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"What is The Correct Level of Autonomy?"

NDIA Ground Robotics Capabilities Conference & Exhibition

Arlington, VA
April 8, 2015

Panel Members

- Moderated by: Mr. Thomas Gonzalez, Senior Vice President, Stratom, Inc.
- LTC Matt Dooley, USA, Chief, Lethality Branch, Training and Doctrine Command, Army Capabilities Integration Center
- Mr. Jim Parker, Associate Director for Ground Vehicle Robotics, Army Tank Automotive Research, Development and Engineering Center (TARDEC)
- LTC Joe Bell, USA (Ret), President, Acquisition Technologies Integrated, Inc.
- Dr. Todd Danko, Lead Robotics Research Scientist, Lockheed Martin Advanced Technology Laboratories
- LtCol Hank Lutz, USMC, Ground Systems Lead, JRAST Joint Staff, J8 Force Application

Ground Rules

Enjoy and please hold all your questions until the end!

Autonomy in Joint Operations

LtCol Hank Lutz, USMC

Ground Domain Lead

Joint Staff Robotic and Autonomous Systems Team (JRAST)

Autonomy vs. Automation

- **Autonomy: the level of independence that humans grant a system to execute a given task in a given environment**
  - **The condition or quality being self-governing to achieve its assigned mission based on the system's own situational awareness (integrated sensing, perceiving, analyzing) planning and decision-making**
  - **Autonomy is not an end state; it is a point on a spectrum that can be tailored to the specific mission, level of risk, and degree of human-machine teaming**

- **Automation: a system functions with no/little human operator involvement; system performance is limited to the specific actions it has been designed/programmed to do**
  - **Well-defined tasks that have predetermined responses**
  - **No ability to adapt or learn from unanticipated inputs**

Autonomy in Warfare

- Autonomy in weapon systems does not change the nature of war
- Autonomous weapon systems may change risk calculations for going to war; increasing the likelihood of kinetic operations
- Autonomy may allow operations in complex, contested environments that currently exceed human performance limits
- Autonomy may decrease risk to humans in certain mission areas and expand mission options
  - Free humans to perform other tasks
  - Increase amount of data/information humans can manage/ process
- The level of autonomy for a given system will not be based solely on technology available (mission, risk, available forces, etc.)

How do humans apply autonomy in systems for the conduct of military operations?

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Leader-Follower (LF) Technology for Convoy Operations

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Support Starts Here!

Problem

- TWVs are at maximum protection level due to weight without sacrificing payload and mobility capabilities.
- Truck units have lost significant throughput capability due to manning CPPs.
- US spends hundreds of millions of dollars to build better armored TWVs, while the enemy spends hundreds of dollars to design better explosives.

Proposed Solution and Benefits

- Develop Leader-Follower kits for the heavy and possibly medium truck fleets
- Benefits:
  - Provides Risk Reduction/Force Protection – reduces # of manned targets to the enemy
  - Allows manning of Convoy Protection Platforms with unit personnel without reducing task vehicles
  - Fully resources convoy requirements, which we have not been able to do organically
  - Possibly return the cargo vehicles to the unit
  - High potential to Increases cargo throughput capability by:
    - Enabling 24 hr operations
    - Enabling more cargo trucks per convoy
  - Potential for significant cost savings
    - Converts non-armor capable trucks to combat-ready unmanned trucks
    - Cheaper than complete armor package

Leader-Follower Description

Leader-Follower capability is a kit appliquéd to TWVs. It is a single robotic mode of driving 4-8 trucks with only two soldiers. This is accomplished by electronically linking a Soldier driven ‘Leader’ vehicle with 3-7 unmanned ‘Follower’ vehicles*. It is to be used through ***combat/high threat*** areas.

(*Leader Follower concept demonstrated in AMAS JCTD. Follower vehicles have several methods of tracking the leader, which provides redundant tracking solutions.)

Leader-Follower Performance Metrics (condensed)

- (APA #1) System should have at least **four modes**: “off”, “manual drive”, “leader”, and “follower”
- (APA #2) A Leader-Follower **serial will contain one leader and three to seven follower vehicles**
- (APA #3) Follower vehicles should follow the **Leader** vehicle within 9” from point on ground
- (APA #4) The Leader and Follower vehicles shall be able to **operate with and without trailers**
- (APA #5) The convoy commander shall be able to establish a **set or variable gap** of 10 to 150 meters between trucks at speeds 3 – 55MPH
- (APA #6) The system shall **avoid static and dynamic obstacles** and then reestablish gap spacing
- (APA #7) The system shall have an **operator take-over capability**
- (APA #8) The Leader-Follower Operational Mode Summary/Mission Profile (OMS/MP) is the same as the PLS’s OMS/MP to include **operating in a GPS-denied area**
- (APA #9) The leader/follower system must not be affected by or hinder its self defense systems
- (APA #10) The system shall have noise and light discipline (BO drive) equal to or less than the PLS
- (APA #11) The system shall not present a threat to the various cargo or supplies the vehicle may carry
- (APA #12) The reliability of the system shall not be less than **15,000 mean miles between system abort** and available 90% or more, with a mean time-to-repair in the field at 20 minutes
- (APA #13) The design of the system should be **interoperable with other systems** and modular to facilitate repairs, upgrades, and improvements
- (APA #14) Automated and non-automated portions of the system’s **PMCS** checks must add **no more than 10 minutes** to the normal PMCS routine
- (APA #15) Follower vehicles should conduct **a safe and controlled stop** when communications with the leader is lost
- (APA #16) The systems should be compatible with and powered by the host’s electrical system, **not to exceed 25 amps**
- (APA #17) The Leader vehicle shall be able to **assembly the convoy** before movement
- (APA #18) A **convoy C2 device** should be provided at a ratio of not less than one per four kits
- (APA **#**19) The system shall not impact the vehicle’s **shipping dimensions** and not interfere with tie-down devices
- (APA #20) The system shall have safety features to include a **collision warning and adaptive cruise control**

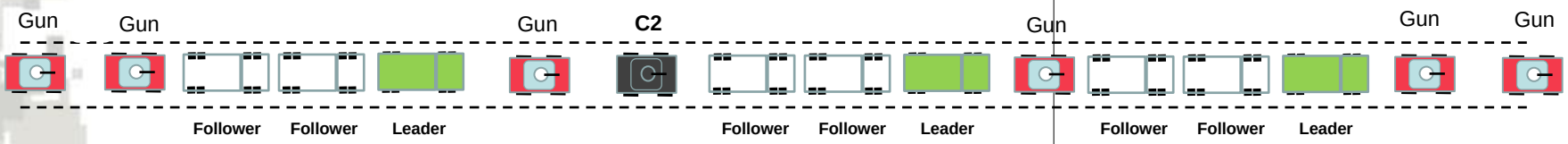
LF CONOPS

- LF is a Force Protection capability and a Combat Sustainment multiplier
- PLS Unit missions remain unchanged
- Used only in combat environments
- Employed ***between*** origin and destination; Civilian traffic not in close proximity
- Manned Leader vehicles followed by unmanned Follower vehicles, a 1:3 ratio of manned to unmanned vehicles
- TTPs similar to manned convoys, except for actions upon enemy contact, halting, and arrival
- During CONVOY Ops, Follower vehicles' crews operate Convoy Protection Platforms (aka, Gun Trucks) and other vehicles/duties
- No change in vehicle's Operational Mode Summary/Mission Profile (OMS/MP)

LF CONOPS - Damaged *'Follower'* Vehicle

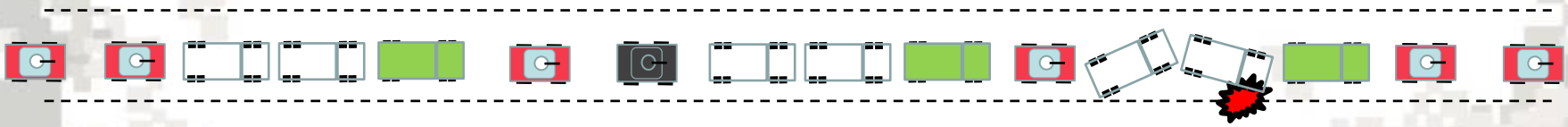
1:2 LF Ratio

Legend:
Gun Truck C2 vehicle Follower Truck Leader Truck



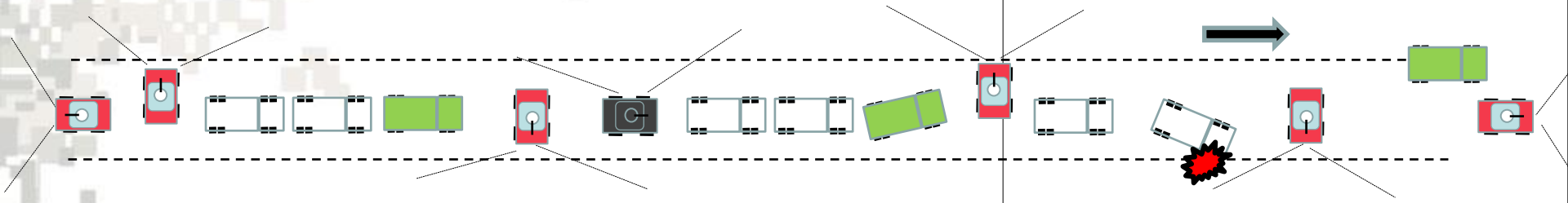
- Convoy consists of one C2 vehicle, 6 gun trucks, 9 cargo trucks, and 27 personnel. (3 people per gun truck and C2 vehicle, 2 people per Leader cargo vehicle)

- Convoy arrangement is a gun truck on point, a gun truck leading 1st serial of 3 LF cargo trucks. This serial is trailed by another gun truck with a LF three vehicle serial. The C2 vehicle is next, and another gun truck with a LF three vehicle serial. The last serial is trailed by two gun trucks.

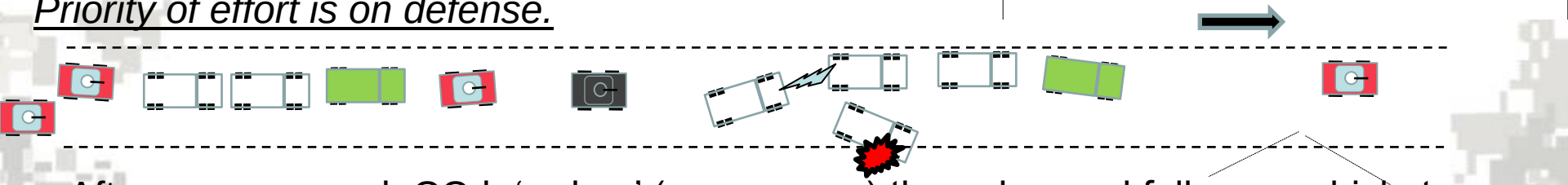


- Convoy proceeds down road, an IED detonates in front of 1st follower vehicle.

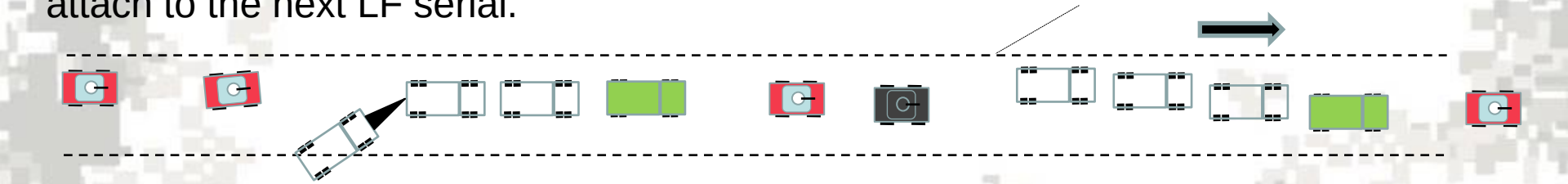
LF CONOPS - Damaged *'Follower'* Vehicle



• 1st follower is damaged, 2d follower loses signal and quickly stops, awaits 'orders'. Vehicle beyond blast moves forward out of danger zone with lead gun truck. Vehicles behind blast stop, gun trucks assume defensive perimeter. All manned vehicles report, Cdr acknowledges an unmanned follower vehicle damaged. *No aid/rescue required. Priority of effort is on defense.*



• After area secured, CCdr 'orders' (reprograms) the unharmed follower vehicle to attach to the next LF serial.



• Dismounts secure the damaged follower vehicle, attach tow bar, remount, vehicle is towed by last follower truck.

Summary

✓ The Leader-Follower is a single robotic mode that provides a risk reduction/force protection capability to our soldiers.

✓ It is also a sustainment multiplier, capable of returning lost throughput to distribution units.

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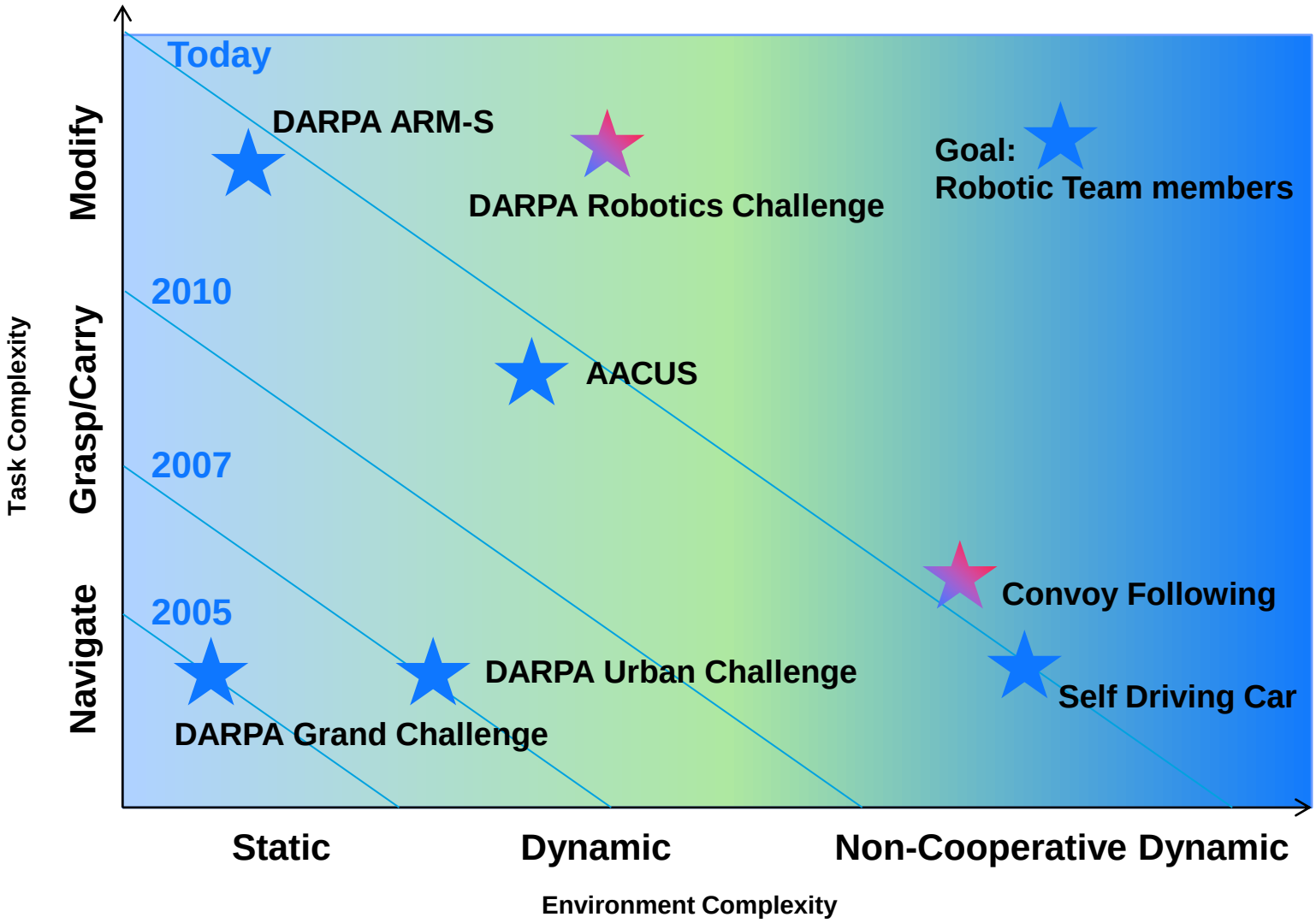
LOCKHEED MARTIN

Todd Danko, PhD
Lead Robotics Research Scientist

Robot Mission Complexity



Frontier of Autonomy is Limited by Overall Mission Complexity

Human-Guided Autonomy

- Current autonomy approaches are brittle in uncertain environments
  - What is around it (situation)
  - What to do (goals and actions)
- Teleoperation nearly impossible for high-DOF systems & fails under low bandwidth or high latency communications

Human	Human-Robot Collaboration	Robot
Semantic Understanding of Environment	Build Shared World Model	Sensor Data and Scene Segmentation
Intuitive Knowledge About What to Do	Make Decisions and Plan Actions	Real-time Actions

Weighing the Costs and Benefits of Autonomous Systems for Force 2025

LTC Dooley

Lethality and Robotics Branch Chief

MASD, ARCIC

8 April 2015

US Army Strategy for Remote and Autonomous Systems (RAS) Purpose

RAS capabilities must provide forces capable of *expeditionary maneuver* that can:

-see and fight across extended distances

-operate widely dispersed while maintaining mutual support

-make contact with the enemy under favorable conditions

--sustain high tempo operations at the end of extended and contested lines of communication

--establish and maintain security across wide areas

--pose enemy forces with multiple dilemmas while reducing risk to Soldiers and units.

Ensure limited DoD investment delivers maximum return for the Warfighter

Compelling Argument

- Development of Remote and Autonomous Systems (RAS) are vital to the Army.
  - Potential for advantage and overmatch*
  - Use of RAS over the last 15 years has saved lives (EOD UGS) and enhanced situational awareness and precision strike capability (UAS, LMAMS)
  - Potential exists to do more as technology rapidly matures (lightweight Soldier Borne Sensors and autonomous convoy capabilities)
  - Emerging threats and technology aggressively seek to exploit this emerging technology
  - Underinvestment (means driving ends) will put the U.S. at a disadvantage by 2025

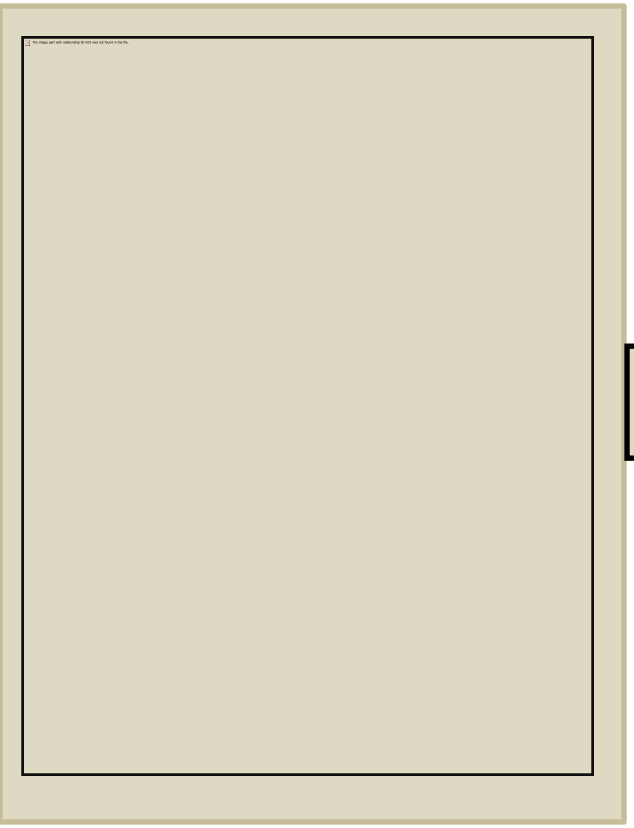
ENDS

Army ground forces are capable of expeditionary maneuver* and joint combined arms* operations. RAS will provide Army formations with an appropriate combination of situational understanding, mobility, protection, lethality, and flexible sustainment to overmatch current and future threats across the range of operations.

- **Ways:** Integrated approach to Innovate, Develop, Improve, Assess, Sustain
- **Means:**

  - Innovate and exploit emerging autonomy technology to enable **RAS as full team members** – not just tele-operated tools- for the Soldier operating at the point of contact
  - Develop autonomous convoy capabilities to displace Soldiers from the cabs of trucks
  - Develop systems for the Soldier that lighten both the physical and cognitive burden
  - Assess in experimentation and research

Supporting Army TRADOC Documents



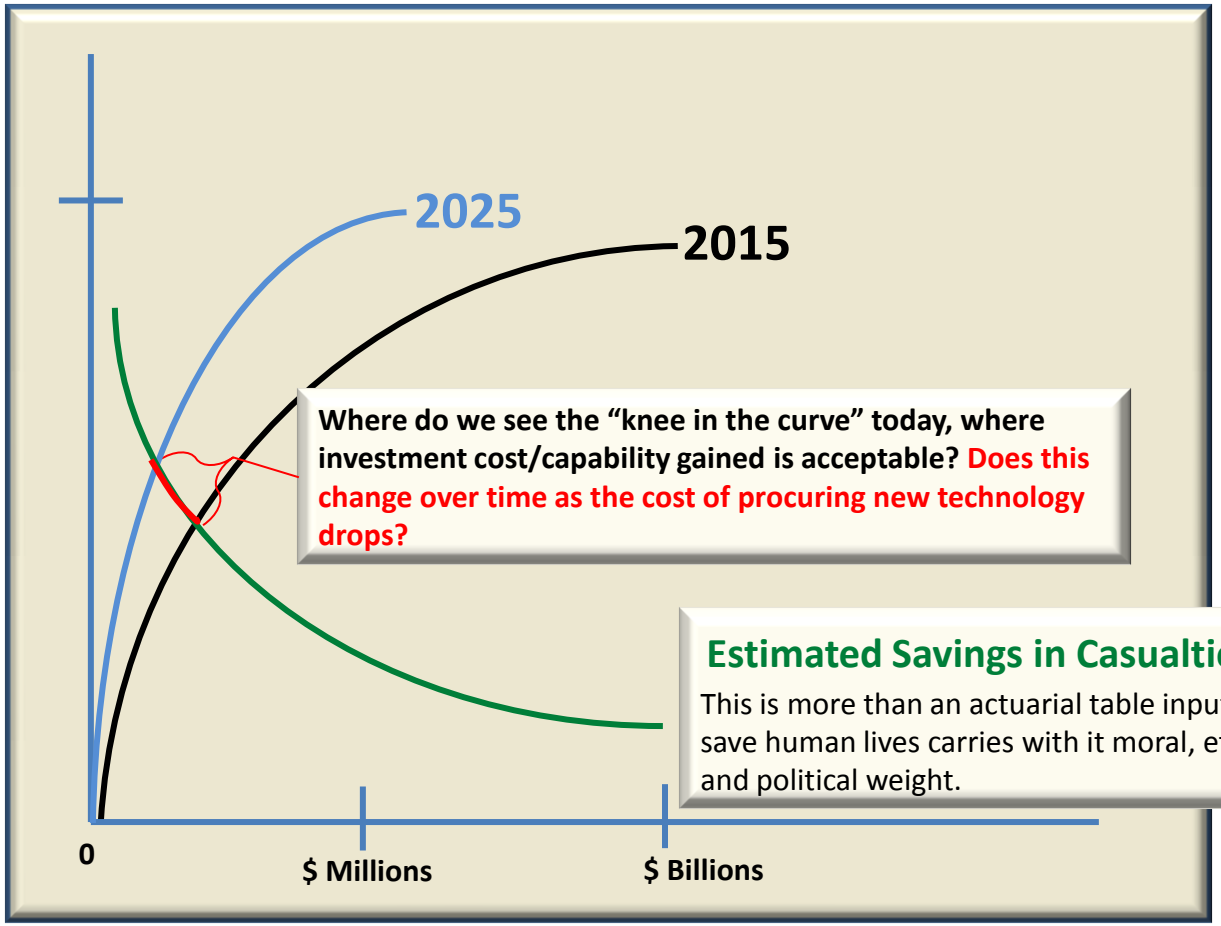
TRADOC Pam 525-3-1, Appendix C-2.
'Army science and technology investment areas'

"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.

Technologies will exist to improve the **autonomy** of unmanned systems. These technologies will enable unmanned cargo delivery via air and enable robots to be a part of the squad to reduce and lighten Soldier loads.

Investments in micro autonomous air and ground systems will also enhance platoon, squad, and Soldier situational awareness."

Risk in Seeking an 'Affordable' Revolution in RAS
What Price Humans vs Machines?



Why Remote and Autonomous Systems?

Opportunity: Autonomy-enabled systems are the next 'revolutionary capability' for Force 2025 and beyond. The Army envisions a future operational concept where autonomy-enabled formations augment the Warfighter as team members- not just tools. These RAS capabilities will provide significant advantages over adversaries permitting the U.S. Army to win in a complex world.

RAS System's Task	*Purpose*
• Gain & maintain contact	• Allow manned forces to maneuver out of contact and exploit known enemy positions
• Conduct logistical resupply	• Frees soldiers for mission critical tasks
• Conduct initial entry	• Set conditions for manned forced entry
• Conduct persistent screening operations	• Enable smaller manned expeditionary force advantage
• Conduct deception ops	• Present multiple dilemmas to the enemy and enhance manned freedom of maneuver
• Conduct persistent surveillance	• Enhance security for manned units, and increase the depth of knowledge of the enemy
• Conduct land operations in a tactical CBRN environment	• Mitigate risk and allow freedom of maneuver to manned forces

RAS/ Unmanned systems help set conditions. Manned systems and Soldiers exploit and consolidate the gains of unmanned systems