Heterogeneous Robotic and Team Autonomy R&D

TECHLAV Seminar Series
22 January 2016

North Carolina A&T State University

Dr. Edward Tunstel

Edward.Tunstel@jhuapl.edu

APL
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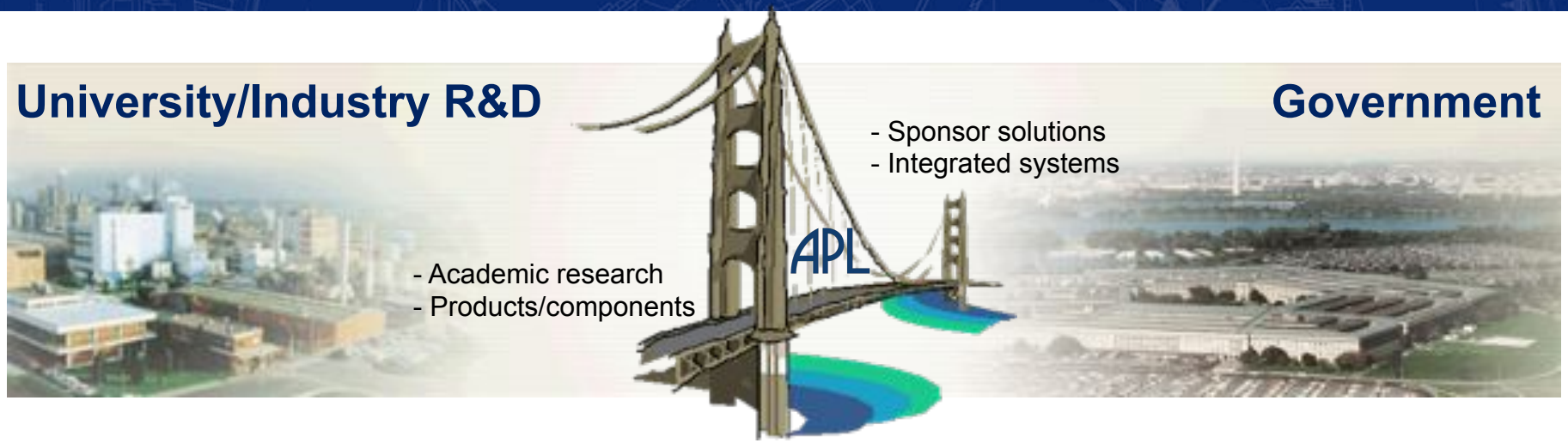
APL Role in Robotics & Autonomous Systems

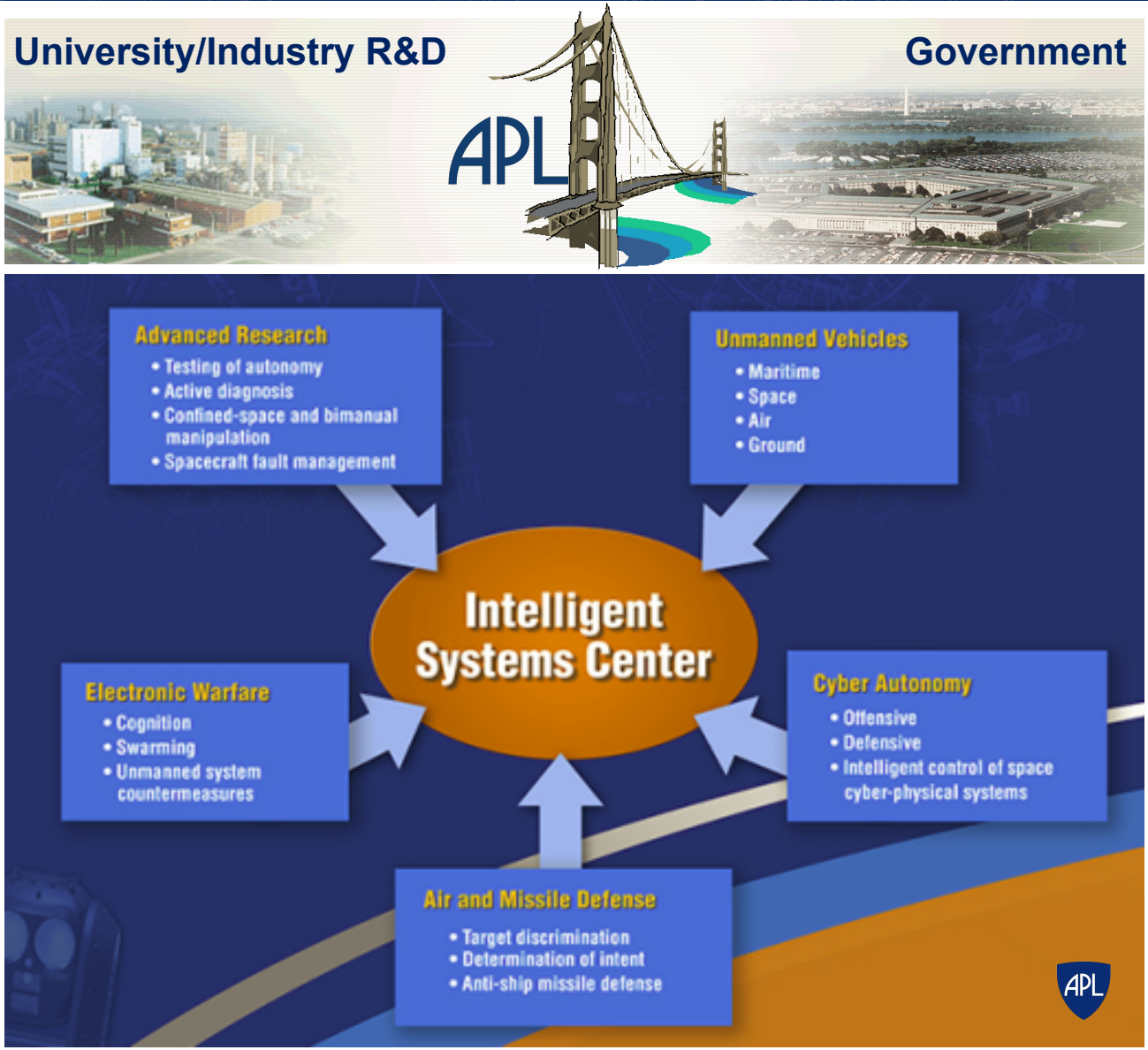


6.1 6.2 6.3 6.4 6.5 6.6 6.7

JOHNS HOPKINS UNIVERSITY
Applied Physics Laboratory
APL
Robotics and Autonomous Systems

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

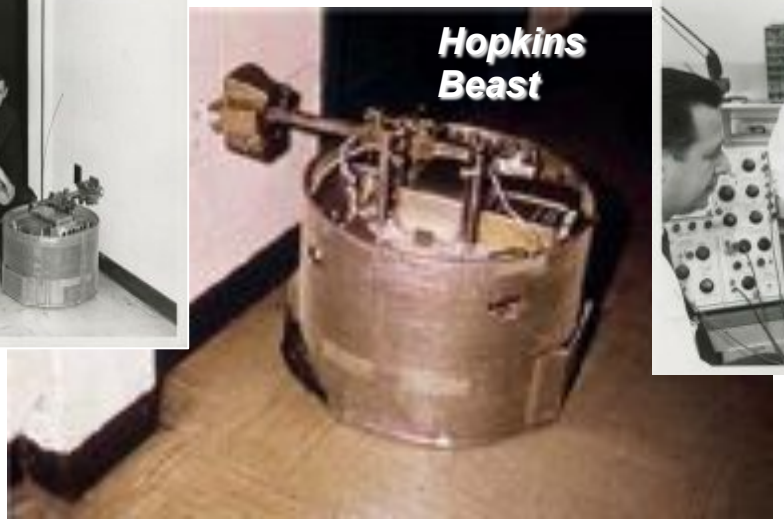
- **Chair, TECHLAV Scientific & Industry Advisory Board**
  - **Advising on research plan development, technical barrier identification, research, demonstration, and verification.**

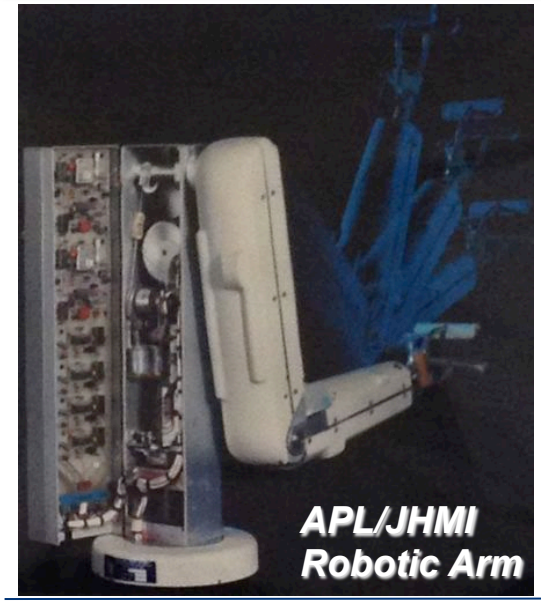
- **Autonomous robotic vehicle R&D, integration, field testing & real-world mission execution experience**
- **Perspectives from current activity on, and exposure to, related projects at APL**
  - **Intelligent Co-Robots (PI) [ongoing, IR&D]**
  - **Organic Persistent ISR [completed 2011, IR&D]**
  - **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


Ferdinand

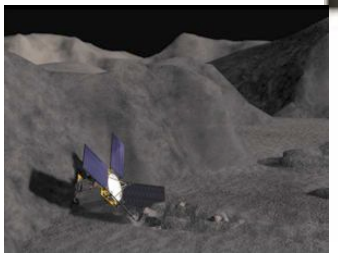
1960s


Hopkins Beast


APL/JHMI Robotic Arm

1980s

1990s



2000s

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.

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DARPA Robotics Challenge Tech Exposition 2013

- 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

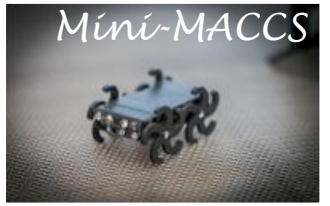
DRC Tech Exposition 2015

Multi-Robot Search & Sampling in Increasingly Constrained Environments

"Russian Doll" scenario

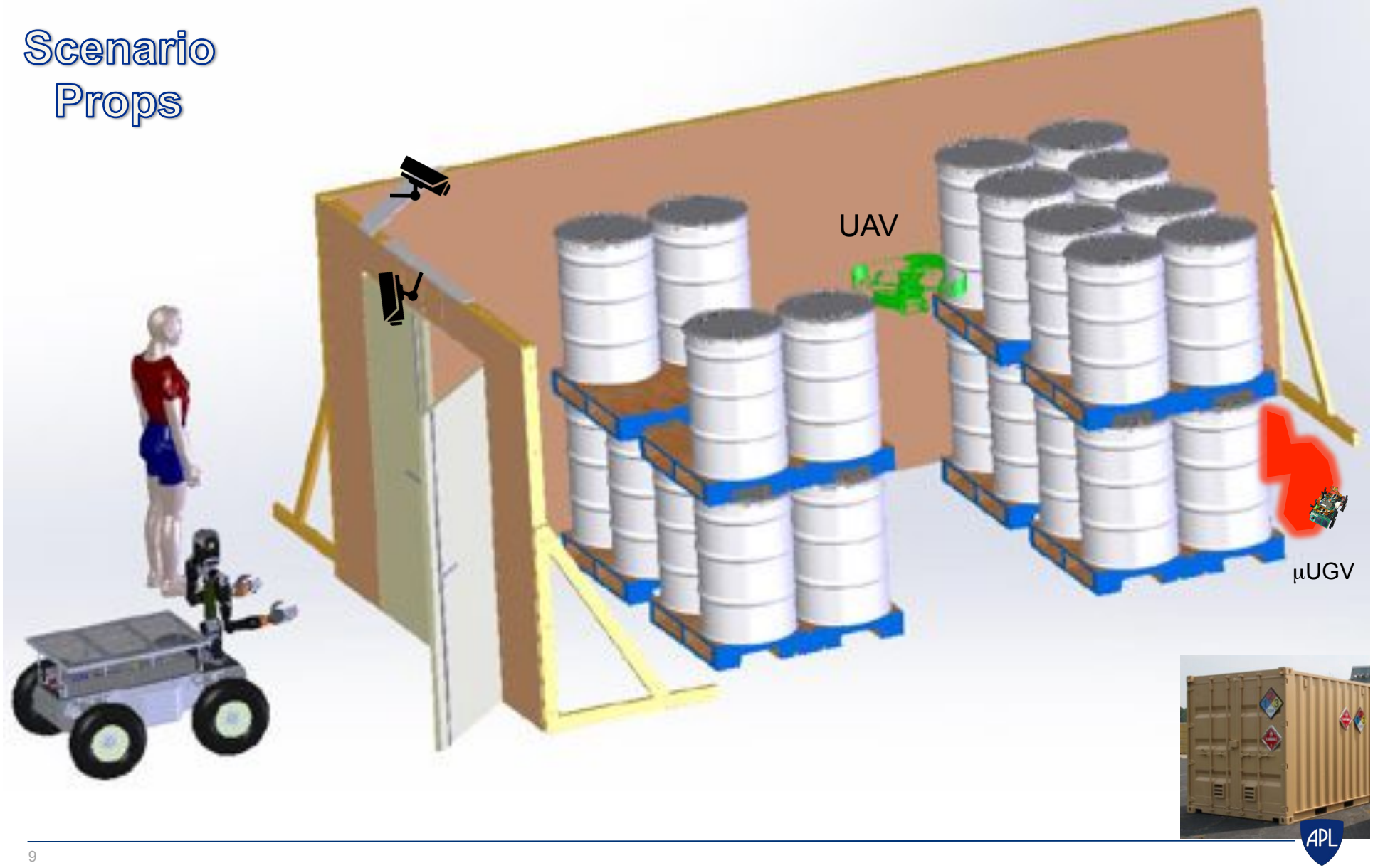
UGV → UAV → micro-UGV

- **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



DRC Tech Expo 2015 demo – YouTube video

Intelligent Co-robots: Demonstration

JHU Applied Physics Laboratory

Subscribe 4,188

383 views

Add to Share More

Published on Sep 16, 2015

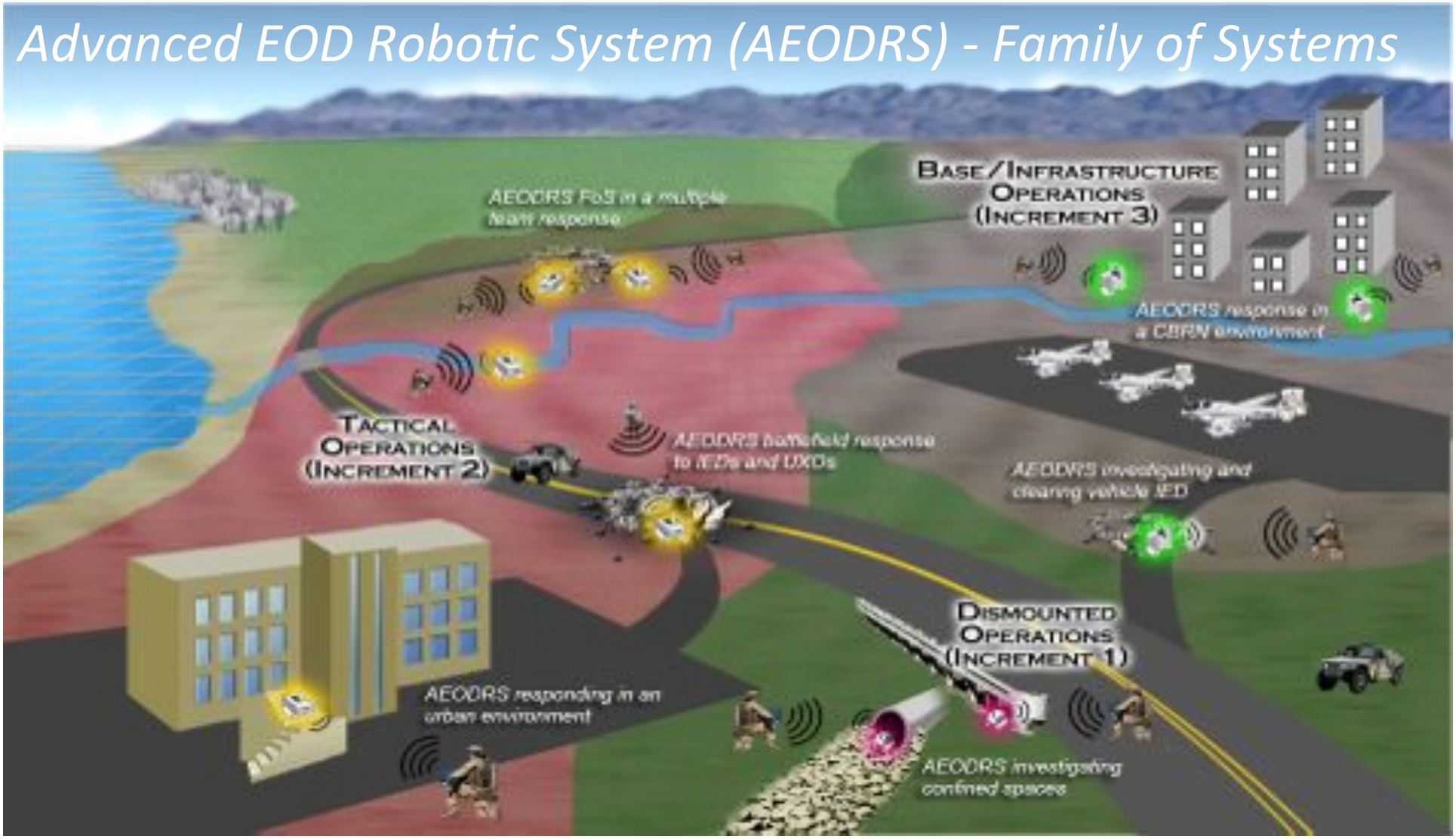
This video presents processed footage from robotic demonstrations showcasing 2014-2015 progress on an independent research & development project, Intelligent Co-Robots, conducted by the Research and Exploratory Development Mission Area at the Johns Hopkins University Applied Physics Laboratory.

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

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

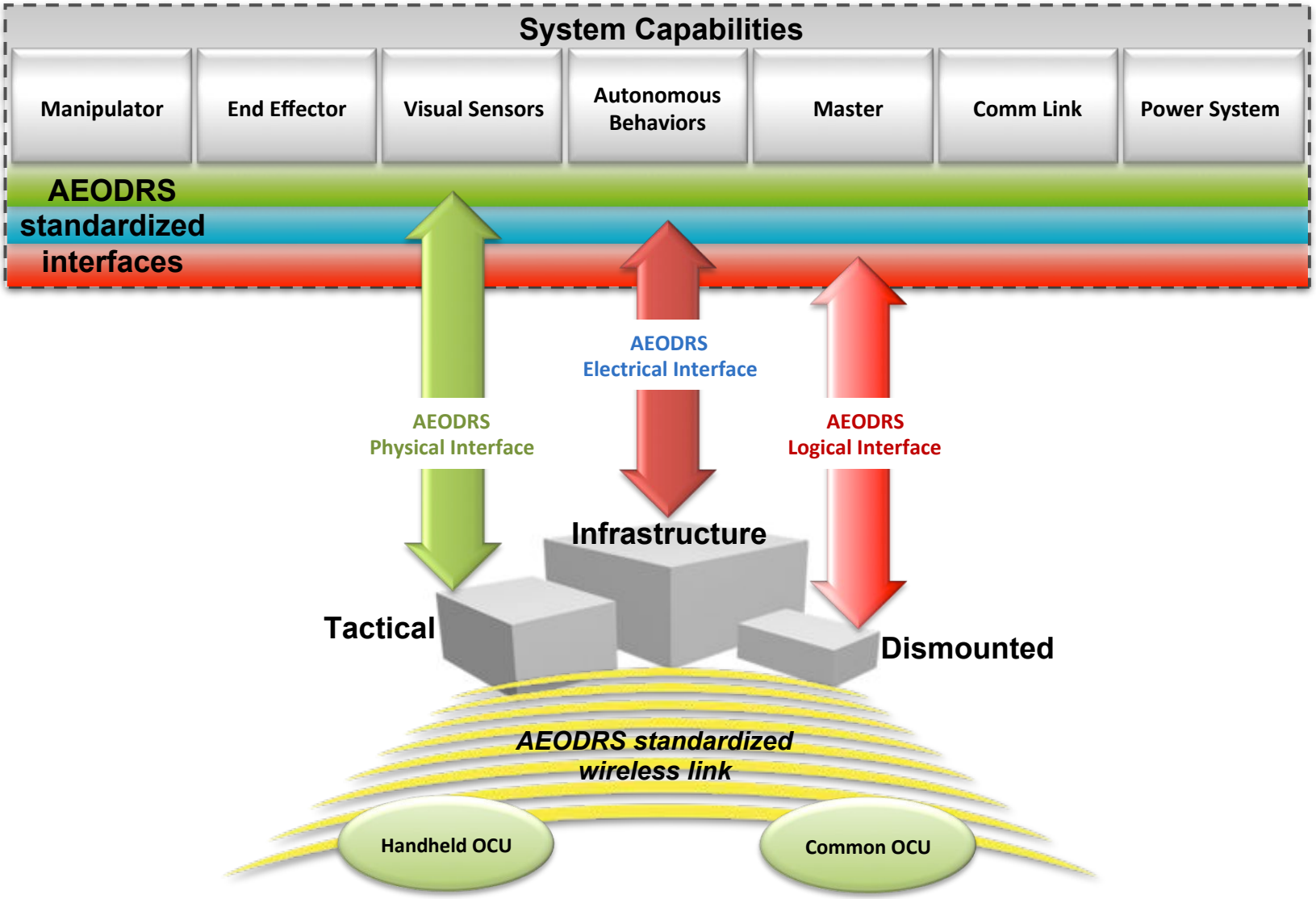
https://www.youtube.com/watch?v=Hvh20ySwgPw&index=1&list=PL542FC32ACC8D2513

Advanced EOD Robotic System (AEODRS) - Family of Systems



Increment 1: Dismounted Operations	Increment 2: Tactical Operations	Increment 3: Base/Infrastructure Ops
Back-packable	2-man portable	Trailer transportable
Recon. and assessment (to 100m)	Down range recon and prosecution assessment (to 1 km)	Provides heavy lifting capability
Smallest unit (< 35 lbs)	Unit size (< 165 lbs)	Largest unit size (750 lbs)
Fills Capability Gap	Replaces existing robot class	Replaces existing robot class

AEODRS Standards-based Common Open Architecture



Interchangeable and Interoperable

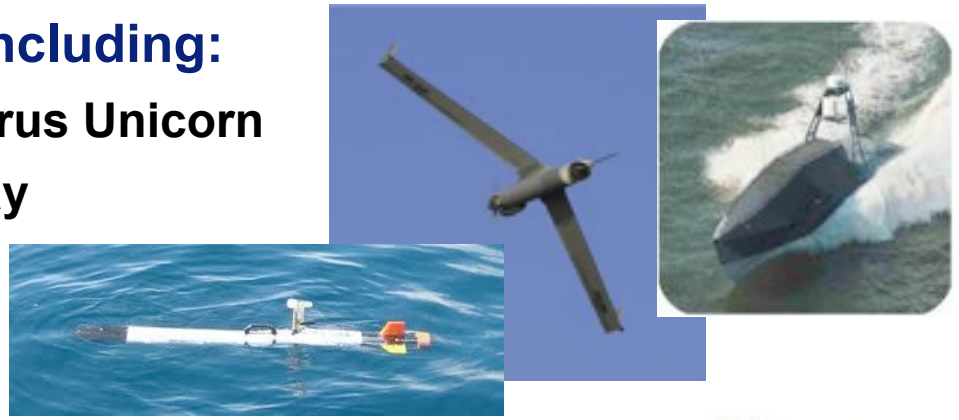
http://www.ndia.org/Divisions/Divisions/Robotics/Documents/7.%20Mike%20Zeher.pdf

AEODRS – A Modular Open System

UxV Collaborative Autonomy

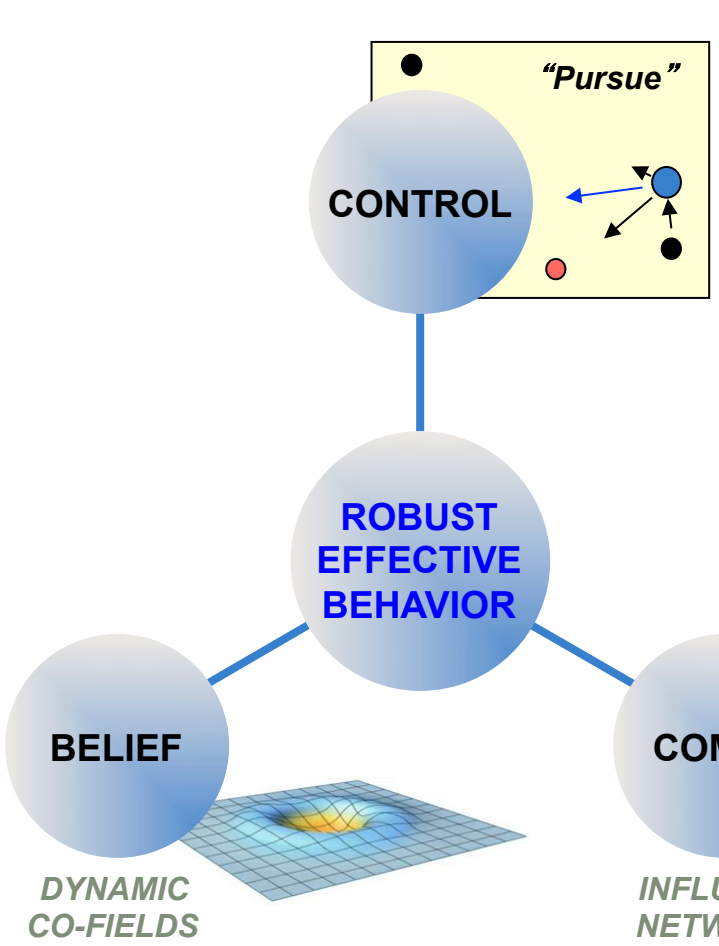
Thought Leader: Dave Scheidt

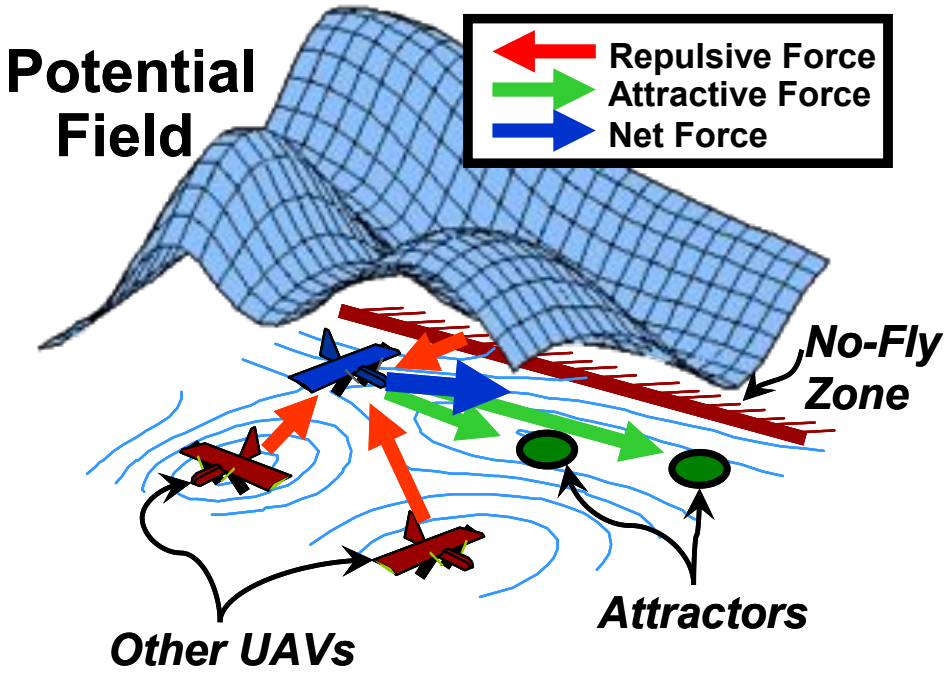
- **Ongoing UxV distributed control & coordination technology development and field testing**
- **ConOps: heterogeneous team of vehicles performing a task autonomously (at *mission level* and *task level)***
- **Field demonstrations of teams including:**
  - **UAVs: Boeing ScanEagle, Procerus Unicorn**
  - **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





R.C. Hawthorne, J. Stipes, R.W. Chalmers, D. Scheidt, "Demonstration of Effects-Based Operations Using Fully Autonomous Heterogeneous Vehicle Swarms," IEEE Intl. Conf.on Robotics and Automation, Rome, Italy, April 2007.

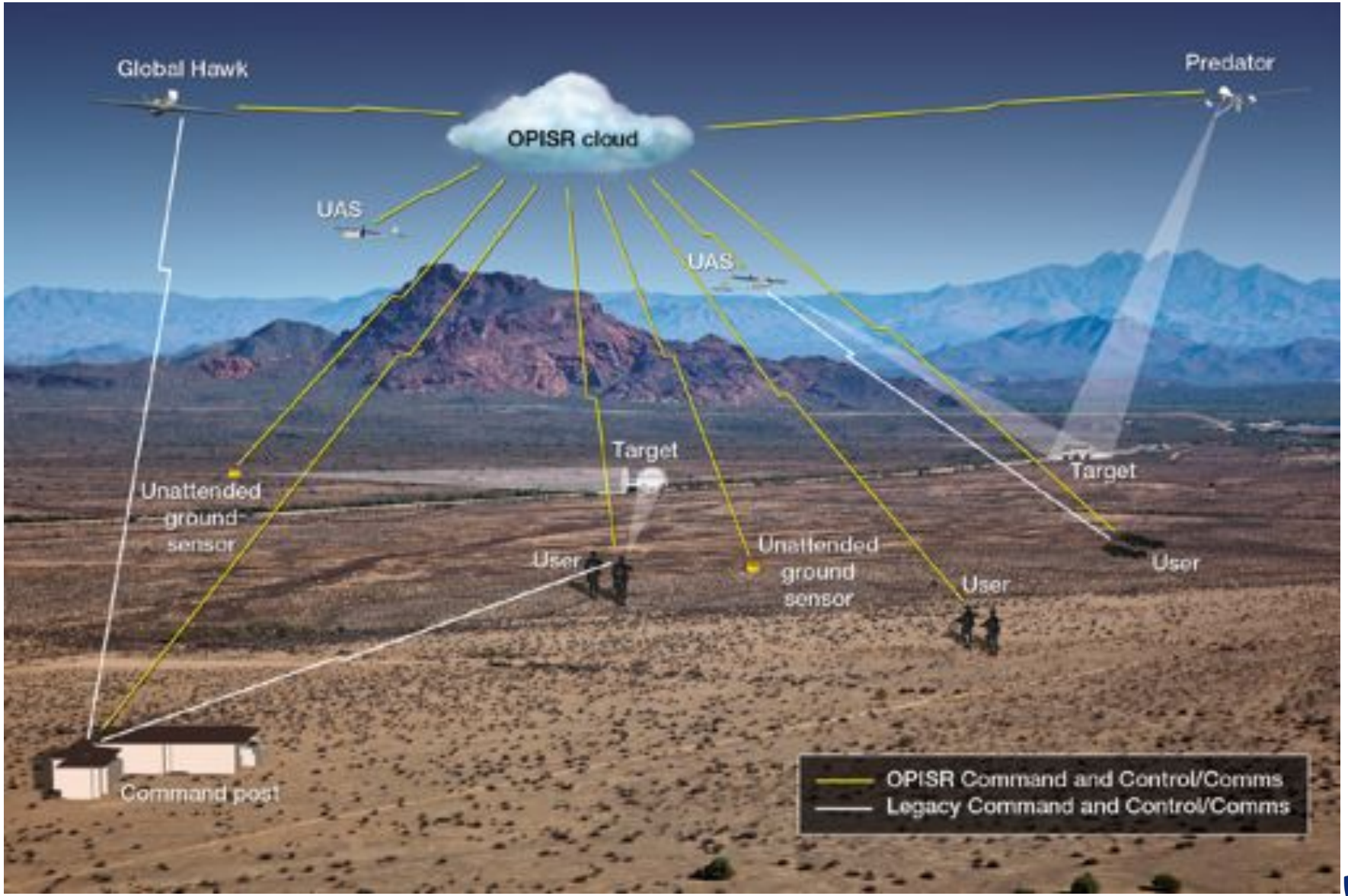
D.H. Scheidt, "Command and Control of Autonomous Unmanned Vehicles," in K.P. Valavanis, G.J. Vachtsevanos (eds.), Handbook of Unmanned Aerial Vehicles, Springer Science+Business Media Dordrecht, 2015.

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

OPISR Concept of Operations



http://www.jhuapl.edu/techdigest/TD/td3102/31_02-Scheidt.pdf

TACE
Safe Testing of Autonomy in Complex Interactive Environments

http://www.dtic.mil/ndia/2014groundrobot/Rumford.pdf (slide 10)

http://www.iitsec.org/about/PublicationsProceedings/Documents/15348_ECIT_Paper.pdf

Conclusion & Q&A

- **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