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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 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

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Robotics Outdoor Test Range

- Paved & unpaved roads
- Off-road terrain
- Bunkers & tunnels
- VTOL UAV flight range
- Ocean access

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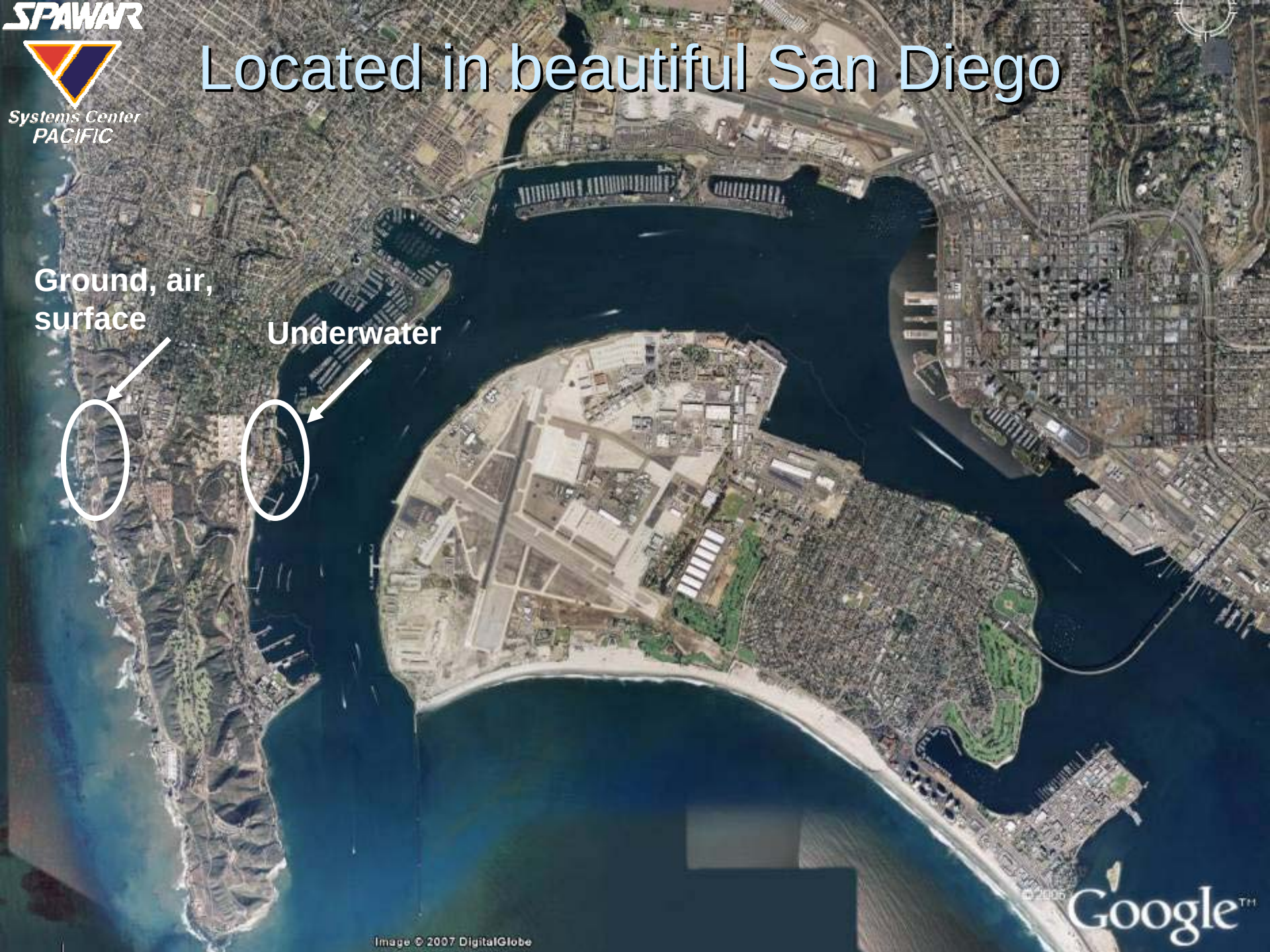
Located in beautiful San Diego



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Collaboration

Organization	Project/Focus
JRP/AFRL/AMRDEC/NIST	Joint Architecture for Unmanned Systems (JAUS)
Army DBBL	Army user test and evaluation
JPL	Stereo vision, obstacle avoidance
INL	Collision avoidance/target tracking/intelligence kernel
SWRI	Robotics test and evaluation
SRI	Simultaneous Localization and Mapping (SLAM)
USC	Robotics simulation and device drivers, precision landing
UCSD	Advanced machine vision
NUWC	SPARTAN (ACTD), LCS ASW MM
Army MANSCEN	Countermine
ARL/UT Austin	Human Presence Detection and Assessment
NSWC Panama City	Joint Unmanned Systems Common Control (JUSC2)
AFRL	Remote Detection Challenge and Response (REDCAR)
Carnegie Mellon Univ.	Beacon-based landmark referencing, countermine
JRP/NUSE2	National Unmanned Systems Experimentation Environment
NPS	Surveillance and Target Acquisition Network experiment
AFRL/AMRDEC	UGV/UAV Collaborative Engagement Experiment
NG Remotec	Family of Integrated Rapid Response Equipment
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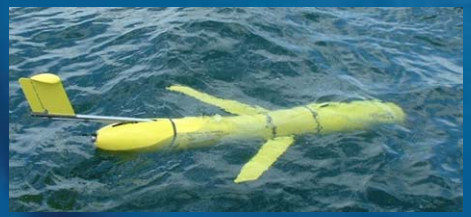
Technology Development Across All Domains Air, Land, and Sea

Robotic Systems Pool

Common Operator Control Unit (Common OCU)



Adaptive Mission Planning

Networked Remotely Operated Weapons

Automatically Deployed Communication Relays

Unmanned Surface Vehicle Technologies

Man-Portable Robots

Unmanned Underwater Vehicle Technologies

Technology Transfer

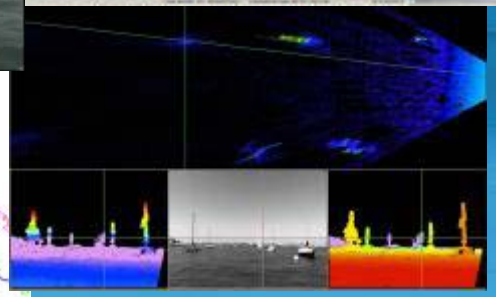
Unmanned Surface Vehicle (USV)

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

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)



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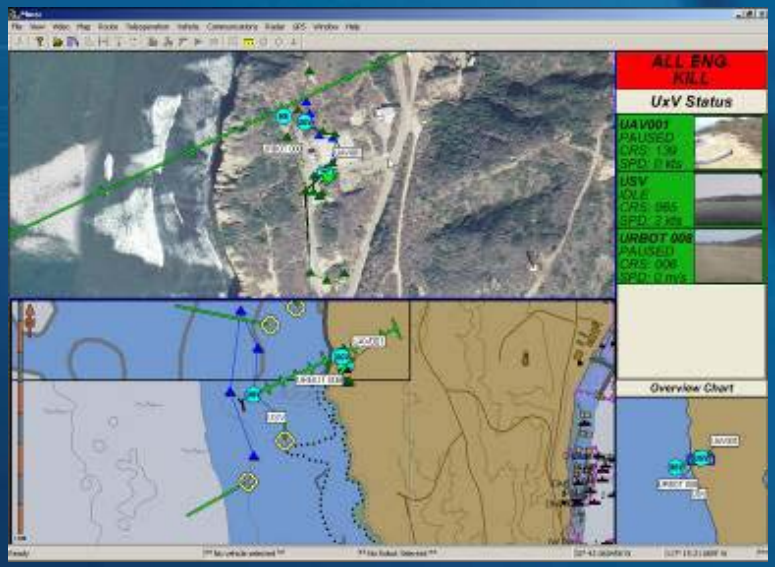
Multi-Robot Operator Control Unit (MOCU)

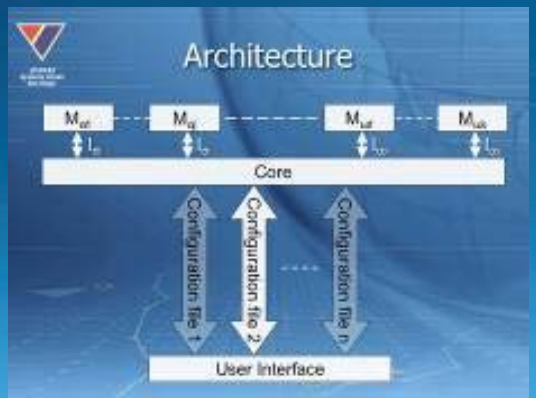


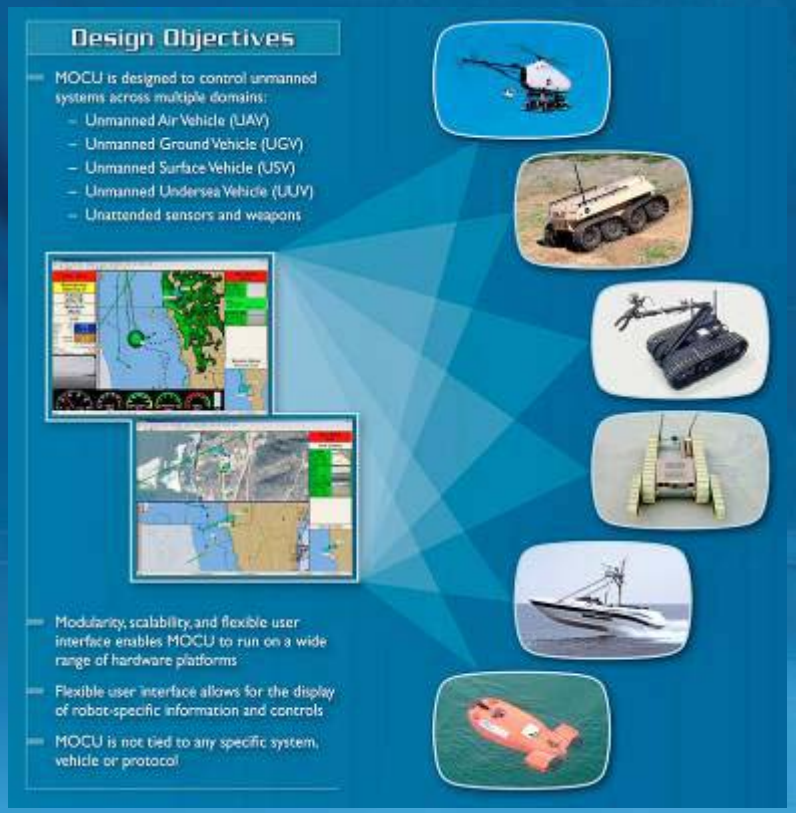
Operational Relevance

- 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





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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.

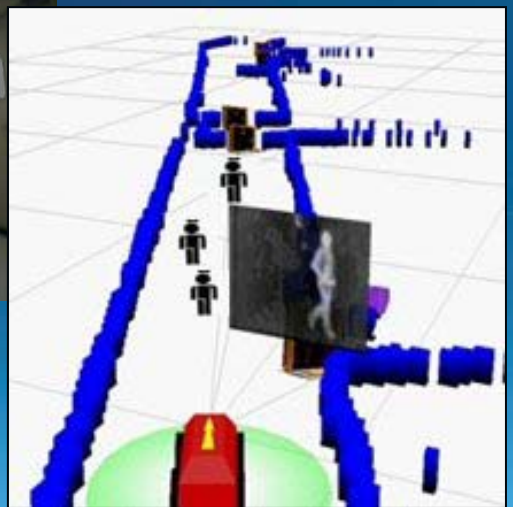
Accomplishments & Milestones

- BAA contract for platform development awarded in 1993.
- Led system integration and tests of BAA prototype, 1993-1998.
- BAA Final Demonstration successfully conducted in October 1998.
- Passed Technical Feasibility Testing (TFT) conducted by U.S. Army Test Command in May 2000.
- System Development and Demonstration (SDD) contract awarded in 2001.
- Early User Appraisal (EUA) at Hawthorne Army Depot in 2004 – 2005.
- 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.

Human Motion/Presence Detection

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

Force Protection Joint Experiment (FPJE)

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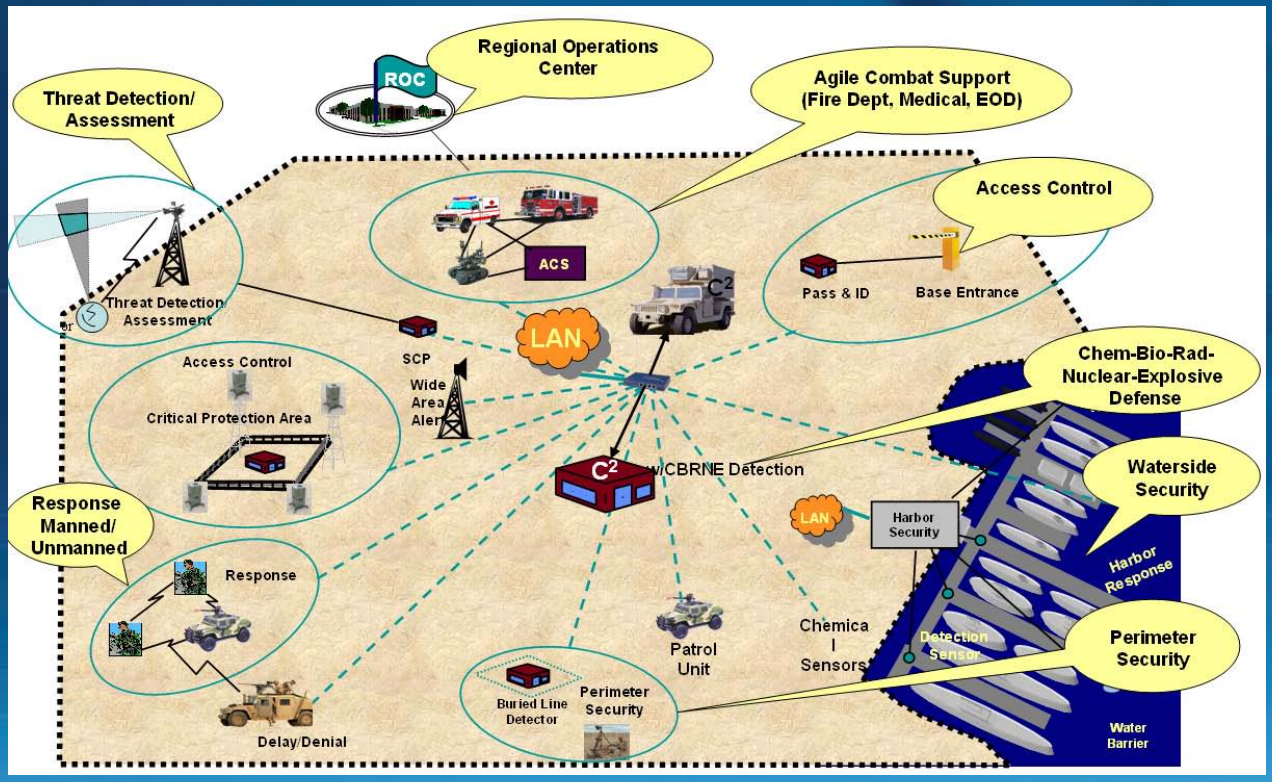
Operational Relevance

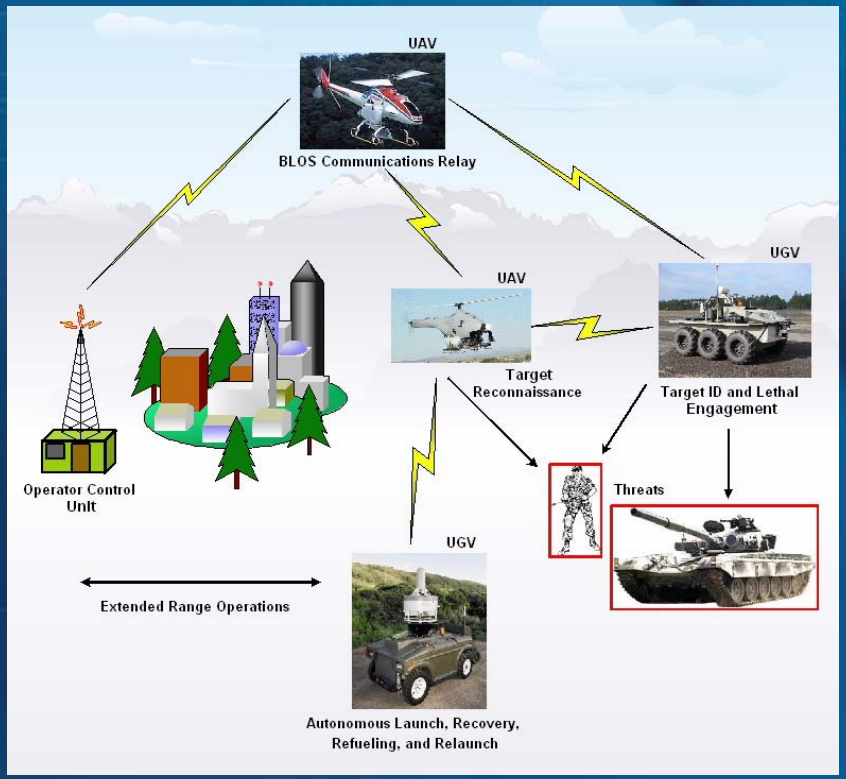
- Identify Force Protection solutions candidates for the Joint Force Protection Advanced Security System (JFPASS) JCTD
- Assess the feasibility of integration, automation and fusion of information
- Integrate Physical Security and CBRNE
- Exercise Joint CONOPS and TTPs
- Provide insight and analysis 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)



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

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

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

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Automatically Deployed Communication Relays (ADCR)

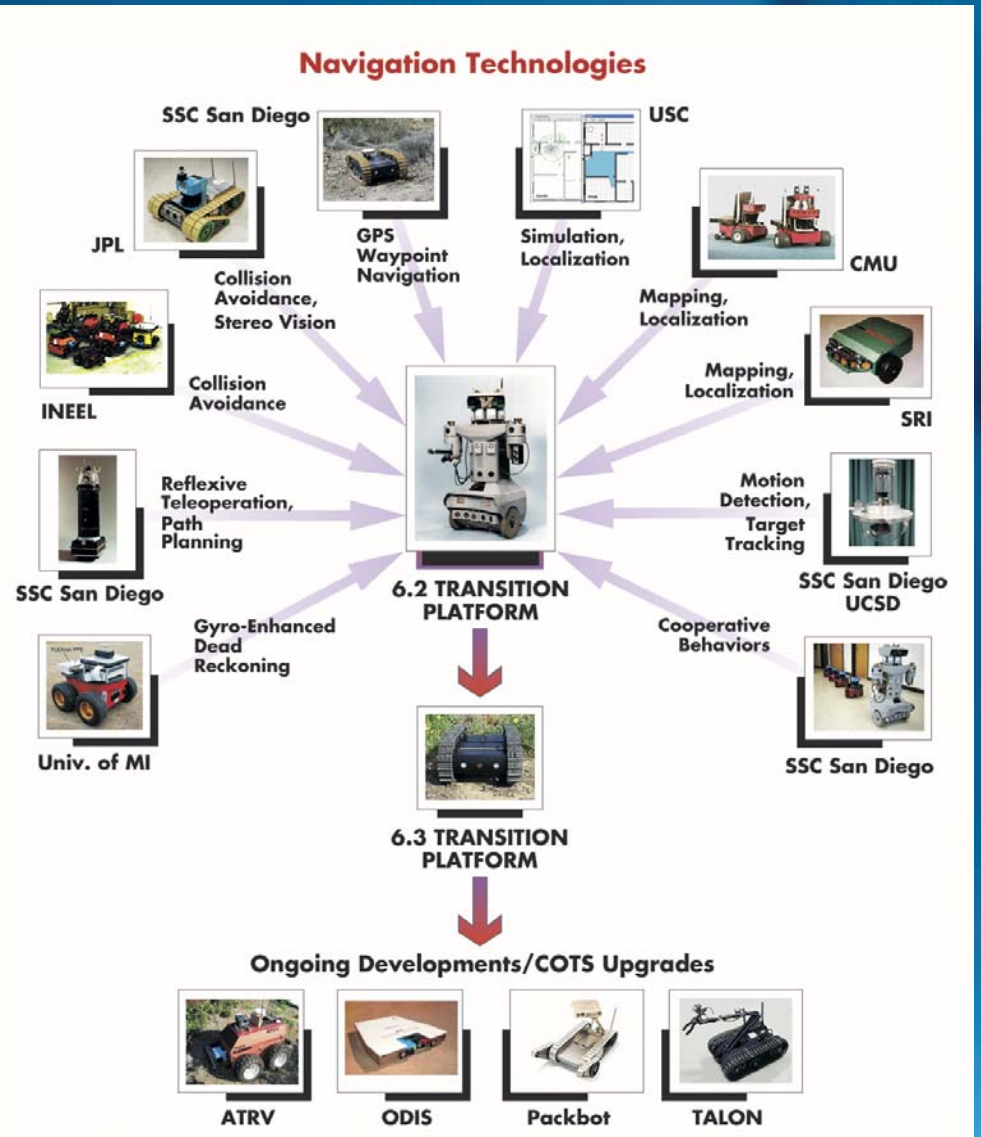
Operational Relevance

- 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.

Robotics Technology Transfer



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*.

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
- ….

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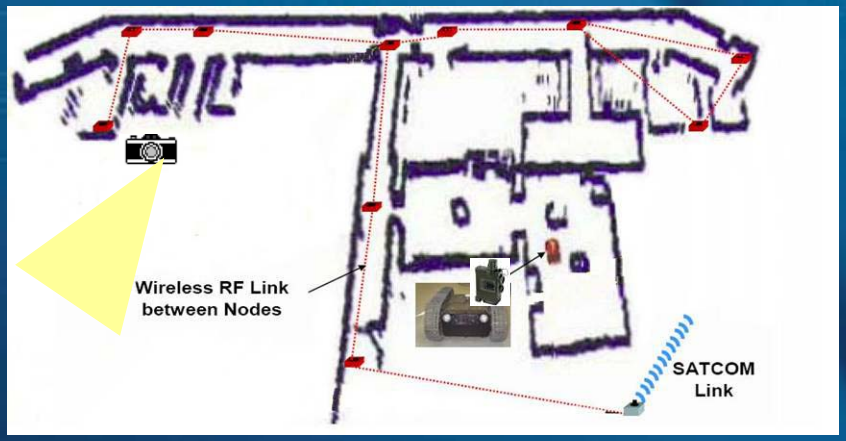
Examples of recent TechTXFR collaborations

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 (ladar, INU) and stereo vision payloads

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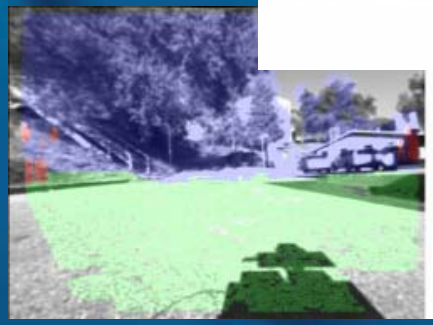
Autonomous Navigation for Small UGVs



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)

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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)

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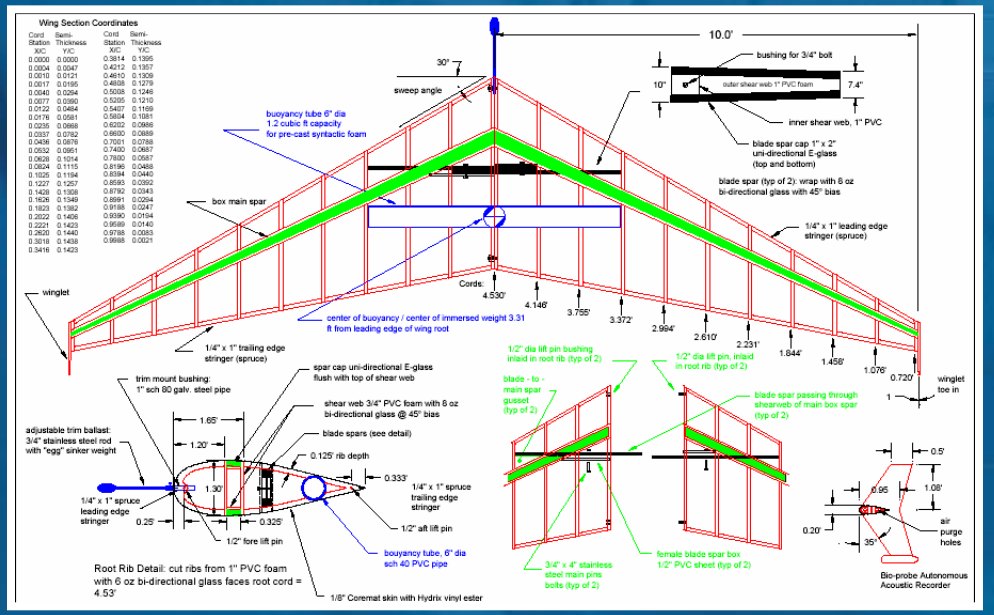
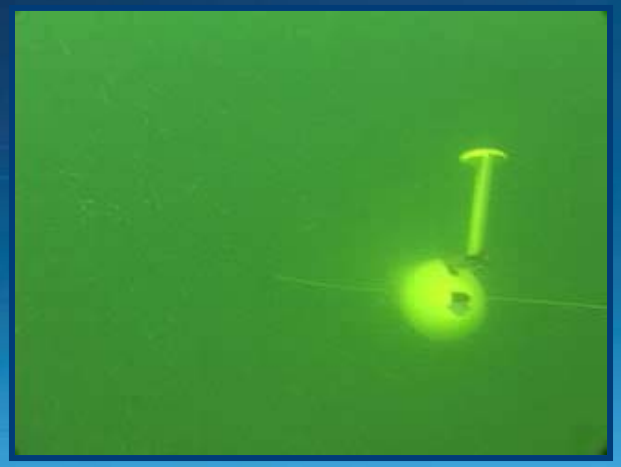
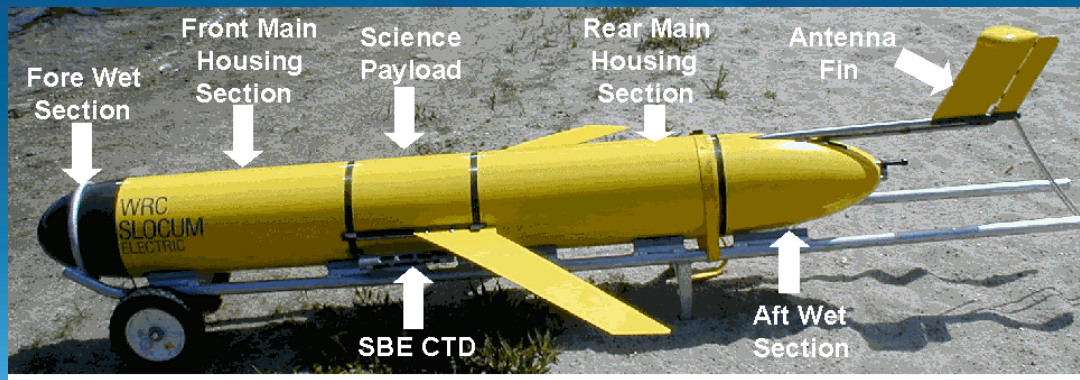
Underwater Gliders

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



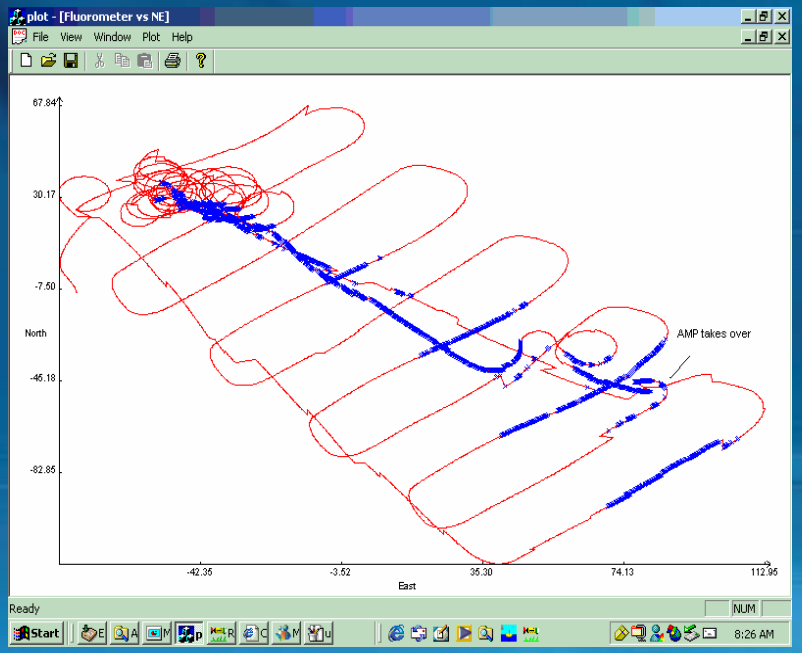




UUV Autonomous Controls: Adaptive Mission Planner

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.



Data Plot from AMP computer, 2003

Mobile Robot Knowledge Base (MRKB)

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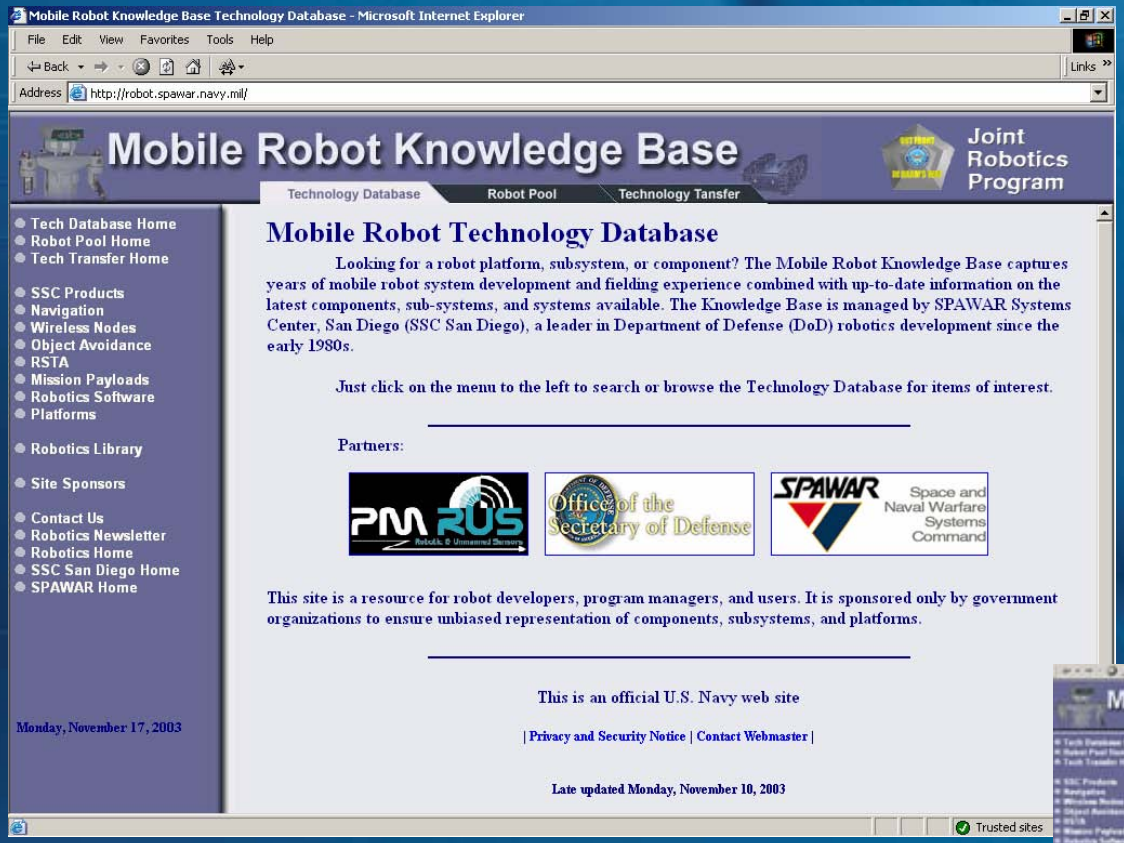
http://robot.spawar.navy.mil



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.
- Mobile Robot Technology Knowledge Base internal launch Oct 2001, initial public launch Dec 2001.
- Currently undergoing major upgrade.

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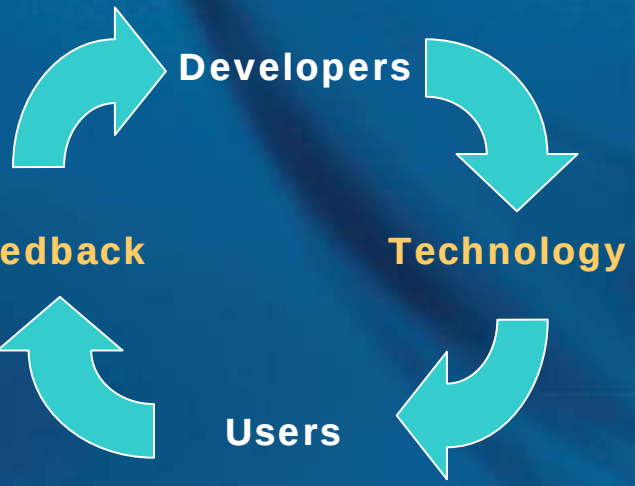
Robotic Systems Pool (RSP)

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

- 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.



Spiral Development

World Trade Center

Iraq/Afghanistan

Remington

Inuktun

ARA

Foster-Miller

Allen-Vanguard

SSC San Diego

iRobot

Utah State University

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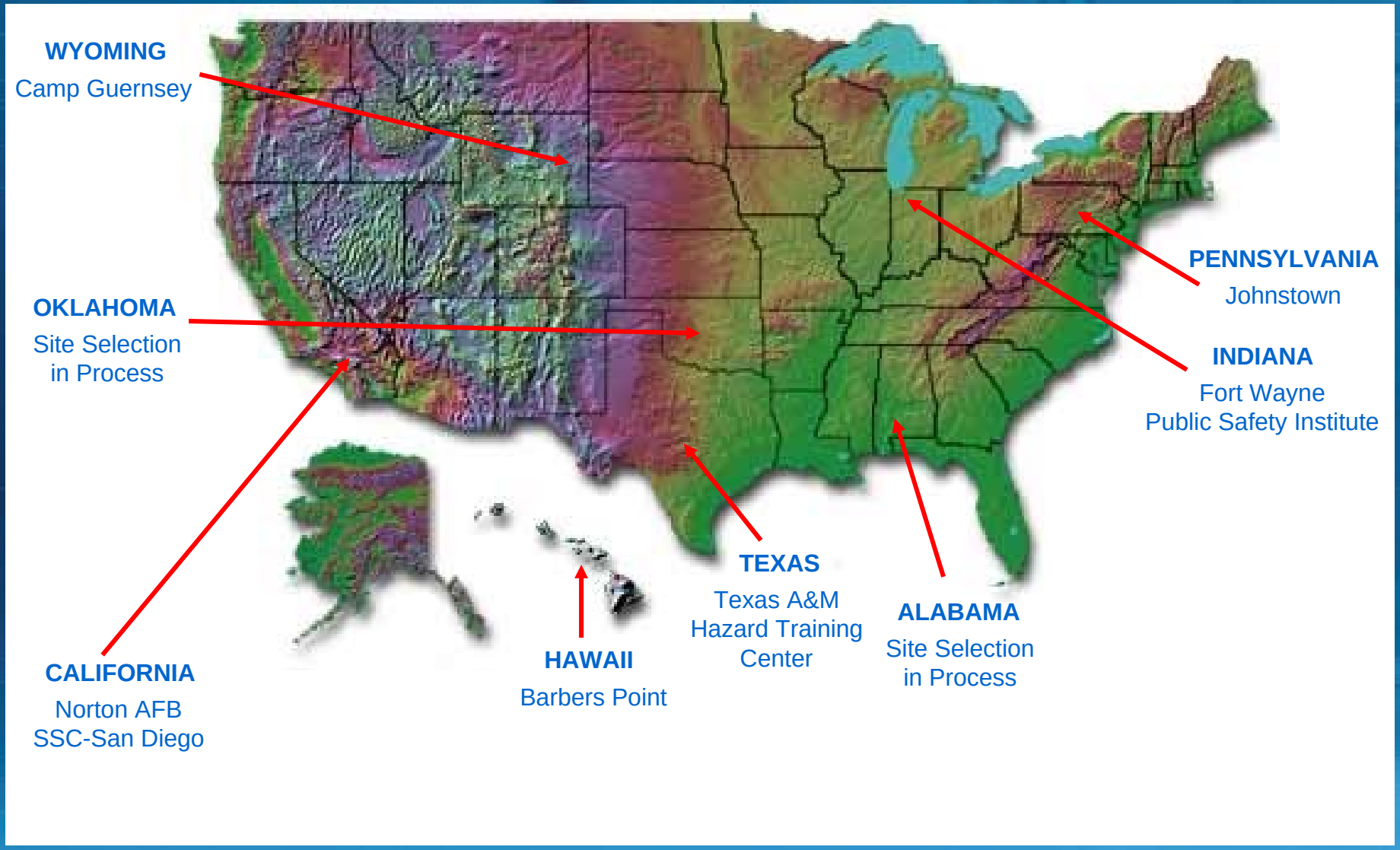
ASD (HD&ASA) Section 1401 Technology Outreach Centers



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