Trailblazers of Unmanned Ground Vehicles

Defense Threat Reduction Agency and Marine Corps Warfighting Lab

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We need to change where it makes sense, adapt as quickly as possible, and constantly innovate to stay ahead of our adversaries. Our ability to adapt more quickly than our enemies will be vital to our future success.

—Gen. Robert Neller,
Commandant of the Marine Corps

Necessity is the Mother of Innovation

The Canadian Corps' victory at the Battle of Vimy Ridge on 12 April 1917 was, at that point, the largest territorial advance of any Commonwealth force during World War I. The Canadian forces' success was due to the confluence of a new form of artillery tactics called "creeping barrage" and the proliferation of the wristwatch. The Battle of Vimy Ridge illustrated how an existing and innocuous technology such as the wristwatch coupled with changes in tactics created overmatch and subsequent dominance against German forces (see the sidebar on page 61). Fast forward 102 years and several wars—tactical innovations within the U.S. military need to adapt and overmatch adversaries at a rate inconceivable in 1917. To accomplish this, adaptability

requires ingenuity, partnership, collaboration, and exploitation of existing technology.

A brief examination of the U.S. military's twenty-first-century medium-weight unmanned ground vehicle (MUGV) and the eight years of collaborative efforts amongst Department of Defense (DOD) and industry partners illustrates how eight years of collaboration allowed nontraditional industry partners to develop innovative solutions to wicked problems (see figure 1, page 63).[1] This article also highlights opportunities for the Army's maneuver support formations to capitalize on other DOD research, development, test, and evaluation (RDT&E) to inform both the fielded force concepts and the future force concepts.[2]

The first military MUGV, the Gladiator Tactical Unmanned Ground Vehicle, made its debut in 2004 as a teleoperated unmanned ground vehicle (UGV) with the primary focus to support dismounted marines across a range of military operations.[3] Six years later, and after observing lessons learned from the Army's MUGV acquisition endeavor with the Future Combat System, the DOD UGV community of interest was ready to showcase its latest MUGV: the Ground Unmanned Support Surrogate (GUSS). GUSS was an optionally manned platform consisting of a commercially available Polaris chassis and existing government-owned architecture.[4] The application for GUSS was simple: to assist marines on the battlefield. From 2011 to 2016, the U.S. military made numerous incremental improvements to its MUGV portfolio, sometimes at pace with commercial industries and at other times dabbling in the world of science fiction. While GUSS and its successors were suitable prototypes for the current operating environment, they did not address the changing character of war nor how to fight a war. The U.S. Army's latest operating concept, *The U.S. Army in Multi-Domain Operations 2028*, provides a framework for how the Army intends to *compete*, *defeat*, and *win* in the future operating environment.[5] Before delving into the DOD's most recent MUGV collaboration, it is necessary to briefly describe what robotic governance exists within the DOD during the twentieth century.

A U.S. Army Pacific soldier walks down a trail 22 July 2016 while controlling an unmanned vehicle as part of the Pacific Manned Unmanned–Initiative at Marine Corps Training Area Bellows, Hawaii. (Photo by Staff Sgt. Christopher Hubenthal, U.S. Air Force)

Consortium of Innovation

The goal of the DOD Joint Robotics Program (JRP) was to increase the focus of robotics on operational requirements while enabling an interservice coordination and governance forum. After twenty-five years as a directly funded program, the JRP ended in 2013 but not before the majority of its projects became either a system of systems or a stand-alone project within other DOD programs. Despite the end of JRP, new MUGVs from the Marine Corps Warfighting Laboratory (MCWL) and the Defense Threat Reduction Agency (DTRA)—the combat support agency of the DOD—J9-CXW Weapons and Capabilities Division (DTRA/CXW)—as well as an unlikely partnership with a high performance race car company, emerged in 2014. MCWL's MUGV, called Expeditionary Modular Autonomous Vehicle, and DTRA/CXW's Modular Autonomous Counter Weapons of Mass Destruction System Increment A (MACS-A) are multiyear projects that leverage organizational investments in autonomy, platform

Tactical Innovation

Timepieces and Artillery

Up until the start of World War I, timepieces were not only a display of wealth but also gender classification—women wore wristwatches and men used pocket watches. The evolution of the pocket watch began in the late nineteenth century as a practical, tactical tool worn by officers to synchronize movement and maneuver. Halfway through World War I, traditional tactics to defeat trench warfare plateaued significantly and the Allied forces needed a new method of bombardment to regain momentum. Traditional bombardment, a standard barrage, was predictable but not effective against German bunkers, and provided German forces ample time to return to their defensive lines before Allied forces reached the front lines. A "creeping barrage" provided a defensive screen for the advancing infantry. However, it required meticulous planning and numerous rehearsals to execute synchronization between infantry and artillery.

Soldiers with 1st Battalion, 87th Infantry Regiment, 1st Brigade Combat Team, 10th Mountain Division, prepare to enter a mock insurgent-held structure with the aid of a 310 Small Unmanned Ground Vehicle piloted by another soldier 15 November 2018 at Fort Drum, New York. (Photo by Staff Sgt. James Avery, U.S. Army)

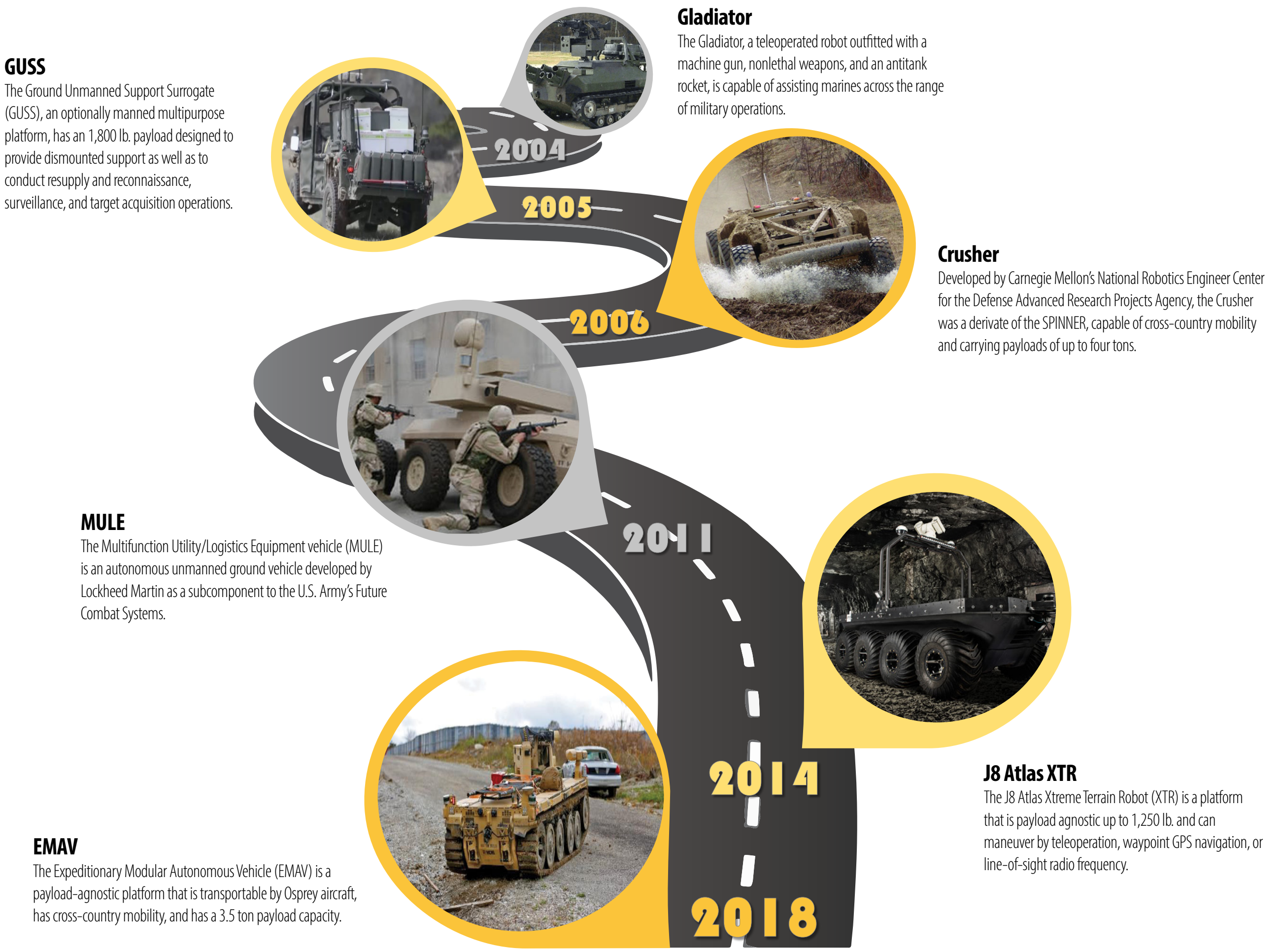
development, and system integration of payloads for interoperable autonomous platforms. The year 2013 also marked an inflection point where commercial development in robotic and autonomous systems (RAS) influenced, if not surpassed, military MUGV technology. Diffusion of RAS technology became the catalyst for Pratt & Miller Engineering's partnership with TORC Robotics, MCWL, and DTRA/CXW and the creation of the Pratt & Miller Engineering Defense Division.[6]

Solution Agonistic Requirements

We're finding we can be quicker by working with industry and being a little less prescriptive in finding what type of technology is available, and opening up to … nontraditional industry partners as we go forward by providing them a problem statement.

—Gen. James McConville, Army Vice Chief of Staff[7]

In an attempt to deliver a nonprescriptive materiel solution, DTRA analyzed various operating environments where potential customers' missions could benefit from capabilities within its MACS-A program.[8] DTRA's iterative solution agnostics approach and partnership with MCWL shortened the RDT&E timeline. The MCWL's leveraging of the U.S. Navy's set-based design concept to flesh out requirements that would generate materiel and nonmateriel solutions for the future operating environment was critical to this collaborative effort. The set-based design not only produced tangible outcomes but also assisted decision-makers with making trade-offs relative to future capabilities. The application of set-based design methodology is important to the U.S. Marine Corps because its budget is 16 percent of the average of all three services combined. A prime example of converting an idea (littoral operations in a contested environment) into a usable product is the transformation of the Navy's USS *San Antonio* (LPD-17) into an LX(R)-class amphibious warfare ship.[9] Set-based design allowed both the U.S. Marine Corps and the Navy to understand not only what the cost was in dollars but also the tradeoff cost vis-à-vis capabilities—such as how many square feet of vehicle storage to forgo in order to obtain another two to four knots of speed. Understanding these trade-offs led to the design of MCWL's Expeditionary Modular Autonomous Vehicle. Together, all partners used an



(Figure by author)

Figure 1. Timeline of the U.S. Military's Twenty-First-Century Medium-Weight Unmanned Ground Vehicle

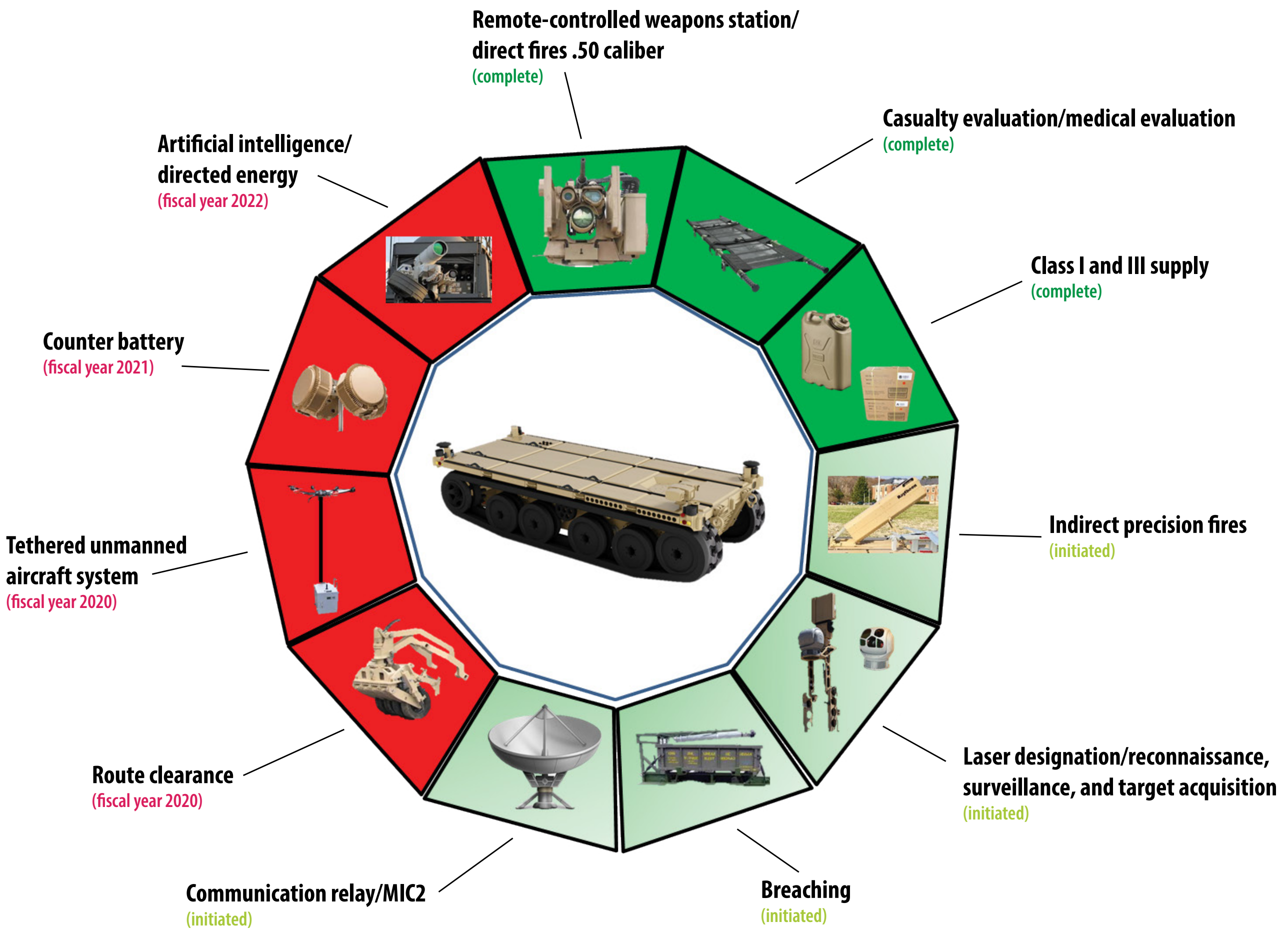
existing government-owned architecture to create a platform that was payload agnostic, reusable, agile, lethal, and autonomous (see figure 2, page 64).

Envisioning Future Maneuver Support Formations

No one starts a war—or rather, no one in his senses ought to do so—without first being clear in his mind what he intends to achieve by that war and how he intends to conduct it.

—Carl von Clausewitz[10]

The physics of warfare require Army formations to support maneuver forces. Whether those formations are a platoon of MUGVs or manned formations, the employment of RAS will be part of the calculus as the commander decides how to manage risk. The capability of a commander to employ manned-unmanned teams (MUMTs) exemplifies the disruptive innovation that garners more emphasis within boutique Army formations, specifically maneuver support forces. (Not because of burgeoning and trending phases such as robotic integration of artificial intelligence or the need for U.S. military forces to establish convergence across all domains but because of the principles behind multi-domain operations [MDO] and the Army military strategy.) Adhering to MDO and Army military strategy principles of increased lethality, increased readiness, doctrine, and tactics,



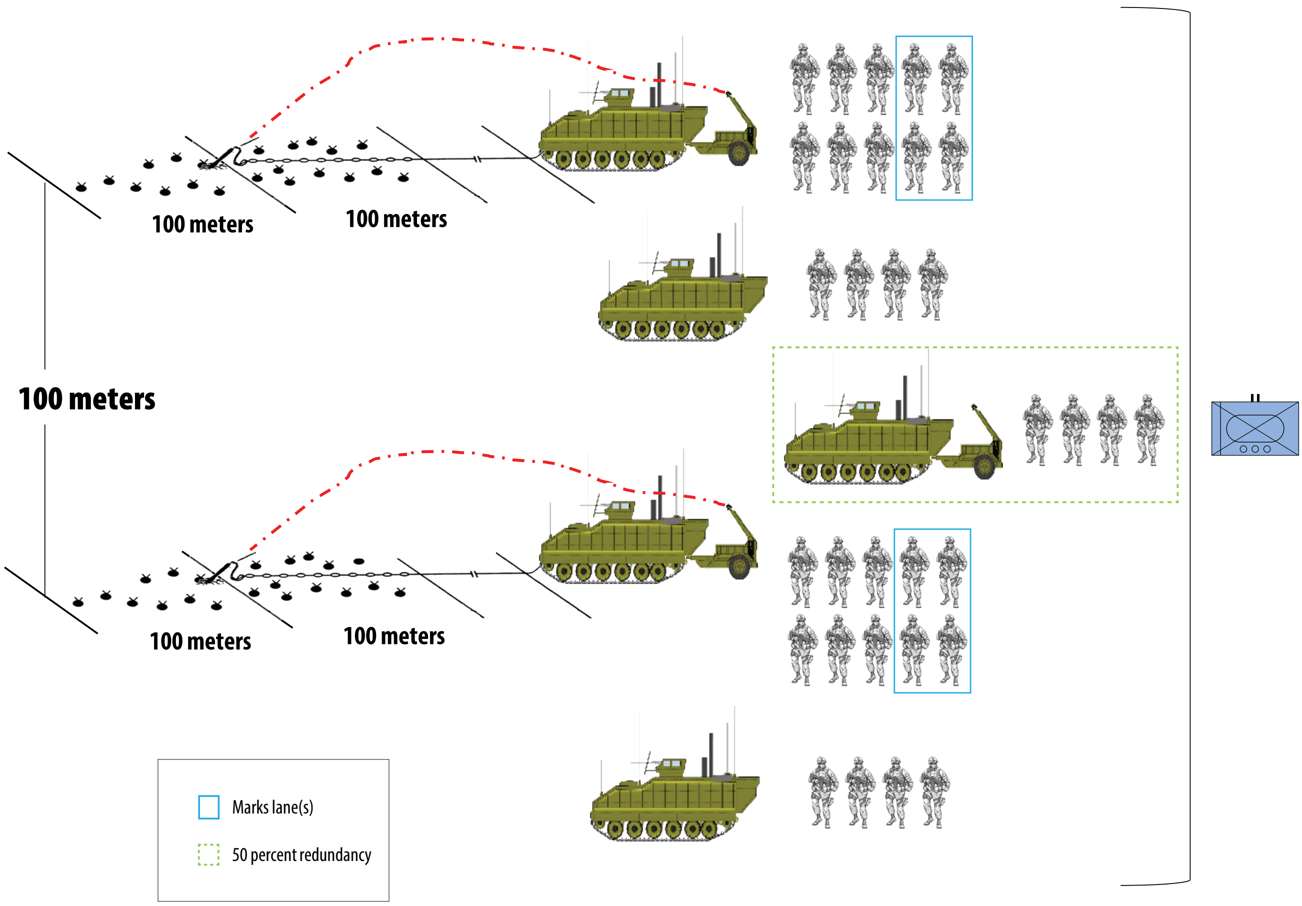
(Figure by Marine Corps Warfighting Lab)

Figure 2. Expeditionary Modular Autonomous Vehicle Payload Variations

Lt. Col. A. C. Turner, U.S. Army, is the commander of 1st Battalion (Engineer), 395th Regiment. She holds a BS from Roger Williams University, an MS from Missouri University of Science and Technology, and an MMAS from the Command and General Staff College. Her previous assignments include serving as the Engineer Modernization Branch chief for the U.S. Army Chief of the Engineers and as a Chief of Staff of the Army Strategic Study Group fellow in the Army Future Studies group and the Army Modernization Task Force.

maneuver support forces are better prepared to provide assured mobility to maneuver forces conducting subterrain and ground operations. Reducing the aperture to a combat engineer company conducting a minefield breach illustrates the exponential growth of capability within a brigade combat team (BCT). Figure 3 (on page 65) illustrates how today's echelons above brigade's combat engineer company structure and the rules of allocation conduct a minefield breach with a mine-clearing line charge (MICLIC).[11]

Using the same force structure, but replacing a traditional MICLIC with a MICLIC on a MUGV chassis, a combat engineer company is three times more lethal and effective in its MUMT employment than today (see figure 4, page 66). Ostensibly, the combat engineer company's three platoons can explosively provide a breach for all four of the BCT's combined arms battalions (see figure 5, page 67). The proliferation of MUGV MICLICs within a combat engineer company not only provides a 1.1 modernization solution but also causes multiple breach dilemmas for adversaries while increasing the BCT's lethality, speed, and operational reach.[12] In addition to providing mobility and maneuver



(Figure by author)

Figure 3. Current Force Structure of a Minefield Breach

overmatch for the BCT, this option allows the engineer regiment to use the remaining force structure to alleviate strategic mobility shortfalls and improve the support of the *National Defense Strategy*. This theoretical application of a MUGV MICLIC becomes a trailblazing capability that not only changes the way maneuver support formations are organized and fight but also how those same formations acquire and train talent; thus, spurring a potential identity crisis and provoking pushback from laggards.[13]

The raison d'être of maneuver support formations is to provide capabilities that enable maneuver forces to maintain momentum and deliver lethal effects against an adversary. Therefore, it ought not to matter whether that capability is a revolutionized fifty-six-person, echelons-above-brigade sapper company, a company of robots, or a MUMT. Rather, what matters is if existing technology and research fosters overmatch. Then Chief of Staff of the Army Gen. Mark A. Milley's address at the 2016 Association of the United States Army Dwight David Eisenhower Luncheon drives home the aforementioned point:

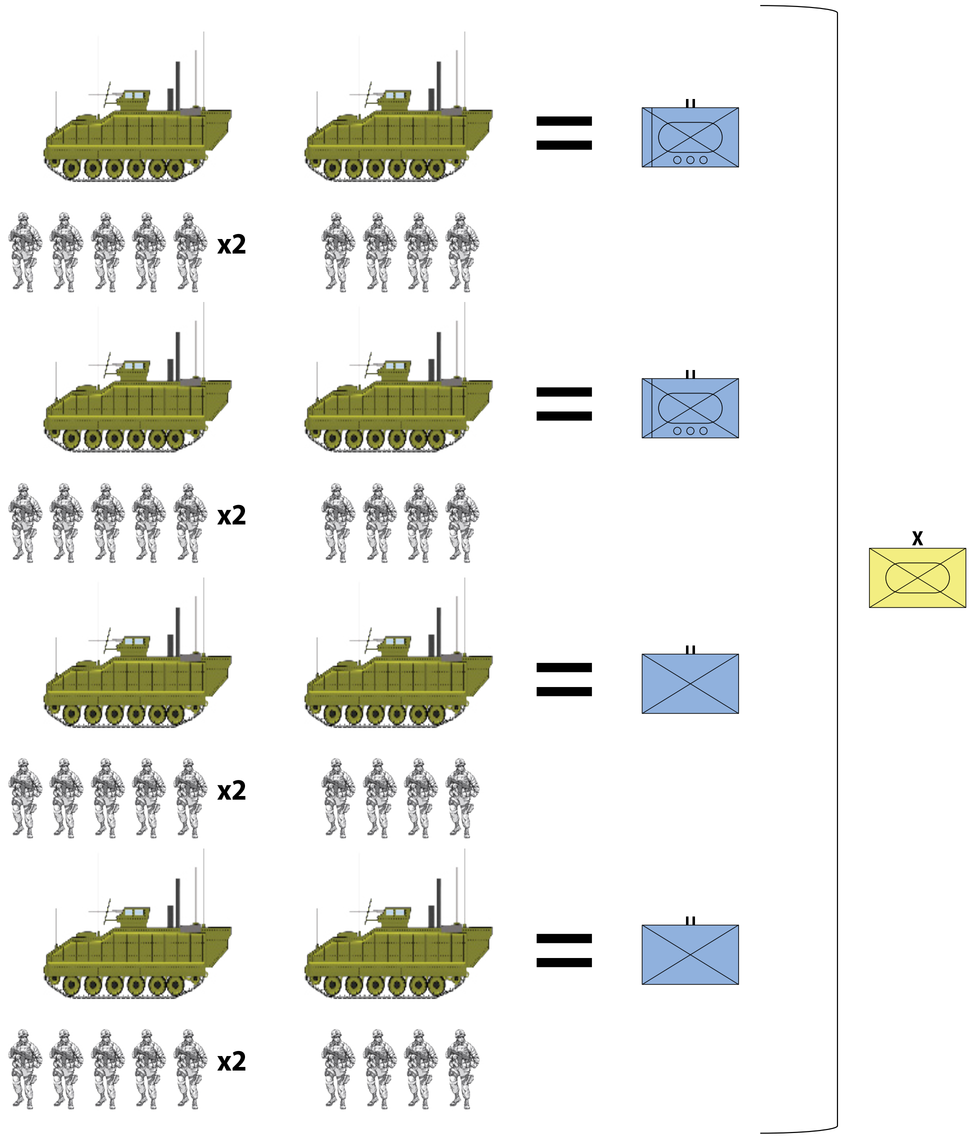
> War tends to slaughter the sacred cows of tradition, of consensus, of group-think and myopia. The next war will be no different. Those of us, or those nation states that stubbornly cling to the past will lose. They will lose that war, and they will lose it in a big way. … And it's better for us to slaughter our sacred cows ourselves, rather than lose a war because we're too hidebound to think the unthinkable.[14]

The DTRA and MCWL's MUGV program provides an opportunity for maneuver support regiments to leverage existing DOD RTD&E efforts (time, money, and expertise) to address current shortfalls and deliver a solution to the maneuver commander faster.

Always in Motion

Armies rely so much on past experiences to validate current practices that they are often regarded as inherently conservative organizations, resistant to meaningful change and innovation. … Yet armies have often stood at the cutting edge of technological, organizational, and methodological change, for in the violent competition that marks their trade, survival has often gone to the smartest and most innovative force rather than to the largest or best armed one.

—Jeffrey J. Clarke, Chief of Military History[15]

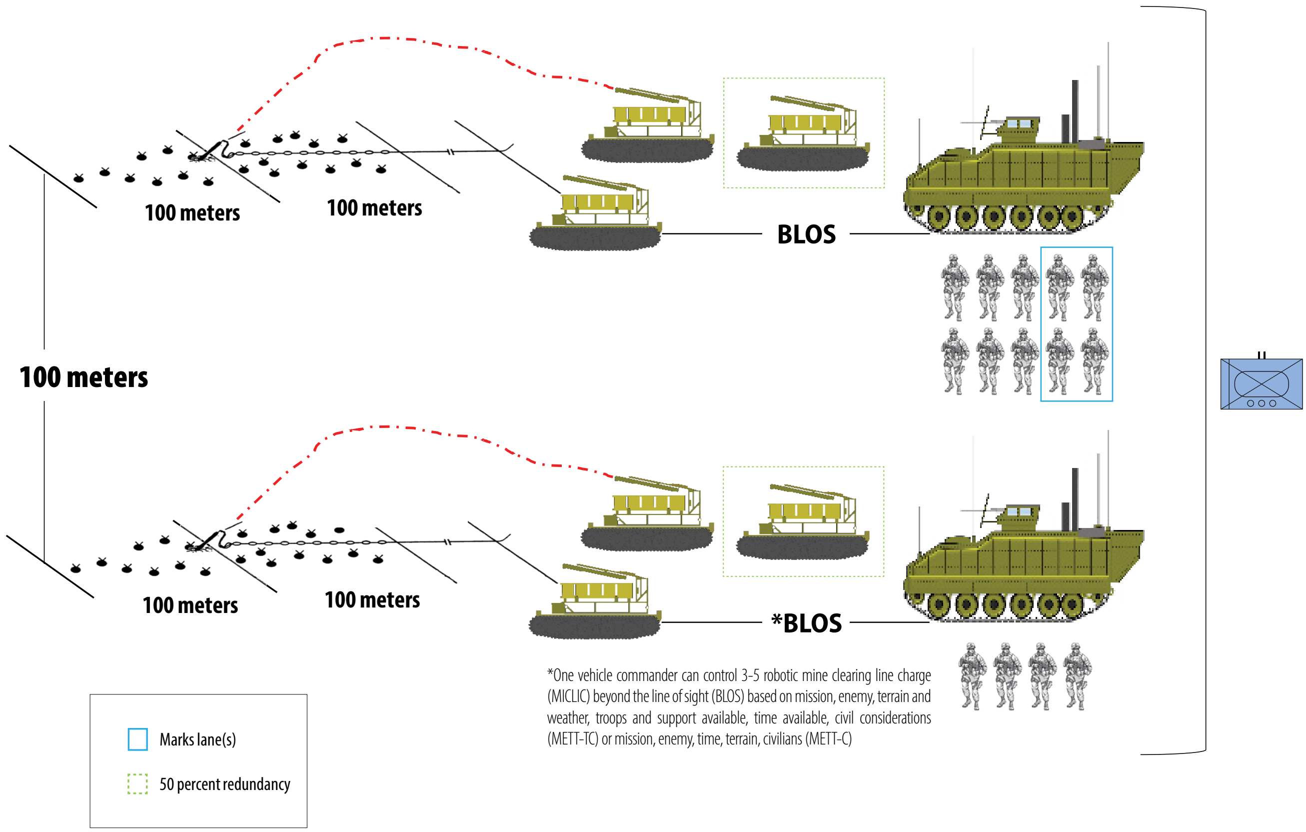


(Figure by author)

Figure 4. Revolutionized Echelons-Above-Brigade Combat Engineer Company

Prior to the War Office issuing wristwatches to all Commonwealth combatants in 1917, few foresaw the transformative role of wristwatches in military operations and civilian society. The same could be said about UGVs' likely impact on tactical innovation in MDO. Much like the wristwatch and trench warfare, MUGV MICLICs possess the capability to provide accuracy and reliability during a combined arms breach.

The MUGV MICLIC is an example of the U.S. military exploiting existing technology and collaborating with industry and DOD partners to create feasible alternatives for the commander to increase lethality, increase readiness, improve doctrine, and change tactics. The Battle of Vimy Ridge showed what was within the realm of possibility by underpinning "creeping barrage" with the proliferation of wristwatches. While the MUGV MICLIC has yet to be developed, the concept of reducing risk, establishing overmatch, and generating production volume is unarguably hard to dismiss. ■



(Figure by author)

Figure 5. Hypothetical Manned-Unmanned Teams Concept of Operations for a Minefield Breach Supporting a Combined Arms Battalion

Notes

Epigraph. Robert B. Neller, foreword to *Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century* (Washington, DC: Department of the Navy, September 2016), 3.

1. The U.S. Navy uses four categories to describe unmanned ground vehicles (UGVs): small (less than 400 lb.), lightweight (400 lb. to 1 ton), medium (1 ton to 15 tons), and large (above 15 tons). The Army uses four categories as well, but the weight classification differs: micro UGV (less than 10 lb.), small (10 lb. to 200 lb.), medium (200 lb. to 1.5 tons), and large (above 1.5 tons). This article will adhere to the Navy's classification as it is congruent with the U.S. Army's Robotic Combat Vehicle modernization efforts.

2. *Future force concepts* address future military problems and drive capability development. *Fielded force concepts* address current problems with existing or readily available capabilities.

3. *Teleoperated* means that a human controls all the UGV's movement via a control unit and visual systems. An *autonomous* movement describes a UGV that is both self-sufficient and executes missions without any human interaction. A *semiautonomous* platform can perform an autonomous function such as obstacle avoidance and navigation but may require a human interface to employ weapons.

4. Government-owned architecture includes, but is not limited to, navigation systems, control units, mapping software, system integration software, and platforms.

5. U.S. Army Training and Doctrine Command (TRADOC) Pamphlet 525-3-1, *The U.S. Army in Multi-Domain Operations 2028* (Fort Eustis, VA: TRADOC, 6 December 2018).

6. It is important to distinguish between *diffusion* and *adoption*. Diffusion is a phenomenon describing how innovation spreads and by whom. Adoption describes the stages that individuals complete prior to finally accepting a product, process, or ideology.

7. Jon Harper, "Army Revamping Intellectual Property Policies," *National Defense Magazine* (website), 21 August 2018, accessed 1 February 2019, http://www.nationaldefensemagazine.org/articles/2018/8/21/army-revamping-intellectual-property-policies.

8. Department of Defense, *Fiscal Year (FY) 2013 President's Budget Submission: Research, Development, Test & Evaluation, Defense-Wide* (Washington, DC: Department of Defense, February 2012), 70, accessed 26 July 2019, https://comptroller.defense.gov/Portals/45/documents/defbudget/fy2013/budget_justification/pdfs/03_RDT_and_E/Defense-Wide_PB_2013_1_FINAL_RDTE.pdf.

9. The transformation entailed testing various parameters to determine the maximum size of an amphibious platform in the hull of the ship and if

that platform could perform its task and purpose as designed without compromising the ship's key performance parameters.

10. Carl von Clausewitz, *On War*, ed. and trans. Michael Eliot Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 579.

11. One sapper company, which is capable of conducting three mechanical breaches, consists of three sapper platoons, thirteen armored personnel carriers, and three mine-clearing line charges. In order to support more than a battalion task force during a combined arms breach and provide redundancy to account for attrition at each vehicle lane, the maneuver commander would need capabilities from two sapper companies.

12. Department of the Army, *Report on the U.S. Army Modernization Strategy, Directed by Section 1061 of the National Defense Authorization Act for Fiscal Year 2018* (Washington, DC: Department of the Army, 30 April 2018), 2. The *Report on the U.S. Army Modernization Strategy* breaks down materiel solutions into three categories: 1.0—Close the Gap, 1.1—Achieve Overmatch, and 2.0—Strengthen Overmatch.

13. Everett Rogers, *The Diffusion of Innovation* (New York: The Free Press, 2003). Rogers categorizes adopters as either innovators, early adopters, early majority, late majority, or laggards. Innovators are willing to take a risk as their risk tolerance facilities the "fail often and fail early" mentality. Early adopters are individuals who use a product or procure technology as soon as it is available (e.g., individuals/investors who buy the first generation of Teslas or Apple and Microsoft products). Using the smartphone as an example, the early majority are individuals who have used smartphones prior to smartphone usage reaching 39 percent in 2012. The late majority approach innovation with exceptional levels of skepticism even as they join the fray after the majority of society has adopted the innovation. Laggards, the last of the five categories, are averse to change agents and are wedded to "traditions" and the status quo.

14. Mark A. Milley, "Address at the AUSA's Dwight David Eisenhower Luncheon" (speech, Washington Convention Center, Washington, DC, 4 October 2016), accessed 28 June 2019, http://wpswps.org/wp-content/uploads/2016/11/20161004_CSA_AUSA_Eisenhower_Transcripts.pdf.

15. Jeffrey J. Clarke, foreword to *A History of Innovation: U.S. Army Adaptation in War and Peace*, ed. Jon T. Hoffman (Washington, DC: Center of Military History, 2009), v.

A Last Moment Caught

Tom Sheehan

It comes again,

without prejudice,

in another millennium:

I know the weight of an M-1 rifle

on a web strap hanging on my shoulder,

the awed knowledge of a ponderous steel helmet

atop my head, press of a tight lace on one

boot, wrap of a leather watch band

on my wrist,

and who stood beside me

who stand no more.

Three soldiers from the 3rd Battalion, 34th Infantry Regiment, 35th Infantry Division, crouch behind rocks 11 April 1951 to shield themselves from exploding mortar shells near the Hantan River in central Korea. (Photo courtesy of the U.S. Army Signal Corps via the Library of Congress)