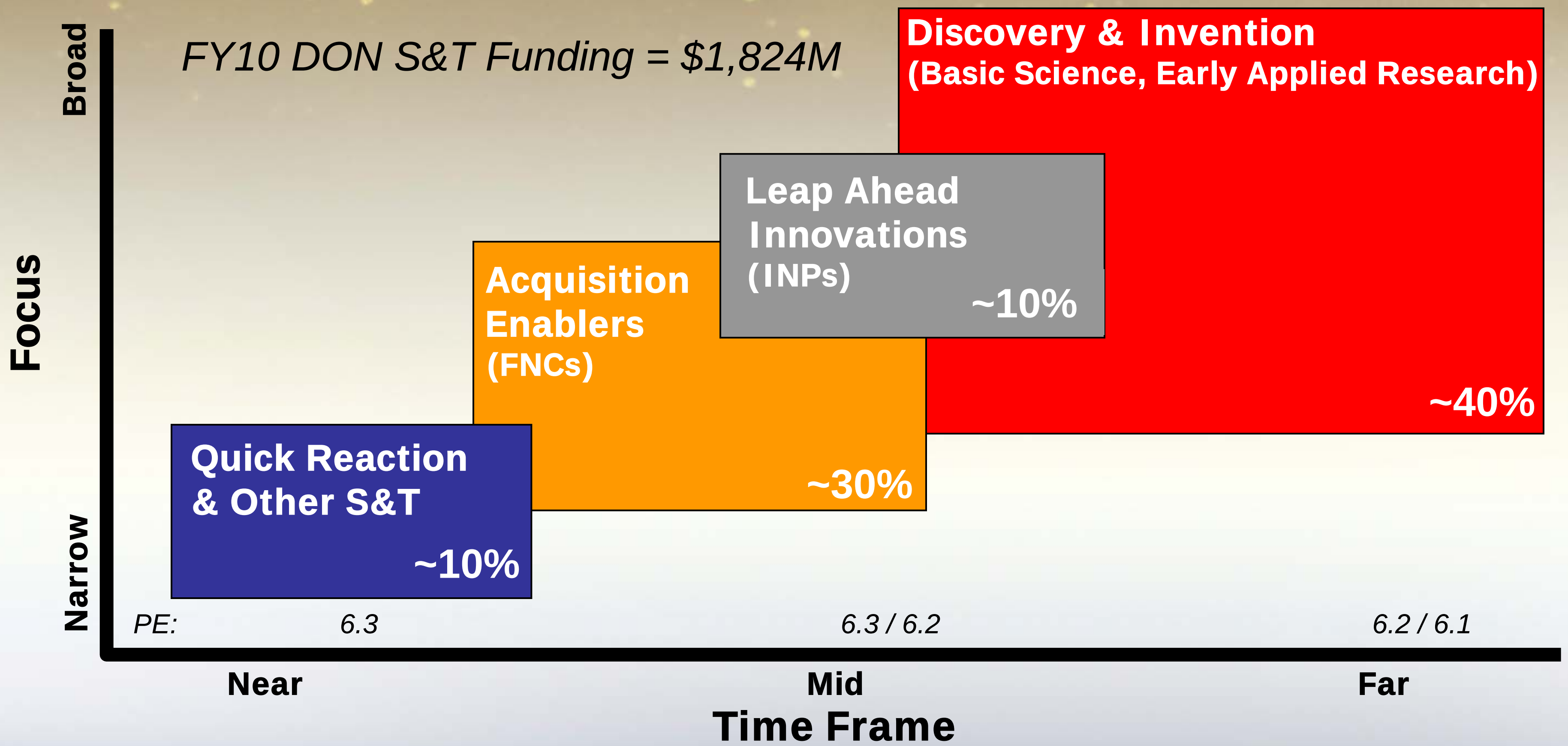
Ground Robotics Capability Conference and Exhibit

Mr. George Solhan

Office of Naval Research
Code 30

18 March 2010

S&T Focused on Naval Needs



Quick Reaction
(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

Revolutionary Research . . . Relevant Results

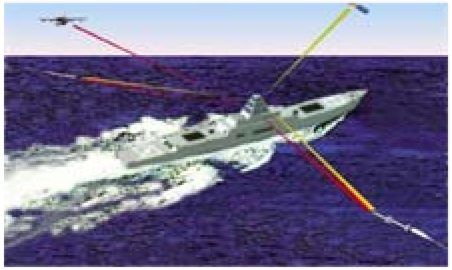
ONR S&T Departments

Code 30

Expeditionary Maneuver Warfare & Combating Terrorism

Code 31

C4ISR



Code 32

Ocean Battlespace Sensing

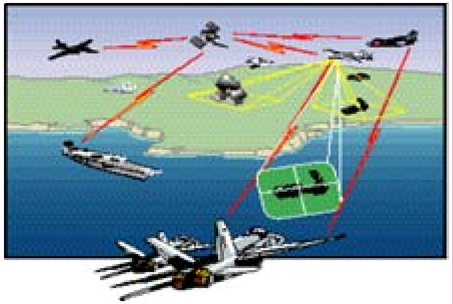
Sea Warfare and Weapons

Code 33

Warfighter Performance

Code 34

Air Warfare and Weapons



Code 35

ONR 30 Organization

Revolutionary Research . . . R

Expeditionary Maneuver Warfare and Combating Terrorism S&T

Human, Social, Cultural, and Behavioral Sciences (HSCB)

Hybrid Complex Warfare Sciences Division (301)

- Basic Research Counter IED

Applications Division (302)

- FITE JCTD

Combating Terrorism & Integration Division (303)

- Maritime Irregular Warfare
- Operational Adaptation + HSCB

FY2011 R2 Activity Areas & ONR Code 30 Thrust Areas

ONR Code 30 Technology Investment Areas – Focused Thrust Level S&T Investments

HPT&E* Thrust
- ✓ Enhanced Physical Readiness
- ✓ Mental Resilience & Cognitive Agility
- ✓ Expertise Development

C4 Thrust
- ✓ Network Centric Warfare -Interoperability
- ✓ Over-The-Horizon Comms & Gateways
- ✓ Small Unit Technologies

ISR Thrust
- ✓ Persistent ISR
- ✓ Knowledge Generation
- ✓ ISR - C2 (Actionable Intelligence)
- ✓ Biometrics
- ✓ Tag, Track & Locate

Fires Thrust
- ✓ Targeting & Engagement
- ✓ Advanced Ammo
- ✓ Advanced Weapons

Logistics Thrust
- ✓ Asset Visibility
- ✓ Logistics Transport
- ✓ Operational Self-Sufficiency
- ✓ Maintenance Reduction
- ✓ Infrastructure

Maneuver Thrust
- ✓ Survivability
- ✓ Advanced Mobility
- ✓ Maneuver Enablers

Force Protection Thrust
- ✓ Detection
- ✓ Neutralization
- ✓ Mitigation

* HUMAN PERFORMANCE, TRAINING & EDUCATION

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

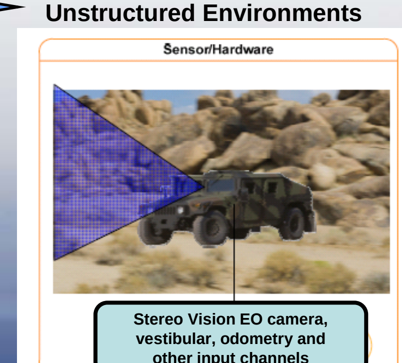
S&T challenges:

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

Advanced perception system and algorithms to reduce number of sensors and to allow operations in unstructured environments

Future Tactical System in Unstructured Environments



Remote Control Versus Autonomy

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.

Semi-autonomous

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

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.

Remote Control

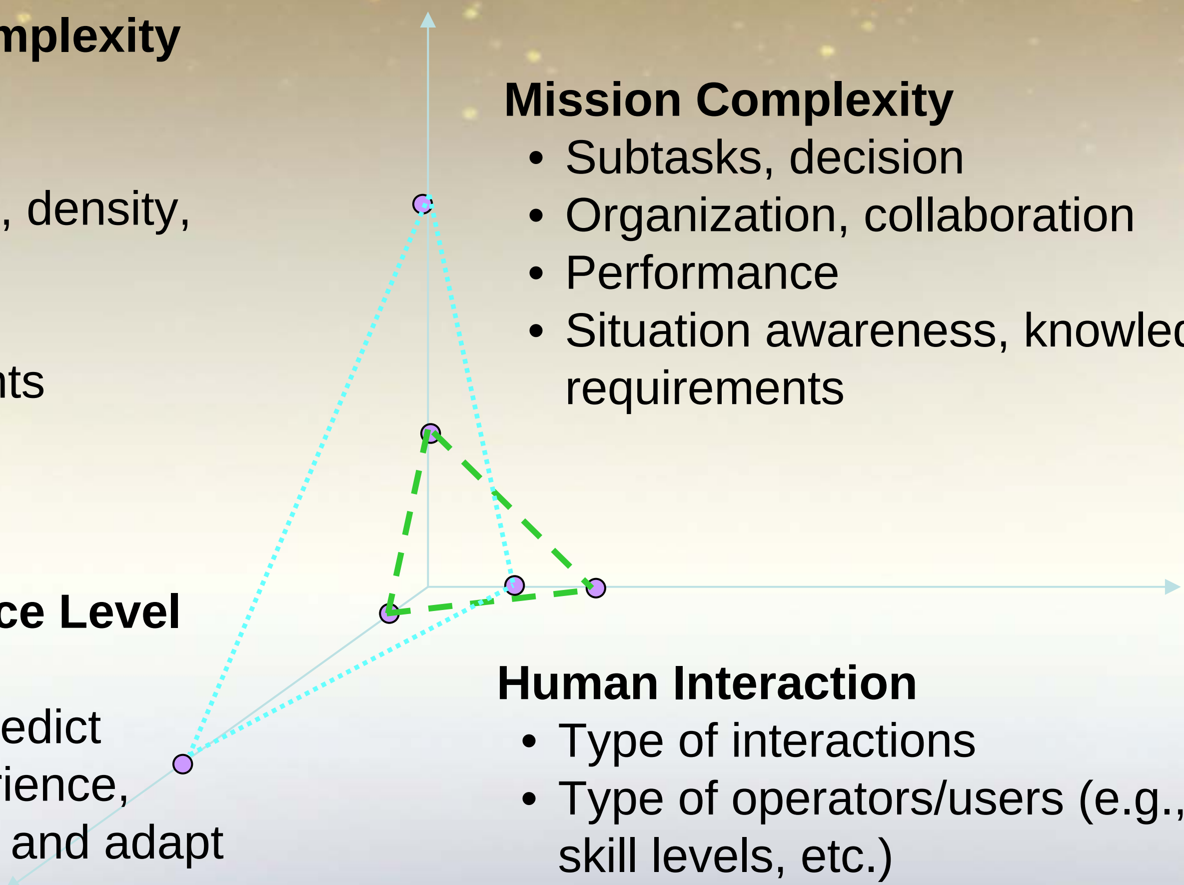
Operator continuously, visually controls the platform via tether or radio. UMS takes no initiative.

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

ONR 30 Unmanned Ground Systems Areas of Interest

Revolutionary Research . . . Relevant Results

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[tm])
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:

http://www.onr.navy.mil/Home/Science-Technology/Departments/Code-30.aspx

To submit a white paper:

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

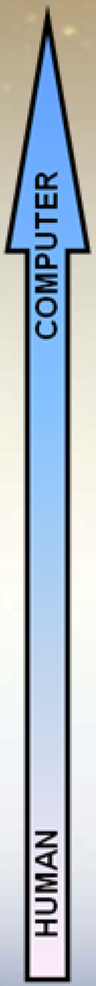
Click on “Contracts and Grants”
Click on “Broad Agency Announcements”
Select “BAA10-001”

Questions?

Back-Up Slide

Man versus Machine

Revolutionary Research . . . Relevant Results



Level	Observe	Orient	Decide	Act
8	The computer is responsible for gathering and filtering data without displaying any information to the human.	The computer overlays predictions with analysis and interprets data for a result that is not displayed to the human.	The computer performs the final ranking task, and does not display the result to the human.	The computer executes the decision and does not allow any human interaction.
7	The computer is responsible for gathering and filtering data without displaying any information to the human. Though, a "program status indicator" is displayed.	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).	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.	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.
6	The computer is responsible for gathering, filtering, and prioritizing information displayed to the human.	The computer overlays predictions with analysis and interprets the data. The human is shown all results for potential override.	The computer performs the ranking task and displays a reduced set of ranked options while displaying "why" the decision was made to the human.	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.
5	The computer is responsible for gathering and displaying unprioritized information to the human. The computer filters out the unhighlighted data displayed to the human.	The computer overlays predictions with analysis and interprets data. The human is the backup for interpreting data.	The computer performs the ranking task. All results, including "why" the decision was made, are displayed to the human.	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.
4	The computer is responsible for gathering and displaying unfiltered, unprioritized information to the human. The computer highlights the relevant non-prioritized information displayed to the human.	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.	Both the human and the computer perform the ranking task, the results from the computer are considered prime.	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.
3	The computer is responsible for gathering and displaying unfiltered, unhighlighted, and unprioritized information to the human. The human is responsible for filtering and prioritizing the data, with computer backup.	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.	Both the human and the computer perform the ranking task, the results from the human are considered prime.	The computer executes the decision after human grants authority-to-proceed. In the event of a contingency, the human can independently execute the decision.
2	The human is the prime source for gathering, filtering, and prioritizing data, with computer backup.	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.	The human is the only source for performing the ranking task, but the computer can be used as a tool for assistance.	The human is the prime source for executing the decision, with computer backup for contingencies (e.g. deconditioned humans).
1	The human is the only source for gathering, filtering, and prioritizing data.	The human is the only source for analyzing data, making predictions, and interpreting data.	The human is the only source for performing the ranking task.	The human is the only source for executing the decision.

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