PROJECT MANAGER FORCE PROJECTION

Army Ground Robotics Overview:

OSD Joint Technology Exchange Group

24 April 2018

Mark Mazzara
Robotics Interoperability Lead
PM Force Projection

PEO CS&CSS Robotics Portfolio

M160 Light Flail

Route Clearance & Interrogation System

Leader/Follower

Robotic Enhancement Program

Man-Transportable Robotics System Increment II

Common Robotic System Individual

Squad Multipurpose Equipment Transport*

Next Generation Combat Vehicle – Unmanned (a.k.a. Robotic Combat Vehicle)

Non-Standard Equipment

MTRS MK II MOD I (Talon IV RESET)

MTRS MK II MOD II (Talon 5A)

TALON IV CBRNe

Dragon Runner

FirstLook

SUGV 310 Mini-EOD

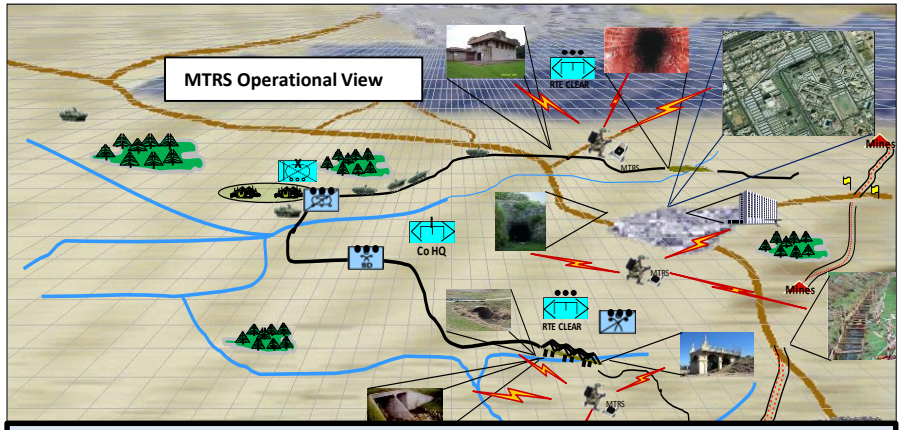
Common Robotic System Heavy*

Enhanced Robotics Payloads*

Automated Convoy Operations

** Images are conceptual representations, not endorsements*

MTRS Inc II Program Overview / Update



- The Man Transportable Robotic System (MTRS) Inc II is a remotely operated, man-transportable, robotic system
- Provides a standoff capability to interrogate, detect, confirm and neutralize presence across War-fighting functions
- Capability to identify and disposition explosive hazards
- Army's medium sized common platform allowing use of various platform payloads in support of current and future missions

* AAO includes EOD requirement of 587

- ✓ **CPD: Approved, 15 MAY 2013**
- ✓ **RFP Released: 09 NOV 2016**
- ✓ **Contract Award: September 2017**
- **First Unit Equipped: 4QFY19**
- **AAO: 1,210**
- **Users: Engineer, CBRN and EOD**

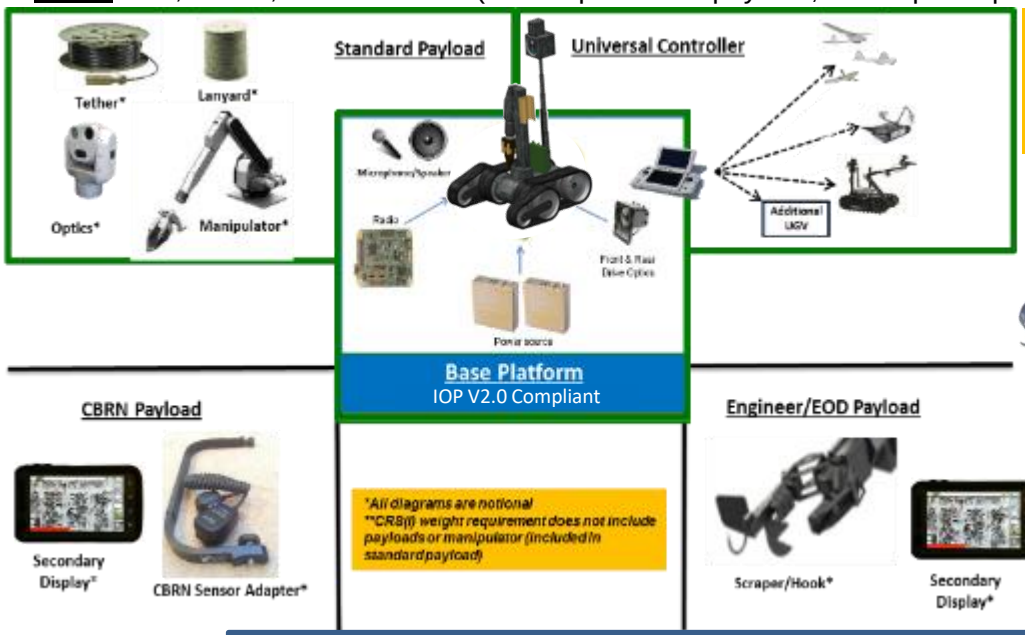
Common Robotic System (Individual) {CRS(I)}

System Description: A man-packable (< 25lbs), miniature, highly mobile, unmanned robotic system with advanced sensors and mission modules for dismounted forces. Designed so that operators can quickly reconfigure for various missions by adding/removing modules and/or payloads.

Common Robotic Platform Enabling Payloads to Address the Operational Capabilities Gaps:

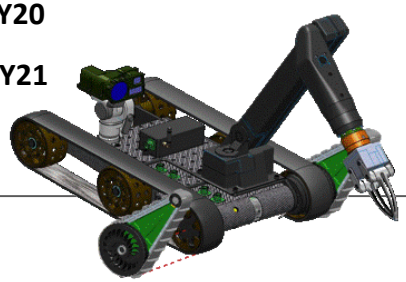
- Standoff short range Intelligence, Surveillance, & Reconnaissance (ISR)
- Remote Chemical, Biological, Radiological, and Nuclear (CBRN) detection
- Remote Explosive Obstacle Counter Measure (EOCM)
- Remote Explosive Ordnance Disposal (EOD) operations
- Remote clearance of danger areas

Users: INF, CBRN, ENG and EOD (EOD equals ENG payload; no unique requirement)



Entire CRS(I) System required to fit into single Large MOLLE

- ✓ **AAO: 3,258 (Does not include Marines)**
- ✓ **RFP Released: 16 May 2017**
- ✓ **Milestone B: 26 March 2018**
- ✓ **EMD Contract Award: 30 March 2018**
- **Milestone C: 2QFY19**
- **FUE: 2QFY20**
- **IOC: 3QFY21**



EMD contract awarded to Endeavor & QinetiQ on 30 March 2018

Endeavor ROBOTICS™ QinetiQ North America

Squad Multipurpose Equipment Transport (SMET)

System Description: The SMET provides the small unit with the ability to support squad and platoon operations for 72 hour missions. Provides unmanned or optionally manned internal resupply capability to the small unit.

SMET Capabilities:

- ❑ Carry up to 1000 lb. of Soldier gear
- ❑ Operate for 60 miles within 72 hours without external resupply
- ❑ Provides mobile power generation capability to the small unit
- ❑ Operable with remote control with options for Follow-me, Teleoperation and Operator Control Unit

- **Acquisition Category (ACAT):II (Pre-MS C)**
- **Acquisition Objective (AAO): 5723**
- **Program of Record (POR) Acquisition Cost: $100K each**
- **Directed Requirement: 3QFY17**
- **Urgent Material Release (UMR) of Directed Requirement: 4QFY18**
- **Capability Production Document (CPD): 1QFY20**
- **Milestone C: 1QFY20**

SMET Directed Requirement Status

Phase I – Vendor Solution Assessment

- Successfully completed 5 weeks of testing with 7 Contractors (8 platforms)
- 2 Contractors ran tests in parallel
  - Separate, secure staging areas
  - Offset testing schedules
- 5 days of testing for each contractor
  - 24 hour range access and Government support/supervision
- Contractors operated their own systems through the tests using remote control only
- Pass/fail and weighted scores assessed for each test; used as phase II down select criteria

Phase II – Operational Technology Demonstration

Selected Platforms

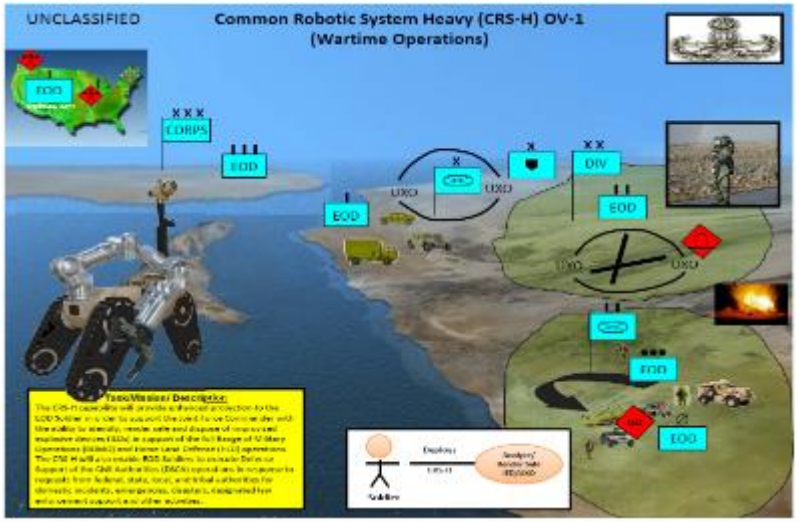
- Phase II IBCT Locations
  - 1/101st at Fort Campbell, Kentucky
  - 1/10th at Fort Drum, New York
- Contractor Requirements
  - Dedicated Field Service Representatives (FSR) at ATC and both IBCT locations
  - Provide Contractor Logistics Support (labor, spare parts, supplies, and tools)
  - Operator Training Support Package
  - Commercial Off-The-Shelf Operator Manual
  - Operator Task Videos
  - Conduct Operator New Equipment Training (24 curriculum hours for 12 students)
  - Participation in a Government-led T&E WIPT

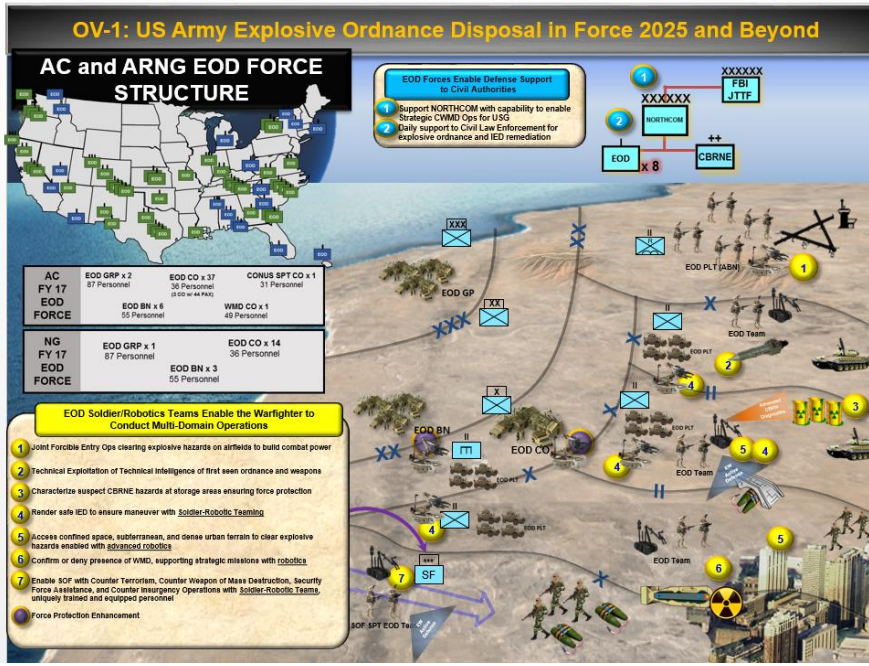
CRS(H) Program Overview

System Description:
The CRS(H) is the Army's large sized, vehicle transportable, common robotic platform capable of accepting various mission payloads enhancing protection to the EOD Soldier by providing increased standoff capability to identify, render safe and dispose of explosive ordnance and improvised explosive devices in support of the Range of Military Operations and Homeland Defense operations.

Emerging Threshold Performance :
- Manipulator Arm Lift Capacity
  - Close to Platform > 275 lbs;
  - Full Extension (72 in) > 100 lbs
- Platform Speed > 6 mph
- Obstacle Clearance > 32 in (Jersey Barrier)
- Platform Endurance > 7 hrs
- Weight < 700 lbs curb weight, 1000 lbs gross system weight (includes 300 lbs of non-native payloads
- Interoperability – IOP compliant
- Cyber Hardened

- **CPD: Projected April 2018**
- **RPP Released: Projected 3QFY18**
- **Contract Award: Projected 4QFY18**
- **Fly-Off: SEP - OCT 2018 (T)**
- **AAO: Projected 248**
- **Target AUMC: TBD**
- **Users: EOD and CBRN**





** Images are conceptual representations, not endorsements*

CRS-H Acquisition Strategy (Emerging Insights)

OTA Fly-Off: Phase I

- Evaluate vendor proposals and down-select (up to 5) to participate in a fly-off
- Candidate systems put through operational demonstrations
  - 5 days per vendor with same evaluation team
  - Vendors bring (1) system; only FSR's will operate the system in accordance with current EOD TTPs
  - Gov't team (incl. user) will observe and evaluate
- Vendors will be provided Gov't assessment two weeks after completion of event
- SEP-OCT 2018 at Fort Leonard Wood
- Execute under REP 18.2

** Images are conceptual representations, not endorsements*

OTA Fly-Off: Phase II – ATEC/User Evaluation

- Down-select (up to 2) to participate in ATEC/User evaluation
  - Proposals based on Fly-off #1 results; include cost for (3) production representative systems, data to support safety confirmation and logistics development
  - Systems (x2) will be put through both safety testing and user operation
  - Additional system (x1) will be utilized for concurrent logistics development
  - May-JUN 2019 at Aberdeen test Center (APG)
- Evaluations will inform follow-on production phase

CRS-H Acquisition Strategy
Emerging Insights (Cont)

OTA Production Phase

- Fly-Off #2 participants submit final production proposal
- Down-select from two OEM's to one pending:
  - Performance Data
  - Technical Proposal
  - Cost Proposal
  - Safety Assessment
  - User Evaluation
  - Product Support Assessment
- Production award to one OEM (Target award - JUL 2019)
- Immediate fielding under CMR
- FMR achieved within two years

** Images are conceptual representations, not endorsements*

Rapid fielding of critical capabilities

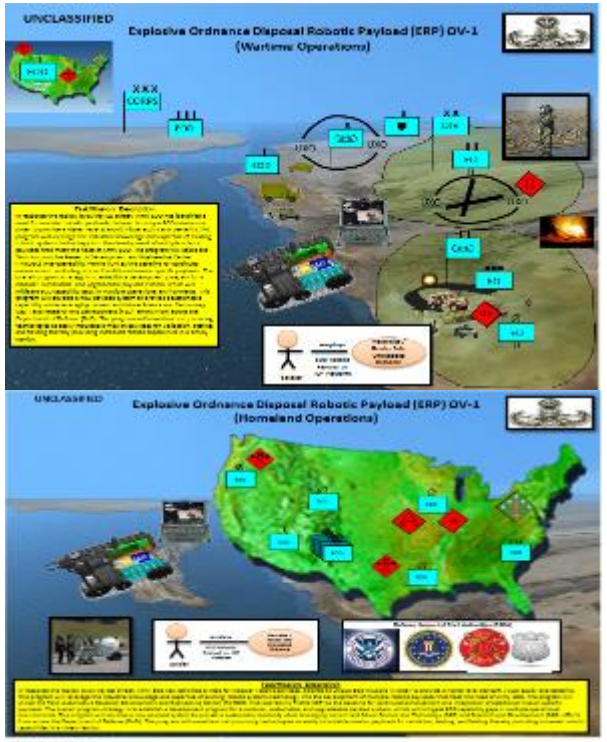
Enhanced Robotic Payloads (ERP)

System Description:

The ERP is a suite of modular capabilities designed with open architecture to provide an increased level of standoff, situational awareness, disruption capability and dexterity to respond to current and emerging Engineer, CBRN and EOD requirements. These multiple, modular robotic mission payloads will use open architecture to integrate with the MTRS Inc II and CRS(H) platforms to form the Army's next generation platform adaptable robotics systems.

Capabilities*:

- Dual Arm Dexterity
- Multi-Shot Disrupter
- Fine Precision Aiming Module
- Multispectral Overlay Camera
- Obstacle Avoidance & Digital Modeling
- Extended Range Radio & Mesh Networking
- Extended Range UAV & Surveillance



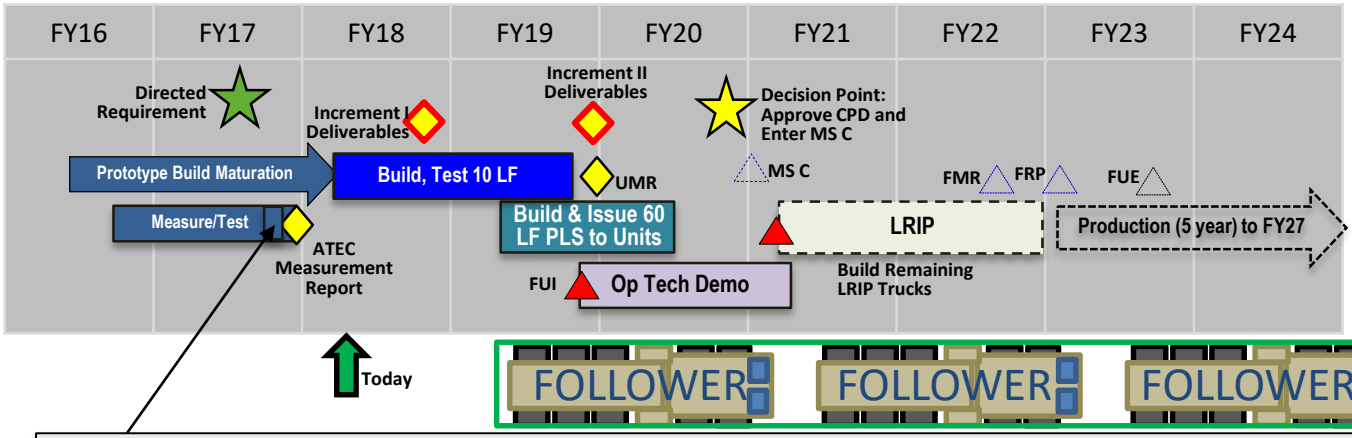
- **CDD Approval: ~4QFY18/1QFY19**
- **RFP Release: TBD**
- **AAO: Projected 743**
- **Users: CBRN and EOD**

* Only obstacle avoidance & mapping and extended range/mesh networking will be fielded to CBRN units

** Images are conceptual representations, not endorsements*

Leader Follower Operational Technology Demonstration

Leader Follower is a robotic applique kit to provide an optionally manned capability to current Tactical Wheeled Vehicles (TWV)



- Operational Evaluation with Soldiers at Camp Grayling on 11-22 SEP 2017
- Supported by (7) Soldiers from Army's 1st Armored Division out of Ft. Bliss, TX
- Evaluation included:
  - Driver Warning/Assist
  - Teleoperation
  - Leader Follower

Autonomous Trucks Testing: "Long Tail" of Use-Cases

Use case variables include:

Operations:
Wartime - High Intensity (7-day Surge)
Wartime - Low Intensity (30-day Period)
Peacetime - Low Intensity (240-day Period)

Hauling:
Local Haul
Line Haul

Terrain:
Primary Roads
- High Quality Paved
- Secondary Pavement
- Rough Pavement Degraded
- Rough Pavement Highly Degraded

Secondary Roads
- Loose Surface
- Washboard & Potholes
- Belgian Block

Off-Road
- Trails
- Rough Trails

Speeds:
45 - 55 mph Primary Roads
30 - 45 mph Secondary Roads
10 - 30 mph Trails
5 - 15 mph Rough Trails

Mobility:
Dry (Sand)
Wet (Rain)
Snow

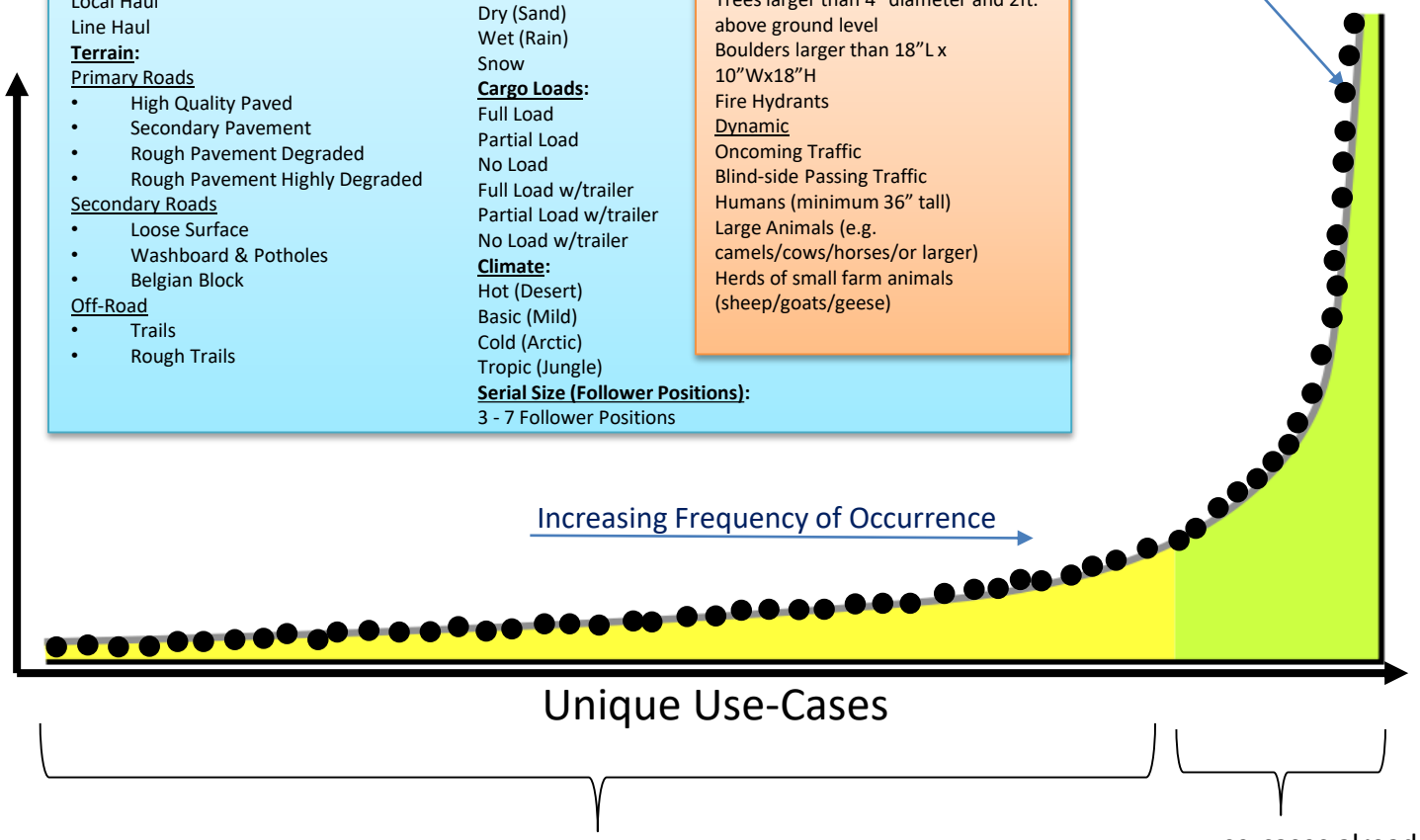
Cargo Loads:
Full Load
Partial Load
No Load
Full Load w/trailer
Partial Load w/trailer
No Load w/trailer

Climate:
Hot (Desert)
Basic (Mild)
Cold (Arctic)
Tropic (Jungle)

Serial Size (Follower Positions):
3 - 7 Follower Positions

Obstacles:
Static
Trees larger than 4" diameter and 2ft. above ground level
Boulders larger than 18"L x 10"Wx18"H
Fire Hydrants
Dynamic
Oncoming Traffic
Blind-side Passing Traffic
Humans (minimum 36" tall)
Large Animals (e.g. camels/cows/horses/or larger)
Herds of small farm animals (sheep/goats/geese)

Each point on the line represents a unique use-case.



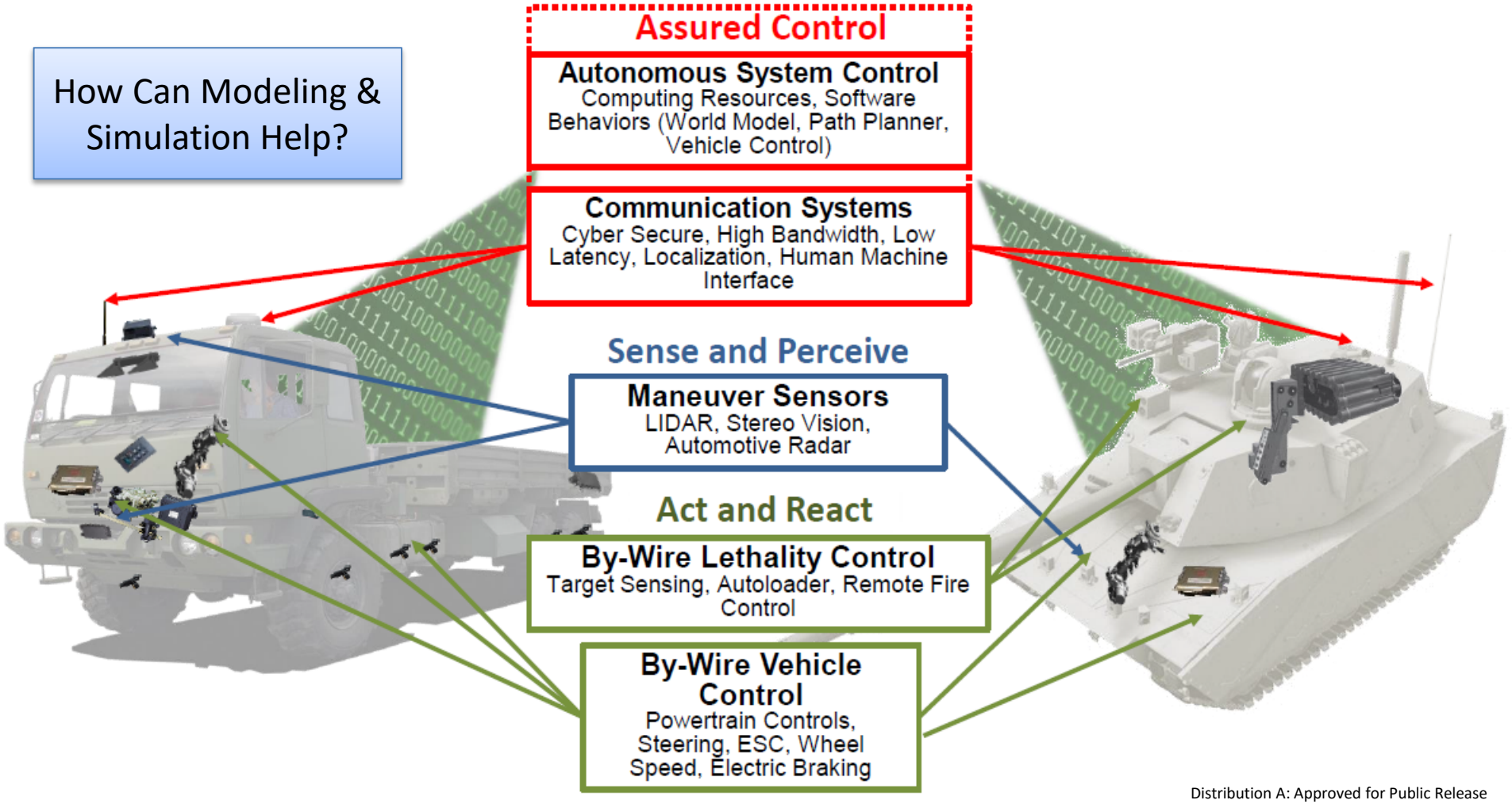
"long tail" of use cases: cost driver for achieving reliability
For manned systems, testing organization (ATEC/OTC) trusts human driver's decision making process to address these use-cases

use-cases already demonstrated

Robotic and Autonomous System Components

Regardless of mission role, there are many **common components** that enable RAS platforms to **perceive** the environment, make **decisions** and **execute** the mission.

How Can Modeling & Simulation Help?

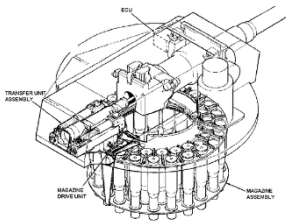


While all systems are required to make RAS platforms function, most critical for successful military applications is Assured Control

RCV Major Technical Hurdles

In order to accelerate unmanned combat platforms there are three major technical hurdles to overcome

Remote Lethality



Autoloader for Main Armament System

Safety certification for Soldier use

Remoting Manual Fire Control Processes

Correcting Targeting Solutions Based on Latency

Unmanned Maneuver

Cross country maneuver at operationally relevant speeds

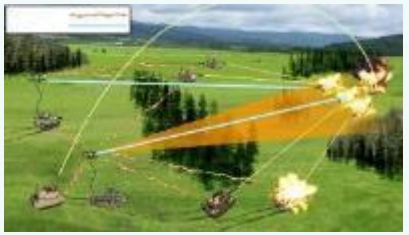
Reliable semi-autonomous behaviors

Robust by-wire actuation of mobility systems

Intuitive Human Machine Interface between operators and unmanned platforms

Network

Plan on utilizing commercial communication system to support field experiments until military multi-band capable radios are available



Require low latency, secure high bandwidth communications

How Can Modeling & Simulation Help?

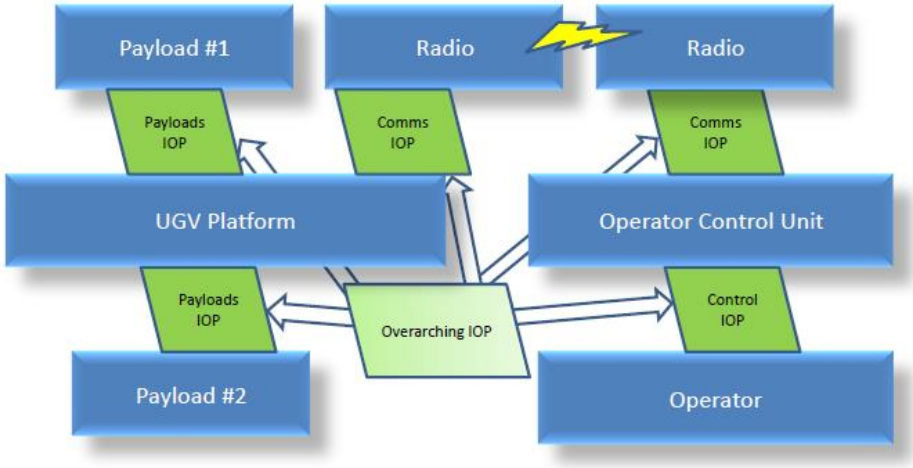
Robotic Combat Vehicle (RCV) Considerations

- What mission?
- What system? 
- What would the human machine interface considerations be for manual teleoperation?
- What should be the role of the human versus the machine?
- What decisions can be made by the machine and what decisions require a human?
- What subsystems should be automated?
- How does the RSTA mission change based on new technology? What about other missions?

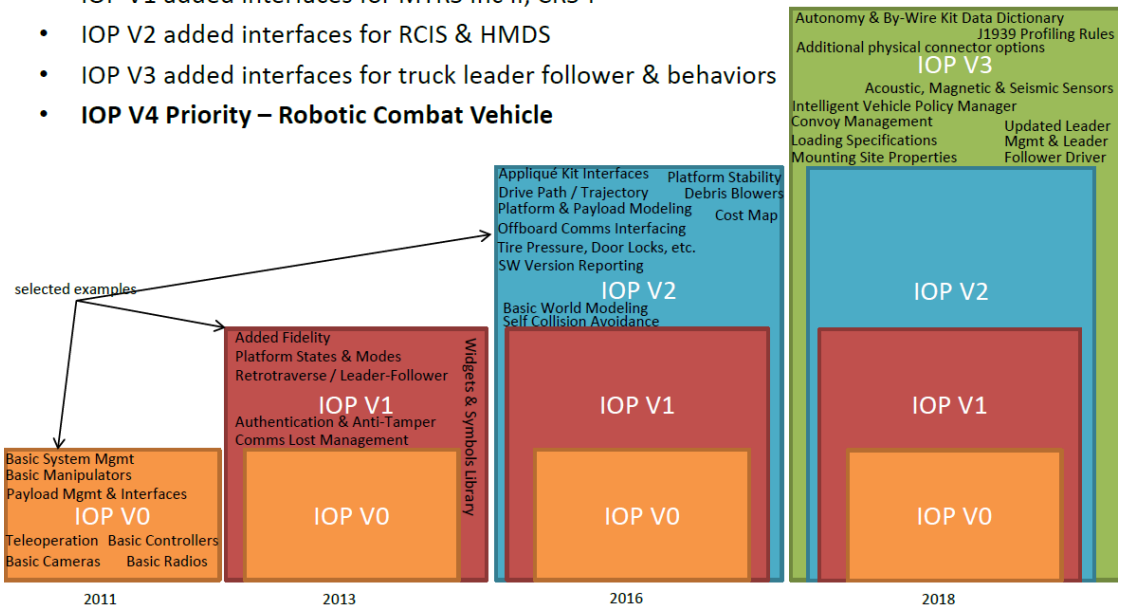
How Can Modeling & Simulation Help?

RAS-G IOPs Basic Overview

- Robotics & Autonomous Systems, Ground (RAS-G) Interoperability Profiles (IOPs)
- Defines software messaging & hardware interfaces between major subsystems of unmanned ground systems

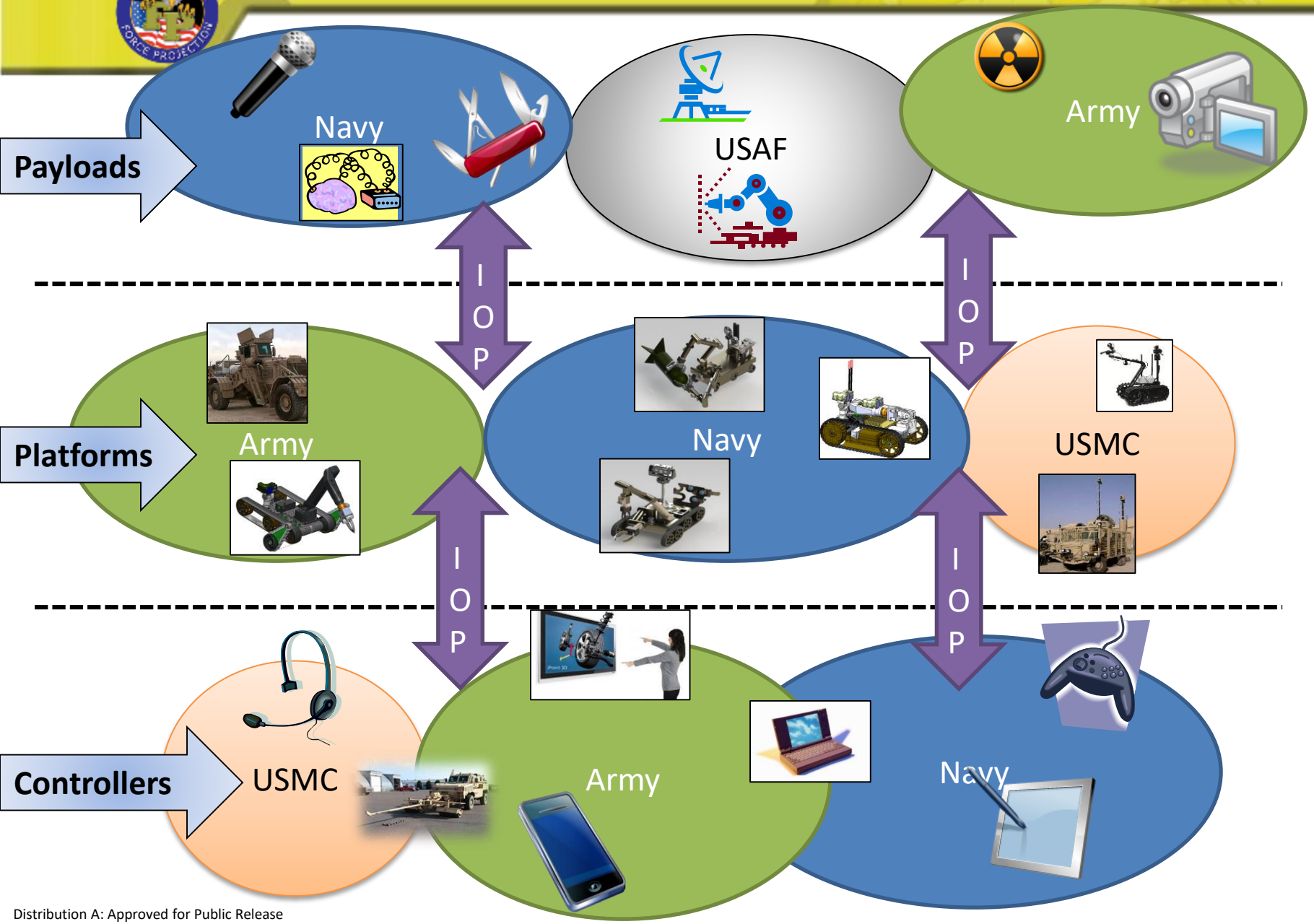


- IOP V0 provided interfaces for capabilities already fielded
- IOP V1 added interfaces for MTRS Inc II, CRS-I
- IOP V2 added interfaces for RCIS & HMDS
- IOP V3 added interfaces for truck leader follower & behaviors
- **IOP V4 Priority – Robotic Combat Vehicle**



IOP V3.0 Release February 2018

RAS-G Modularity Vision



Existing Universal Controller Requirements & Architecture

Distribution A: Approved for Public Release

RQ-11 Raven (MRR)

Short Range Recon (SRR)

RQ-20 Puma (LRR)

Lethal Maneuver Aerial Munition System (LMAMS)

PM UAS

PM UAS

PM UAS

PEO Missiles & Space

Architecture Extensible to RAS ICD Systems

PD-100 / Soldier Borne Sensor (SBS)

IOP/JAUS

PEO Soldier

SMET

SPAWAR MOCU 3.0/4.0

OSD Unmanned Control Segment (UCS)

OSD Joint Communication Architecture for UxS (JCAUS)

Unmanned Systems Waveform/Common Robotic System (Communication Link) (CRS(CU))

Acronyms:
IOP: Robotics & Autonomous Systems, Ground (RAS-G) Interoperability Profile (IOP)
JAUS: Joint Architecture for Unmanned Systems (JAUS)
MOCU: Multi-Operator Control Unit

IOP/JAUS

IOP/JAUS

IOP/JAUS

IOP/JAUS

IOP/JAUS

Light Reconnaissance Robot (CRS(LR))

CRS(H)

MTRS Inc II

MTRS MK II

CRS(I)

CRS(I) Universal Controller CDD Language: 6.2.2 (U) KPP 6 - Unmanned System Control.
The CRS (I) OCU must have the ability to achieve and maintain active and/or passive control of any current Army and Marine Corps PoR battalion and below level Unmanned (Air or Ground) System (UxS) and/or their respective payloads in less than three (T), one (O) minute(s).

CRS(I) (including Universal Controller) currently in EMD Phase

All graphics are notional to convey the general size and type of system

Value of Commonality

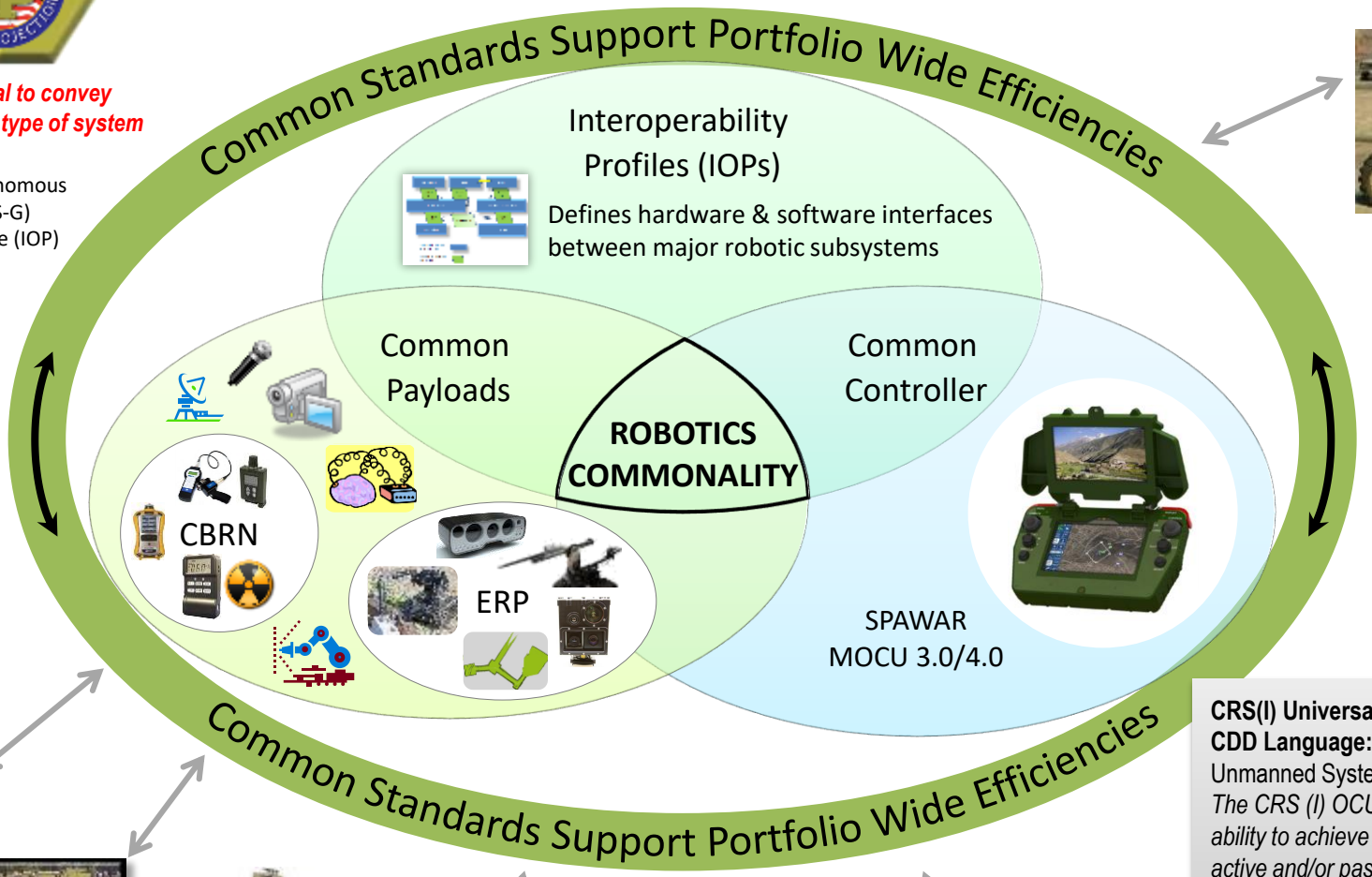
Graphics are notional to convey the general size and type of system

Acronyms:

IOP: Robotics & Autonomous Systems, Ground (RAS-G) Interoperability Profile (IOP)

JAUS: Joint Architecture for Unmanned Systems (JAUS)

MOCU: Multi-Operator Control Unit



Future Robots

CRS(H)

SMET

MTRS Inc II

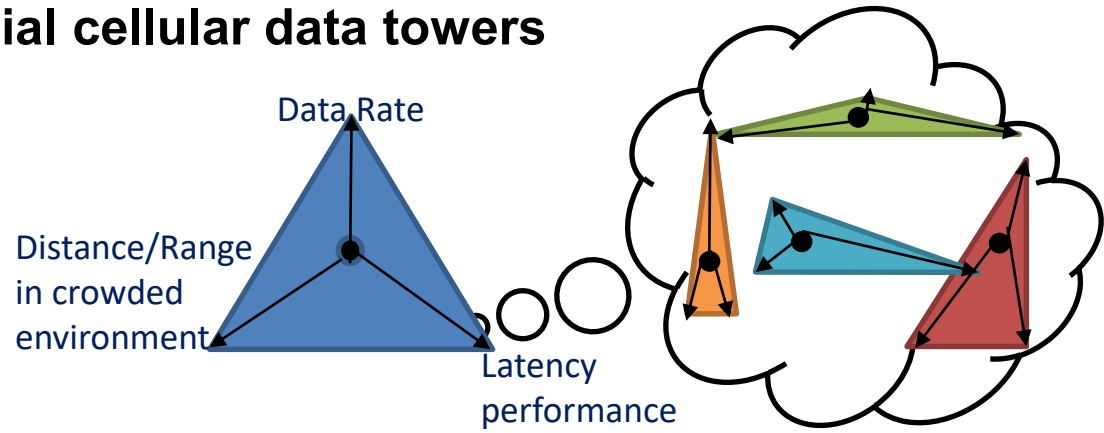
Talon 5a

CRS-I

CRS(I) Universal Controller CDD Language: 6.2.2 (U) KPP 6 - Unmanned System Control. *The CRS (I) OCU must have the ability to achieve and maintain active and/or passive control of any current Army and Marine Corps PoR battalion and below level Unmanned (Air or Ground) System (UxS) and/or their respective payloads in less than three (T), one (O) minute(s).*

Unique Wireless Comms Requirements

- **Data rate: > 2 Mbps**
  - Driven by streaming video requirements
    - Encoding, Resolution, Color Depth, Frame Rate, Multiple Simultaneous Streams
- **Ground-to-Ground LOS/NLOS Distance/Range of < 1km**
  - **Can't rely on commercial cellular data towers**
- **Latency < 250 ms**
- Resistant to Jamming
- Spectrum Agile
- Channel Selectable
- Low SWaP
  - Low power consumption for extended battery operation
  - Weight and size
- Compliant with latest version of RAS-G IOP
- Cybersecurity Hardened
- Low Detectability



Dexterous Manipulators / Specifying Manipulator Performance

- Robotic arms & manipulators (grippers, hands, etc) can be difficult to articulate requirements for

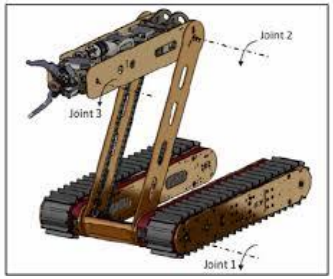




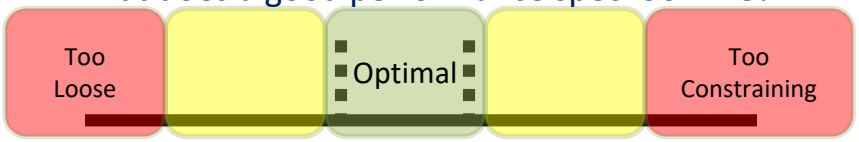
Images from Google search for "Public Domain _____"





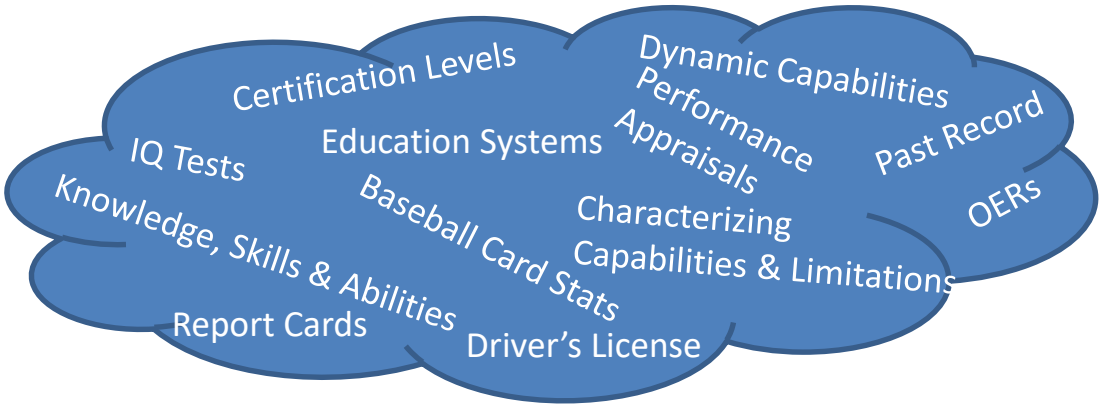


What does a good performance spec look like?



Managing a System w/ Uncertain Behavior

- How do you specify requirements for a system that will encounter new situations that may result in unexpected or unplanned for behavior?
- How do you test a system that will encounter new situations that may result in unexpected or unplanned for behavior?
- How do you specify requirements for a system that learns?
- How do you test & characterize a system that learns?



Potential Ground Robotics Applications for Maintenance & Sustainment

(Quick Brainstorm)

- Remote system operation
  - Nuclear contaminated facilities
  - Ship inspection, maintenance & repair
  - Bridge inspection
- Hard to reach access or delicate operations
  - Performing of (maintenance) tasks in close quarters (e.g., on ship))
  - Changing scale (i.e. miniaturizing surgical hands a la Da Vinci)
- Automated operation
  - Repetitive tasks – material integrity inspection
  - Painting, surface removal, etc.
  - Road repair?
- Sensors & intelligence
  - Machine vision: subtle pattern recognition for quality inspection
  - Predictive analytics for CBM+
- Sustainment Mission (Combat Support)
  - Construction equipment – forklifts, dozers, graders, airfield repair, etc.
  - Material handling equipment
  - Material resupply


PROJECT MANAGER
FORCE PROJECTION
PM SKOT
PD TMDE
EQUIPMENT
MEASUREMENT
DIAGNOSTIC
SUPPORT CENTER
GROUND VEHICLES

Discussion

Requirements & System Definition Cascade

Informed by mission, threat, etc.

Operational Baseline

Explosive Hazard Defeat ICD

CRS(H) CPD

Controlled by TRADOC

Informed by operational requirements, current state of technology, cost/availability of systems

Functional Baseline

System Level Performance Spec

CRS(H) Performance Spec

Allocated Performance Specs

Robotic Platform

Native Manipulator Arm

PTZ Cameras

Radio Relay

(Not defined by CRS(H) PoR)

Universal Controller (UC)

EOD Robotic Payloads (ERP)

Controlled by PM

Informed by performance spec requirements & allocations, designs, manufacturability, cost, IP

Product Baseline

(Example of what final product baseline could look like)

Chassis

Wheels/Tracks

10 DOF Arm

Gripper

Etc.

Cameras

Radios

Etc.

Autonomy Software

UC Hardware Shell

IOP Interfaces

MOCU 4

ERP Disruptor

Etc.

TDP or Product Build Specifications Owned by OEM

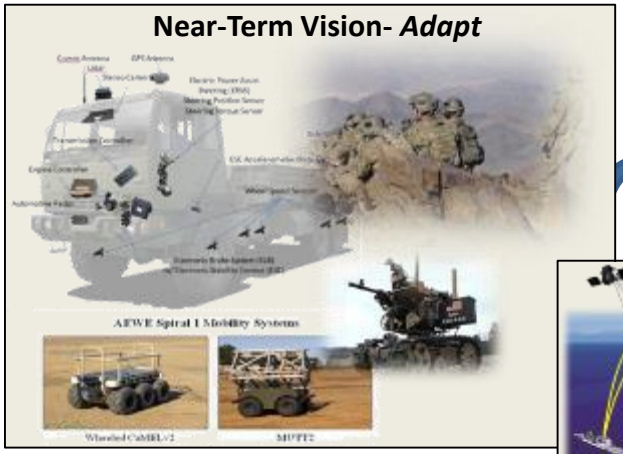
TDP or Product Build Specifications Owned by Third Party Manufacturer

TDP or Product Build Specifications Owned by Gov't

Framing the Army's Robotics and Autonomous Systems (RAS) Strategy

As the Army articulates RAS integration across multiple Warfighting Functions, this vision must also show ***realistic objectives*** in the **near-term**, ***feasible objectives*** in the **mid-term,** and ***visionary objectives*** for the **far-term.** Beginning with near-term objectives, each successive phase links its objectives to and builds from the achievements of the previous phase.

Near-Term Vision- *Adapt*



Near-Term Objectives:

- *Leader-Follower Convoy Technology Employment*
- *Lighten the Soldier load*
- *Enhance stand-off from threats and improve situational awareness*

Mid-Term Objectives:

- *Technologies improve the **autonomy** of unmanned systems*
- *Technologies will enable unmanned cargo delivery*
- *Robots act as "teammates" rather than tools*
- *Micro autonomous air and ground systems will also enhance Platoon, Squad, and Soldier situational awareness*

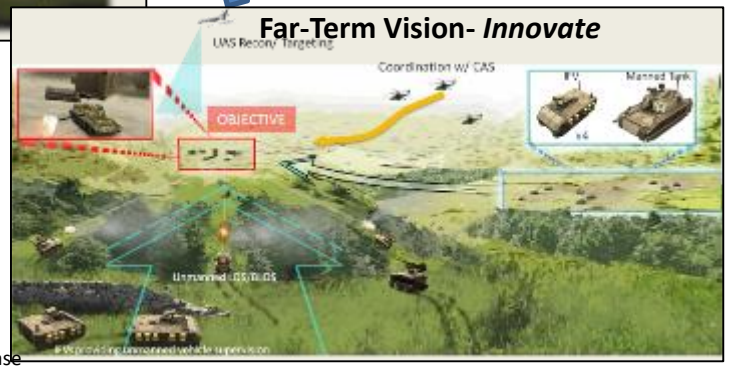
Mid-Term Vision (F2025)- *Evolve*

Source for All Listed Objectives: **TRADOC Pam 525-3-1, *Army Operating Concept*, Appendix C-2.**

Far-Term Objectives:

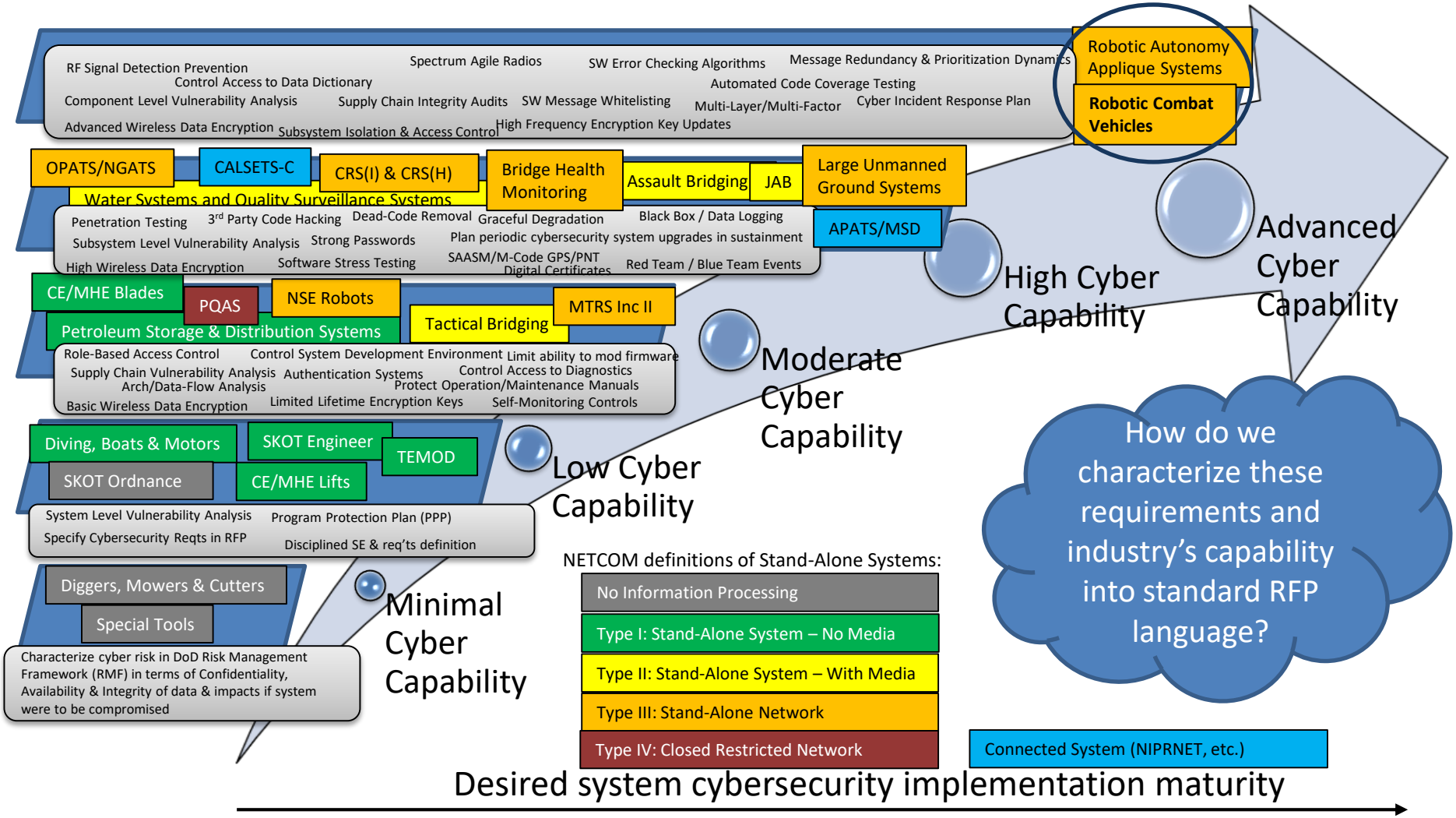
*Technologies will **enable manned and unmanned teaming in both air and ground maneuver** though investments in scalable sensors, scalable teaming, **Soldier-robot communication**, and shared understanding through advancements in machine learning.*

Far-Term Vision- *Innovate*



PM FP Cybersecurity Considerations

PM FP needs industry's help in defining this



Note: Color coded programs above are unofficial PM office anticipated classifications

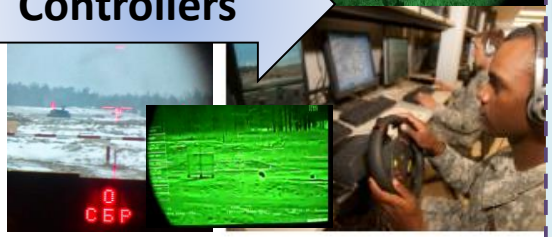
Robotic Combat Vehicle Interoperability

Is this the answer?

C4ISR/EW Systems

Platforms

Controllers



VICTORY

VICTORY

ROS-M

ROS-M

ROS-M

IOP

IOP

VIS

Asset Controller

UxS Control Segment (UCS) w/ DDS

Graphical Layer / UI

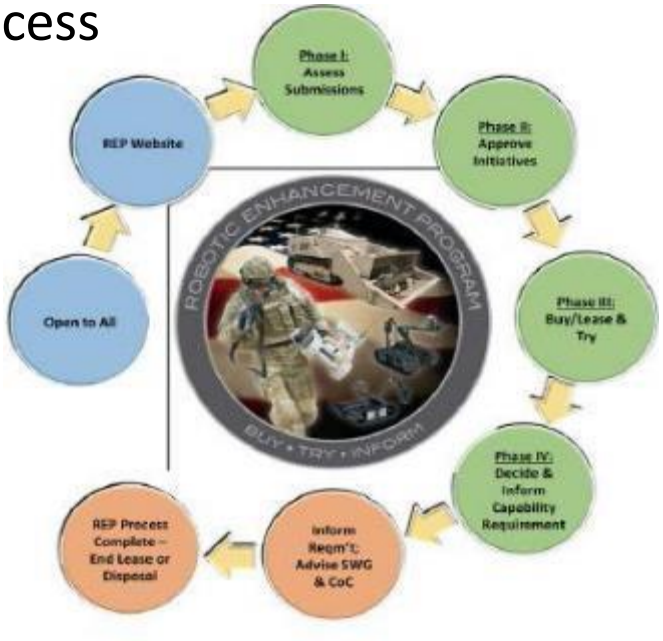
Graphical Layer / UI

MOCU

WMI

Robotic Enhancement Program (REP)

- "Buy/lease, try and inform" - evaluate state-of-the-art robotic systems and/or payloads that are Government-Off-The-Shelf (GOTS), Commercial-Off-The-Shelf (COTS) and Non-Developmental Items (NDI) to inform the requirement and acquisition process
- Status:
  - REP Cycle 16.1 – 18.1
    - Proposals submitted: 186
    - Proposals Selected: 50
  - REP Cycle 18.2
    - Additional proposals submitted: 43
    - CoC occurred on 21 March 2018.
    - 5 proposed initiatives approved.



REP Cycle 19.1 proposal submission windows closes 1 MAY 2018.

REP Submission Site: http://www.peocscss.army.mil/rep.html

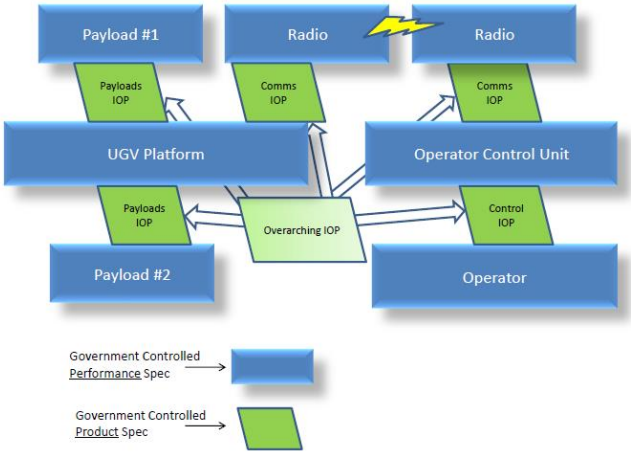
Army Unmanned Ground Systems Design Philosophy

- While the exact composition of the Army's future RAS portfolio of systems remains volatile, there are several intended design philosophies that stakeholders can plan to – regardless of exact requirements.

1. Modular Open Systems Approach thru IOP
2. Common Mobility Platforms & Varying Mission Payloads
3. Design for Growth & Technology Evolution
4. Limit Unnecessary Redundancy
5. Materiel Development Preference (GOTS>COTS>NDI>Developmental Item)
6. Utilize Modular "Kits" Where Appropriate
7. Provide Intelligent Behavior to Existing Systems
8. Take Advantage of Intelligent Systems (i.e., CBM+)
9. Warfighter Centric Design

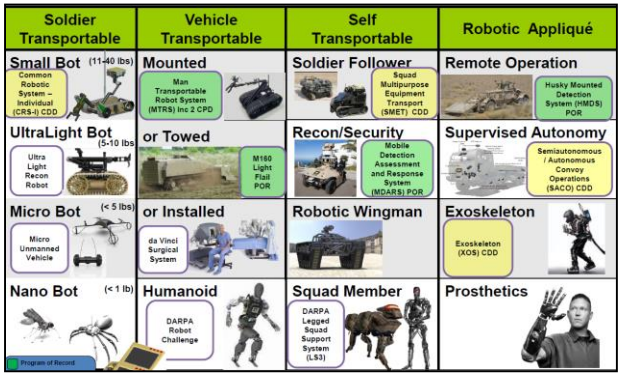
#1: Modular Open-Systems Approach (MOSA)

- The fundamental guiding design philosophy for RS JPO's future portfolio is the MOSA architecture.
- Amid evolving requirements, changing threats, evolving technology, and obsolescence risks, modularity will position the PM for managing these trends at minimal lifecycle cost.
- MOSA will be achieved through interface control using the RAS-G IOPs.



#2: Common Mobility Platforms & Varying Mission Payloads

- Enabled by the MOSA philosophy, the other basic tenet of the Army's future robotics portfolio design is to utilize a small number of common mobility platforms, which can accept a variety of mission payloads to perform a variety of different missions for a variety of different user groups.
- The 4 major envisioned classes of common mobility platforms are:
  - Soldier Transportable
  - Vehicle Transportable
  - Self-Transportable
  - Appliqué.



- To achieve this vision, the PM will continue to work with Combat Developers to lay the foundation for a sustainable Family of Systems (FoS) with common platforms for major robotics classes.

#3: Design for Growth & Technology Evolution

- Again based upon the MOSA priority, the Army's future fleet of robotic systems will be designed for growth & technology improvement.
- Size, Weight and Power (SWAP) margins, as well as additional payload interfaces, will be designed into appropriate systems to enable growth.
- As the technological improvement of sensors, manipulators, computing devices, radios, and other devices continues to accelerate, the design for evolution will be central to the Army's future robotics programs.

#4: Limit Unnecessary Redundancy

- Peripherally related to modularity and interface management, the Army intends to optimize its future robotics systems by limiting unnecessary redundancy.
- What this means is that the system will be capable of communicating across its internal boundaries in order to smartly leverage all information available.
- Achieving this design philosophy entails utilizing well defined data representations and more importantly, conducting rigorous systems engineering to optimize system level performance.

For example, a mobility platform may include a GPS receiver on it. When this is the case, it becomes unnecessary for any of the other payloads on the system to include their own GPS receiver (unless the requirements for precision are different). Instead, those payloads would simply pull the GPS information from the platform. Similarly, a sensor collecting valuable information can make that information available to other elements of the system to optimize overall behavior.

#5: Materiel Development Preference

- As the Army acquires systems to comprise its future portfolio, it will consider an order of precedence as to the materiel acquisition model of choice. This general rule of thumb provides a model for how the PM will acquire systems:
  - The 1st tier of preference is to utilize Government-Off-the-Shelf (GOTS) systems to meet unmanned requirements.
  - The 2nd tier of preference is to utilize a Commercial-Off-the-Shelf (COTS) approach and procure mature end-items.
  - The 3rd tier of preference is to acquire Non-Developmental Items (NDI) – this means taking mature systems from industry and conducting some minor non-recurring engineering (NRE) in order to meet all requirements.
  - The 4th tier of preference is to acquire Developmental Items (DI) – this means developing systems from the conceptual level and conducting rigorous systems engineering to transform general concepts into a sustainable, affordable product.

#6: Utilize Modular "Kits" Where Appropriate

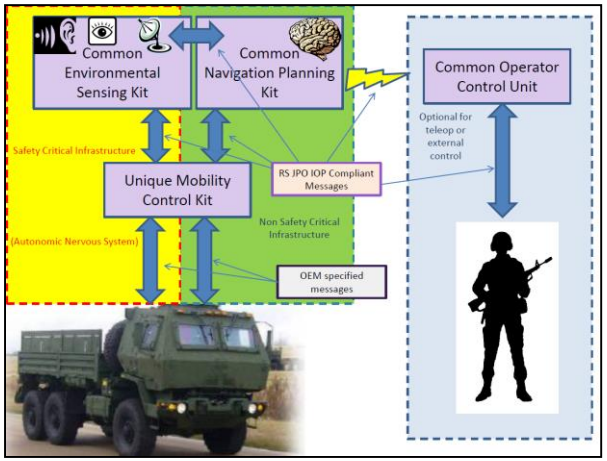
- In many cases it will be advantageous to separate certain system functions into different "kits".
- If a certain function can be made common across varying systems, it makes sense for that function to be managed as a common kit.
- Similarly, when the technology pace or obsolescence rate for certain subsystems are anticipated to move at a significantly different pace from other parts of the system, it makes sense for them to be managed as kits.

The most obvious planned use for this kitted approach is in appliqué kits for converting existing manned systems into unmanned or assistive-driving systems. For these systems, it makes sense to separate functions into an "A-Kit" that provides common autonomous navigation services or other unmanned technologies, and a "B-Kit" that provides the interface to a specific vehicle. In these cases, the "A-Kit" could be a common autonomous perception/navigation kit for use on many different platforms, while the "B-Kit" would be a unique drive-by-wire kit. It may also be of use on these types of systems to include a "C-Kit" that provides mission-specific payload packages. Methods such as axiomatic design may be of use for determining which functions could optimally be "decoupled" from each other through the use of kitted separation.

#7: Provide Intelligent Behavior to Existing Systems

- As a means for leveraging previous investment and infrastructure, the Army adopts a philosophy for giving preference to systems that can augment existing DoD inventory to exploit unmanned technology, instead of solely pursuing ground-up new system developments.
- This will avoid redundancy and introduce unmanned technology gradually into the DoD fleet.
- The appliqué kit approach described previously provides an example of this preference.

Two of PM FP's current programs (the RCIS and the HMDS) have already adopted this approach, and emerging programs (such as that of the Autonomous Convoy Operations (ACO) emerging requirement) will also adopt this approach.



#8: Take Advantage of Intelligent Systems

- The nature of unmanned technology (particularly with built-in modularity) includes a variety of data and software-enabled data processing on systems.
- The Army's design philosophy is that this data and data processing should be exploited (within reasonable cost, SWAP & requirements basis) to enable additional valuable capabilities.

A perfect example of a capability that is enabled through the exploitation of data and data processing on unmanned systems is that of Condition Based Maintenance Plus (CBM+). The same data being used to provide intelligent mobility, sub-system monitoring, etc. can be readily used for improving system diagnostics and enabling prognostics and smarter maintenance planning/responsiveness. It should be noted that while there are DoD sub-communities advocating the ground systems adoption of CBM+ and other DoD sub-communities advocating the ground systems adoption of unmanned systems, the same technology can often be used to provide both capabilities.

#9: Warfighter Centric Design

- Similar to the Occupant-Centric Protection (OCP) design philosophy that the DoD manned ground systems community has been moving toward, PM FP adopts a Warfighter-Centric philosophy that seeks to:
  - 1) provide maximum protection by removing the Warfighter from direct physical danger, and
  - 2) minimize the cognitive workload of the Warfighter in stressful situations and free up the human talents for more creative and critical-thinking tasks that demand focused attention