Joint Ground Robotics Enterprise

Ground Robotics Capabilities Conference and Exhibition

August 2014





Current Environment

- Transitioning from wartime needs to long term requirements for ground robotics
  - AEODRS/MTRS Increment 2 moving forward with open architecture
  - Army Unmanned Ground Systems Strategy focusing on Manned-Unmanned Teaming (MUM-T)
- Senior Leadership has embraced Unmanned Systems and expect future employment to reduce "tail" and overall support costs, augmenting a reduction in manpower
  - *GEN Dempsey, CJCS, establishes Joint Staff Remote/Unmanned Futures Office*
  - *HON Robert Work, DSD, Preparing for War in the Robotic Age*
  - *GEN Odierno, ACS, tasked TRADOC to '…discuss the costs associated with expediting fielding of unmanned vehicle technologies earlier than 2025.'*

Current Environment

- Tactical Warfare Systems oversight for land, air and naval platforms
  - Unmanned Systems Office (Dyke Weatherington) efforts distributed and air platforms split between Tactical and Strategic offices
  - Land Warfare & Munitions portfolio includes Army UAV assets as well as ground robotics (JGRE)
- Congressional DRAFT introduction of new Defense Office solely for Unmanned Systems

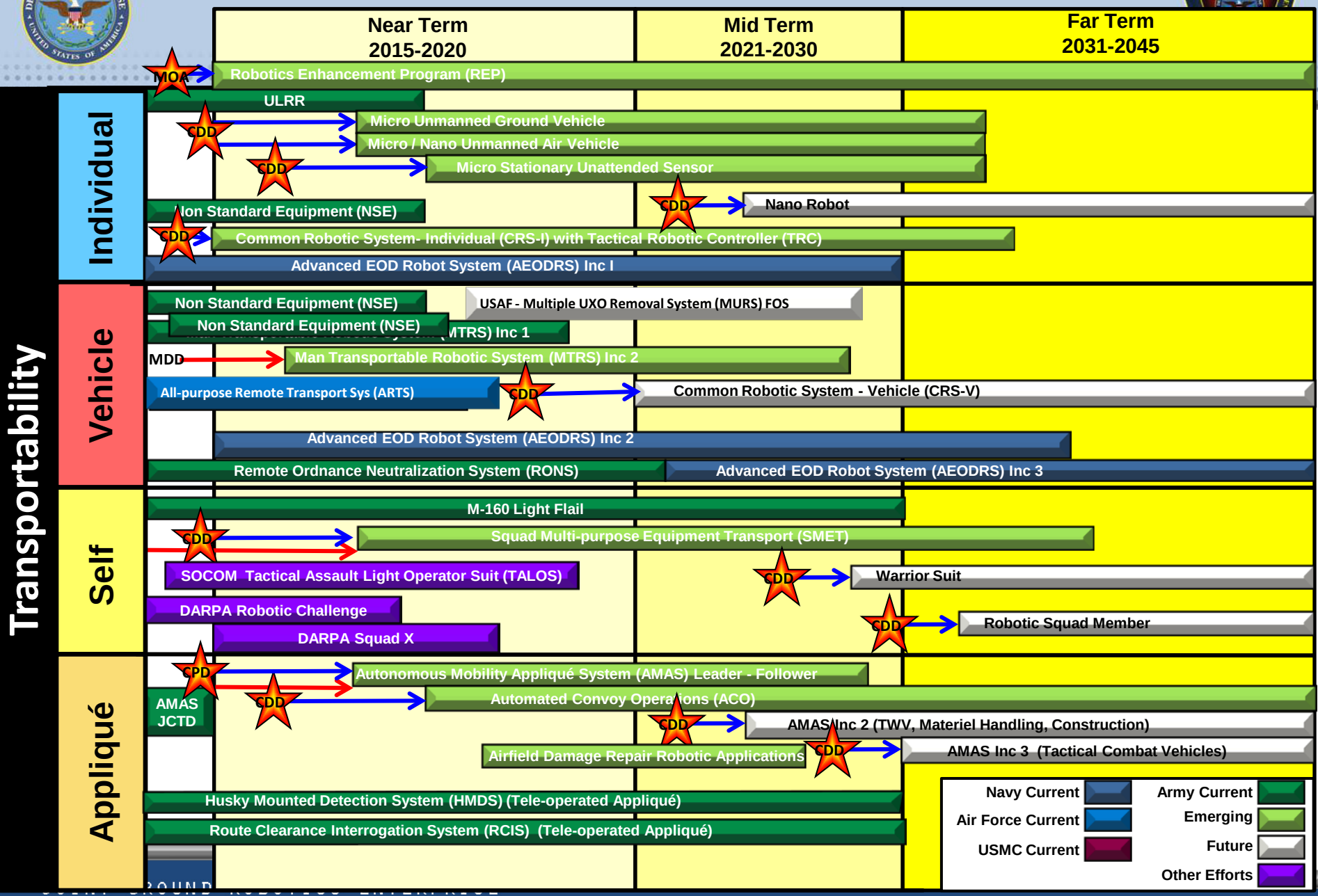
  H. R. 4495, Section 102. Establishment of Department of Defense unmanned systems office ~ … It is the policy of the United States to maintain an independent organization within the Department of Defense to develop and coordinate the unmanned air, land, and sea capabilities of the United States to ensure unity of effort and the prudent allocation of resources in accordance with military needs.

Current Environment

- Joint Staff Remote / Unmanned Futures Office (JRUFO) Coordination Working Group, COL Bowery, J8
  - JOINT CONCEPT FOR REMOTE, ROBOTIC, AND AUTONOMOUS SYSTEMS (JCRRAS)

- Lethal Autonomous Weapon Systems
  - United Nations, Geneva, Convention on Certain Conventional Weapons Meeting of Experts on LAWS, 13 to 16 May 2014

Joint Services Unmanned Ground Systems Strategy



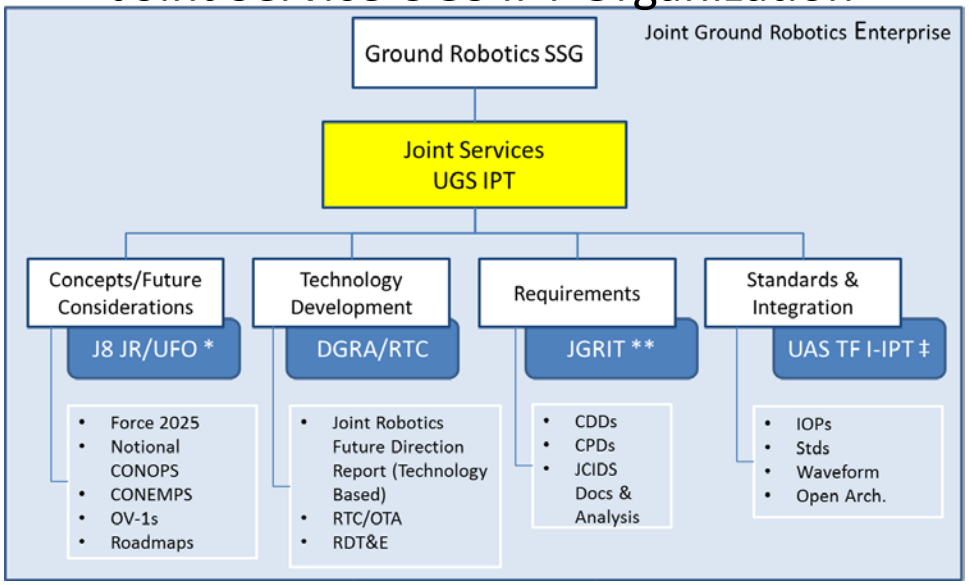
JGRE Senior Steering Group

- The JGRE Senior Steering Group (SSG) was initiated in 2008 previously known as a General Officer Steering Committee (GOSC)
- In 2010 the membership was expanded to have representatives from the Acquisition, Combat Developer and Research and Development areas
- In 2013 the membership was revisited to align more closely with the current environment
- The SSG meets several times annually to review and discuss activities/events and provide oversight/guidance to the unmanned ground systems community
- Membership:
  - Organized by OSD(AT&L), Tactical Warfare Systems, Director, Land Warfare and Munitions
  - Joint Staff-J8, EOD
  - Army G-3/5/7, TARDEC, ARL, TRADOC, ARCIC, G-8, ASAALT
  - Navy-ASDN/ELM, OPNAV, ONR
  - Air Force-AFCEC, AFRL, SAF-AQ
  - Marine Corps-MCWL, MARCORSYSCOM, MCCDC
  - Test Community-DOT&E, DT&E
  - DARPA

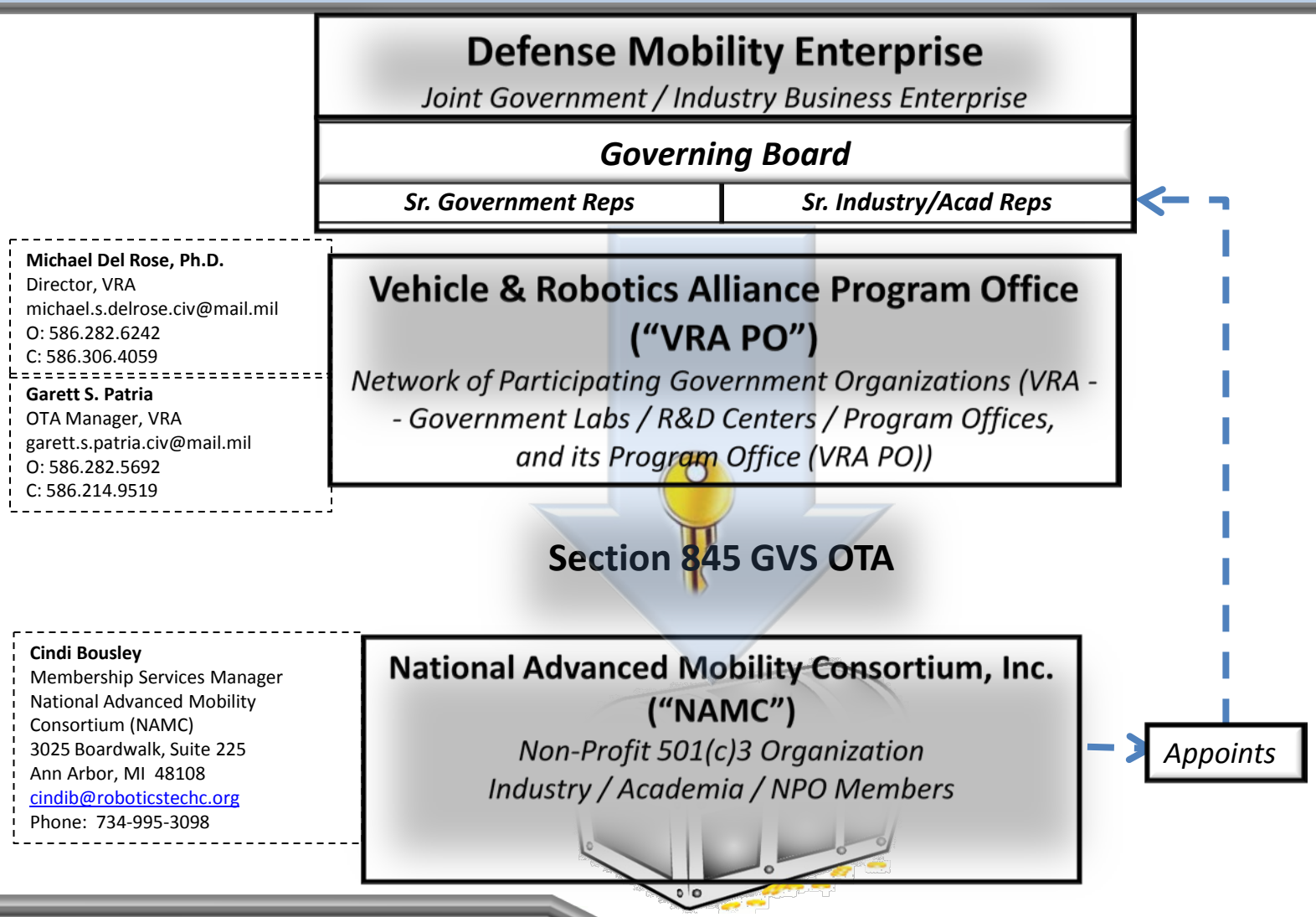
Joint Services UGS IPT

- Established via Joint Services Memorandum of Agreement, signed 27 May 2014
  - JGRE SSG Appointed Chairpersons LTC Stu Hatfield, Army G-8, and Ms. Brenda Beisner, ASN RDA/DASN ELM
  - Initial Meeting of Members
    - 25 Jul 2014, Pentagon (VTC)
  - Report to JGRE SSG
    - 13 Aug 2014

Proposed
Joint Service UGS IPT Organization



Defense Mobility Enterprise



OTA Requirements for Participation

DoD-Specific

The GVS Section 845 Other Transaction Agreement is for Technology Development and Prototype Demonstration Initiatives. The purpose of this OTA is to further the DoD's capabilities in the areas of **vehicle and robotics technology research**, development, test and evaluation projects, as well as the implementation of best practices across the VRA's Technology Area Objectives: *Modeling and simulation, vehicle collaboration, platform design, mobility, powertrain, vehicle and occupant survivability, fuels and lubes, vehicle architecture, modularity, and vehicle payloads*.

Projects awarded through VRA have the following characteristics:

- Have Prototype Deliverables
- Are relevant to DoD Weapons and/or Weapon Systems
- Are funded through RDT&E or Procurement* type funds
- Are pre-Milestone C** in the Acquisition Lifecycle
- Include significant participation by a nontraditional defense contractor or 1/3 cost share by a traditional defense contractor

* If Procurement funding, the project must address a prototype, product improvement or single point failure

** The OTA can be used to award prototype demonstrations up to a Low Rate Initial Production (LRIP) decision point; LRIP and beyond are not allowed under the Section 845 OTA authority.

JGRE Roles

Interoperability

Interfaces, protocols, profiles, standards

Test and Evaluation

Infrastructure, processes, metrics, resources

Modeling and Simulation

System performance, terrain physics, environments

Interoperability Background

- Fielded Unmanned Ground Systems (UGSs) are predominantly proprietary systems originally developed for Service-specific needs driven by rapid fielding timelines in support of immediate operational requirements
  - limited to NO interoperability with other manned and unmanned platforms in all domains (ground, air & maritime)
- Payloads, sensors, software & computing devices are anticipated to evolve much faster than base mobility platforms requiring modularity within a system
- Open architectures (OAs), nonproprietary interfaces, government-owned data rights, and standard Interoperability Profiles (IOPs) are required for a broader net-centric environment

Ensuring Success in IOPs

- Combat Developers & Battle Labs:
  - Requiring IOP compliance in CDDs/CPDs cannot hurt (although simply asking for "interoperability/modularity" is sufficient)
  - Encourage industry adoption of IOPs
  - Help synch IOP adoption w/ other domains through requirements
    - i.e., AMDS, NGCS, UAS, mobile/hand-held, manned/unmanned, radios, joint/multi-national, etc.
- S&T Organizations:
  - Encourage IOP compliance in S&T programs
  - Increase body of knowledge in gov't labs
- PM Offices
  - Require IOP in RFPs; Develop IOP Instantiations
- Resource Providers
  - Recognize the value of 1) IOP development/evolution (across programs), and 2) IOP application (within programs)
  - Recognize IOP as an investment for BBP 2.0
    - BBP 2.0 >> Promote Effective Competition >> Enforce Open System Architecture

Interoperability Path Forward

- Alignment and transition of current military standards and Interoperability Profiles (IOPs) to industry standards
  - Kick-off Meeting at TARDEC, Warren, MI (Aug/Sep 2014)
  - Leads: RTC, JHU-APL (SAE AS-4)
- Transition military waveform communications investment for small robotic/unmanned systems
  - KICK-OFF Meeting at Aberdeen PG, MD (July 22, 2014)
  - Bi-Weekly telecons on-going
  - Leads: JTNC/APG, JGRE
- Establishment of long-term hierarchy for common control architectures for small unmanned systems
  - Kick-off Meeting at AMRDEC, Huntsville, AL (Aug/Sep 2014)
  - Leads: RTC, AMRDEC (PM UAS)

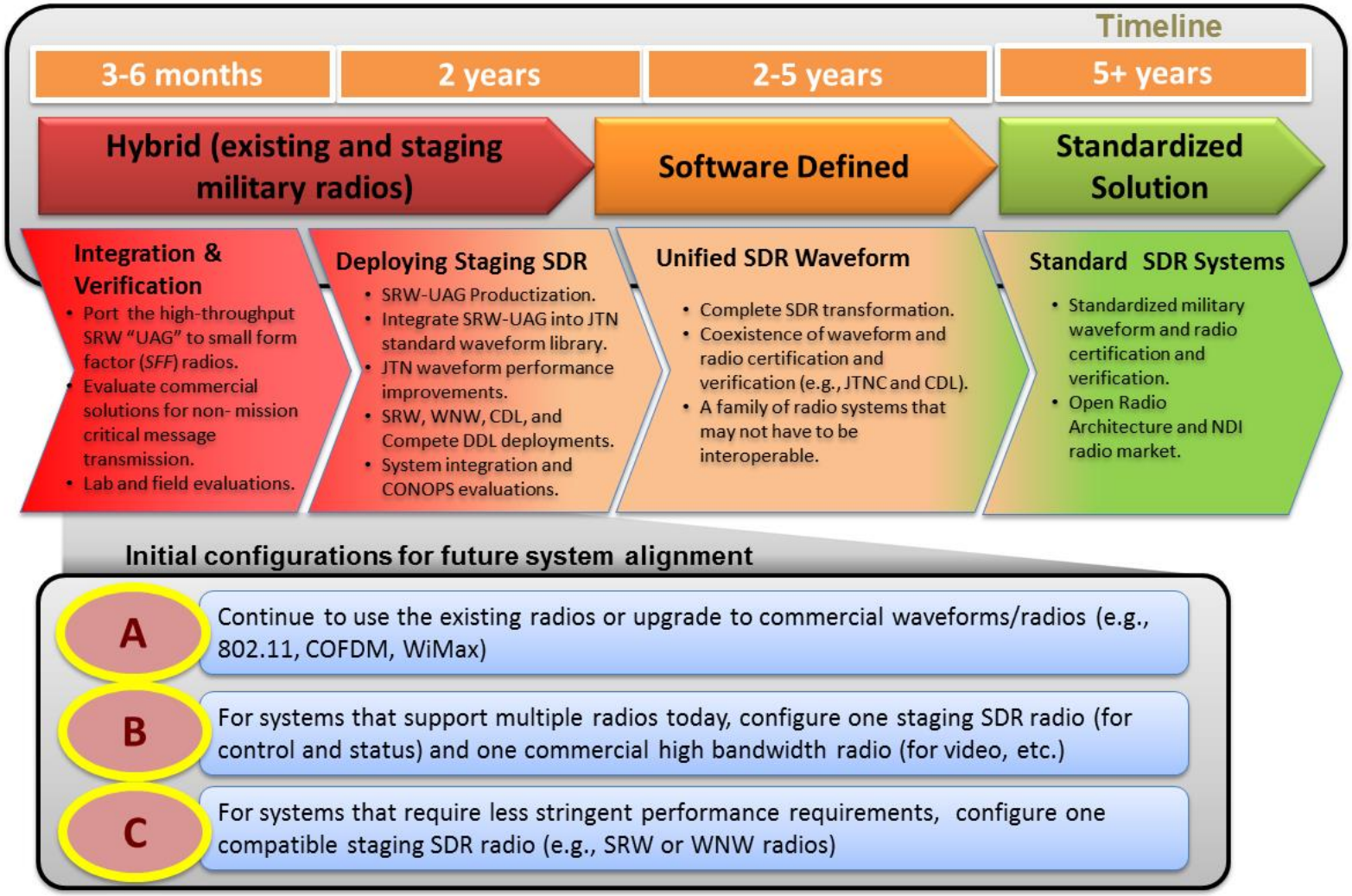
Unmanned Systems Communications

DoD plans to heavily leverage unmanned systems on the Tactical Edge before 2025 but proprietary commercial point to point solutions for communications and controls present the following challenges:

- Cost
  - Duplicative RDT&E costs among UxS due to lack of available common military radios and waveforms
  - Additional staffing and expertise requirements to identify and sustain non standard communications equipment
- Schedule
  - Current programs of record and radio upgrade programs require a near term solution to provide opportunity to coordinate requirements to challenge industry to provide military approved communications
  - Window of opportunity rapidly closing for M160, AEODRS, and MTRS MK2
- Operations
  - UxS radio technology being developed independently from DOD UXS mission requirements
  - Lack of overarching cyber protection approach increases network vulnerability
  - Limited interoperability across different systems and AOR
  - Cannot support current EMI and EMC requirements.

JGRE is leading a collaboration effort with community stakeholders to jointly define an engineering approach for a standardized solution

Unmanned Systems Communications Way Forward

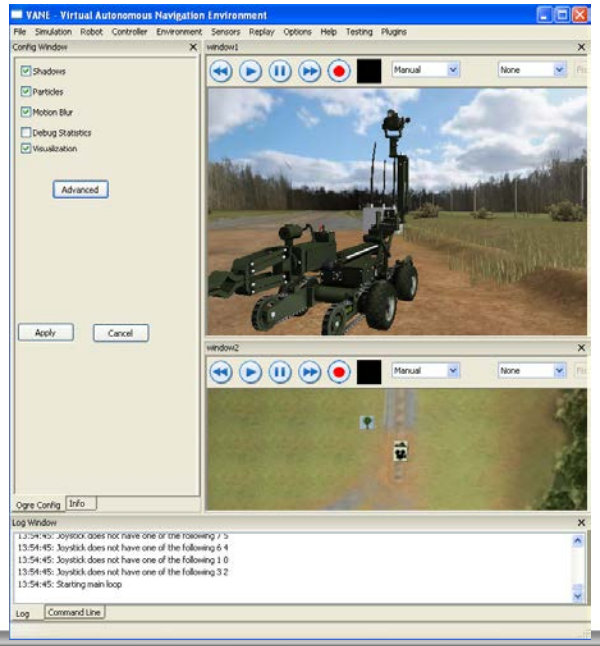


T&E Background

- Emerging requirements, declining budgets, and the Department's need for preparedness pushed coordination between the JGRE and the OSD test community for collaboration with regards to UGSs testing
- Test Range Management Center, Unmanned and Autonomous System Test (UAST) Technology Area develops technologies for accessing autonomous and intelligent systems performance
- OSD Autonomy Community of Interest; Test and Evaluation, Verification and Validation Working Group coordinates and reports needed TEVV standards, best practices, and resources (including technical competencies and test ranges) required to enable future autonomous and self-governing defense systems.

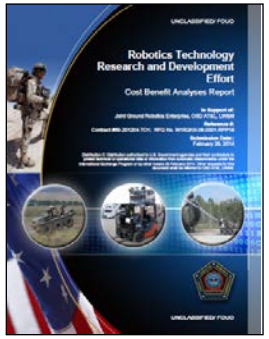
M&S Background

- As UGS continue to mature as an enabling capability for our future forces, M&S is a critical technology that will underpin requirements to research & development to test & evaluation
  - Working with the Modeling and Simulation Coordination Office to identify existing capability
- The complexity of these UGS, combined with declining budgets for development and full representative testing, will require an increased reliance on M&S
- Need for alignment of existing models
  - VANE/ANVEL
  - RIVIT
  - ModSim, etc.
- Joint Common Simulation Environments
  - H/W & S/W Interfaces *(interoperability)*
  - Current Applications



JGRE CBA Purpose of the Study

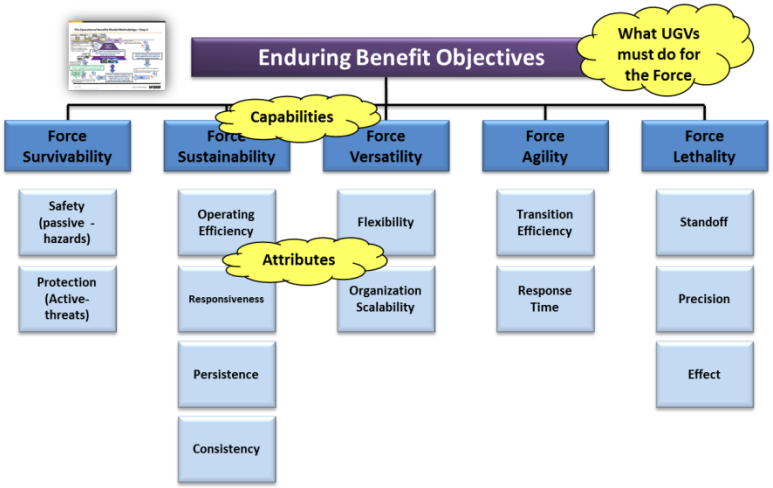
- A key JGRE mission focus area is the ability to justify the value of robotics investments, reduce duplicative efforts, and increase efficiency of research and development across the UGV portfolio
- ***The challenge*** - Future UGV investment strategies across various types of missions require a compelling business case that justifies a system's value to the Warfighter and identifies its ability to reduce or reallocate force structure and/or personnel
- To meet this challenge and craft an optimized portfolio of robotic systems, JGRE conducted a 16 month study to develop a repeatable, scientific approach for assessing the cost-effectiveness, or ***net-benefit***, of UGVs across the joint forces
- Supported by a Study Team, JGRE developed a framework to assess a UGV's operational benefit and then conduct cost benefit analysis (CBA) of five systems across four different mission profiles
- CBAs were conducted on the UGVs that exhibited the most significant operational benefit



Net benefit is a function of Operational Benefit and Cost Benefit. Operational Benefit is reflected in the scores derived from the Operational Benefit Model. Cost benefit is reflected by Internal Rate of Return (IRR).

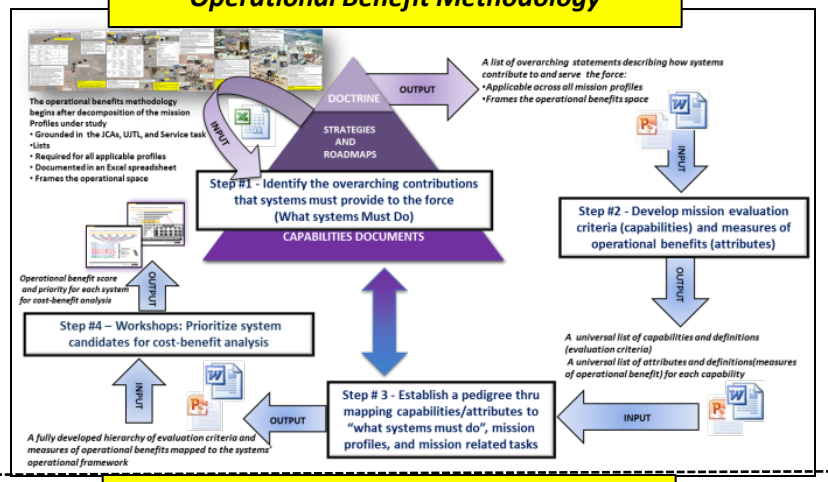
JGRE CBA Study Tasks *(1 of 2)*

- Task 1: ***Develop a methodology*** for estimating the potential integration of robotic systems:
  - Near-term (1-5 years)
  - Far-term (6-15 years)



- **Lighten human physical and / or cognitive workloads**
- **Conduct a variety of missions and tasks that would otherwise expose humans to risk**
- **Conduct tasks to support assured mobility and freedom of maneuver**
- **Assist in preventing attacks or mitigating effects**
- **Improve persistent reconnaissance and surveillance in all domains**
- **Sustain the force with improved distribution, throughput and efficiency**
- **Increase mission flexibility across the full spectrum of operations**
- **Demonstrate financial viability with a positive return on investment, limited payback period and positive rate of return**

Operational Benefit Methodology



Operational Benefit Model

Capability	Attribute	Attribute Metrics/Profile Mapping
Force Survivability The ability of the force to remain mission capable by avoiding or withstanding the effects of hostile environments (manmade or environmental) *(AR 70-75)* ***Benefit categories: 1, 2, 4, 5,***	**Safety** (passive - hazards)	• Decreased number of personnel required for task (DCO, FP&PS, BSO&FM, DMH&L) • Decreased equipment damage from accidents (for example, due to inattentive operation, fatigue, etc.) (DCO, BSO&FM, DMH&L) • Decreased personnel injury or death from in accidents (for example, due to inattentive operation, fatigue, etc.) (DCO, FP&PS, BSO&FM, DMH&L) • Decreased exposure to hazards (DCO, FP&PS, BSO&FM, DMH&L) • Improved situational awareness (DCO, FP&PS, BSO&FM, DMH&L)
	Protection (active - threats)	• Decreased number of personnel exposed to threats (DCO, FP&PS, BSO&FM) • Increased accuracy of threat assessment (screen/assess/identify) DCO, FP&PS, BSO&FM) • Improved (timely) warning (DCO, FP&PS, BSO&FM) • Improved warning reach (notification) DCO, FP&PS, BSO&FM) • Improved situational awareness (detection) DCO, FP&PS, BSO&FM)
Force Sustainability The ability to ensure forces are provided the support and services to enable freedom of action, extend operational reach and prolong endurance. (MCDP 1-0 and (Army Pub 3-0, Unified Land Operations, section 66) **Benefit categories: 1,3, 5, 6, 7**	**Operating Efficiency**	• Reduced energy demand (DCO, FP&PS, BSO&FM, DMH&L) • Reduced logistics footprint / supporting infrastructure (DCO, FP&PS, BSO&FM, DMH&L) • Interoperability
	Responsiveness	• Simplified logistics thru multiple sources of repair parts (commercial, allied, government) (DCO, FP&PS, BSO&FM, DMH&L) • Improved logistics flexibility thru common services across a broad range of service providers (allied, commercial, government) (DCO, FP&PS, BSO&FM, DMH&L))
	Persistence	• Increased duration (time) of operations (DCO, FP&PS, BSO&FM, DMH&L) • Increased spatial coverage(DCO, FP&PS, BSO&FM, DMH&L) • Improve reliability and availability (DCO, FP&PS, BSO&FM, DMH&L)
	Consistency	• Increased the number of successful repetitions of a task (DCO, FP&PS, BSO&FM, DMH&L) • Decrease force burden(DCO, FP&PS, BSO&FM, DMH&L)
Force Lethality The ability to overmatch an enemy while mitigating collateral damage (TRADOC Standards Benefit Paper) **Benefit Categories: 1, 2, 4, 5,**	**Standoff**	• Increased unit's acquisition range (distance) • Increased unit's engagement range
	Precision	• Increased target identification range (earlier decision to engage or not) • Improved targeting location
	Effect	• Increased situational awareness (to determine appropriate fires)

JGRE CBA Study Tasks *(2 of 2)*

- Task 2: ***Analyze the cost-effectiveness and net benefit*** of potential unmanned solutions for the selected mission profiles
  - 4 manning options: status quo, enhanced operations, tele-operated, fully autonomous unmanned operations
  - *Outcome: an independent, monetary assessment of robotics systems' impact on force structure and/or personnel*

C-BA Overview

1 Objective

Globally assess the unit level, life cycle savings of robotics by analyzing their employment against a variety of missions profiles

2 Scope

1 CBA per mission and solution combination

CBA	4 Mission Profiles	6 Solutions	3 Platforms
1	Deployed Convoy Ops	U2UARV	Polaris
2	Force Protect & Perimeter Control	MDARS	
3	Base Ops and Facilities Maint	U2UARV	
4		6/10T Diesel Forklift	Forklift
5	Depot Mat Handling & Logistics	6T Electric Forklift	
6		3.5T Stacker	Stacker

3 Solution Selection Criteria

- Minimal investment
- Minimal cost/schedule/tech risks
- Full autonomy achievable
- Near term availability (5 years)
- Leverages COTS, reduces risks
- Ease of integration with current processes and infrastructures

4 Framework

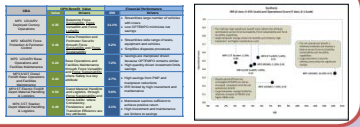
- CES attributes
  - Tailored for each mission/solution
  - Same for As-Is and To-Be
  - Used for savings calculations via subtraction
- 2 objectives
  - Consistency across each mission's As-Is and To-Be alternatives
  - Symmetry in quantifying costs and savings for every element

5 Analyses

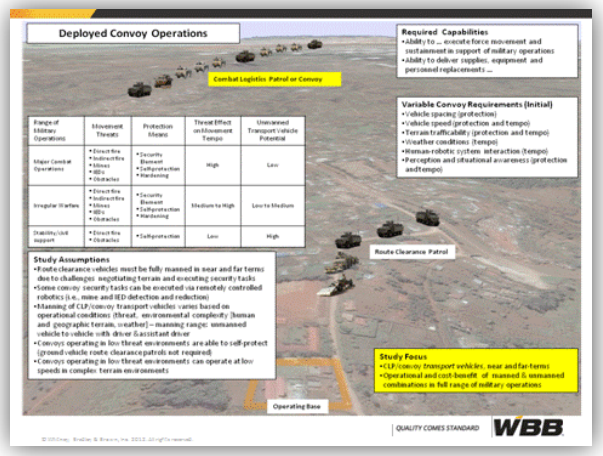
Each C-BA subject to
- 4 phase LCCE: R&D; P&D; O&S; D&D
- Finances: cash flow; ROI; IRR; pay back period
- Risk and Sensitivity

6 Synthesis

- Operational Benefit Score
- Internal Rate of Return

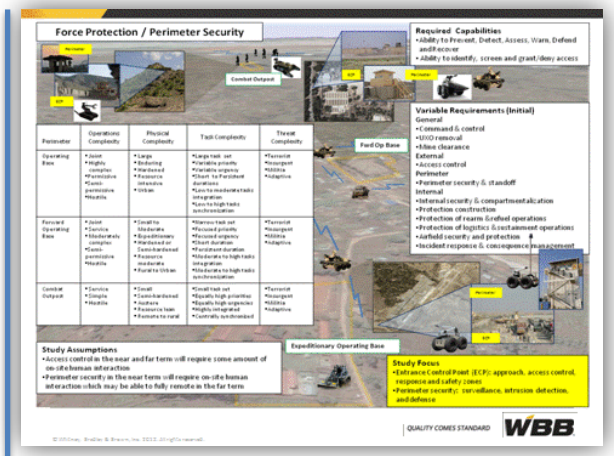


JGRE CBA Four Mission Profiles



Deployed Convoy Operations

- Expeditionary and Enduring Base
- Focused on transport mission
- Near-term (1-5) and Far Term (6-16)



Force Protection/ Perimeter Security

- Entrance Control Point & Access Control
- Surveillance, intrusion detection
- Near-term (1-5) and Far Term (6-16)

Base Operations & Facilities Maintenance

- Expeditionary and Enduring Base
- Logistics resupply and Material Handling Activities
- Near-term (1-5) and Far Term (6-16)

Depot Material Handling & Logistics

- Enduring Warehouse (Distribution)
- Material Handling Activities
- Near-term (1-5) and Far Term (6-16)

Summary of JGRE CBA Results and Findings

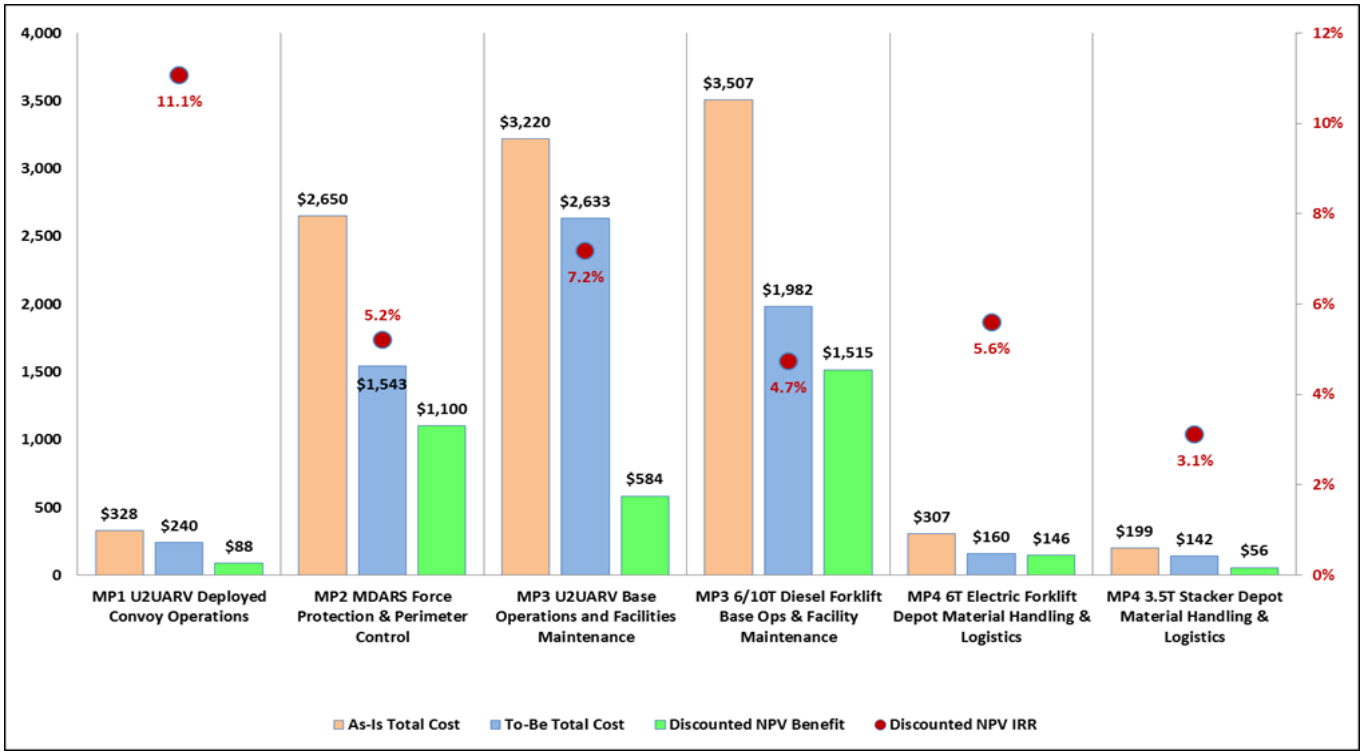
Savings from vehicle and crew reductions for security

Savings gained from simplified processes and streamlined tasks, equipment and vehicles

Savings from high manpower savings under large scale operations

High operations vehicle and manpower savings muted by high investment requirement

Manpower savings offset by high maintenance costs



JGRE WAY AHEAD

- Services identifying capabilities and preparing documents and resourcing needs
- Work with industry to identify open architecture way forward for ground robotics and interoperability with other unmanned domains
- Participate with DoD T&E and modeling communities to identify path forward for unmanned systems

Questions?

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