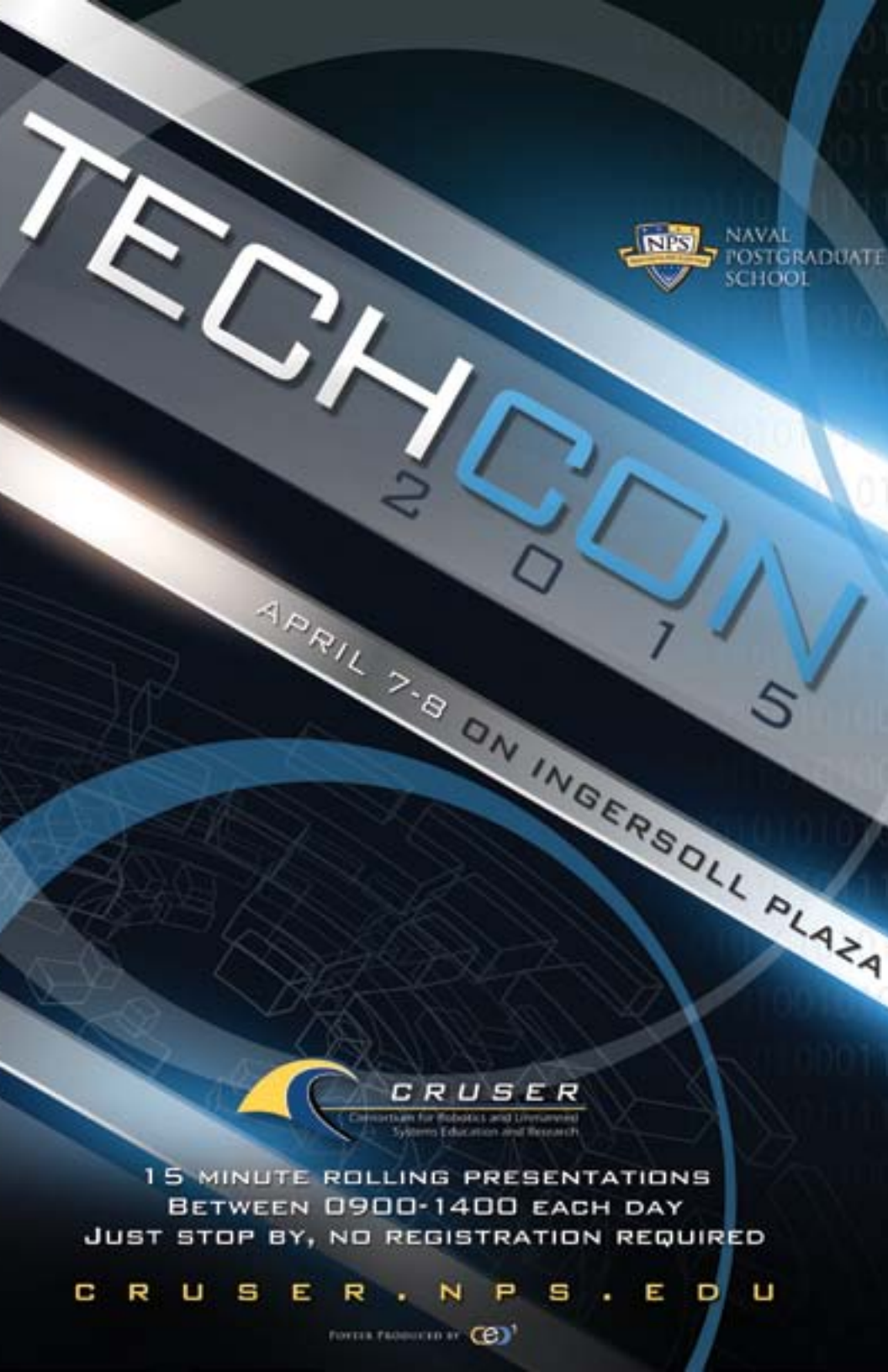

TECHCON
2015
NAVAL POSTGRADUATE SCHOOL
APRIL 7-8 ON INGERSOLL PLAZA
CRUSER
Consortium for Robotics and Unmanned Systems Education and Research
15 MINUTE ROLLING PRESENTATIONS
BETWEEN 0900-1400 EACH DAY
JUST STOP BY, NO REGISTRATION REQUIRED
CRUSER.NPS.EDU
POSTER PRODUCED BY

Tuesday 7 April 2015

0900 Dr Ray Buettner, CRUSER Director

0905 Dr Timothy Chung - “Advancing Swarm and Counter-Swarm UAV Capabilities and Technologies”

0925 Prof Peter Guest, LT Chris Machado, USN - “Are Atmospheric Measurements from Miniature Multi-Rotor UAS Accurate Enough to Provide Useful Data on Electromagnetic and Meteorological Conditions in the Vicinity of US Navy Ships?”

0945 Prof Xiaoping Yun, James Calusdian - “A MATLAB Interface for the P3-DX Mobile Robot”

1005 Prof Peter Chu - “Glider and Ship Measured Underwater Optical Characteristics for Naval Operations”

1025 Prof Ronald Giachetti - “Agent-based Simulation of System-of-system Architectures Combining Manned and Unmanned Air Vehicles”

1045 Mr Curtis Blais - “Representation of Unmanned Systems in Naval Analytical Modeling and Simulation”

1105 Prof Ric Romero - “Adaptive Beamsteering for Search-and-Track Application with Cognitive Radar Network”

1125 Prof Qing Wang - “Autonomous Wave Gliders for Air-sea Interaction Research”

1145 LT Shannon Zoch, USN - “An Efficient Routing Protocol for Dynamic Flying Ad-Hoc Networks (FANETs).”

1205 Dr Kristin Giammarco, Dr Mikhail Auguston - “Advancing Model-Based Design and Assessment of Robotics and Unmanned Systems”

1225 Dr Kevin B Smith, Prof Roberto Cristi, LT Renato Peres Vio, Brazilian Navy - “Real-time undersea networking using acoustic communications for improved UUV positioning and collaboration”

1245 Dr Richard C. Millar, LT Matt Kiefer, USN - “Development of a Process for Airworthiness Assessment of Unmanned Aircraft ”

1305 Prof David Jenn - “Wireless Power Transmission for Battery Charging and AUV/UAV Power Applications”

1325 LT Raymond Davis, USN, LT Patrick Livesay, USN - “The Design and Optimization of Swarm Capable, Smart UAV Launchers”

1345 Dr Douglas Horner - “AUV Operations in Extreme Environments: Under-Ice Operations”

Wednesday 8 April 2015

0900 Dr Ray Buettner, CRUSER Director

0905 Dr Kevin Jones, Dr Qing Wang - “Low-Cost Expendable UAS with Application to Lower Atmospheric Measurements”

0925 LCDR Brian Judy,USN and SEA21A - “Organic Surface Combatant Over-The-Horizon Targeting for 2025 and Beyond”

0945 Prof Isaac Kaminer, Ms Claire Walton - “Optimal Motion Planning for Search of Uncertain Targets and Defense against a Swarm Attack using UxSs”

1005 Dr Kwang sub Song, Prof Peter Chu- “Conceptual Design of Future Undersea Unmanned Vehicle (UUV) System for Mine Disposal”

1025 Prof Noel Du Toit - “Robotic Outposts: Enabling Persistent AUV Operations”

1045 LT Douglas McIntosh, USN - “Preventing Encroachment by Hobby Grade Small Unmanned Aerial Systems”

1105 Prof Marcello Romano, Mr Alessio Grompone - “Artificial Vision Estimation of Relative Motion of Autonomous Vehicles”

1125 LT David J. Cummings, USN - “Viability of Open Source Software in Department of Defense Unmanned Aerial Systems”

1145 Prof John Joseph - “Application of ocean gliders in tactical oceanography: Characterizing ambient noise”

1205 Mr Sean Kragelund - “Intelligent Sensing: Initial Results with an ATLAS sonar on the NPS SeaFox USV”

1225 Capt Scotty Black, USMC - “The Missions, the Tactics, the Implementation: a Simulation for Aerial Combat Swarms”

1245 Dr Joshua H. Gordis, Ms Claire Walton - “On the use of UxVs in Seabasing Cargo Transfer ”

1305 LT Fatih Sen, Turkish Air Force - “The Use of Unmanned Combat Aerial Vehicles in Conjunction with Manned Aircraft to Counter Active Terrorists in Rough Terrain”

1325 LTJG Salim Unlu, Turkish Navy - “Assessing the Tactical Effectiveness and Performance of Prospective ASW Unmanned Surface Vehicles in Naval Convoy Operations”

1345 Prof Susan M Sanchez - “Closing Capability Gaps: Data Farming Methods for New Concept Exploration in the CRUSER Community”

Dr. Timothy Chung
NPS Systems Engineering Department

Title: Advancing Swarm and Counter-Swarm UAV Capabilities and Technologies

Abstract:
With continued concept development and advances in technologies, the realization of swarm unmanned system capabilities continues to accelerate, with growing interest, increasing operational relevance, and demonstration events helping to drive this area of research forward. This presentation highlights the numerous research activities and aligned student and collaborative efforts in support of the Aerial Combat Swarms initiative for Swarm versus Swarm UAVs, led by the NPS Advanced Robotic Systems Engineering Laboratory (ARSENL). Several key thrusts have recently been pursued and actively advanced to include novel contributions across many facets of the autonomous systems spectrum. Such efforts include the design, development, and field testing of a new Swarm UAV Concepts of Operations, which not only facilitates the employment of swarm UAVs but also emphasizes the deployment constructs necessary to launch, command, manage, and (optionally) recover such a system of systems. Similarly, to support and advance the state-of-the-art in human-swarm interaction, we have initiated a number of student and collaborative efforts to develop novel user interfaces for the "swarm operator" and conduct validation studies of the impact of human factors of such systems. These models of future interactions with swarm UAVs have necessitated both the investigation and design of new swarm tactics as well as the accelerated development and engineering of the requisite underlying technologies. Further, advances in modeling, simulation, and software engineering capabilities to promote concept exploration while simultaneously enabling rapid transition and implementation for field-ready systems have also greatly contributed to the swarm UAV testbed's operational and academic relevance. Other highlights addressed in this presentation include the implementation details, integration challenges, and impact of communications, command and control, and computational considerations in the large-scale, live-fly swarm UAV capability of interest. Additionally, we showcase a number of specific swarm UAV contributions in analysis and/or technology development by associated researchers, students, and collaborators, and further reinforce ARSENL's vision and roadmap for achieving our stated goal of live-fly demonstration of 50 versus 50 swarm UAVs.

Notes:

Prof Peter S. Guest, LT Chris Machado, USN
NPS Meteorology Department

Title: Are Atmospheric Measurements from Miniature Multi-Rotor UAS Accurate Enough to Provide Useful Data on Electromagnetic and Meteorological Conditions in the Vicinity of US Navy Ships?

Abstract:
Atmospheric structure and meteorological conditions over the ocean can have major impacts on US Navy missions. Humidity and temperature profiles strongly affect the transmission of electromagnetic (EM) radiation. If the humidity decreases rapidly with elevation, an electromagnetic duct will form, which results in greatly extended radar, communication, jamming and electronic surveillance measure ranges. Decreased ranges will occur when the humidity increases with elevation, a feature known as subrefraction. The Navy currently has no operational capability to directly quantify these important features and relies on numerical models to provide forecasts of EM propagation. However, recent field programs showed that these weather forecast models have poor skill in predicting these important EM features, resulting in a major gap in the Navy's Battlespace Awareness capability, especially with the recent emphasis on Electronic Maneuver Warfare.

One possible solution to this problem is the use of unmanned aerial systems (UAS) to perform in situ meteorological measurements and directly quantify EM propagation conditions. Several such systems could potentially be used, but all come with costs in terms of equipment purchase and maintenance, personnel, safety, ship deck space and air space. Inexpensive, miniature multi-rotor UAS capable of vertical take off and landing and operation by just one person represents a potential cost-effective solution for determining EM and lower atmospheric conditions in marine environments.

For the last two years, the authors have performed experiments with the PSI InstantEye quad-rotor UAS to explore its use as an atmospheric sensor platform. Although fixed-wing UAS have been used successfully and extensively by the meteorological community for atmospheric measurements, the use of miniature multi-rotor UAS for this purpose has not been reported in the literature. There is a concern that the effects of the rotor wash contaminate the measurements. However, until now, there have been no published studies that have quantified the prop wash and other potential negative effects on the accuracy of measurements using multi-rotor UAS.

To address this shortcoming, the authors performed a series of accuracy tests at Camp Roberts by flying an InstantEye UAS with a radiosonde (with temperture, humidity and pressure sensors) payload alongside a calibrated meteorological tower to quantify the prop-wash and other potential contamination effects. These tests were performed under a variety of meteorological conditions. We found that above about 5 meters elevation, the prop wash effects are negligible. During unstable conditions (surface warmer than the air) the UAS/radiosonde system had large variations, but these were determined to be natural turbulent fluctuations. By performing several measurements over a period of 1 -5 minutes at each level, the turbulent fluctuations averaged out and reasonable accurate profiles of mean temperature and humidity profiles were obtained. In stable (surface colder than air) low wind situations, the lower levels (below 5 m) were mixed by the prop wash and therefore it was not possible to resolve the temperature and humidity gradients directly. This presentation will provide details on the results of these several accuracy tests.

Notes:

Prof Xiaoping Yun and James Calusdian
NPS Electrical and Computer Engineering Department

Title: A MATLAB Interface for the P3-DX Mobile Robot

Abstract:
Within the field of robotics, there is the need for an environment in which to build and develop robot applications. Many solutions have been developed for this including Player/Stage from the University of Southern California, Carmen from Carnegie-Mellon University, and Microsoft Robotics Developer Studio. Undoubtedly, one of the most popular and successful application development environments is the Robot Operating System (ROS) from Willow Garage, which is a collection of open-source libraries and tools. ROS has become the standard for robotics engineers and researchers worldwide. Its architecture facilitates the collaboration of researchers through the use of packages that are available for download from their websites.

In spite of its versatility and popularity, ROS requires some degree of experience to be used to its full potential. For teaching an introductory robotics course to a broad range of students who take it as an elective while pursuing studies in such diverse areas as communications, signal processing, power electronics, cybersecurity, and electromagnetics, it is highly desirable to have an easy-to-use MATLAB-based interface for students to program and conduct robot experiments. MATLAB is now the programming language of choice for most engineering students to analyze data and visualize experimental results with various graphical plotting tools. In this presentation, a simple interface that uses MATLAB to communicate and control the P3-DX Mobile Robot will be described.

The P3-DX is one of several models of mobile robots manufactured by Adept Mobile Robots, LLC. The robot is equipped with an array of sonars for sensing obstacles, wheel encoders for odometry, and bumpers to detect collisions. At the heart of the P3-DX is the Advanced Robot Control and Operations Software (ARCOS), which runs on the robot's installed microcontroller. ARCOS handles all of the low-level control of the robot, such as, operating the motors, tracking wheel encoder signals, reporting sonar data, and communications with a connected client. ARCOS has a client-server architecture where the user is required to develop their own client application to communicate with the ARCOS server. Since the ARCOS server manages the low-level control of the robot, this architecture allows the user to focus on the higher-level functionality of the robot control application.

The MATLAB interface directly communicates with the P3-DX ARCOS server. Since the interface is completely implemented in MATLAB, it is easy to use by engineering students already versed in the use of this high-level language. A prototype of the MATLAB interface has been successfully used by students in the ECE robotics course, and the student response was very positive. It allows students to focus on studying robotics concepts such as navigation, motion planning, and mapping without the burden of learning a new programing language. For future work, we plan to enhance the interface with more features and functions, and to make it available for use by other researchers and educators.

Notes:

Prof Peter Chu
NPS Oceanography Department

Title: Glider and Ship Measured Underwater Optical Characteristics for Submarine Minefield Navigation

Abstract:
Bioluminescence is most commonly observed as a result of a ship or other surface craft moving through a body of water containing a population of luminous organisms. The turbulence attributed to the ship's transit mechanically stimulates the luminous display. A ship in this situation is often clearly outlined a by a "glowing" bow wave and stern wake that persist for a distance equal to or greater than the ship's length. Two students, LCDR Ramon Martinez and LT Mary Doty, have been working closely with Peter Chu on analyzing historical hydrographic and optical (bioluminescent, chlorophyll-a, fluorescence, backscattering) variables for the East Asian Marginal Seas and Persian Gulf collected by the NAVO 's ships and gliders. LCDR Ramon Martinez has completed his thesis entitled "Bio-optical and hydrographic characteristics of the western Pacific Ocean for undersea warfare using SEAGLIDER data". LT Doty is working on her thesis entitled "Bioluminescence and optical variability in the South China Sea." The immediate naval application is the use of marine bioluminescence in the detection or tracking of either surface or subsurface vessels during darkness. Specifically, submarines are known to operate at depths of zero to 50 meters and in coastal waters where bioluminescence is most abundant. Submarines, therefore, may mechanically stimulate bioluminescent organisms, and light produced may be detected by low light level image intensifiers mounted on aircraft or other platforms. The statistical characteristics of underwater optics and their applications are presented.

Notes:

Prof Ronald Giachetti
NPS Systems Engineering Department

Title: Agent-based Simulation of System-of-system Architectures Combining Manned and Unmanned Air Vehicles

Abstract:
The presentation describes a simulation modeling intended to support development of system-of-system (SoS) architectures combining unmanned vehicles and manned vehicles. The agent-based modeling paradigm provides an intuitive modeling approach because it represents each real-life system with a corresponding model agent with representative properties and behavior. Agent-based simulation allows for the emergence of SoS-level behavior due to the interactions between the agents which is an important means to verify and validate SoS architectures. We model communication and electronic warfare with physics-based models, which is an improvement over many military simulation frameworks using exogenously defined probabilities. We model navigation as a leader-follower pursuit because we assume navigation is done by the manned vehicles and unmanned vehicles follow the manned. Ingress and regress routes are determined during pre-mission planning. Pre-mission planning is done on the ground and out of scope for the simulation -- it is a model input. Flight dynamics describing the vehicle's flight is represented based on average performance during each phase (e.g., climb, cruise, descend) of the overall flight profile. We do not do the more precise six-degree of freedom motion because the greater precision available with six-degree of freedom modeling does not enhance our ability to understand SoS behavior. The base simulation scenario is strike against integrated air defense system (IADS) starting with ingress, engagement, and regress. In the scenario each vehicle is assigned a role, where a role is a higher-order concept of the vehicle's function in the SoS. The user inputs the types of vehicles, number of vehicles, vehicle properties, and their roles. The mission plan is an input as well. The simulation output is the measures of effectiveness and performance for the SoS and the individual vehicles. The intended purpose of the simulation model is to enable architects to verify and validate operational architectures, and to identify vehicle-level, coordination and control, and operational activity improvements with their estimated SoS level impact.

Notes:

Mr Curtis Blais
NPS Modeling, Virtual Environments and Simulation Institute

Title: Representation of Unmanned Systems in Naval Analytical Modeling and Simulation

Abstract:
Combat models are used in major acquisition assessments supporting Quadrennial Defense Reviews for Naval system acquisition and future force structure decisions. For example, the Navy has been adding capabilities to the Synthetic Theater Operations Research Model (STORM) originally developed by the US Air Force. Similarly, the Army and Marine Corps employ a specific analytical model called the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) to evaluate major proposed changes in materiel and associated warfighting operations and tactics. The CRUSER Charter identifies numerous Naval initiatives for study and development of unmanned systems. With such current initiatives and high-valued procurements occurring with respect to unmanned systems, there is concern that expected improvements to warfighter effectiveness, through tactics, techniques, or procedures, are not well supported by analytical processes and findings.

Models such as STORM and COMBATXXI serving as the basis for major procurement decisions are largely deficient in representations of such emerging systems, making it impossible to conduct studies investigating future force structures (e.g., 2020 and beyond) requiring planning and acquisition decisions in the near-term. Instead, decisions are being made without an analytical basis that can show the benefits, limitations, and challenges (manpower, training, logistics, combat service support, vulnerabilities, etc.) of introduction of such systems into the battlespace. The current project is investigating current and planned capabilities of critical Naval analytical models, such as STORM and COMBATXXI, to identify improvements needed in representations of unmanned system capabilities thereby improving the scope and value of studies conducted using such tools. This is an initial effort to bring improved representations of unmanned systems into analytical environments, recognizing that it is part of a larger need to bring such representations into gaming environments for concept exploration, into constructive simulations for experimentation and mission planning, and into training environments for low-level (operator) to high-level (staff) skill development. This presentation will report on findings to date and work to be completed through the remaining period of performance.

Notes:

Prof Ric Romero
NPS Electrical and Computer Engineering Department

Title: Adaptive Beamsteering for Search-and-Track Application with Cognitive Radar Network

Abstract:
Unmannned systems employ various feedback subsystems to bring some form of intelligence in the design. Various intelligent systems and subsystems have emerged. In radar, a recent development is called cognitive radar (CR), which is unlike a traditional radar system in that previous knowledge and current measurements obtained from the radar channel are used to form a probabilistic understanding of its environment. Moreover, CR incorporates this probabilistic knowledge into its task priorities to form illumination and probing strategies thereby rendering it a closed-loop system. In this presentation, we demonstrate a multiplatform CR network for integrated search-and-track application. The two radar platforms cooperate in developing a four-dimensional probabilistic understanding of the channel. The two radars also cooperate in forming dynamic spatial illumination strategy, where beamsteering is matched to the channel uncertainty to perform the search function. Once a target is detected and a track is initiated, track information is integrated into the beamsteering strategy as part of CR's task prioritization.

Notes:

Prof Qing Wang
NPS Meteorology Department

Title: Autonomous Wave Gliders for Air-sea Interaction Research

Abstract:
The Wave Glider (WG), built and introduced by Liquid Robotics in 2008, is an autonomous ocean vehicle completely powered by ocean waves. This slow-moving platform makes it feasible for long-term deployments and data collection, especially in data sparse regions or hazardous environments. In particular, WG can be used for meteorological and upper oceanic data collection in these data sparse area. The standard WG hosts a meteorological station (Airmar PB200) that samples air pressure, temperature, and wind speed and direction about 1 m above the ocean surface. WG automatically transmits 10-minute averaged data from the Airmar through the Iridium Communications satellite network. In an effort to evaluate the Liquid Robotics installed Airmar and seek alternative sensors suitable for air-sea interaction studies, we developed an independent suite of meteorological and oceanographic sensors. NPS measurements include pressure, air temperature, wind, sea-surface temperature, and surface waves. Under CRUSER support, we have deployed WG and new instrument suite three times, collocated with NPS Marine Air-Sea Flux (MASFlux) buoy with proven flux, mean, wave, and SST measurement capabilities for comparison and validation. In this presentation, we will present an evaluation of the WG default meteorological sensor suite first followed by an introduction of the new sensor suite NPS developed. Our initial analyses on data from the new sensor package will be compared to the MASFlux buoy based measurements. We will also present results of surface fluxes of momentum, heat, and water vapor using the mean measurements from the new sensor suite as input to a surface flux model. Finally, we will present a prototype of the WG sensor suite to include turbulence measurements under current CRUSER support.

Notes:

LT Shannon Zoch, USN
NPS Electrical and Computer Engineering Student

Title: An Efficient Routing Protocol for Dynamic Flying Ad-Hoc Networks (FANETs).

Abstract:
Of all Mobile Ad-Hoc Networks (MANETs), Dynamic Flying Ad-Hoc Networks (FANETs) propose an especially unique challenge for developing, maintaining, and updating routes. The factor most contributory to this challenge is the rapid speed at which the aircraft are moving. For example if two aircraft have a radio range of 1 km and are moving at the relatively slow airspeed of 20 m/s and just passed they would be out of radio range in only twenty-five seconds. This necessitates a very efficient routing protocol that can quickly converge and quickly heal when routes are no longer valid. Current Ad-hoc protocols fall into two general categories: proactive and reactive. Reactive protocols are on-demand as a route is found when it is needed. Ad-hoc On Demand Distance Vector (AODV) is currently the most popular reactive routing protocol. Proactive protocols attempt to maintain up-to-date routing tables with regular polling on a set periodicity. Optimized Link State Routing Protocol (OLSR) is currently the most popular proactive protocol. However, both of these methods have disadvantages. In AODV, overhead is required to find routes when needed if they have not been established and in a Dynamic FANET this will occur often. For OLSR, the dynamic network will demand massive overhead to attempt to maintain accurate routing tables. A protocol which has been developed to attempt to overcome these weaknesses is the Reactive-Greedy-Reactive (RGR) protocol. The RGR protocol uses AODV initially and if the AODV route is found to be broken while a packet is in route, the packet uses Greedy Geographic Routing to continue routing the packet. Greedy Geographic Routing utilizes the shared GPS position of the aircraft to continue forwarding packets in the correct direction (geographically). The disadvantage of this is the added overhead of sharing the GPS coordinates through the AODV protocol. For my Thesis I propose a variant of the Greedy Geographic Routing that utilizes the health status messages, GPS coordinate messages, and speed/bearing messages already shared by the Unmanned Aerial Vehicle (UAV) swarm in conjunction with Angle of Arrival data to do local Greedy Geographic Routing for local traffic and a variant of AODV for traffic beyond a couple of hops.

Notes:

Dr Kristin Giammarco and Dr Mikhail Auguston
NPS Systems Engineering & Computer Science Departments

Title: Advancing Model-Based Design and Assessment of Robotics and Unmanned Systems

Abstract:
This cross-cutting research advances the design processes used to develop operational and technical descriptions for and conduct evaluations of robotics / unmanned system architectures by modeling the environment (people, facilities, other systems) as well as the systems under design. In FY14, the best practices of traditional architecture were captured in a Lab Manual for Systems Architecting and Analysis, to lay the foundation for FY15 advancements that the Monterey Phoenix approach and language brings with its separation of concerns about behavior and interaction - concerns that are, in current practice, traditionally interwoven as hard-coded constraints on multi-actor activity models, or otherwise limited to stochastic simulations that address in comparison only a small subset of possible behaviors. MP restructures the very process by which system behaviors are modeled by chunking them into distinct, reusable agent (actor) models of possible agent behaviors, modeling agent interactions as separate constraints (in what is called an abstract interaction specification), and computing every possible permutation of agent behavior with every other possible agent behavior automatically from these models, to generate an exhaustive set of possible scenarios up to a specified scope limit. Setting a scope limit (e.g., a scope of 3 limits any behavior loop to three iterations) leverages the small scope hypothesis (from Daniel Jackson at MIT), which states that most of the types of flaws present in a design can be exposed on small examples.

This presentation takes the audience on a quick tour through the traditional, state of the art architecting practices as applied to the modeling of a UAV for use in a Search and Rescue (SAR) mission, and then present a recently created Monterey Phoenix model of UAV Concepts of Operations (CONOPs) being evaluated for implementation at Camp Roberts, highlighting several general advantages of modeling operational (business) processes in MP. The presentation concludes with future work planned through FY15, including exposure and incorporation of swarm failsafe behaviors into a design through models of unmanned/robotic agents interacting with each other and with the human controllers, and a glimpse into the types of analyses that will be possible by continued development of MP models into FY16 and beyond, such as assertion checking and visual filtering of information about a design.

Because of the fundamental nature of this behavior modeling and analysis capability, it has implications for the design of any type of unmanned/robotics system concept. Anyone who designs robotics/unmanned system architectures should consider supplementing their current strategies with this new approach to modeling and exposing behaviors of their system under design.

Notes:

Dr Kevin B Smith, Prof Roberto Cristi, LT Renato Peres Vio, Brazilian Navy
NPS Physics Department, NPS Physics Student

Title: Real-time undersea networking using acoustic communications for improved UUV positioning and collaboration

Abstract:
The primary objective of this work is the enhancement of the navigational and positioning accuracy of autonomous underwater vehicles through the use of autonomous surface vehicles as navigation and communication gateways. For the first year of this project, we successfully integrated a Teledyne-Benthos acoustic modem onto one of the Littoral Glider UUVs, and a towed acoustic modem system was integrated into one of the Wave Glider USVs. The acoustic modem installed onto the Littoral Glider is interfaced with the on-board science computer, which has the ability to interface with other sensors and the glider's command-and-control system. The development of algorithms that will allow the gliders to obtain improved estimates of positions, and adjust their navigational operations to meet mission objectives, was also initiated. In the second year of this project, we have begun to collect at-sea data in order to test these algorithms, and will expand the system to include a second Littoral Glider UUV and a second Wave Glider USV with integrated acoustic modems. With two Wave Gliders deployed simultaneously, the glider's position can be triangulated for even better position estimation. And if similar data links are established between multiple submerged Littoral Gliders, the overall system accuracy can be further improved. In addition to using basic time-of-flight calculations based on simple direct path propagation, the gliders sample information about the environment, including sound speed profiles. Some relatively straight-forward ray tracing algorithms can be incorporated to refine the propagation distance from time-of-flight measurements. Subsequent improvements in accuracy will be quantified from this approach.

Notes:

Dr Richard C Millar, LT Matthew Kiefer, USN
NPS Systems Engineering Department, Systems Engineering Student

Title: Development of a Process for Airworthiness Assessment of Unmanned Aircraft

Abstract:
The diversity and criticality of military aircraft missions and development has bred a rigorous process for evaluation and containment of flight test hazards and risks, resulting in a well-earned reputation for exemplary experimental and developmental flight safety standards. Unmanned aircraft development, with its freewheeling build/test/fix paradigm (enabled by the lack of a pilot aboard) is now being harnessed to exploit unmanned aircraft systems' (UAS) potential for greater effectiveness with minimal risk to the human in the command loop, despite the inherent complexities and vulnerabilities added by remote command and control.

The culture clash between the details-oriented, bottom up, manned aircraft developmental airworthiness assessment process and UAS development and flight test practices has hindered experimental flight test of military UAS, threatening the benefits of low developmental cost with rapid response to emerging threats and opportunities. To remain militarily competitive we need to tighten the developmental decision loop while maintaining negligible levels of threat to test personnel, property and the general population (in increasing order of importance).

An initial study exposed this mismatch in design and analysis capability & requirements of the contrasting developmental modes and resources, but also highlighted the procedural flexibility of the UAS developmental model. Rapid identification and ad hoc prevention of emerging risks, combined with disciplined processes to document and share effective design and procedural mitigations, seemed to be effective and permeating the UAS community. However, the need for a more effective but suitable process for managing small UAS flight test risks was recognized.

A critical insight was that the engineering intensive airworthiness process might be stifling not just UAS experimental test effectiveness, but also the ability of human insight and seasoned engineering judgment to rapidly assess risk potential. Given the reduced scope of the consequences of small UAS hazards, could a more top-down risk assessment accelerate the emergent UAS risk mitigation process? One suggestion was the application of the Bayesian Belief Network (BBN) tools used in risk identification & mitigation for nuclear power plants and oil drilling rigs, and other complex systems. It was agreed to give this counter-intuitive idea a try, hence our BBN hazard risk analysis tool (HRAT).

As this research progressed, it became evident that BBN hazard risk assessment was more than a software tool; it was an interactive and reiterative human process for eliciting and evaluating risks. We learned that the BBN HRAT process stages of hazard identification, risk decomposition, probability estimation and mitigation invention should be deployed early in the conceptualization of the UAS and its mission, and maintained as a necessary adjunct throughout UAS design and flight test.

We conceived and trialed the concept of teaming experienced BBN HRAT facilitators (modelers) with "technical area experts" (TAE) in the iterative development of the HRAT models, in the process learning that models focused on individual hazards were both computationally efficient and more practical for eliciting meaningful risk probability ratings. The modelers developed tricks of the trade to assess more complex scenarios, but nevertheless parsimony is valuable for comprehension.

Notes:

Prof David Jenn
NPS Electrical and Computer Engineering Department

Title: Wireless Power Transmission for Battery Charging and AUV/ UAV Power Applications

Abstract:
Wireless power transmission (WPT) can be used to directly power electronics or charge batteries without any physical contact. For example, batteries can be recharged at a distance without running cables or docking a AUV/UAV. Two types of WPT are discussed: (1) inductive and (2) radiative. An inductive system is essentially a core-less transformer (a coil at the power source and a coil at the receiver), and its range is limited to very short distances (several inches). A radiative system employs a power source that transmits through an antenna to a receiving antenna on the client. Radiative systems are also relatively short range (up to hundreds of meters) depending on the power supplied and the propagation conditions. In both cases the received power is rectified and conditioned to supply the battery.

In phase 1 (2014) the design principles and tradeoffs (power requirements, environmental limitations, frequency of operation, safety, etc.) of both approaches were established and some system concepts simulated. Also some system efficiency measurements were collected in the Microwave Laboratory.

The primary goal of the current phase of research (2015) is to achieve an end to end demonstration of an inductive WPT system in the laboratory environment. The system includes the transmitter, antenna and coils, matching networks, and rectification circuits. The design of the system and development progress will be discussed.

A secondary task in the current phase is to investigate concepts for charging multiple clients simultaneously. Progress on this task will also be covered.

Notes:

LT Raymond Davis, LT Patrick Livesay
NPS System Engineering Students

Title: The Design and Optimization of Swarm Capable, Smart UAV Launchers

Abstract:
This research explores the design and optimization of swarm capable Unmanned Aerial Vehicle (UAV) launchers in support of UAV swarm research. Fully autonomous swarms are predicted to play a significant role in the future of war fighting, but the capability is currently limited by a number of technological deficiencies. While research covering a wide range of topics is underway in hopes of facilitating these unmanned group behaviors, one important and often overlooked capability gap that has yet to be bridged is the ability to facilitate operationally relevant sortie generation rates. The ability to create a swarm of UAVs will, in turn, require the ability to rapidly and safely launch large numbers of UAVs. This challenge requires a departure from existing UAV launch solutions as the logistical and tactical requirements are uniquely different.

The end goal of this research is to successfully design, build, and test a UAV launching platform to fulfill key capability gaps in existing UAV launch-system technologies. Specifically, these theses focus on the identification, selection, and iterative development of the mechanical and electrical interfaces and sensors-based supporting capabilities that will facilitate and optimize the process of launching a swarm of UAVs, and will follow accepted systems engineering practices and explore the optimization of rapid prototyping using phased development. Iterative system designs and feature sets are identified, categorized and prioritized based on the overall utility provided to the system and are subsequently implemented into prototype launching systems as part of an iterative system development process. This process will eventually culminate in the creation of a UAV launch system capable of high launch rates, a high degree of integration with ground-based flight control systems, unique electrical mechanical propulsive systems, and a suite of sensor-based capabilities that have heretofore never been seen in a UAV launch platform.

Notes:

Dr Douglas Horner
NPS Mechanical and Aerospace Engineering Department

Title: AUV Operations in Extreme Environments: Under-Ice Operations

Abstract:
The Arctic is steadily increasing in strategic, military and economic importance, driven by global policies and climate change. The Department of Navy (DoN) recognized this with the establishment of the Ice Experimentation (ICEX) program, a collaborative effort between DoN and scientists to understand oceanographic and ice conditions in the Arctic. However, this environment is extremely inaccessible and dangerous to humans, necessitating the use of unmanned system operations. Significant advances have been made in ground and aerial robotics, but solutions are lagging for the underwater domain, and even more so for under-ice operations. This is in large part due to the harsh operating environment and challenges in underwater robot localization, sensing, perception, control, and communications. Most existing above-the-surface solutions simply do not transfer to the underwater domain due to different sensing modalities, quality, and data rates.

In this talk, we will review efforts in the development of AUV navigation and control for under-ice operations. Principally this includes Terrain Relative Navigation (TRN) and 3D mapping. The AUV TRN approach involves building a bathymetry map and subsequently navigating relative to the map with high-resolution downward-looking sonar. Critical to this process is the building and representation of the map given uncertainty with respect to the vehicle's position and sensor performance. The talk will include results from a recent expedition to Pavilion Lake, British Columbia where under-ice operations were accomplished with 2 AUVs – the NPS REMUS 100 and the SeaBotix LVBL-300 Tethered Hovering Autonomous Undersea System (THAUS).

Notes:

Dr Kevin Jones and Dr Qing Wang
NPS Mechanical and Aerospace Engineering, Meteorology Departments

Title: Low-Cost Expendable UAS with Application to Lower Atmospheric Measurements

Abstract:
Accurate characterization of the lower atmosphere is needed to initialize or constrain forecast models or as an independent validation for model evaluation, and may also be used to support tactical decisions, aiding in the prediction of electromagnetic (EM) wave propagation, where the atmospheric refractive properties are dependent on state variables such as pressure, temperature, and humidity in the lowest 2 km of the atmosphere. Quantifying the low level gradients of these variables is critical for predicting radar and communication signal propagations through the atmosphere.

Historically, most in situ measurements of the atmosphere were by radiosondes launched from land-based stations or ships. Unfortunately, the Navy discontinued its radiosonde program in 2011, eliminating in situ measurements over operational areas of the ocean. This has degraded forecast model accuracy and adversely impacted the accuracy of EM propagation prediction for the Navy. Alternative methods for obtaining in situ atmospheric measurements, particularly in the lowest 1 km of the atmosphere are needed to fill this data void during a time when forecast model accuracy is still being refined. Preferably, new sensing capabilities should be low cost and should not interfere with normal shipboard operations.

We intend to develop a low cost, expendable Unmanned Aircraft System (UAS) that can be fielded from land or ship. The objective is to design an asset that is simple to assemble and deploy, with a system cost roughly the same or less than the sensor payload that it carries. To achieve this, the design will rely heavily on COTS products, open-source components and rapid prototyping techniques such as 3D printing and desk-top CNC machining. The COTS hobby market has produced a wide array of molded foam airframes, and a selection process will take into account the weight and volume of the sensor components, clean access to the air for sensing, and a size and wing-loading that is able to support the desired speed range and endurance. The entire package must be able to survive an at-sea landing in mild seas.

There are many options for instrumenting the small UAS, constrained by available payload size, weight, and power consumption (SWaP). The initial sensor suite will include a modified IMET radiosonde for pressure, temperature, humidity, GPS location and time, a 5-hole probe for static and dynamic pressure (true air speed and flow angles), and an IMU system for attitude angle measurements. The 5-hole probe and the IMU system will sample at 20 Hz, while the radiosonde will sample at 1Hz. Initially, data will be stored locally, but we will work on a solution to have data transmitted to a ground station via the autopilot telemetry link or Iridium Communication Satellite network. The total payload is expected to be less than 1 kg.

The proposed work will involve significant effort and research for developing a meteorological sensor suite for UAS. Developments include sensor viability and calibration, data acquisition and telemetry, and lastly wind/turbulence data retrieval algorithms. Test flights with different flight patterns will be designed to optimize measurements within the UAS flight envelope.

Notes:

LCDR Brian Judy, USN and SEA-21A Cohort

NPS Systems Engineering Students

Title: Organic Surface Combatant Over-The-Horizon Targeting for 2025 and Beyond

Abstract:
The Systems Engineering Analysis Cohort 21A (SEA-21A) is tasked with designing a maritime Intelligence, Surveillance, Reconnaissance, and Targeting system of systems and concept of operations capable of detecting, classifying, and engaging targets in support of organic Over-The-Horizon (OTH) tactical offensive operations in a contested littoral environment in the 2025-2030 timeframe. Using a systems engineering approach, the team is considering manned and unmanned systems in an effort to provide organic OTH targeting capability for naval surface combatants. Special attention is being paid to system requirements and limitations, operating area considerations, bandwidth and connectivity of communications, impact of electromagnetic effects, issues of interoperability and compatibility, and the challenges associated with logistics and forward deployment of assets.

A critical aspect of the group's scenario development is the presumption of an Anti-Access, Area Denial (A2AD) environment, which may preclude the ability of a Carrier Strike Group (CSG) to provide OTH maritime strike without exposing an aircraft carrier to an unacceptably high risk of attack by medium-range ballistic missiles in a littoral environment. Left without the support of the CSG, the outcome of engagements between surface combatants will likely be predicated upon who can strike the other first. Without an organic OTH targeting capability, U.S. Navy surface ships are left extremely vulnerable in such a scenario.

Recent project efforts have focused on a decomposition of key terms and required functions in order to provide the capability for a single surface combatant to complete its own kill chain against an enemy surface target. The resulting analysis will inform the design of a system of systems that should provide the ability to find, fix, track, target, engage, and assess battle damage against a target beyond the reach of current organic sensors and without reliance on CSG air support. Multiple alternatives are currently being considered and analyzed for feasibility.

The merits of these alternatives are being used to create simulation models in the Extended Air Defense Simulation software package (EADSIM), a system-level simulation which is used by combat developers and operational commanders to assess the effectiveness of Theater Missile Defense (TMD) and air defense systems. EADSIM also provides a theater-level simulation of air and missile warfare, and an integrated analysis tool to support joint and combined force operations. Additionally, theoretical models and software packages such as ExtendSim and MS Excel, for example, are also being used to derive detection probabilities based on characteristics of search platforms and anticipated behavior of potential targets. These modeling and simulation efforts will aid the team in comparing alternative design architectures.

This briefing reports the current progress of the SEA-21A capstone project and highlights preliminary results and recommendations generated to date. Ongoing efforts include refinement of analytic and simulation models, and continued scoping to provide a coherent, sensible recommendation to enhance the U.S. Navy's ability to conduct OTH tactical offensive operations against surface targets by 2025.

Prof Isaac Kaminer and Ms Claire Walton

NPS Mechanical and Aerospace Engineering Department

Title: Optimal Motion Planning for Search of Uncertain Targets and Defense against a Swarm Attack using UxSs

Abstract:
This talk explores the potential for applying newly available numerical methods in optimal control to solve motion planning problems motivated by three sets of operational scenarios:

1. Search for targets
2. Defense against a swarm attack
3. Herding against a swarm attack

In all cases the target or attacker's motion is uncertain with uncertainty characterized by constant but unknown parameters. Our recent work enables efficient computation of optimal numerical solutions for search and swarm defense problems with multiple unmanned searchers and defenders, nonlinear dynamics, and a broad class of objectives. We demonstrate the efficacy of these methods by implementing multi-UxS optimal search, swarm defense, and herding scenarios.

Notes:

Dr Kwang sub Song and Dr Peter Chu
NPS Oceanography Department

Title: Conceptual Design of Future Undersea Unmanned Vehicle (UUV) System for Mine Disposal

Abstract:
A conceptual design is proposed for an effective mine countermeasure (MCM) system, which consists of three unmanned underwater vehicles (UUVs) and 10–20 small charged deliverable vehicles. New underwater optical communication systems are introduced to improve on-board mine reconnaissance and decision making with the key technologies focused on system and communication efficiency, capability of data processing, and cost-effectiveness of MCM systems. The proposed UUV MCM system is cost-effective due to adapting disposable mine neutralization instruments, upgrading data process units, and configuring optical communication systems between heterogeneous underwater and surface vehicle units in operations. At the same time, efficient and reliable underwater optical and electromagnetic wave communication systems are also introduced and analyzed for future system applications.

Notes:

Prof Noel Du Toit
NPS Mechanical and Aerospace Engineering Department

Title: Robotic Outposts: Enabling Persistent AUV Operations

Abstract:
Autonomous Underwater Vehicles (AUVs) have not yet reached their full potential for undersea warfare operations. Current AUVs (and unmanned systems more generally) require launch and recovery as well as logistics support from manned surface platforms (e.g., LCS). One concept for achieving increased persistence without burdening manned support vessels is an "undersea garage," or robotic outpost. This robotic outpost is intended to be self-sustaining while providing power and communications to untethered heterogeneous UxV assets for vehicle-specific mission execution. In contrast with current unmanned underwater systems, the robotic outpost negates the need for persistent operational and logistics support, thereby enabling clandestine deployment and continuous AUV operations in denied areas. Furthermore, there is a need to autonomously deploy and recover as well as inspect and maintain the outpost's associated local infrastructure, outpost facility, and mobile assets – the robotic outpost requires an organic inspection and intervention capability.

Results from the first 15 months of the two year effort to develop and deploy various components of the robotic outpost concept will be presented: autonomous docking with the REMUS 100 AUV in Monterey Bay, terminal REMUS control using active acoustic sensors, localization using directional active acoustic sensors, dynamic stabilization of the intervention asset (THAUS AUV), 2.5D and 3D environment mapping, and asset recovery. These capabilities have been developed and tested in Monterey Bay, during NEEMO 18 in July 2014 (in collaboration with NASA JSC), and at Pavilion Lake, BC (in collaboration with BAER and SETI Institutes, and PLRP) in November 2014 and February 2015.

Ongoing research tasks and upcoming field trials will additionally be discussed, including infrastructure deployment and surveying using THAUS as the organic robotic outpost tender, underwater intervention tasks (in this case a REMUS AUV recovery), terrain-relative navigation using passive sensors (cameras). These capabilities will be tested and refined during NEEMO 20 in Key Largo, FL in July 2015.

Finally, proposed future directions of the robotic outpost program will be discussed, including robotic intervention, as well as extending the robotic outpost concept for application with the LDUUV.

Notes:

LT Douglas McIntosh, USN
NPS Systems Engineering Student

Title: Preventing Encroachment by Hobby Grade Small Unmanned Aerial Systems

Abstract:
The expanding capability of Hobby Grade Unmanned Aerial Systems exposes a significant capability gap in the fields of Detection and Defense. Increased adoption by the consumer market, paralleled with efforts to use UASs to cross borders, make political statements at public events, survey sporting events, interfere with Government and Private activities, and accidental flights into protected portions of US National Air Space demonstrates the real threat posed to Military, Government and Private interests. This thesis proposes a method to counter the encroachment of a UAS into a protected area through a phased approach, while providing an estimation of the possible threat the UAS could pose as determined by its size and operating characteristics. The investigated factors were drawn from literature review to create a database of existing UASs that could then be forecasted into a representative conglomeration of the threat. The sample of UASs includes a comparative examination of the trade space of flight characteristics, logistical footprint, and operational practices, with a focused evaluation of fixed wing versions versus multi-rotor designs. Through the use of analogous three dimensional models of the representative UAS from every aspect, the visual cross section of a UAS in flight, when correlated with its range and trajectory, probabilistically determines possible payload capacity. By overlapping electrooptical or electromagnetic sensors, to determine the UAS visual cross section and trajectory, with infrared and acoustic sensors, the classification of the UAS can be further refined, accounting for variations in propulsion and insuring proper target discrimination. The threat range of UASs, how an opposing force would use the UAS against a protected location, were then subjected to risk management analysis, relating the threat to its probability of occurrence, and the impact if it were not negated. The result of the analysis was then codified into a recommended procedural response that could be enacted by a defensive station.

Notes:

Prof Marcello Romano and Mr Alessio Grompone
NPS Mechanical and Aerospace Engineering Department

Title: Artificial Vision Estimation of Relative Motion of Autonomous Vehicles

Abstract:
The primary objective of this research is to develop a vision-based algorithm for real-time target tracking, rendezvous, docking and manipulation. The main challenge addressed is to validate an algorithm able to track and estimate the pose of non-modeled uncooperative targets using only monocular and stereovision images.

The algorithm is based on a combination of well-known image processing and motion estimation methods accurately analyzed and compared through literature review.

The algorithm has been developed with a modular structure in Matlab/Simulink for open source Linux Real-Time OS to provide a code interface that adapts to different scenarios and applications, but that can also be modified during the implementation until best performance is reached.

A performance analysis is presented through numerical simulations and tests on benchmark operations videos appositely provided by NASA and 3D computer rendered videos.

Hardware-in-the-loop experimentation on the Floating Spacecraft Simulator Testbed provides a real-time validation of the algorithm on an almost Newtonian/disturbance-free 2D environment with controlled illumination.

A custom made multi-copter with on-board vision and robotic arm capabilities will be developed and used for the experiments. The use of multi-copter will provide a real-time, limited computational resources, disturbed 3D environment simulation.

The final purpose of this work is to validation of the algorithm for a wide range of unmanned partially teleoperated and/or fully autonomous terrestrial, air and space applications.

The research will also strengthen the Spacecraft Robotics Laboratory capabilities and know-how foundations on vision-based navigation and manipulation techniques, providing an advanced software repository and hardware test-bed for future education and research applications in autonomous satellite and multi-copter robotics projects.

Notes:

LT David J. Cummings, USN
NPS Systems Engineering Student

Title: Viability of Open Source Software in Department of Defense Unmanned Aerial Systems

Abstract:
Although open source software (OSS) is currently used in many ways in the DoD, apprehension and fear sometimes block its implementation. OSS is widely used to provide partial or complete functionality in many web servers, operating systems, and database managers used in industry. This type of software development needs to be analyzed to improve government understanding and increase awareness of its potential. While it may seem unconventional or even out of place in the traditional military acquisition engine, OSS has the potential to match or even out-perform its proprietary counterparts. In fact, in a memorandum published by the DoD Chief Information Officer, OSS was described as "commercial computer software that shall be given appropriate statutory preference" when considering software for any DoD function.

This research aims to evaluate open source software as a viable option for use in DoD systems. Specifically, it will be investigated as a solution for Unmanned Aerial Vehicle flight control software. There are several OSS programs designed to operate UAVs which have been in existence since 2003. Historically, they have been sponsored by hobbyists and drone community members. Recently, the Linux Foundation launched a project called "Dronecode," which aims to standardize software engineering practices for UAV code developers and unite programmers working on similar projects. OSS technology and its backing from corporate sponsors indicate future UAV software innovation may lie in the hands of the open source methodology.

OSS will be evaluated in two ways. First, several fundamental metrics that apply to OSS and proprietary software will be identified. Examples and case studies of software will be evaluated to compare the two types based on the metrics. OSS and proprietary software will then be examined as alternatives for use in an unmanned aerial vehicle system. The metrics analyzed will include reliability, scalability, performance, total cost of ownership, and security.

The second form of evaluation is a survivability analysis. The OSS development model will be judged in its ability to withstand an attack from an enemy. In the scenario, an adversary uses the open source development methodology to plant malicious viruses or vulnerabilities into the source code for UAV flight control software. The enemy then attempts to exploit these vulnerabilities during operation of the UAV, taking command of the vehicle or forcing it to abort its mission. The steps in the open source development process will be decomposed and evaluated to determine the enemies success rate in compromising the system.

Notes:

Prof John Joseph
NPS Oceanography Department

Title: Application of ocean gliders in tactical oceanography: Characterizing ambient noise

Abstract:
The performance of naval sonar systems relies on the signal-to-ratio (SNR) found in the operation environment. Working against quieter targets of interest infers that operators require more detailed knowledge of the background ambient noise characteristics to plan the optimal use of limited assets to enhance overall performance. Currently, estimates of ambient noise are derived from smoothed, static databases such as Wenz curves or spot measurements taken on-scene, neither of which provides insight into noise variability and the statistics that can assist with optimal deployment of ASW assets. To gather the data needed to provide the appropriate characterization of ocean noise, long time-series of data can be collected using ocean gliders outfitted with an acoustic recorder. Powered by pumping fluid in and out of a pressure vessel to induce buoyancy changes, ocean gliders inherently have long (multi-month) endurance and are capable of making measurements deep into the ocean. Here, we report the results of our examination of an acoustic data set collected during a month-long deployment of a NPS Spray ocean glider equipped with a small acoustic recorder. The glider was deployed over Smooth Ridge just outside of Monterey Bay during the Winter-2015 Tactical Oceanography course in support of class projects. The mission demonstrates the capability of a low-cost, long-endurance sensing platform to provide comprehensive information characterizing ambient noise in this region. The effort was made possible through support provided by the CRUSER program and done in collaboration with the Monterey Bay Aquarium Research Institute (MBARI).

Notes:

Mr Sean Kragelund
NPS Mechanical and Aerospace Engineering Department

Title: Intelligent Sensing: Initial Results with an ATLAS sonar on the NPS SeaFox USV

Abstract:
Autonomous Underwater Vehicles (AUVs) have proven themselves in a wide variety of missions, but energy constraints still dictate the types of missions and operational areas that an individual vehicle can cover. Therefore, a team of low-cost AUVs can potentially conduct wide-area operations more efficiently than a single all-purpose vehicle, subject to cost vs. accuracy trade-offs. Unmanned Surface Vessels (USVs) are an enabling technology for this concept, capable of deploying multiple low-cost AUVs and serving as mobile communications gateways and external navigational aids for the underwater vehicles. This type of "marsupial" robotic system is well-suited to wide-area environmental monitoring or mine neutralization missions; since individual AUVs may be expendable, the ability of the USV to localize and communicate with each AUV is key to improving the system's navigational accuracy and responsiveness to new information.

The Center for Autonomous Vehicle Research (CAVR) is developing a concept whereby a USV, equipped with forward-looking sonar and acoustic communications, autonomously commands a team of AUVs to investigate targets detected with its sonar; the USV then tracks the AUVs and provides navigational feedback to guide them to their objectives via an acoustic link. CAVR recently integrated an Autonomous Topographic Large Area Sonar (ATLAS) system onto its SeaFox USV and received FY15 CRUSER research funding to investigate USV-coordinated operations using CAVR's SeaFox USV and REMUS AUVs. This project is focused on experimental characterization of the ATLAS sonar and on development of intelligent sensing algorithms that leverage its unique capabilities.

The ATLAS sonar system was designed for two primary applications: 1) as a forward-looking obstacle avoidance sonar for manned submersibles, and 2) as an object detection and bathymetric mapping sonar for AUVs, including the Mk 18 Mod 2 Kingfish and Large Displacement Unmanned Undersea Vehicle (LDUUV). The FY15 research effort will utilize the ATLAS sonar's ability to autonomously detect and report small objects, large features, and terrain data, with corresponding measures of uncertainty. CAVR has been conducting sonar surveys against known target types and locations to gain insights into the accuracy of the contact reports that ATLAS publishes to the vehicle autopilot. This information will be used to develop probabilistic sensor models for use in AUV tracking and motion planning algorithms.

Another goal of intelligent sensing is to strike a balance between exploiting prior knowledge (e.g. previously mapped areas) and deliberately exploring unknown portions of the environment. Motion planning algorithms which explicitly account for sensor characteristics can generate vehicle maneuvers that explore a search area more efficiently, particularly for under-actuated vehicles like the SeaFox USV. The development of optimal, sensor-based USV maneuvers in uncertain environments is one of the objectives of this research.

This presentation will discuss the technical approach and potential future directions for this research. Recent results obtained with the ATLAS sonar in Monterey Bay will also be presented.

Notes:

Capt Scotty Black, USMC
NPS Modeling, Virtual Environments and Simulation Institute Student

Title: The Missions, the Tactics, the Implementation: a Simulation for Aerial Combat Swarms

Abstract:
Given the current dynamic and uncertain fiscal environment, the Department of Defense's shift of focus to the Pacific, and the proliferation of inexpensive technologies that may allow any group or nation to quickly and easily field cheap yet deadly weapons, it becomes imperative that we find innovative, low-cost alternatives to the current high-cost and technologically advanced solutions to current and future threats.

This study explores and evaluates the use of swarming unmanned aerial vehicles (UAV) in a virtual, operationally-relevant battlespace by creating a high-resolution 3D simulation that allows for the development, evaluation, and analysis of the swarm UAV concept in a holistic manner. Furthermore, we develop and incorporate a prototype user interface to serve as a 'Swarm Command Center,' allowing one or few operators to effectively control and tactically employ one or more swarms of UAVs.

This notion of swarming mirrors that of the emergent group behaviors found in nature as can be observed from a flock of birds or a school of fish. Individually, each agent has very limited awareness of the environment and limited chances of survival; in a group, however, their combined behaviors becomes complex, dynamic, and unpredictable, virtually guaranteeing their survival. Specifically, we envision using small, low-cost, expendable UAVs working in conjunction with conventional weapons by employing swarm tactics to execute `kamikaze'-like attacks on a well-defended high value target (HVT).

The idea of employing UAVs in a swarming context is not new and has been researched and explored to varying degrees in recent years. However, though the technology exists to realize such a novel and potentially revolutionary concept within the next few years, a comprehensive evaluation and analysis of such an employment has yet to be conducted.

Using the Unity game engine, we build a realistic combat environment around a capable HVT. We then design the UAVs by developing and implementing the necessary behaviors for the individual agents to execute offensive swarm tactics. Concurrently, we design, develop, and implement a 'Swarm Command Center' allowing for a single operator to manage, command, and employ these swarms in an operationally relevant mission and battlespace.

With this simulation, we evaluate and analyze both the swarm concept and the user interface by conducting statistical design of experiments and rigorous regression analysis to identify key significant factors, determine best tactics, explore optimal levels of autonomy, and discern critical information from the implemented prototype user interface.

Notes:

Dr Joshua H Gordis and Ms Claire Walton
NPS Mechanical and Aerospace Engineering Department

Title: On the use of UxVs in Seabasing Cargo Transfer

Abstract:
In the first part of the talk will describe a general program for the modeling and simulation of seabasing cargo transfer. In seabasing, a network of ships and connectors (sea, air, land vehicles) is used to transfer cargo to the seabase, and then to the operational objective. Of importance is the throughput of the network - the rate at which equipment and supplies can be delivered to forces ashore. The simulation program we developed allows an arbitrary network to be defined, parameterized, and both the net throughput and fuel consumption of the network to be calculated. The program has demonstrated the ability to reveal non-intuitive behaviors of these networks. This program will help the Navy (and potentially the Marine Corp) plan for the allocation of funds for the upgrading/replacement of systems for improved throughput and also serve as a real-time tool for designing seabase networks. We believe that UxVs can play an important part in seabasing, in particular, they can be used as connectors transporting supplies between ships and operational objectives. Thus, in the second part of the talk we will address the benefits and challenges inherent in using UxVs for seabasing.

Notes:

LT Faith Sen, Turkish Air Force
NPS Operations Research Student

Title: The Use of Unmanned Combat Aerial Vehicles in Conjunction with Manned Aircraft to Counter Active Terrorists in Rough Terrain

Abstract:
Terrorism is one of the biggest problems of our age. Many countries around the world have suffered at the hands of terrorists over the years. Turkey has lost over 40000 Turkish soldiers and civilians as a result of terrorist attacks. Turkey has also lost helicopters, aircraft, and surface vehicles while attacking terrorists because of man-portable air defense (MANPAD) attacks by terrorists, rough terrain, and severe meteorological conditions. The southeast border of Turkey contains the majority of terrorist activities. This region is known for its steep mountains and deep dales. Terrorist teams are well adapted to hard conditions and the environment. Most of their plans are based on the geographical structure of the region. Terrorist teams use ever-changing guerrilla tactics. Simultaneous raids are a recently-used tactic in this region.

Currently, manned bomber aircraft play a key role in defusing detected terrorists and preventing them from attacking military stations, government agencies, police lodgings, and civilians along the borders. A military base receives intelligence of terrorist activities from either a reconnaissance unmanned aerial vehicle (UAV), or from another source. Once this occurs, the base scrambles aircraft that take off and fly to the area. The aircraft then find and attack the terrorist groups in coordination with UAVs or by using only their onboard sensors. It takes some time to reach the area and drop the ordnance on terrorists, depending on the distance that must be covered. Due to this inevitable delay, sometimes terrorists reach their goals or get to protected positions before aircraft reach the area. Moreover, sometimes terrorist partisans who live in the cities where air force bases are located may inform terrorists about aircraft activities in the base, giving the terrorists more time to time to hide in caves or in deep valleys before fighter aircraft arrive.

Unmanned Combat Aerial Vehicles (UCAVs) could become critical components of modern day counter-terrorism operations. The use of UCAVs may increase our ability to eliminate terrorists. However, the UCAV effectiveness is highly dependent on onboard sensors and characteristics of the region. UCAVs carry less ordnance than manned aircrafts. The purpose of this thesis is to analyze the use of UCAVs, in conjunction with manned bomber aircraft, to defuse active terrorists who use the southeast border as passage from northern Iraq into Turkey.

This thesis will use an agent-based simulation platform, in conjunction with state-of-the-art design of experiments tools and high-performance computing, to address the following questions: (i) How might UCAVs enhance Turkey's ability to secure the border characterized by rough geographical conditions? (ii) How many UCAVs are needed to kill detected terrorists and to secure border assets or civilians? (iii) How many terrorists can be killed or prevented from attacking border assets and civilians in various scenarios? (iv) How might UCAVs be loaded and configured to maximize their efficacy? (v) By varying parameters of UCAVs, how can we maximize the cost effectiveness of UCAVs? (vi) What are the advantages and disadvantages of using UCAVs only, manned aircraft only, or both UCAVs and manned aircrafts in certain scenarios?

Notes:

LTJG Salim Unlu, Turkish Navy
NPS Operations Research Student

Title: Assessing the tactical effectiveness and performance of prospective ASW Unmanned Surface Vehicles in naval convoy operations

Abstract:
The purpose of naval convoy operations is to protect the high value units (HVUs) within the group through an area of high threat. As long as conventional submarines are serious threats to logistic ships in the littoral waters, convoy protection usually focuses on defensive Anti-Submarine Warfare (ASW). Convoy operations require a detailed organization. In order to protect the convoy against possible submarine attacks, the navy employs frigates, destroyers, and helicopters equipped with active sonar for this task. These ASW assets are deployed to patrol certain areas relative to the convoy's position. These types of operations require a certain number of ASW units, manpower, and much effort. Current ASW techniques are effective in most cases, but Unmanned Surface Vehicles (USVs) have the potential to greatly improve ASW capabilities in the future. Given today's highly constrained fiscal environment, it is vitally important that the Navy should be able to leverage unmanned systems. USVs should be able to be used in naval convoy operations to reduce the risk to manned platforms and free them for other purposes, to act as force multipliers, extend the reach of warships, and provide greater cost-effectiveness.

This research will examine the tactical effectiveness and performance of prospective ASW USVs in naval convoy operations. This study will use an agent-based simulating platform known as Map Aware Non-Uniform Automata (MANA) to model ASW screen scenarios. Choosing significant factors and the ranges of these factors are important for answering questions such as: Can USVs act as an ASW sensor node against diesel submarines ahead of naval convoys? What are the main advantages and disadvantages of employing ASW USVs for naval convoy operations? Which classes, and what numbers, of ASW USVs are desirable for naval convoy operations? How might a change in the decision parameters affect the probability of detection? How might water conditions and sea state affect the tactical effectiveness of ASW USVs?

For example, consider a diesel-electric submarine operating in a Submarine Action Area (SAA) ahead of a naval convoy with the intent of sinking the HVU in the convoy. The submarine will always try to maneuver into an attack position and enter into the Torpedo Danger Zone (TDZ). On the other side, a certain number of ASW assets will form a shield around the HVU and protect the HVU within the convoy against submarine attacks. At the end of simulation, tactical effectiveness will be measured by how often the HVU safely reaches its destination.

After modeling the scenario in MANA, a large-scale simulation experiment will be executed. After collecting simulation results, statistical tools will be used to analyze the tactical effectiveness of USVs in naval convoy operations. The major goal of this study will be to determine which factors have the greatest effect on the probability of detection of diesel submarines, in terms of both technical capabilities and employment tactics. Thus, this study will help decision makers understand how ASW USVs can be employed in naval convoy operations in littoral waters.

Notes:

Prof Susan M. Sanchez
NPS Operations Research Department

Title: Closing Capability Gaps: Data Farming Methods for New Concept Exploration in the CRUSER Community

Abstract:
Computer experimentation is integral to modern scientific research, national defense, and in public policy debates. These computer models tend to be extremely complex, with thousands of factors and many sources of uncertainty. Data farming helps researchers understand the impact of those factors and their intricate interactions on model outcomes. Data farming is the process of using computational experiments to grow data, which can then be analyzed using statistical and visualization techniques to obtain insight into complex systems. Effective data farming draws on state-of-the-art technologies including design and analysis of experiments, high-performance computing, and data mining.

NPS's Simulation Experiments & Efficient Designs (SEED) Center for Data Farming is internationally recognized for its advancement of both the theory and the practice of large-scale simulation experiments. Many SEED Center students have already applied design of experiments (DOE) techniques on agent-based or discrete-event simulation models to explore the potential use of unmanned vehicles in operational environments, with great success. The students have come from the Army, Navy, Marines, and Air Force, as well as international allies. They have investigated unmanned vehicles of many types—aerial, ground, surface, and underwater—for missions related to reconnaissance and surveillance, IED detection, mine detection, border security, asset protection, casualty evacuation, humanitarian logistics, and more. We will highlight some of the types of results that can be obtained during the presentation, including the results of two recent student theses that received CRUSER support. The first, by LCDR Maxine Gardner, explores the Navy's logistics role in humanitarian assistance, and incorporates the use of unmanned aerial logistics vehicles. The second, by LT Andy Thompson, investigates the use of unmanned underwater vehicles for mine clearance operations in a joint environment.

Those seeking more in-depth exposure to the data farming concepts and approach are encouraged to take advantage of other opportunities. Hands-on demonstrations will be available for CRUSER participants during the latter part of the TechCon 2015 week of activities. SEED/CRUSER Data Farming Mini-Workshops will continue on a quarterly basis; we anticipate offering continuing education credit to participants beginning in late FY15 or early FY16. Note that these workshops are not limited to analysts. Previous workshops—as well as previous projects—have benefitted from having teams of student officers, operators, subject matter experts, software developers, modelers, and analysts bring their rich array of talents and enthusiasm to collaboratively explore a breadth of global security issues.

Notes:

CRUSER's Vision

CRUSER provides the foundation for a community of interest and a collaborative environment for the advancement of unmanned systems education and research endeavors across the Navy, Marine Corps and Department of Defense. CRUSER spans the research, education, and experimentation efforts in unmanned systems and robotics at NPS and across the naval enterprise.

The CRUSER community of interest welcomes researchers from all disciplines; if you are interested in robotics and unmanned systems we're interested in you. We explore ethics, policy, human capital resource requirements, cultural and societal issues associated with robotics and unmanned systems in addition to the technical aspects such as work on extended battery life, controls, sensors, design and architectures. Whether it's exploration of new concepts or new ways to employ existing platforms the CRUSER community welcomes you.

What is CRUSER?

CRUSER is a SECNAV initiative to build a community of interest on the application of unmanned systems in military and naval operations.

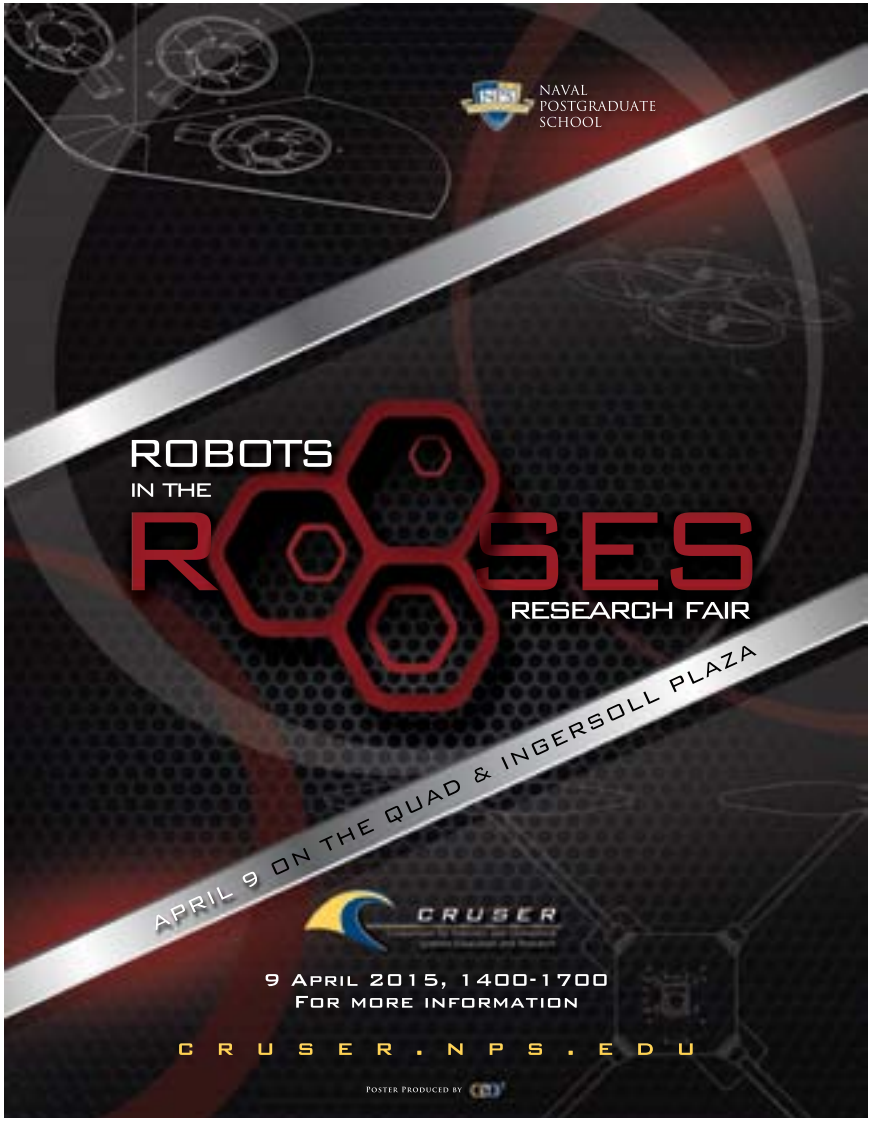
Why should I join?

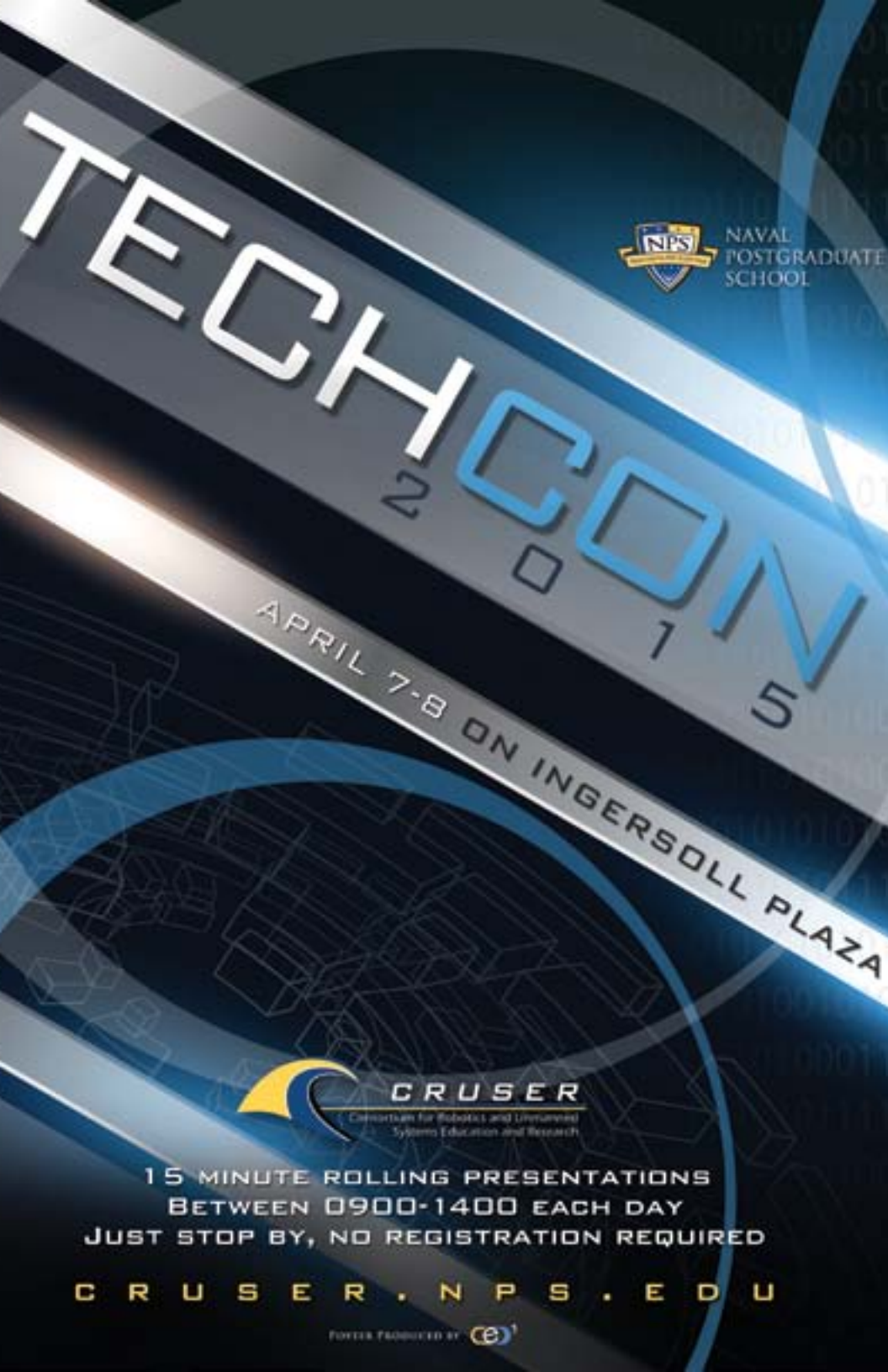
- Enjoy the camaraderie of a focused community of interest
- Seize the opportunity to expand your list of contacts
- Share your research progress and ideas through our monthly newsletter
- Participate in Concept Generation
- Participate in Unmanned Systems/Robotics experimentation
- Learn about your colleagues discoveries at the monthly CRUSER meetings – available via VTC and dial-in

How do I join?

- Sign-up on our website
- Send us your name, e-mail, org name, and title to cruser@nps.edu

For more information on CRUSER and upcoming events visit: http://CRUSER.nps.edu




TECHCON
2015
NAVAL POSTGRADUATE SCHOOL
APRIL 7-8 ON INGERSOLL PLAZA
CRUSER
Consortium for Robotics and Unmanned Systems Education and Research
15 MINUTE ROLLING PRESENTATIONS
BETWEEN 0900-1400 EACH DAY
JUST STOP BY, NO REGISTRATION REQUIRED
CRUSER.NPS.EDU
POSTER PRODUCED BY