



# Graduate Education for Unmanned Vehicles and Undersea Warfare

NPS Teaching, Research and Partnership Strategies

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16 June 2005



# Topics

- NPS
- Undersea Warfare curricula
- Unmanned Systems research
- Partnerships with industry
- Exemplar projects



# Naval Postgraduate School (NPS)

- U.S. Navy's University
  - Mission: graduate education + relevant research
- Numerous curricula, most sciences & engineering
  - 2-year masters degrees with thesis
  - Ph.D. research
- Joint, allied and civil-service students, faculty
  - USN, USMC, USA, USAF: ~1300
  - International student officers: ~350
  - Faculty ~300
- Research efforts significant
  - FY2004 reimbursables: \$100M



# USW Curriculum

<http://www.nps.navy.mil/usw>

- Multiple masters degrees (*not* a USW degree)
  - Physical Oceanography
  - Electrical Engineering – Signal Processing
  - Physics – Engineering Acoustics
  - Operations Research – TDAs, search etc.
  - Proposed: MSES Unmanned Systems
- Each major typically a 2-year program
  - 29 students on board, plus 7 graduating tomorrow
  - 2 dozen interdisciplinary faculty
  - Special 1-year Immediate Grad. Ed. Program (IGEP)
  - Must have: masters thesis of directed independent work



# Critical curriculum components

- Accredited hard-science degrees
- Apply learning to real research challenges
  - Masters thesis, doctoral dissertation
- Cross-disciplinary exposure
  - Academic disciplines
  - Tactical communities for “team-sport” USW: aviation, surface, subsurface, environmental
- Apply naval-officer student expertise



# NPS ASW Certificate

- Four courses offered via distance learning
  - Correspond to initial courses in USW curriculum
  - Offered quarterly, cross-disciplinary subjects
  - Some prerequisites necessary
- Various mechanisms for distance-learning delivery: Web, video teleconferencing, etc.
- Naval officers and civil servants eligible
- Looking for students and sponsorships



# Partnerships with industry

- Joint work, use of equipment, software
- Cooperative Research and Development Agreements (CRADA)
- Key players at NPS:
  - USW Chair VADM Roger Bacon USN Ret.
  - MIW Chair RADM Rick Williams USN Ret.
- Unparalleled cross-disciplinary faculty
  - Cover full range of scientific and engineering disciplines
  - Leaders: please send us your list of too-hard problems
- Industry and government welcome to use our work
  - Visiting engineers and scientists also welcome



# We operate vehicles every week

- Center for Autonomous Underwater Vehicle (AUV) Research
  - Tony Healey, Principal Investigator
  - 3<sup>rd</sup>-generation ARIES vehicle, also one REMUS
  - Over 120 M.S., Ph.D. graduates since 1987
- UAV center also established
  - Multiple airframes, nearby airport
  - 23 Km range to surfaced AUV with 802.11G
- USV center being proposed
  - Have applied for SeaFox USV, others welcome





# Associated exemplar NPS efforts



# SeaWeb Acoustic LAN

- Communications at speed and depth
- Synthesis of acoustics and networking
- Bandwidths are not becoming huge, but steady connectivity is possible
- Ongoing series of demonstrations including Pacific Fleet TASWEX fall 2005



# usw-xml Working Group

- The usw-xml working group is improving Undersea Warfare (USW) interoperability using Extensible Markup Language (XML) tagsets for system data interchange.
- Cooperative collaboration between many stakeholders is needed for interoperability.
  - No one community can solve this in isolation
- Sponsored by NAVSEA PEO IWS
  - Perhaps first tactical DoD Community of Interest
- NPS and NUWC Newport lead this effort



# MOVES Institute

## **Modeling, Virtual Environments and Simulation (MOVES)**

- Our mission is research, application and education in the grand challenges of modeling, virtual environments, and simulation.

## **Research Directions**

- The research product directions include
- 3D visual simulation and networked virtual environments
- Computer-generated autonomy, computational cognition
- Human-performance engineering, immersive technologies
- Game-based simulation, understanding, and analysis
- Combat modeling and analysis



# AUV Workbench

- Underwater, air, surface unmanned vehicles
- Build scientific TDA with full-fidelity physics
  - Rehearsal: mission planning
  - Reality: real-time tasking and monitoring
  - Replay: playback telemetry
- Multiple sponsors & partners: NAVO/NRL, NUWC Newport, NAVAIR, Sonalysts, et al.
- Open source, open standards, new tech
  - Extensible 3D Graphics (X3D) for large worlds
  - XML, binary compression for GIG Web Services



UavWaypointMission.xml  
WWWGridDemo2.xml UsvBoxTest.xml  
WWWGridDemo1.xml

- 0. UUV Position
- 1. Thrusters
- 2. UUV Waypoint
- 3. UUV Waypoint
- 4. UUV Waypoint
- 5. UUV Waypoint
- 6. UUV Waypoint
- 7. UUV Waypoint
- 8. UUV Waypoint
- 9. UUV Waypoint
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- 18. UUV Waypoint
- 19. UUV Waypoint
- 20. UUV Waypoint
- 21. UUV Waypoint
- 22. UUV Waypoint
- 23. UUV Waypoint
- 24. UUV Waypoint
- 25. UUV Waypoint
- 26. SetPropeller

Save mission Save mission as... Close mission

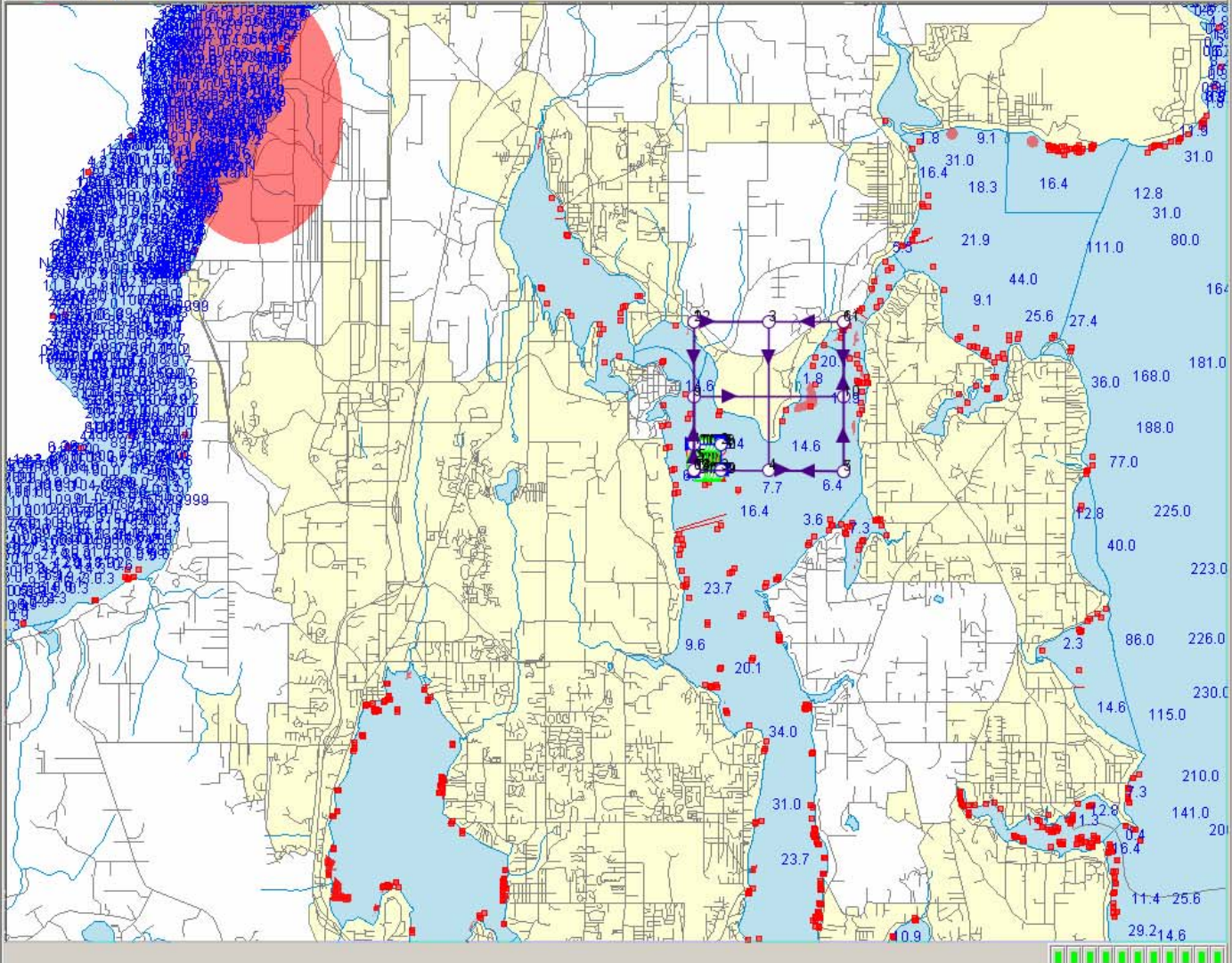
Vehicle type  Multiple loops   
NPS Aries AUV  Enable thrusters

Start Stop Email Clear Save...

Run (choose action to apply to all missions)

OpenMap Geographic View 2D Mission Planner 3D Scene Viewer

1:120,000



```

New DIS node: siteID: 0 appID: 1 entityID: 20 marking: USV-1
New DIS node: siteID: 0 appID: 1 entityID: 1 marking: AUV-2
New DIS node: siteID: 0 appID: 1 entityID: 21 marking: USV-2
New DIS node: siteID: 0 appID: 1 entityID: 22 marking: USV-3
AUV Workbench system console

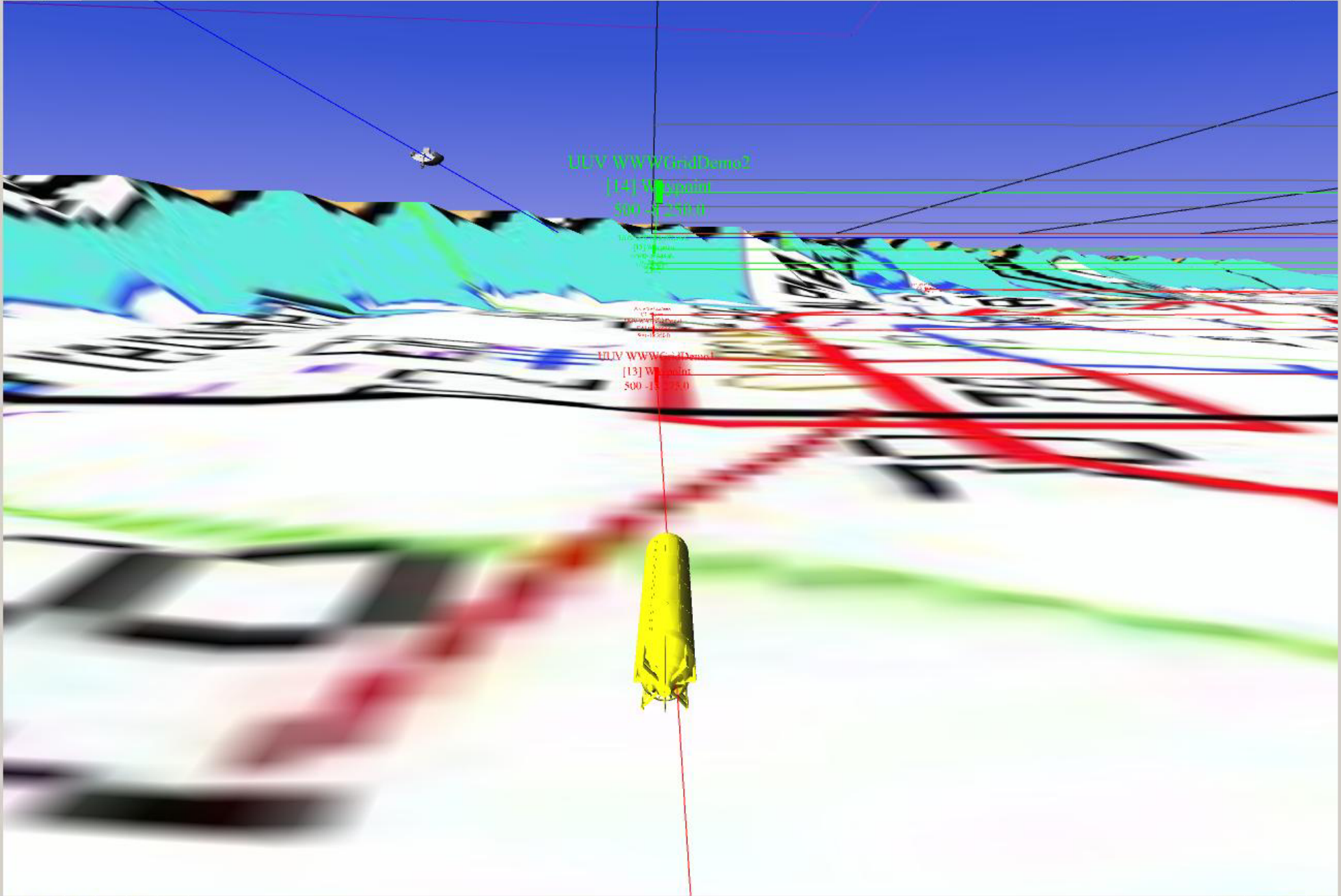
```

Email output Clear Save...

- About
- Snap
- Image
- Browse
- Text
- jEdit
- X3D
- ADS
- Jabber
- gnuplot
- Open...











# Summary themes

- NPS is the Navy's corporate university
- Solid graduate education is essential for naval officers and civilian engineers
- USW (ASW + MIW) robotics are hard
- Cross-disciplinary interoperability is the key to solving next-step challenges
- Test & evaluation are essential throughout



# Contact

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