Unmanned Underwater Vehicles: Enhancing and Extending our Operational Influence

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Why do I need a UUV?

– **Dangerous Environments:**
  - Active sonar
  - Mines
  - Live fire exercises
  - Under Ice Operations
  - Extended shallow water operations
  - Deep water operations

– **Additional sensor capabilities:**
  - Video / Audio / Sonar
  - Remote communications

– **Diver Assistance:**
  - Communications
  - Site Mapping
  - Perspective
  - Inspection
  - Tool delivery / collection

UUVs overcome challenges that are too costly or dangerous for personnel.
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Unmanned underwater systems

- ROVs (Remotely Operated Vehicles)
  - Tethered
  - Agile
  - Expert Operators
  - Mission Adaptation
  - High Bandwidth communications

- AUVs (Autonomous or Semi-autonomous Vehicles)
  - Tethered / Untethered
  - Intelligence to execute missions with limited or no human oversight
  - Accurate repeatable localization
  - Precision control, dynamic stabilization

ROV’s and AUV’s have different advantages and mission sets
ACQUAS is an inexpensive flexible development platform

- **Agile Close-Quarters Underwater Autonomous System**
  - Development platform: safety and flexibility
  - Small, agile: close-quarters, joint human ops

- **SeaBotix vLBV300 miniROV**
  - 300 m rated
  - 250 m fiber-optic tether
  - 3+ kts max speed
  - 4 DOF (incl. lateral due to vectoring)
  - Standard payload
    - Pivoting Camera + LEDs
  - Extended payload configuration
    - Teledyne RDI Explorer DVL/ADCP
    - BlueView Imaging/profiling SONAR
    - Greensea Systems Inc. FOG-based INS with GPS
  - Joystick control
  - Computer control via API
  - Adopted by Navy communities (e.g., EOD)
• Supports various levels of autonomy
  – Remote operation (local and via network)
  – Tele-operation (force-commanded)
  – Semi-autonomous control (velocity-commanded)
  – Semi-autonomous control (position-commanded)
  – Autonomous control: waypoint following
Complex Underwater Environments: NEEMO

- NASA Extreme Environment Mission Operations (NEEMO) – NASA JSC
  - Bill Todd, Marc Reagan
  - Astronaut training: Extra-vehicular activities in simulated gravity
  - Technology evaluation

- Aquarius Underwater Habitat (FIU)
  - Unique facility, Key Largo, FL
  - Saturation diving (7-31 day missions)
  - 45’ depth

- NPS CAVR - NASA JSC collaboration
  - Close-quarters operations
  - Joint human-robot operations
  - Multi-vehicle operations
  - Multi-resolution information gathering

NPS collaborates with NASA/FIU annually to improve/test UUV capabilities
ACQUAS at NEEMO 20

• Precursor: Low-resolution data, wide area
  – 100km of track line, 1.5km², 1m resolution
  – Select 1-2 medium-sized (0.04km²) areas for detailed survey

• Day 1: Medium resolution data, medium area
  – REMUS survey, 10-20km, 0.1m-0.25m resolution
  – Select 5-6 sites of interest (100m²)

• Day 2: High-resolution data, small area
  – ACQUAS operations, habitat controlled (on location)
  – Select 3 sites for human exploration - video stream

• Day 3: Joint ACQUAS-Aquanaut operations
  – ACQUAS leads divers to sites

NPS' ACQUAS demonstrated vital importance of UUV support at NEEMO 20
ACQUAS: Crew monitoring, site inspection

NEEMO 20 - July, 2015
Key Largo, FL

Noel Du Toit, Ph.D., in collaboration with NASA JSC
Center for Autonomous Vehicle Research (CAVR)
Mechanical and Aerospace Engineering
ACQUAS: Receive tool

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Possible Operations

• What could we do?
  – Maintenance, construction
  – Diver support
  – Increased operational range:
    • Project sensors/communications
  – ISR, mapping, monitoring, inspection
  – Documentation (Video/Audio/Sonar)
  – Object delivery & recovery (tools/samples)
  – Environmental Interaction
  – ...

Other missions would be more safe / cost effective with UUV support
My focus

– Close Quarters Navigation:
  • Docking
  • Diver Interaction
  • Environment Interaction

– Challenges:
  • Ranging - difficult to assess underwater
    – depth perception
    – fish eye (objects appear larger underwater)
    – turbidity
    – covert?
  • Inertial Navigator Precision

– Possible Solutions:
  • SONAR
  • structured light imaging (KINECT)
  • laser ranging/scanning
  • stereovision (3D video feed)
Docking

NAVAL
POSTGRADUATE
SCHOOL

ACQUAS: Docking

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ACQUAS: 3D mapping

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Questions?

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