Heterogeneous Robotic and Team Autonomy R&D

TECHLAV Seminar Series
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APL Role in Robotics & Autonomous Systems

University/Industry R&D
- Academic research
- Products/components

Government
- Sponsor solutions
- Integrated systems

6.1  6.2  6.3  6.4  6.5  6.6  6.7
TRL 1  TRL 2  TRL 3  TRL 4  TRL 5  TRL 6  TRL 7  TRL 8  TRL 9
TECHLAV project benefits

- APL serves as team member and Trusted Agent to government
- APL develops or matures capabilities and transitions them to government apps.
- APL’s new ISC has mutual research interests, a focus on T&E of autonomous systems, and will foster university collaborations
- TECHLAV graduates will be potential new APL staff members acclimated to APL interest areas

Technical and human resource benefits
TECHLAV project support

- Chair, TECHLAV Scientific & Industry Advisory Board
  - Advising on research plan development, technical barrier identification, research, demonstration, and verification.

- Autonomous robotic vehicle R&D, integration, field testing & real-world mission execution experience

- Perspectives from current activity on, and exposure to, related projects at APL
  - Intelligent Co-Robots (PI) [ongoing, IR&D]
  - Organic Persistent ISR [completed 2011, IR&D]
  - Autonomous UxV Swarming [past decade, IR&D]
  - Safe Testing of Autonomy in Complex Interactive Environments [TRMC S&T]
  - Rapid Adversarial Planning Tool [TRMC S&T]
  - APL Autonomy Testbed [ongoing, IR&D]
APL Robotics History

1960s
- Ferdinand

1980s
- APL/JHMI Robotic Arm

1990s
- Modular Prosthetic Limb

2000s
- Hopkins Beast
Intelligent Co-Robots -- Multi-year Focus

Build on APL robotic and unmanned system autonomy foundation to enable human-collaborative and autonomous UxV systems capable of enhancing first responder effectiveness in disaster response/recovery scenarios.
Invited by DARPA primarily to demonstrate research on human capabilities projection

Leverages dexterity of bimanual prosthetic limb system on a mobile platform

Collaborative robotic demonstration with IAI & HDT
  - Casualty evacuation response

Mix of teleoperation and supervised autonomy

Related video: “DARPA Robotics Challenge -- Collaborative Multi-Arm Robot Casualty Evacuation (CASEVAC),” https://www.youtube.com/watch?v=YqBR0hH4BDA
MULTI-ROBOT SEARCH & SAMPLING IN INCREASINGLY CONSTRAINED ENVIRONMENTS

“Russian Doll” scenario

UGV → UAV → micro-UGV

- A unique demonstration scenario that focused our development of underlying capabilities in key IRAD areas
  - Autonomous UAV and UGV mobility/navigation
  - Intelligent co-robots and human-robot teaming
  - Dexterous manipulation
  - Robot vision and perception
  - Data fusion, distribution, and display
DRC Tech Expo 2015 - demo scenario

Scenario
Props

µUGV
UAV
DRC Tech Expo 2015 demo – YouTube video

Shows 1 of 4 live public demos of several IRAD developments:

- Supervised autonomy
- Robot vision
- Autonomous manipulation
- Autonomous mobility
- Marsupial teleoperation

https://www.youtube.com/watch?v=Hvh20ySwgPw&index=1&list=PL542FC32ACC8D2513
### Advanced EOD Robotic System (AEODRS) - Family of Systems

#### Increment 1: Dismounted Operations
- Back-packable
- Recon. and assessment (to 100m)
- Smallest unit (< 35 lbs)
- Fills Capability Gap

#### Increment 2: Tactical Operations
- 2-man portable
- Down range recon and prosecution assessment (to 1 km)
- Unit size (< 165 lbs)
- Replaces existing robot class

#### Increment 3: Base/Infrastructure Ops
- Trailer transportable
- Provides heavy lifting capability
- Largest unit size (750 lbs)
- Replaces existing robot class
AEODRS Standards-based
Common Open Architecture

System Capabilities

- Manipulator
- End Effector
- Visual Sensors
- Autonomous Behaviors
- Master
- Comm Link
- Power System

AEODRS standardized interfaces

AEODRS Electrical Interface

AEODRS Physical Interface

AEODRS Logical Interface

Infrastructure

Tactical

Dismounted

AEODRS standardized wireless link

Handheld OCU

Common OCU

Interchangeable and Interoperable

AEODRS – A Modular Open System
UxV Collaborative Autonomy

Thought Leader: Dave Scheidt

- Ongoing UxV distributed control & coordination technology development and field testing
- ConOps: heterogeneous team of vehicles performing a task autonomously (at mission level and task level)
- Field demonstrations of teams including:
  - UAVs: Boeing ScanEagle, Procerus Unicorn
  - UGVs: iRobot ATRV/mini, Segway
  - USVs: USSV-HTF, Bouys
  - UUV: Iver 2
- Emergent behavior obtained through use of dynamic coordination-fields
- Ad Hoc decentralized situational awareness
  - Distributed blackboard scheme
- Current focus testing of autonomy
Cooperating UxV Approach

- **CONTROL**
- **ROBUST EFFECTIVE BEHAVIOR**
- **BELIEF**
- **COMMS**

**DYNAMIC CO-FIELDS**

**INFLUENCE NETWORKS**

"Pursue"

Potential Field

- Repulsive Force
- Attractive Force
- Net Force

No-Fly Zone

Other UAVs

Attractors

- **Stygmergic Potential Fields**

- The "environment" consists of beliefs:
  - Location of entities, sensor coverage, etc.

- Beliefs are used to create a virtual potential field:
  - Lower elevations represent more desirable configurations.
  - Translation of beliefs to field depends on the type of vehicle and its operating mode.

- Vehicles "move downhill" by reconfiguring:
  - Changing location, pointing sensors, etc.

- Attractors

- **Other UAVs**

- **Attractive Force**

- **Repulsive Force**

- **Net Force**

- **Centralized Control**

- Scaleable
- Adaptable to Unreliable or Low Bandwidth Comms
- Minimal to No Supervision
- Supports Heterogeneous vehicle coordination
- Robust to system and platform failures

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Organic Persistent Intelligence, Surveillance, and Reconnaissance (OPISR)

- 10 Autonomous Vehicles: Air (6), Ground (1), Sea Surface (2), Undersea (1)
- + 3 Unattended Ground Sensors
- Supporting 3 users

http://www.jhuapl.edu/techdigest/TD/td3102/31_02-Scheidt.pdf
TACE
Safe Testing of Autonomy in Complex Interactive Environments

- APL is very active in R&D focused on autonomous unmanned vehicles and robotics
- APL R&D activities are strongly related to the technical scope of TECHLAV
- APL could gain technical and human resource benefits from the final product of TECHLAV and through collaboration as related research activities forge ahead

A few key APL Points of Contact:
- Reed Young, Ph.D.; Program Manager, Robotics & Autonomy
- Eddie Tunstel, Ph.D., SME, Robotics & Autonomy
- Dave Scheidt, Project Manager/SME, Autonomy, C2, & T&E
- Chad Hawthorne, Project Manager/SME, Autonomy & T&E