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Consortium for Robots and Unmanned Systems Education and Research (CRUSER) briefing

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http://CRUSER.nps.edu
https://www.facebook.com/CRUSER.Coi
UNSECNAV Guidance

- UnderSecretary of the Navy Work – 1 Feb 2011:

  “...to shape generations of naval officers through education, research, concept generation and experimentation in maritime applications of robotics, automation and unmanned systems......”

  “......provide a DoD-wide community of interest to exchange research and experimentation results”
FY11-FY14 Objectives

- Concept Generation
- Experimentation Program
- Education Venue
- DoD-wide forum for collaboration
Innovation Thread

A two-year event cycle starting in September with a Warfare Innovation Workshop and ending with a research presentation at ONR showcasing the results of the innovation thread.

- **Sept Year 1**: Warfare Innovation Workshop
- **Spring Year 1**: Technical Continuum
- **Spring Year 2**: Field Experiment
- **Summer Year 2**: Research Expo

Teams of academic, govt., and scientific community representatives propose concepts within a scenario.

Review of Technical Papers and proposals for concepts selected from Warfare Innovation Workshop. Includes a Research Fair.

Testing of physical models as a follow-on to the Tech Continuum.

Expo to showcase the results of the Innovation Thread – “Concept to Experimentation”
Current Innovation Threads

UxS Employment in Naval Operations
- Field Exp (APR 13)
- Expo (JUN 13)

Advancing the Design of Undersea Warfare
- WIW (NPS, SEP 12)
- Tech Continuum (NPS, APR 13)
- Field Exp (APR 14)
- Expo (JUN 14)

Thread #3 – Focus area TBD
- WIW (SEP 13)
Concept Generation:
“UxS Employment in Naval Operations”

Selected Concepts:

1) **Counter-UAV measures**: UAVs that specifically threat other UAVs – such as an expendable “hunter-killer” UAV for defense of allied forces.

2) **Low possibility of intercept (LPI) comms**: covert and innovative networks – such as the “Digital Semaphore” concept being taken to field experimentation in FY13.

3) **UxS support of ISR missions**: Tagging and tracking operations, innovative surface and subsurface observation platforms.

4) **Bandwidth and data management**: Advanced algorithms for “information triage” or onboard/in situ processing to reduce network loads, and improved data farming of metadata.

5) **Non-kinetic strike operations**: UxS employed in non-kinetic operations to disable enemy assets – such as fouling agent deployment, jamming or spoofing/decoy operations.
**TOPIC**

| Project MISSION: Maritime In Situ Sensing Inter-Operable Network | Professor Joe Rice, NPS |
| Wave Powered Unmanned Surface Vehicle Operation in the Open Ocean: a station keeping asset for distributed netted systems | LT Timothy Rochholz, USN |
| Mine Burial Expert System for Changing MIW Doctrine | Dr. Peter Chu, NPS |
| Channel Modeling and Time Delay Estimation for Clock Synchronization Among Seaweb Nodes | LCDR Pascal Gagnon, RCN |
| NILUS - An Underwater Acoustic Sensor Network Demonstrator System | Dr. Roald Otnes, FFI |
| Underwater Acoustic Network as a Deployable Range | ENS Rebecca King, USN |
| Tailorable Remote Unmanned Combat Craft (TRUCC) | LCDR Loren Jacobi, USN |
| Countering Inundation with Innovation: Defeating Swarm UAV Threats with Aerial Combat Swarms | LT Adam Bush, USN |
| Autonomous System Support for Maritime Visit, Board, Search and Seizure Operations | Dr. Noel du Toit, NPS |
| Emerging Applications of 4K Ultra-high Resolution Full Motion Video for Unmanned Systems and Remote Sensing | Jeff Weekley, NPS |
| Digital Semaphore | Dr. Don Brutzman, NPS |

**SPEAKER**

- **7-10 May 2012**
  - Held in conjunction with Tenth International Mine Warfare Symposium

- Industry and Navy labs invited to demonstrate technical capabilities related to the selected topic areas

- Two concepts selected for continued development and field experimentation:
  - Aerial Combat Swarms
  - Digital Semaphore

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**Consortium for Robotics and Unmanned Systems Education and Research**
• 10 May 2012
• Held in conjunction with the CRUSER Technical Continuum
• Over 20 exhibitors from NPS, DoD, industry and international militaries
• S.T.E.M. event
• Research showcase
Aerial Combat Swarms: 
Swarm vs. Swarm UAV Competition

A grand challenge where tactics drive the technology

- Develop enabling capabilities for **attacking** the opponent’s aerial bots and their home base while actively **defending** own home base

- Conduct **live-fly, outdoor competition** in tournament-style event

- Seek **innovations** in tactics, concepts of operations, autonomy algorithms, hardware platforms, etc.

- Provide **common standards** and infrastructure for rapid evolution
Initial results: Demonstrated QR codes can be extracted at distances at least 500 times farther than typical (600’ versus 1-1.25’).

Findings: Many controllable factors - QR encoding, QR display, sensor, optics, image processing, data processing can all be adjusted based on conditions. Additionally, Dynamic QR Codes for streaming and moving capture are possible.

Recommendations: Continued Research Warranted - Adaptive Optics to Extend Range past 10K yards, Software for Encode/Decode and Image Processing, Continued Field Testing with Unmanned Systems
• Venue to showcase the results of CRUSER Innovation Thread #1, UxS Employment in Naval Operations

• Concept Generation:
  • Sept 2011 Warfare Innovation Workshop

• Field Experimentation:
  • Aerial Combat Swarms
  • Digital Semaphore

• Target is June 2013 at ONR
Warfare Innovation Workshop: Concept Generation

• “Advancing the Design of Undersea Warfare”
• 17 – 20 Sept 2012
• Sponsored by NWDC, NUWC and CRUSER
• Directly supports the NWDC Line of Operation in developing the DUSW

• Focus on employment of the Undersea Warfare Operating Concept in the War at Sea Strategy
• Junior officers from NPS and the fleet, early career engineers from Navy laboratories and NWC SSG Director Fellows
• Innovative Concept Generation for leveraging U.S. strengths in the Undersea Domain to counter A2AD in Phase 0/1
**Selected Concepts:**

1) **Decoys and military deception (MILDEC):** Designs to obfuscate targeting or cloud the enemy’s operational picture – such as a USV swarm fleet or acoustic deception by unmanned systems.

2) **Vessel tagging:** For domain awareness and tracking – such as remora tag with hydro-fan generator.

3) **Non-lethal kinetic effects:** Generation of non-lethal stopping tactics and mechanisms – such as condenser fouling agents.

4) **Undersea positioning, navigation and timing:** For navigation accuracy and domain awareness as an alternative to GPS and surrogate for underwater use.

5) **Undersea “garage”:** Autonomous docking, power generation and transfer, deployment and to extend time on station.

6) **Hybrid unmanned vehicles:** Multi-domain vehicles that transition between domains.

7) **Crowd-sourcing:** Leveraging white shipping, regional fishing fleet and other entities to meet mission data collection needs.
• 25 – 28 March 2013 Warfare Innovation Workshop

• Sponsored by Electric Boat and CRUSER

• Goal – advance the Navy’s Design for Undersea Warfare, focusing on relationships between manned submarines and unmanned undersea vehicles (UUVs)

• Junior officers from NPS and the fleet and early career engineers from Navy laboratories and other DoD partners
Technical Continuum/Research Fair

- Showcase selected technologies identified in Sept 2012 and Mar 2013 Warfare Innovation Workshops

- 3rd Annual Robots in the Roses Research Fair

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Consortium for Robotics and Unmanned Systems Education and Research
Five Day Field Experimentation for technologies selected from the April 2013 Technical Continuum presentations
Research Expo: Washington DC

• Venue to showcase the results of CRUSER Innovation Thread #2, Advancing the Design of Undersea Warfare

  • Concept Generation:
    • Sept 2012 Warfare Innovation Workshop
    • Mar 2013 Warfare Innovation Workshop

  • Field Experimentation:
    • To be determined at the Apr 2013 Technical Continuum

• Target is June 2014 at ONR
Innovation Thread

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Consortium for Robotics and Unmanned Systems Education and Research
Education

- CRUSER Continuing Education: Roboethics – Rhetoric vs Reality – Jan 2012/May 2013

- Catalog degree programs, short courses, and certificate programs country wide – FY13

- Create short course programs as identified by community of interest - Continuous

- Align curricula for interdisciplinary autonomous systems education – Continuous

- S.T.E.M Outreach - Continuous
Continuing Education: Robo-Ethics

- January 2012
- Four panels, 2 days
- Over 100 Participants from the DC area
- Commands represented included ONR, OSD, NAVAIR, NAVSEA, USNA, NPS, NWC, PEO LCS, NRL, DOS, JGRE, Navy Staff
- Template for future continuing education
Continuing Education: Robo-Ethics

- May 2013
- Naval Station San Diego
- Same construct as Jan 2012 DC Symposium
- 4 panels/2 days
- Target audience: fleet concentration warfighters
# STEM Outreach Events

- OR Robotics Day
  - Aug 2010
- First Lego League of Monterey
  - Nov 2010/Apr 2011
- Monterey Academy of Oceanographic Sciences (MAOS)
  - Mar 2011
- “Girl’s Day In”
  - Mar 2011
- Robots in the Roses Research Fair
  - Mar 2011/May 2012/May 2013
- Monterey County Science Fair Judges
  - Mar 2011
- Expanding your Horizons Career Fair
  - Nov 2011
- Brownie Troop 30608 – Mindstorm Robots
  - Jan 2012
- Cub Scout Pack 125 – Mindstorm Robots
  - Apr 2012
- La Mesa Elementary – Mindstorm Robots
  - Apr 2012
Collaboration

- CRUSER Community of Interest (CoI) data base

- CRUSER newsletter
  - http://CRUSER.nps.edu

- Unclassified Website
  - Col Listing
  - Calendar of Events
  - https://wiki.nps.edu/display/CRUSER/

- Classified Website
  - https://cruser.nps.navy.smil.mil

- Facebook Page
  - https://www.facebook.com/CRUSER.CoI
Submission of thesis topics for NPS Students via Proposal Form on CRUSER Website available to entire Community of Interest - 47 submitted since Jan 2012

66 CRUSER thesis or Capstone projects have been completed from March 2011 through Sept 2012

Monthly CRUSER CoI Meetings – VTC, Elluminate (webinar), and dial-in now available due to increasing call-in demand
Community of Interest

- 980 Members and growing
Community of Interest

Examples of CRUSER Member Organizations

- NPS
- NSWC
- NUWC
- ONR
- Northrop Grumman
- NWDC
- USNA
- SSC Pacific
- Raytheon
- Robotic Systems Joint Project Office
- JHU/Applied Physics Laboratory
- Lockheed Martin
- NRL
- OPNAV N2/N6
- Rockwell Collins
- USFFC
- DUSN
- General Dynamics Electric Boat
- Joint Integrated Air and Missile Defense Organization
- TACOM
- Teledyne RDI
- University of New Brunswick
- USFF
- Institute for Religion and Peace
- NAVAIR
- NAVSEA
- NMAWC
- NWC
- OPNAV
- SAIC
- Virginia Tech
- California Peace Officer Association
- Arizona State University
- Avineon, Inc.
- German Air Force
- COMPACFLT
- COMSUBDEVRON TWELVE
- Draper Laboratory
- Georgia Institute of Technology
- Georgia Tech Research Institute
- HQMC
- iRobot
- Jet Propulsion Laboratory
- MIT
- Northwestern University
- NSWC Carderock
- Orca Maritime, Inc.
- Systems Planning & Analysis, Inc
Questions?
REFERENCE SLIDES
Concept Generation Events

- **Advanced Undersea Warfare Systems (AUWS) Warfare Innovation Workshop**
  - Involved Systems Engineering Analysis students as an innovation kick-off to their AUWS Capstone Project

- **Future Unmanned Naval Systems (FUNS) War game Competition**
  - Sponsored by NPS Chair for Undersea Warfare and BATTELLE
  - Concept generation for the deployment of unmanned systems in a future South China Sea scenario
  - All concepts published in a Technical Report
Aerial Combat Swarms: A Grand Challenge Competition
Swarm vs. Swarm Autonomous Systems

Countering the Adversary’s Autonomous Systems
Emerging threats of saturation attacks with unmanned systems

Fact: Proliferation of unmanned systems is rapidly accelerating
Fact: Lowering cost admits new players in asymmetric warfare

Problem: The adversary can potentially exploit many inexpensive unmanned systems to challenge and overwhelm our defensive capabilities

Case Study: Kamikaze UAVs
- Saturation attack profiles
- Persistent threat
- Minimal human-in-the-loop

Harpy UAV engaging radar source

Aerial Combat Swarm vs. Swarm UAV Competition
Inspire an ambitious grand challenge initiative

Goal: Live fly experiment 50 vs. 50 by 2015!

Aerial Combat Swarms Competition:
- Develop enabling capabilities for attacking the opponent’s aerial bots and their home base while actively defending own home base
- Conduct live-fly, outdoor competition in tournament-style event
- Seek innovations in tactics, concepts of operations, autonomy algorithms, hardware platforms, etc.
- Provide common standards and infrastructure for rapid evolution

Defeating Inundation with Innovation
Utilize a defensive swarm of UAVs

Future concept: Leverage defensive swarm of autonomous assets to find, fix, and engage the enemy swarm

Surface Launch

Swarm “Shield”

Revolutionizing Future Concepts for Swarm vs Swarm UAVs
Challenge and exceed existing frontiers in autonomous systems

Complex systems require holistic approach
- Offensive and defensive tactics
- Autonomy science
- Interoperability
- Human factors
- Manning and logistics
- Networked operations
- Business case analyses
- Platform capabilities
- …

Aerial Combat Swarm vs. Swarm UAV Competition
A grand challenge where tactics drive the technology

Advanced Robotic Systems Engineering Laboratory (ARSENL)

Email: thchung@nps.edu
Web: http://faculty.nps.edu/thchung
Experimentation

- MIO remote sensor control demonstration in Singapore
  - (FY11)

- Seaweb experimentation in coordination with Singapore
  - (FY12-13)

- UxS in Naval Operations Experiment
  - (FY13)
Call for Proposals

Selection Criteria
- NPS Student involvement
- Interdisciplinary, interagency, and partnerships with Naval labs
- Partnerships with other sponsors’ funding
- Research related to unmanned systems’ categories:
  - Technical
  - Organization and Employment
  - Social, Cultural, Political, Ethical and Legal
  - Experimentation
  - Defense against threat UxS capabilities
- New research area (Seed money to attract other contributors)
- Related to CRUSER mission thread
- Alignment with SECNAV’s DoN Unmanned Systems

Amount Funded
- FY12 - $400k
- FY13 - $700K
FY 12
Funded Research Proposals

- Passive UxV Navigation using Visual Sensors

- Tropical Cyclone Reconnaissance with the Global Hawk: Operational Requirements, Benefits, and Feasibility

- Joint Optimization of Sensing and Sampling with Unmanned Undersea Vehicles

- Roadmap for Reduction of Total Ownership Cost (TOC) to Support Acquisition Decisions of Unmanned Autonomous Vehicle - Phase I

- Programming the Laws of Armed Conflict (LOAC) for Unmanned Systems

- Autonomous Multi-vehicle Tactical Surveillance and Support for Maritime Visit, Board, Search and Seizure Operations
FY 13 Funded Research Proposals

- The Use of Unmanned Systems for Environmental Sampling and Enhanced Battlespace Awareness in Support of Naval Operations
- Tactical Long Endurance Unmanned Air System (TaLEUAS)
- Networked Unmanned Systems Formation for Rapid Detection, Interdiction, and Expert Reachback in Maritime Interdiction Operations
- Support for NPS Seaglider Operations
- Comparative Analysis of X-47 UCAS & F-18 Squadron Manpower
- A Collaborative Diver Assistant for Underwater Operations
Examples of NPS Student Research

- Autonomy in Lethal UAVs
  - LT Matthew Larkin, USN

- Autonomous Surf Zone Robot
  - LT Steve Halle, USN and LT Jason Hickle, USN

- Multi-Agent Task Negotiation Among UAVs
  - Mr Michael Day

- Search on Optimized Graph Topologies
  - Maj Christian Klaus, German Army

- Future of Marine Unmanned Aircraft Systems (UAS) in Support of a Marine Expeditionary Unit (MEU)
  - Maj Les Payton, USMC

- Business Case Analysis of Cargo UAS Capability in Support of Forward Deployed Logistics in OEF
  - Capt Troy Peterson, USMC
  - LT Jason Staley, USMC

- An Analysis of the Manpower Impact of Unmanned Aerial Vehicles (UAV’s) on Subsurface Platforms
  - LT Thomas Futch, USN
Examples of NPS Student Research (cont)

- Advanced Undersea Warfare Systems
  - Systems Engineering Analysis Cross-Campus Study (SEA 17B)

- Agent-Based Simulation and Analysis of a Defensive UAV Swarm
  - Mauricio M. Munoz-Lieutenant, Chilean Navy

- Derivation of River Bathymetry Using Imagery from Unmanned Aerial Vehicles (UAV)
  - LT Matthew Pawlenko, USN

- Self-propelled semi-submersibles: the next great threat to regional security and stability
  - LT Lance J Watkins, USN

- The Dispersal Of Taggant Agents With Unmanned Aircraft Systems (UAS) In Support Of Tagging, Tracking, Locating, And Identification (TTLI) Operations
  - Capt Dino Cooper, USMC

- Design Requirements For Weaponizing Man-portable UAS In Support Of Counter-sniper Operations
  - Maj Derek Snyder, USMC

- Autonomous Parafoils: Toward a Moving Target Capability
  - CDR Chas Hewgley, USN

- Unmanned Systems Capstone
  - Systems Engineering Analysis Cross-Campus Study (SEA 18B)
Maritime In Situ Sensing Inter-Operable Network
Joseph Rice, Naval Postgraduate School

Objectives
• Study noisy underwater environments
• Achieve acoustic communications through adverse channels
• Integrate U.S. “Seaweb” and Singapore “UNet” networks

Deliverables
Demonstrate in situ sensor networks in Singapore Strait

Milestones
• MISSION 2012 sea trials
• MISSION 2013 sea trials

Accomplishments to Date
Developed bilateral project plan with National University of Singapore

Payoff to the Navy
Enable distributed wireless architectures for Maritime Domain Awareness and Under-Sea Warfare