Unmanned Systems
Research and Development
at
SPAWAR Systems Center
Pacific

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http://www.spawar.navy.mil/robots/

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### Unmanned Systems Research and Development at SPAWAR Systems Center Pacific

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**Abstract:**


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Unmanned Systems Expertise

- Over 90 in-house personnel
- 60 Government scientists and engineers
- Unmanned Systems Naval Reserve Unit
- 25 years in unmanned ground and air vehicles
- 40 years in unmanned undersea vehicles
- Over 25 active robotics research and development projects
- Infrastructure for UGV, UAV, USV, UUV RDT&E
- OSD JRP-designated Center of Excellence for Small Robots
- Funding from:
  - OSD JGRE, RS-JPO, NAVSEA, PM-FPS, FCS, MANSCEN, CECOM NVESD, ARL, DARPA, DTRA, ONR, NSWG, SOCOM, and others
Robotics Outdoor Test Range

- Paved & unpaved roads
- Off-road terrain
- Bunkers & tunnels
- VTOL UAV flight range
- Ocean access
Located in beautiful San Diego

Ground, air, surface

Underwater
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Technology Development Across All Domains
Air, Land, and Sea

- Robotic Systems Pool
- Networked Remotely Operated Weapons
- Common Operator Control Unit (Common OCU)
- Automatically Deployed Communication Relays
- Adaptive Mission Planning
- Man-Portable Robots
- Unmanned Surface Vehicle Technologies
- Technology Transfer
- Unmanned Underwater Vehicle Technologies
Unmanned Surface Vehicle (USV)

Accomplishments

- Converted Sea-Doo Challenger 2000 jet boat for semi-autonomous operation.
- Port UGV hardware/software for teleoperation and waypoint navigation.
- Develop obstacle avoidance capability for fully autonomous navigation
  - Deliberative path planning
  - Reactive obstacle avoidance
- Develop and integrate sensor technologies to support autonomous operation
  - Digital ARPA Radar
  - Vision (stereo and monocular)

Operational Relevance

- Used to remove the warfighter from dangerous environments and for force multiplication.
- Intended for Tactical and Force Protection:
  - Special Warfare force projection and reconnaissance
  - MCM: detection, inspection, classification and possible neutralization
  - Port and harbor surveillance and security
  - Marine Hydrographic Surveying
  - Environmental/chemical Sensing
Multi-Robot Operator Control Unit (MOCU)

Operational Relevance
- Used for the R3V and Spartan ACTDs
- Used as the common OCU for the Littoral Combat Ship USV programs (ASW and MIW)
- Used for the Army's FIRRE program (as JBC2S)
- Used by a wide variety of other government, industry and academic organizations

Characteristics
- Control multiple sets of heterogeneous sets of vehicles
- Vehicle and protocol type independent
- Modularity
- Scalability
- Flexible User interface
Mobile Detection Assessment Response System (MDARS)

Operational Relevance
- Technical Director for the Army PM-FPS’ MDARS program.
- Robotic platforms autonomously patrol DoD storage sites and air bases, along pre-programmed paths using differential GPS.
- Multi-layer sensor fusion of laser, stereo vision cameras, and radar provides Obstacle Avoidance.
- Robots detect and assess potential intruders, monitor inventory, and check the status of Interior Locking Devices on munitions storage bunkers.

Accomplishments & Milestones
- BAA contract for platform development awarded in 1993.
- BAA Final Demonstration successfully conducted in October 1998.
- Passed Milestone C in December 2006.
- Production contract awarded in December 2007.
- Currently leading the MDARS Modernization Effort—incorporating user-requested capabilities: detection on the move, weaponization, ICIDS, etc.
Physical Security Applications

- Current state: MDARS Intruder Detection and Assessment
  - Requires sensors to be stationary
  - Fuses STS Radar, FLIR, and daylight cameras

- New MDARS requirements:
  - Detection of human presence to a range of 300m
  - 360 degrees horizontal, +/-30 degrees vertical
  - Detect from moving platform
  - Integrate Radar, Ladar, FLIR, and video

**Change Detection on the Move:** 2-stage process

- **Stage 1: Anomaly Detection**
  - Mapping algorithm detects anomalies
  - Location of anomaly is tagged into the map

- **Stage 2: Verification of Human Presence**
  - Location of anomaly is sent to thermal presence detection system to classify
  - Icon representations of confirmed human presence are embedded into map
Operational Relevance
- Identify Force Protection solutions candidates for the Joint Force Protection Advanced Security System (JFPASS) JCTD
- Assess the feasibility of integration, automation and fusion of information
- Integrate Physical Security and CBRNE
- Exercise Joint CONOPS and TTPs
- Provide insight and analysis based on assessments and experiment results

Accomplishments
- Demonstrated integration of:
  - lethal/non-lethal UGVs,
  - ground surveillance radars,
  - unattended ground sensors,
  - fiber optic fence sensors,
  - daylight/thermal/laser-illuminated imagers,
  - sniper detection sensors,
  - chemical, biological, and radiological sensors,
  - plume modeling.
- Conducted 4 operational assessments of CONOPS, TTPs, operator workload, and operational effectiveness
- Extended and integrated the SEIWG ICD-0100 XML protocol into JBC2S for Force Protection interoperability
Joint Collaborative Technologies Experiment (JCTE)

Accomplishments
Demonstrated:
- Beyond Line Of Sight (BLOS) range extension through a UAV-borne communications relay
- Forward deployment, launch, recovery, and refueling of a VTOL UAV by a UGV
- Target ID and lethal engagement

Operational Relevance
- Integrate collaborative technologies that support teaming communications, sustainment, and engagement in manned-unmanned teaming applications
- Effort to develop the capabilities needed to support collaborative behaviors between unmanned systems
- Joint effort from three services
  - SPAWAR, AFRL, AMRDEC
- Demonstration to validate hardware and software with an emphasis on JAUS compliance
Autonomous UAV Mission System (AUMS)

Operational Relevance
- SSC-SD’s portion of JCTE
- Develop an automated system for a UAV to be launched, captured, refueled, and re-launched
- Can operate from USVs, UGVs, HMMWVs, and fixed stations
  - Decreases time and personnel required to refuel UAV
  - Increases the number of missions the UAV can complete and total UAV time on station
- Supports a variety of RSTA, site security, and Force Protection applications

Accomplishments
- Developed an automated launch and recovery platform for use with a variety of Class 1 and Class 2 VTOL UAVs
- Established UAV test facility
- Developed automated refueling system for iSTAR UAV
- Demonstrated precision autonomous landing for a small VTOL demonstration UAV
Automatically Deployed Communication Relays (ADCR)

Operational Relevance
- Transitioned from DARPA-funded Autonomous Mobile Communication Relays (AMCR) project.
- Demonstrates automatic maintenance of high-bandwidth communication link between advancing robot and remote operator.
- Relay deploying module automatically ejects relay “bricks” as needed.
- Next step: concept exploration of leave-behind networked sensors and other payloads.

Technology Development
- Self-righting relay brick with extending antenna.
- Deployment module carrying six relay bricks.
- Four complete systems produced.
- Next-generation systems being developed: smaller, more rugged, higher bandwidth, more secure.
Accomplishments
- Collision Avoidance – NRL/INL, JPL
- Localization/Mapping – USC, CMU, SRI
- GPS Waypoint Navigation – SSC SD
- Navigation in GPS-denied Areas – SSC SD
- Human Presence Detection – UT Austin
- Augmented Virtuality – INL

Operational Relevance
- Increase autonomy for ground robots.
- Harvests state-of-the-art results of prior and ongoing robotic technology development efforts.
- Integrates various researched algorithms into a complete, single system.
- Optimizes a reconfigurable software framework for cross-platform compatibility.
- Provides a convenient enabling mechanism for the subsequent transfer into other programs.
- Enhances platform capabilities, human-robot interfaces, and behavior architecture.
- FY08 focus: urban environment exploration.
Examples of recent TechTXFR collaborations

Collaborative R&D with the *Center for Commercialization of Advanced Technologies* (CCAT)

*CornerTurn, LLC*: Deployment of leave-behind sensor nodes using the ADCR system

*Space Micro Inc.*: Autonomously detect, identify, and locate radiation sources

*SAIC*: Demonstrate Bird Dog/Warfighter’s associate concept

*iRobot Corp.*: Develop the Navigator (lidar, INU) and stereo vision payloads
Autonomous Navigation for Small UGVs

Operational Relevance

- Increase effectiveness of future small UGVs
- Overcome size and height disadvantages
- Open up new applications
- Target technologies:
  - Obstacle detection and avoidance
  - Non-GPS waypoint navigation
  - Retro-traverse
  - Guarded teleoperation
  - Leader-follower

Accomplishments/Plans

- Focus on small, light-weight, low-power sensors and algorithms tailored for sensor and platform characteristics
- Jointly developed the SmartCam with JPL
- Currently working on a full FPGA implementation, giving full frame-rate stereo vision at high resolution
- Evaluating miniature ladar for Simultaneous Localization and Mapping (SLAM)
Networked Remotely Operated Weapon System (NROWS)

Operational Relevance

- Standalone networked weapons platform provides remote lethal response to intruders.
- Fixed installation or deployed by UGV to provide remote response capability for security operations and other tactical missions.
- Provides real-time unattended weapons pod that extends delay/denial response capabilities at high-value installations or in tactical scenario.

Technology Development

- Uses a distributed TCP/IP network control-communication architecture.
- Allows for flexible integration and operation of multiple platforms from a single control station.
- Communications incorporate anti-jamming, encryption, or low probability of intercept/low probability of detection (LPI/LPD).
- Integrated with autonomous surveillance, detection, and automated target tracking.
- Demonstrated operation from unmanned MDARS UGV in April 2005.
- Metal Storm electronic weapon systems being considered.
EOD Robotics Technology

Operational Relevance

- Support NAVEODTECHDIV on the Man-Transportable Robotic System (MTRS) Continuous Improvement Program and the Cooperative Robotics Program.
- Provide EOD tools integration with MTRS platforms.
- Demonstrate advanced technologies for increased autonomy.

Development History

- Designed and prototyped MTRS Mk1 (PackBot) and Mk2 (Talon) deployment mechanisms for disruptors and other EOD tools.
- Demonstrated technologies on MTRS platforms for:
  - GPS and non-GPS waypoint navigation
  - Video-based waypoint selection
  - Retro-traverse
  - Guarded tele-operation
  - 3D visualization
  - Simultaneous Localization and Mapping
  - Human Following
  - Multi-vehicle control (from single OCU)
SSC is exploring and supporting a number of applications for undersea glider technology

- Fixed Wing Glider
  - Form Factor Research
  - Missions/Payloads
  - Testing
- Surveillance Systems Demos
  - DADS Communication Gateway
  - Acoustic Surveillance Glider
The Adaptive Mission Planner, developed with UC Riverside, provides the vehicle with behavior-based, control commands using real-time sensor data.

The planner allows for higher-level autonomy for the UUV.
Mobile Robot Knowledge Base (MRKB)

http://robot.spawar.navy.mil

Operational Relevance

- Provides robotic system developers, program managers, and customers with a web-accessible, centralized knowledge resource for mobile robot components, subsystems, mission payloads, and platforms.
- Minimize redundant product research efforts, maximize efficiency and responsiveness.
- Facilitates technology transfer.
- Supports JRP small robot pool.

Development History

- Small Robot Technology Database launched April 1999.
- Currently undergoing major upgrade.
Robotic Systems Pool (RSP)

- Provides government agencies at all levels with the opportunity to evaluate and experiment with mobile robots in their own unique operational domains.
- Users can make appropriate acquisitions of robots based on their experience.
- Robot Developers benefit from the users feedback and recommendations, enabling them to improve their designs and better meet the emerging needs.

Accelerates the technological advance of US military forces and law enforcement by making the latest robotic technology available through no cost loans.

Developers

Feedback

Users

Technology

Spiral Development

World Trade Center

Iraq/Afghanistan

Utah State University
ASD (HD&ASA) Section 1401
Technology Outreach Centers

- **WYOMING**
  - Camp Guernsey

- **OKLAHOMA**
  - Site Selection in Process

- **CALIFORNIA**
  - Norton AFB
  - SSC-San Diego

- **TEXAS**
  - Texas A&M Hazard Training Center

- **HAWAII**
  - Barbers Point

- **INDIANA**
  - Fort Wayne Public Safety Institute

- **ALABAMA**
  - Site Selection in Process

- **PENNSYLVANIA**
  - Johnstown

- **Site Selection in Process**
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