



Joint Ground Robotics Enterprise



Ground Robotics Technology Considerations

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Agenda



- **Joint Ground Robotics Enterprise Organization**
- **Technologies in the Labs Today**
- **Integrated Unmanned Systems Roadmap**
- **Proposed Ground Robotics Consortium**
- **Joint Ground Robotics Enterprise Initiatives**
- **Wrap Up**



Joint Ground Robotics Enterprise Organization



JGRE Oversight

Senior Steering Group

- Convened as needed
- Enable Service commitment
- Advise Chair on funding priorities and allocations

Flag Level Reps

- Army
- Marines
- Navy
- Air Force
- J8

- Guidance for shaping JGR to the O-6 Council
- Resolve JGR issues submitted by O-6 Council

Chair: Dep Dir, LW&M

Strategic

O-6 Council

- Represent Service Positions
- Generate Departmental Strategy for advancing Ground Robotics
- Proponents for JGR Roadmapping
- Set priority of Robotic Enablers informed by Capability Mapping & Technology Assessments from JGRE TAB

O-6 Combat Dev, Materiel Dev Reps

- Army
- Marines
- Navy
- Air Force
- J8
- Defense Threat Reduction Agency
- JIEDDO
- COCOMs

- Provide guidance to TAB to drive which Capabilities and Technologies to assess
- Executability implies Service Commitment can be secured
- Resolve issues

Chair: ED, JGR

Operational

- Assess maturity of Emerging Technologies

- Identify Opportunities for Warfighter leverage
- Recommends Robotic Enablers Based on assessment of maturity, Linkage to Capability Gaps/ Opportunities

Technology Advisory Board

- Service SMEs
- DDR&E rep
- J8 rep
- Defense Threat Reduction Agency

- TAB Products:
 - Technology & Capability Mapping
 - Technology Maturity & Funding Assessment

Chair: ED, JGR

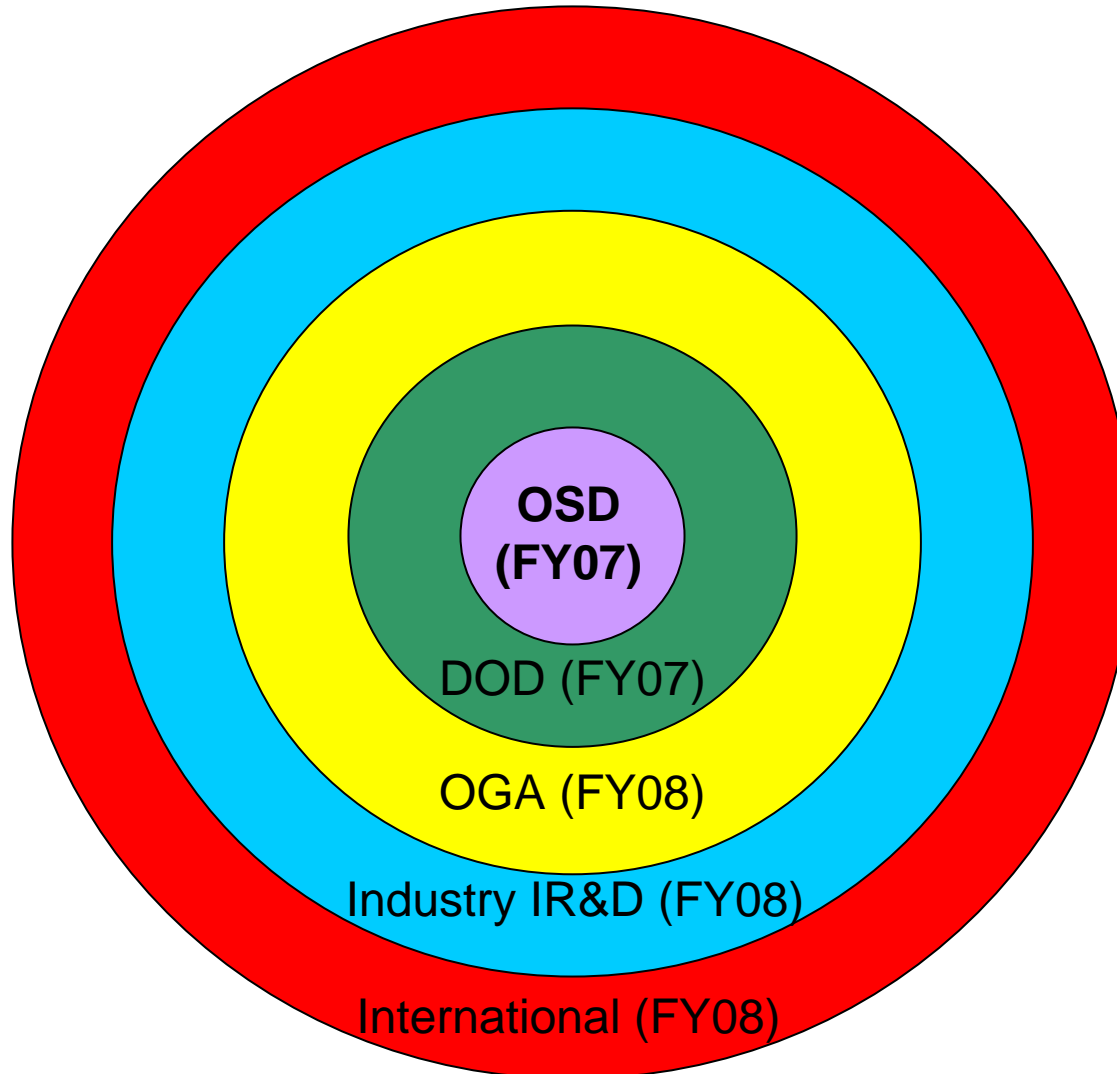
Tactical



Joint Ground Robotics Enterprise Portfolio Synchronization



(Funded Efforts Taken into Account in Portfolio Strategy)





In the Labs Today



Crusher



- **Developed by Carnegie Mellon University to assess the capabilities of large, unmanned ground vehicles operating autonomously in a wide-range of complex, off-road terrains**
- **Made of high-strength aluminum and titanium to withstand below-hull strikes from boulders and tree stumps, and a nose designed to absorb the impact of major collisions.**





Snakebot



- Provides the ability to navigate over rough, steep terrain where a wheeled robotic vehicle would likely get stuck or topple over

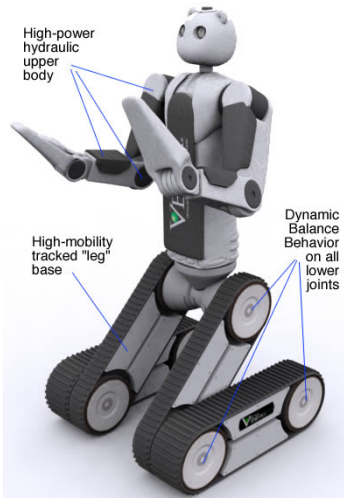
- Recon in severely restricted terrain

- Future software will allow the Snakebot to learn on its own by experience





Battlefield Extraction-Assist Robot (BEAR)



- Currently in the proof-of-concept development phase for US Army's Telemedicine and Advanced technology Research Center
- Designed to find, pick up and rescue people without risking additional human life
- Upper body controlled by hydraulics
- A mobility platform that features two independent sets of tracked "legs"
- Features dynamic balancing behavior (DBB) while on its "ankles", "knees" or "hips"





Wearable Energetically Autonomous Robotics (WEAR)



- **Objective:** Develop a class of robotic systems that are worn by humans, closely match the operator's motion in both space and time, and enable the wearer to carry heavy loads over rough terrain for extended periods of time.



- **1995:** DARPA exoskeleton effort begins
- **2003:** 1st powered lower extremity prototype
- **2007:** Responsibility transitioned to Natick



Sarcos's exoskeleton system



Integrated Unmanned Systems Roadmap



Roadmap Introduction



The Unmanned Systems Integrated Roadmap is a master plan that describes the intended future state of the Unmanned Systems Product Line Portfolios and the actions to be undertaken to achieve that future state.

The Roadmap will serve to inform future decision making associated with the management of the Unmanned System Portfolios as they provide needed capabilities to the joint Warfighter.



Purpose



- The Purpose of the Unmanned Systems Integrated Roadmap is to project a future vision for how unmanned systems will be developed, acquired, and sustained as part of the materiel employed by the DoD.
- The Roadmap will:
 - Identify recommended intermediate states of advancement along the way to achieving that vision
 - Identify Strengths, Weakness, Opportunities, Challenges, and Risks associated with achieving that future vision
 - Identify those actions and responsible organizations that will capitalize on the strengths and opportunities, and mitigate the challenges and risks
 - Be responsive to plans, concerns, and issues of DoD, Services and organizations as well as Statute and Congressional Intent



Scope



The Scope of the Roadmap will address:

- The 3 Product Line Portfolios:
 - Unmanned Aircraft Systems
 - Unmanned Ground Vehicles
 - Unmanned Maritime Systems (Surface and Undersea)
- from 2009 – 2034
- technology development, standardization, interoperability, joint acquisition, policy

The Roadmap will not address:

- detailed operational concepts for employing unmanned systems
- operational requirements for unmanned systems

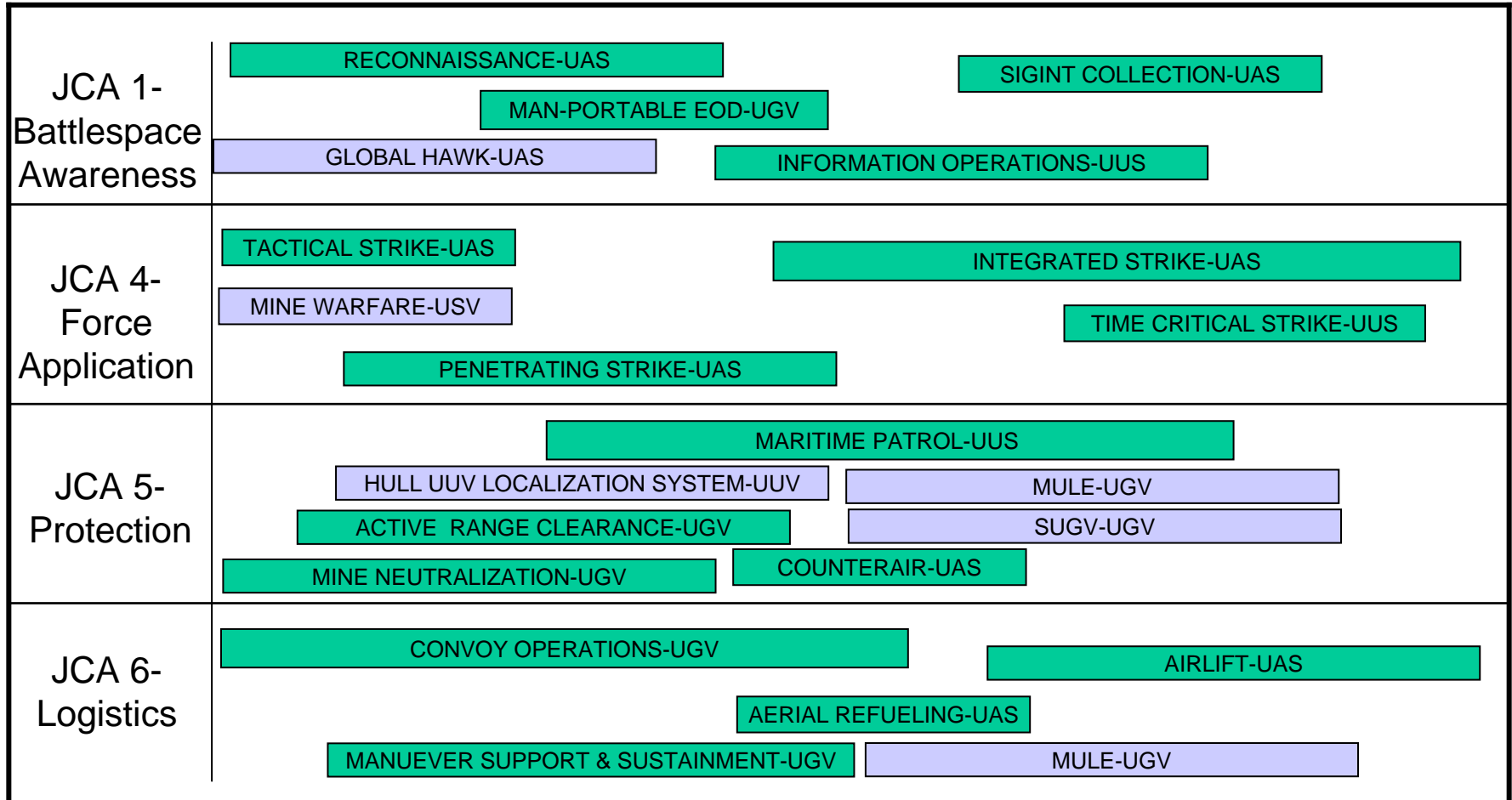


Addressing Capability Needs via Unmanned "Means" (notional)



2009

2034





Unmanned Systems Performance Evolution (notional)



2009

Evolutionary Adaptation

20??

Revolutionary Adaptation

2034

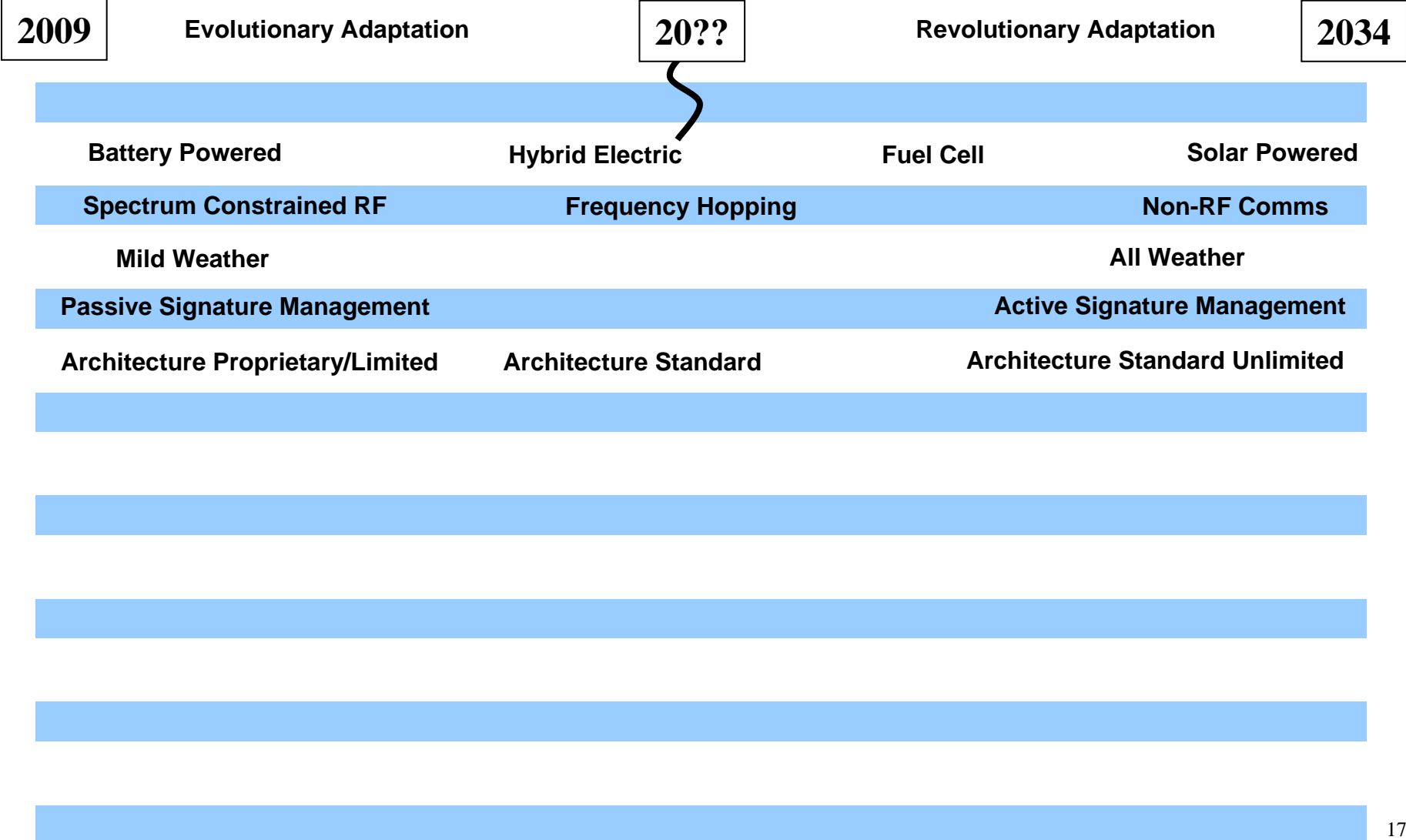
Human Intervention High

Autonomy /Intelligence High

Individual System	Teaming w/in Domain		Collaboration across domains		Teamed Collaboration
Spectrum Constrained RF			Spectrum Independent - Hopping		
Mission Endurance in hours		Mission Endurance in days		Mission Endurance in weeks	
Mission Complexity – operator controlled		Route Planning	Obstacle Avoidance	Adaptive Tactical Behaviors	
Limited Environmental Difficulty			Expanded Environmental Difficulty		
Mission Package Product Line Dependant			Product Line Independent		
OPSEC – Signature High			OPSEC – Signature Low		
Operational Control N:1	1:1	1:# w/in Domain	1:# across domains	1:# Teamed	



Unmanned Systems Technology Enablers (notional)





Ground Robotics Consortium



Purpose of the Consortium



- **Provide opportunity for non-government organizations to participate in DoD research planning, resulting in a plan based on industry expert knowledge of evolving technologies**
- **Allow for better leveraging of IR&D funding through insights gained as a result of this mutual planning process**
- **Lower the entry barriers for small companies to enter into the government acquisition process**



Ground Robotics Enterprise

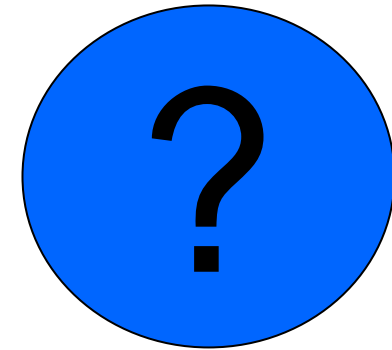


Joint Ground Robotics Enterprise

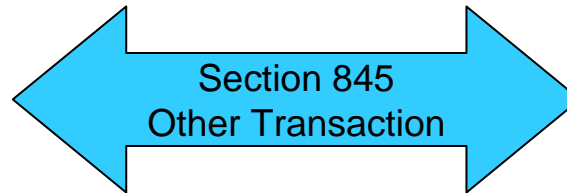


- OUSD(AT&L) PSA/LW&M
- Department of the Army
- Department of the Navy
- Department of the Air Force
- Defense Treat Reduction Agency
- J8
- Other Agencies and Departments

Ground Robotics Consortium



- Defense Contractors
- Small Businesses
- Academic Institutions
- Non-Profit Organizations
- Not-for-Profits Organizations



DoD and GRC ... Partnering to Leverage Capabilities and Investment



Scope



- **The OTA will encompass**
 - Technology Development and Maturation
 - Performance Improvement
 - Autonomous Tactical Behavior Development
 - Standard Maturation and Evolution
 - Mission Equipment Package Integration
 - Technology Transition Preparation

- **The OTA will not encompass**
 - Policy Development
 - Operational Concept Development
 - TTP Development

- **Only US firms as members of the Consortium**



Roles and Responsibilities



- **Joint Ground Robotics Enterprise (JGRE)**
 - Provides Oversight and Guidance
 - Conducts Planning and Budgeting
 - Manages Acquisition Process
 - Liaison with Other Organizations
 - Ensures Development of Annual Research Plan, Requirements and Source Selection Plan
 - Conducts Source Selection
- **Ground Robotics Consortium (GRC)**
 - Liaison among Industry and with JGRE
 - Participates in Development of Annual Research Plan
 - Conducts Technology Development and Maturation, Performance Improvement, Autonomous Tactical Behavior Development, Standards Maturation and Evolution, and Mission Equipment Package Integration



Joint Ground Robotics Enterprise Initiatives



Initiatives



- **Test Implications**
 - Are we ready to test ground robots (infrastructure, e-stop, etc.)
 - What are Test Operating Procedures for characterizing robotic performance?
 - Can we leverage robots to support tests?
- **Joint Architecture for Unmanned Systems (JAUS)/ STANAG 4586**
 - What should AN interoperability standard be?
 - Systematically fuse JAUS and the STANAG?
- **Homeland Defense and Homeland Security**
 - Better partnering between OGAs to achieve mutual benefit and efficiencies.
 - Implications of using DoD robotic capabilities on US soil (airspace, weapons, safety, spectrum, etc.)
 - UGVs on national highways (engage with DOT)



Initiatives (cont.)



- **WarFighter Experimentation**
 - Collaboration between Combatant Command and Combat Developer
 - Institutional process for experimentation to underpin requirements analysis for “game changing” robotic technologies
- **SUGV Product Line Portfolio**
 - MTRS
 - Advanced EOD Robotic System
 - Blow-in Place “Bots” for Engineers
 - FCS SUGVs (Block 1, Spin Out 3, Core)
- **Armed Ground Robots**
 - Are technology advances outpacing policy, rules of engagement, statute?
- **International Engagement**
 - UK-Grand Challenge
 - **Germany-ELROB (European Land Robotics)**



Wrap Up



- A greater awareness of ground robotics is forming across the DoD:
 - PACOM interested in legged robots for transport in complex terrain
 - SOCOM – CAMs JCTD
 - NORTHCOM looking to robotic tunnel exploration for border security
- Interest in ground robotics is world wide, no longer at the periphery of future planning
 - UK – Grand Challenge
 - Germany ELROB – European Land Robotic Competition
- Technology is beginning to outpace concept development – experimentation is key
 - CAST War fighter Experiment
 - Exoskeleton Experiment
 - ARC 2 Countermine War fighter Experiment
- Power continues to be a constraint, tech base investments still needed
- Sensors are starting to exhibit the needed capabilities to enable the next step towards full autonomy

There is much to be done, and DoD is organized and committed to do it