S&T Focused on Naval Needs

FY10 DON S&T Funding = $1,824M

Focus

Broad

Narrow

Near

Mid

Far

Quick Reaction & Other S&T

~10%

Acquisition Enablers (FNCs)

~30%

Leap Ahead Innovations (INPs)

~10%

Discovery & Invention
(Basic Science, Early Applied Research)

~40%

Quick Reaction & Other S&T

(10%)

• Tech Solutions
• Experimentation
• MC S&T (MCWL, JNLW, etc.)

Acquisition Enablers
(36%)

• Future Naval Capabilities
• Warfighter Protection
• Capable Manpower
• LO/CLO

Leap-Ahead Innovations
(12%)

• Innovative Naval Prototypes
• NSPs
• Swampworks

Discovery & Invention
(42%)

• Basic & Early Applied Research
• National Naval Responsibilities
• Education Outreach HBCU/MI

Time Frame

Quick Reaction & Other S&T

~10%

6.3

Acquisition Enablers

~30%

6.3 / 6.2

Leap Ahead Innovations

~10%

6.2 / 6.1

Discovery & Invention

~40%

FY10 DON S&T Funding = $1,824M

PE: 6.3 / 6.2 / 6.1

S&T Focused on Naval Needs

OFFICE OF NAVAL RESEARCH
State-of-the Art

Current state of technology:
Navigation behaviors employing GPS based Route Network Definition Files (RNDF) and costly, multi-modal sensor suites
- Simple behaviors employing rule-based system
- Rule-based systems are not robust enough for complex environments when encountering uncertainty, imprecision, contradiction, and incompleteness
- Typical sensor suite and CPU cost often exceed $250K, bulky, power hungry
  - Limited environmental context and understanding outside of a pre-planned, structured environment
  - Sensor suite and CPU alone render capability un-affordable

S&T challenges:
1. Affordable Logic/Software
2. Affordable Sensor Suites
3. Advanced Autonomy Algorithms
4. Small unit mobility/maneuverability in extremely complex terrain
5. Dense power and energy devices/sources
6. Fuel independence/energy self-sufficiency for extended ranges

DARPA Urban Challenge Future Tactical System in Unstructured Environments

- Advanced perception system and algorithms to reduce number of sensors and to allow operations in unstructured environments
- Stereo Vision EO camera, vestibular, odometry and other input channels

3 Multi-planar Laser Rangefinders (LIDAR)
4 Single-Plane LIDAR
2 IEEE 1394 cameras
Remote Control Versus Autonomy

Remote Control
Operator continuously, visually controls the platform via tether or radio. UMS takes no initiative.

Tele-operation
Operator, using video or other sensor input either directly controls the platform or assigns incremental goals via tether or radio. In this mode, the UMS may take limited initiative in reaching the assigned incremental goals.

Semi-autonomous
Operator and the UMS cooperatively plan and conduct a mission but still requires varying degrees of Human-Machine Interface.

Fully autonomous
A mode of operation wherein the UMS is expected to accomplish its mission, within a defined scope, without human intervention. Note that a team of UMSs may be fully autonomous while the individual team members may not be due to the needs to coordinate during the execution of team missions.

NIST Special Publication 1011
Autonomy Levels for Unmanned Systems (ALFUS) Framework
Volume I: Terminology
Version 1.1
September 2004
Why Autonomous Behavior is a Hard Problem

Environmental Complexity
Solution ratios on:
- Terrain variation
- Object frequency, density, intent
- Weather
- Mobility constraints
- Communication dependencies

Mission Complexity
- Subtasks, decision
- Organization, collaboration
- Performance
- Situation awareness, knowledge requirements

Machine Intelligence Level
Ability to:
- Reason, Plan, Predict
- Learn from experience, instructions, etc., and adapt to new situations
- Understand the battlespace
- High-level interactions with humans

Human Interaction
- Type of interactions
- Type of operators/users (e.g., workload, skill levels, etc.)
- Frequency, duration, robot initiated interactions
Affordable Sensor Suites and Advanced Perception System

Move away from costly multi-modal sensors suites to low-cost vision based sensors

a. Leverage existing machine vision work performed by DARPA and JPL (LAGR Program)
b. Distributed computing networks to process “at-the-sensor” utilizing FPA, DSP, GPU and reduce the computational burden on the CPU
c. More capable and robust texture analysis algorithms (segmentation, texture, signature)
d. Reasoning algorithms to discriminate between objects and apply context to a near-field spatial scene (rock-bush, puddle-hole, door-window)

Advanced Autonomy Algorithms

Move from point-to-point navigation to autonomous behaviors not reliant on GPS

a. Near-field Tactical Path Planner utilizing a Raster World Model including relative and absolute localization (SLAM)
b. Far-field Advanced Path Planner to include platform master state information and environmental traversability
c. Dynamically generated high-level situation awareness model incorporating information not organic to the vehicle such as threat areas, road and terrain connectivity and traversability, and real-time events and intelligence (Ford Sync System™)
d. Advanced autonomy behaviors which integrate bottom-up perception and top-down reasoning to execute doctrinally correct tasks with no human intervention
ONR Unmanned Systems POC’s

- ONR 30: (Bradel)
  - Genetic Programming/Auto-Code Generation
  - Advanced Perception Algorithms for Vision-Based Sensors
  - Advanced Autonomy Algorithms for UGV’s
- ONR 31: (Kamgar-Parsi)
  - Image Understanding
  - Robotic perception
  - Machine reasoning and planning in uncertain environments
- ONR 32: (Swean)
  - Unmanned Underwater Systems
- ONR 33: (Brizzolara)
  - Intelligent Autonomy for USSV
  - Developing Autonomy for USVs by Using Virtual Environments
- ONR 34: (McKenna)
  - Human-Centric Autonomy
  - Natural-language Dialogue with Autonomous Systems
  - Human Tracking and Activity Recognition
- ONR 35: (Steinberg)
  - Intelligent Autonomy for UAS
  - UAS Mission Control Interfaces
- Naval Research Lab (Schultz)
  - Artificial Intelligence
How to contact ONR

For more information about ONR:

http://www.onr.navy.mil/

For more information on Unmanned Ground Systems, contact ONR Code 30 at:


To submit a white paper:

http://www.onr.navy.mil/

Click on “Contracts and Grants”
Click on “Broad Agency Announcements”
Select “BAA10-001”
Questions?
Back-Up Slide
# Man versus Machine

<table>
<thead>
<tr>
<th>Level</th>
<th>Observe</th>
<th>Orient</th>
<th>Decide</th>
<th>Act</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>The computer is responsible for gathering and filtering data without displaying any information to the human.</td>
<td>The computer overlays predictions with analysis and interprets data for a result that is not displayed to the human.</td>
<td>The computer performs the final ranking task, and does not display the result to the human.</td>
<td>The computer executes the decision and does not allow any human interaction.</td>
</tr>
<tr>
<td>7</td>
<td>The computer is responsible for gathering and filtering data without displaying any information to the human. Though, a “program status indicator” is displayed.</td>
<td>The computer overlays predictions with analysis and interprets data for a result which is only displayed to the human if result fits programmed context (context dependant summaries).</td>
<td>The computer performs the final ranking task and displays a reduced set of ranked options without displaying “why” the decision was made to the human.</td>
<td>The computer executes the decision and only informs the human if required by context. The human is given override ability after execution when physically possible.</td>
</tr>
<tr>
<td>6</td>
<td>The computer is responsible for gathering, filtering, and prioritizing information displayed to the human.</td>
<td>The computer overlays predictions with analysis and interprets the data. The human is shown all results for potential override.</td>
<td>The computer performs the ranking task and displays a reduced set of ranked options while displaying “why” the decision was made to the human.</td>
<td>The computer executes the decision, informs the human, and allows for override ability after execution when physically possible. In the event of a contingency, the human can independently execute the decision.</td>
</tr>
<tr>
<td>5</td>
<td>The computer is responsible for gathering and displaying unprivileged information to the human. The computer filters out the unhighlighted data displayed to the human.</td>
<td>The computer overlays predictions with analysis and interprets data. The human is the backup for interpreting data.</td>
<td>The computer performs the ranking task. All results, including “why” the decision was made, are displayed to the human.</td>
<td>The computer allows the human a context-dependant time-to-veto before executing the decision. In the event of a contingency, the human can independently execute the decision.</td>
</tr>
<tr>
<td>4</td>
<td>The computer is responsible for gathering and displaying unfiltered, unprivileged information to the human. The computer highlights the relevant non-privileged information displayed to the human.</td>
<td>The computer is the prime source for analyzing data and making predictions as a trusted calculator. The human is the prime source for interpreting data.</td>
<td>Both the human and the computer perform the ranking task, the results from the computer are considered prime.</td>
<td>The computer allows the human a pre-programmed time-to-veto before executing the decision. In the event of a contingency, the human can independently execute the decision.</td>
</tr>
<tr>
<td>3</td>
<td>The computer is responsible for gathering and displaying unprivileged, unhighlighted, and unprivileged information to the human. The human is responsible for filtering and prioritizing the data, with computer backup.</td>
<td>The computer is the prime source for analyzing data and making predictions with human checks of the calculations. The human is the only source for interpreting data.</td>
<td>Both the human and the computer perform the ranking task, the results from the human are considered prime.</td>
<td>The computer executes the decision after human grants authority-to-proceed. In the event of a contingency, the human can independently execute the decision.</td>
</tr>
<tr>
<td>2</td>
<td>The human is the prime source for gathering, filtering, and prioritizing data, with computer backup.</td>
<td>The human is the prime source for analyzing data and making predictions, with computer verification when needed. The human is the only source for interpreting data.</td>
<td>The human is the only source for performing the ranking task, but the computer can be used as a tool for assistance.</td>
<td>The human is the prime source for executing the decision, with computer backup for contingencies (e.g. deconditioned humans).</td>
</tr>
<tr>
<td>1</td>
<td>The human is the only source for gathering, filtering, and prioritizing data.</td>
<td>The human is the only source for analyzing data, making predictions, and interpreting data.</td>
<td>The human is the only source for performing the ranking task.</td>
<td>The human is the only source for executing the decision.</td>
</tr>
</tbody>
</table>

NASA FLOOAT (Function-specific Level of Autonomy and Automation Tool)