# Robots on Tracks:
## What Armor Needs to Make Robotic Combat Vehicles Work

**by MAJ John Nimmons and 2LT Patrick Oathout**

One of America's most significant retreats of World War II occurred at the Battle of Kasserine Pass.[1] In early 1943, the U.S. II Corps faced Nazi Germany's GEN Erwin Rommel's Afrika Korps and two divisions from the Fifth Panzer Army at the Battle of Kasserine Pass in Tunisia. This battle was the first opportunity for American troops to test tanks, close air support and anti-tank weapons together in combat.[2]

Despite the inclusion of new technology, the United States lost the battle for several reasons. First, the distribution of American forces across different Allied units – as well as the II Corps headquarters' location 70 miles from the front – created poor command and control (C2). Second, Americans were inexperienced in many ways; namely, Soldiers lacked training and experience employing their new weapons. Finally, Americans could not mass and synchronize ground-air operations, negating the value of new fighters, tanks and artillery.

U.S. forces needed significant doctrinal, organizational and leadership changes to increase the effectiveness of their new weapons and equipment. As a result, during a four-month period, U.S. GEN Dwight Eisenhower replaced senior leaders and initiated reforms to better synchronize new technology with organizations and doctrinal employment. Eventually these changes came together at the end of the Tunisian Campaign, demonstrating the value of synchronizing new technology with compatible doctrine, organization and training. Kasserine Pass taught the United States many lessons, but most importantly, it accelerated the shift to a modern concept of combined-arms combat.[3]

Today the U.S. Army faces similar challenges synchronizing newly developed robotically controlled vehicles (RCVs). The speed, depth and range of combat operations continues to grow. However, unlike World War II, the time available to incorporate needed doctrinal and organizational changes during combat operations is limited.

Recent events in the Nagorno-Karabakh conflict between Armenia and Azerbaijan show the same challenges. Azerbaijan's modern weapons paired with a synchronized, innovative doctrine of employment brought a quick, decisive end to the conflict before Armenia could adapt to make necessary changes during combat operations.[4]

As recent conflicts show, potentially paradigm-changing technology will change the nature and scope of future military operations, directly impacting how the U.S. Army employs RCVs. While these autonomous tanks provide many advantages, Armor does not yet have the doctrine, organization and training to enable their use effectively. Paul Scharre warned of this hurdle in his book on autonomous weapons, ***Army of None***: "With proper design, testing and use, autonomous systems can often perform tasks far better than humans. ... However, if they are placed into situations for which they were not designed, if they aren't fully tested, if operators aren't fully trained, or if the environment changes, then autonomous systems can fail."[5]

Thus, as we look at the impact of RCVs on armor formations in the future, we should consider the following doctrinal, organizational and training changes:

- Consider alternative organizational constructs for RCVs through disaggregated testing at lower echelons;
- Establish a new military-occupation specialty (MOS) that will operate and sustain RCVs; and
- Prioritize digital skills in Armor recruitment and training.

The U.S. Army released its ***Robotic and Autonomous Systems Strategy*** in 2017, outlining near-, mid- and far-term priorities. The strategy stated that RCVs will increase situational awareness, lighten Soldiers' physical and cognitive workloads, sustain the force better, facilitate movement and maneuver and protect the force.[6] To enable this strategy, the Army is currently developing three RCV platforms. These platforms serve different purposes; some RCVs will reconnoiter independently, while others will move alongside human-operated tanks.[7]

Overall, RCVs are quicker and cheaper to produce, increase survivability and perform missions that would challenge even the most experienced armored unit.[8] The U.S. Army recognizes these advantages, and so do near-peer threats. China and Russia are both developing RCV platforms, with the latter testing them in Syria in 2018.[9]

Like the addition of new technology in World War II, RCVs will present initial challenges to sustainment, operational tempo and C2. Small materiel changes at lower echelons can create enormous cascading effects across an organization, especially if there is no overarching doctrine guiding usage. P.W. Singer wrote in his book, ***Wired for War***, "The best parallel [to the development of autonomous weapons] might be the difficulties the Army had before World War II at integrating tanks into its plans and operations, especially when it was led by 'leaders not able to think beyond their [World War I] war experiences, where the pace of war was at a two-and-a-half-mile-an-hour clip.'"[10]

War is now much faster and more complex than World War II, and autonomous weapons will increase this trend. These challenges will severely limit any in-stride adaptation the U.S. Army may need in future conflicts if not addressed.

### Organizing RCVs in formations

The organizational construct of RCVs is fundamental to the efficacy of the program. As Christian Brose described in ***The Kill Chain***, the addition of technology alone will not guarantee

**Figure 1. The RCV-Light can be equipped with a tethered unmanned aerial system, a small drone that can be deployed to conduct aerial reconnaissance while the vehicle is at a safe distance. Other equipment to be tested on the RCV-Light experimental prototype includes the M153 Common Remotely Operated Weapons Station II (CROWS II), the .50 caliber M2 machinegun and the 40mm MK19 Mod 3 automatic grenade launcher.** *(Photo by Bruce Huffman, Michigan National Guard)*

success in future conflicts.[11] In this early stage of testing, it is essential to consider all forms of robotic usage and not limit their organizational designs to military structures of the past.

Proposed RCV organizations currently focus on adding robot-only companies to armored brigades or battalions, where one person commands the robotic unit's action at the direction of higher commanders.[12] The idea here is to empower brigade and battalion commanders to use RCVs as whole units or task-organize them into smaller formations as the mission requires. As observed with Russia's 2018 use of RCVs in Syria, RCVs are still unreliable due to software, mechanical and networking issues: They stall and lose connection, requiring human intervention to continue.[13]

Learning from this lesson, it is likely that these issues will persist in the future, making these systems targetable by adversaries. If coalesced into larger formations, RCVs are vulnerable to single points of failure. Scharre wrote in ***The Army of None*** that "[t]he key factor to assess with autonomous weapons isn't whether the system is better than a human, but rather if the system fails (which it inevitably will), what is the amount of damage it could cause, and can we live with that risk?"[14] As such, the design of RCV organizations should exploit their advantages and mitigate their inevitable failures.

As we continue to test appropriate organizational integration methods, an alternative to company-sized RCV formations at battalion and brigade levels is disaggregating them as pairs of systems across company and platoon formations. There are a couple reasons to consider this alternative organizational construct: increased adaptability and maintenance responsiveness.

First, allocating RCVs to lower echelons below brigade and battalion will decentralize decision-making for RCV employment, creating opportunities for adaptability in dynamic environments. Distributing ownership across lower echelons will also distribute the risk of technological failure – if one unit's RCVs fail during combat, most others can succeed. Scharre wrote, "One of the ways to compensate for the brittle nature of automated systems is to retain tight control over their operation. If the system fails, humans can rapidly intervene to correct it or halt its operation."[15] It is easier to maintain tight control among operators and RCVs in decentralized organizations vs. having them aggregated and controlled at higher echelons.

First, decentralizing control of RCVs flattens the formation, leveraging dynamic decisions at lower levels rather than filtered decisions complicated by multiple levels of staff and command. Given the anticipated speed of future conflicts, decentralized decision-making for RCVs negates a common failure observed in hierarchical systems, namely the timeliness of actions where one person, the commander, ultimately controls the direction and action of a larger formation.[16] When examined at a greater level, multiple systems working independently to achieve a unified effect on enemy forces is the very definition of mission-command principles, namely disciplined initiative.[17]

This change is in keeping with existing doctrine, but the nuanced change to combined-arms warfare enables units to maintain operational tempo without depending on the success or failure of larger RCV formations. Ideally we want formations with new technology to adapt quickly as battlefield parameters change, much like when Sun Tzu stated, "Water shapes its course according to the nature of the ground over which it flows; the soldier works out his victory in relation to the foe whom he is facing."[18] In this case, decentralizing control of RCVs provides "better, faster and more adaptable kill chains … [that] act more effectively under highly dynamic conditions than our opponents."[19]

A second reason to pursue dispersed, decentralized robotics organizations is increased maintenance responsiveness. Placing company-sized RCV formations in brigades may reduce maintenance manning requirements, but this centralized method may not provide adequate support during combat operations. Current Next-Generation Automatic Test System (NGATS) and Direct-Support Electrical Systems Test Set (DSESTS) systems and organizational structure within armored brigade-support battalions (BSB) require a select few integrated family of test-equipment operator/maintainers (94Ys) to conduct all computer repairs, sometimes creating repair wait times that are unsustainable during combat or training operations.

This centralized repair system creates a bottleneck within large formations and lacks dynamic self-repair and diagnostic troubleshooting needed to maintain operational tempo. Instead, a consideration when disaggregating RCVs is to place maintainers closer in proximity to the formations they will supplement for quicker repair solutions should problems arise. In this early stage for RCVs, each forward-support company will need individuals for diagnostic troubleshooting and mechanical RCV maintenance capability, particularly if the RCV platform is not expendable. Placing operators and maintainers physically closer to RCVs on the battlefield enables increased maintenance flexibility to keep these systems in the fight.

## Training RCV operators/maintainers

As the Army increases the number of RCVs in its formations, its Soldiers must increase their expertise with those systems. Over time, as the Armor Branch incorporates RCVs, the operators will need a new 19 Career Management Field MOS: tech-savvy Soldiers who control weapons and many digital systems in tandem with manned equipment. RCVs and updates to the next-generation combat tank will require digitally literate operators, representing another challenge for the Armor Branch. It is important to note that RCVs and tanks are not just vehicular combat platforms – they are now also highly technical computer systems. As a result, RCVs and the next-generation combat tank will require crews with an increased understanding of electronic warfare, digital-systems maintenance and artificial intelligence (AI)/machine learning.

Robotics crews must understand electronic warfare, as these attacks will proliferate in future combat. Friendly RCVs will electronically attack an enemy to jam communications or mask the movement of friendly forces. In turn, friendly RCVs may also jam and need live maintenance to get back into the battle. Soldiers deploying and defending against electronic attacks will need a masterful understanding of this discipline to be lethal, akin to the development of master gunners today.

Secondly, RCVs crews must be proficient in digital sustainment and maintenance. As LTG Gary M. Brito wrote recently, "The future operating environment will require Army forces to operate dispersed with the ability to concentrate combat power rapidly at decisive points and in spaces (domains) to achieve operational objectives."[20]

RCVs will lose effectiveness if they lack the digital maintenance personnel to solve issues on the battlefield. Armored crews presently lack the digital expertise to troubleshoot computer issues on their vehicles, requiring NGATS/DSESTS teams in the BSB to fix all computer-related issues. The current sustainment structure within brigades will not support the addition of RCVs and digital upgrades for next-generation combat vehicles. The limited number of 94Ys that currently exist within a brigade would struggle to sustain the increased digital requirements that come with RCVs. Tank systems will need troubleshooting – fixing a tank's network connection might be as common as replacing a tank's tracks. Soldiers will need to understand networking, cloud computing, cybersecurity and more to manage digital systems.

Finally, these robotics crewmembers must be proficient in informing and guiding AI. AI is already informing RCVs at Project Convergence,[21] the Army's effort to establish joint integration of technology-enabled battlefield insights and C2.[22] While combat Soldiers will not need the requisite knowledge to build and test AI and machine-learning tools, they will need to understand how these programs gather data and arrive at conclusions to set the technology up for success in battle.

Mike Horowitz, a political-science professor at the University of Pennsylvania, wrote, "If human operators, whether in a command center or on the battlefield, do not know exactly what an AI will do in a given situation, it could complicate planning, making operations more difficult and accidents more likely. … If an AI system behaves a certain way in classifying an image or avoiding adversary radars, but cannot output why it made a particular choice, humans may be less likely to trust it."[23] Soldiers need to understand the strengths and limits of the technology they use. Otherwise, they risk overusing or underusing these assets, lessening the potential effect of AI on the battlefield.

## Training, recruiting digital experts

These trends all underline the need for empowered, digitally knowledgeable experts at the point of immediate action. Digital expertise is not built

**Figure 2. The Ripsaw, the fourth and final RCV (RCV-Medium) prototype, was delivered to CCDC's GVSC at Detroit Arsenal, MI, May 13, 2021.** *(Photo copyright Textron Systems; property of Textron Systems. This photo should not be reused, reproduced in any form or any channel, or provided to any other party without the express written permission of Textron Systems)*

overnight, and thus future recruitment efforts should focus on attracting Soldiers who understand basic electronic and software engineering. Armor should incorporate these skills into its program of instruction at all basic courses and provide Army-funded opportunities to earn external micro-degrees in software development, cybersecurity, networking, geospatial intelligence, data science and machine learning.

Developing Soldiers' technological literacy would not only make us a more capable and lethal branch, but it would also improve the Armor Branch's attractiveness to recruits. Based on collected feedback, when Armor loses a candidate, it is often because the branch does not offer the same post-Army career prospects as others. These training changes would make Armor Branch more competitive by providing professional-development opportunities that translate beyond the typical Army career path. In addition to training changes, Armor will also need to revise its recruitment strategy to recruit from organizations producing tech-literate teenagers, like the local high-school robotics club, and update its target knowledge, skills and behaviors. Therefore, the Armor Branch should screen recruits on these technical skills and try to attract the best technical talent to maintain lethality in the 21st Century.

The U.S. Army emerged from World War II with more insight on the power of combining new technology with new doctrine, organization and training. The U.S. Army learned from Kasserine Pass that technology alone was not enough; units needed to better synchronize their actions across echelons and branches. In an effort to not repeat lessons-learned half a century ago, we can get ahead of doctrinal, organizational and training challenges now if we examine more ways to test RCV employment in armored units today. It should be noted that technological changes alone cannot be shoehorned into doctrine and organizations. Iterative experimentation at echelon will inform the requirements that new technology will create.

## Changing warfare

Robots and AI will change warfare, and the U.S. Army can harness the talent and resources to develop the best technology. But no amount of innovation will win wars if the force is not making the correct doctrinal, organizational and training changes. Therefore it is better to experiment early (now) and succeed rather than fail to understand future parameters until experimentation is forced to occur at the cost of life during combat operations.

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## Notes

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[5] Paul Scharre, "Robots Run Amok – Failure in Autonomous Systems"; ***Army of None***, New York, NY: W.W. Norton & Company; 2018.

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[8] Scharre.

[9] Kyle Mizokami, "The Army's Robotic Combat Vehicles Will Invoke WWII's 'Ghost Army'"; ***Popular Mechanics***; Aug. 3. 2021; https://www.popularmechanics.com/military/weapons/a37202757/army-robotic-combat-vehicles-ghost-army.

[10] P.W. Singer, "'Advanced' Warfare: How We Might Fight with Robots"; ***Wired for War***; New York, NY: Penguin Books; 2009.

[11] Christian Brose, ***The Kill Chain: Defending America in the Future of High-Tech Warfare***; New York, NY: Hachette Books; 2021.

[12] The idea of adding robot-only companies to armored brigades or battalions is a discussion point across multiple Army organizations that look at modernization. These briefs and proposed ideas are still in the initial stages of conceptualization.

To date, most of these discussions only focus on the technical aspect of RCV additions and not necessarily the impact such an addition would require to modify existing organizations for better employment.

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[21] Project Convergence is the U.S. Joint Force experiments with speed, range and decision dominance to achieve overmatch and inform the Joint Warfighting Concept and Joint All-Domain Command and Control. A campaign of learning, it leverages a series of joint, multi-domain engagements to integrate artificial intelligence, robotics and autonomy to improve battlefield situational awareness, connect sensors with shooters and accelerate the decision-making timeline.

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## Acronym Quick-Scan

**ABCT** – armored brigade combat team
**AI** – artificial intelligence
**BSB** – brigade-support battalion
**C2** – command and control
**CCDC** – Combat-Capabilities Development Command
**CIG** – commandant's initiatives group
**DSESTS** – Direct-Support Electrical Systems Test Set
**GVSC** – Ground Vehicle Systems Center
**MCCC** – Maneuver Captain's Career Course
**MOS** – military-occupation specialty
**NGATS** – Next-Generation Automatic Test System
**OIF** – Operation Iraqi Freedom
**RCV** – robotically controlled vehicle