The U.S. Department of Defense (DoD) has initiated several efforts to accelerate development and fielding of warfighting capabilities incorporating artificial intelligence and machine learning (AI/ML) (Department of Defense Directive 3000.09, 2017). For example, the Secretary of Defense established the Joint Artificial Intelligence Center (under the Chief Information Officer) as a DoD-wide center of excellence for AI/ML, and each of the services has established an artificial intelligence (AI) Task Force or Cross-Functional Team. DoD’s leadership views fielding AI/ML capabilities as a high priority. The development and fielding of AI/ML capabilities requires the cooperation of operators and engineers. Wargames and tabletop exercises are ways to engage these two communities to enhance their understanding of AI/ML technologies, the capabilities they enable, and the considerations inherent in their adoption. Wargames and tabletop exercises also help operators and engineers develop realizable requirements and engineering specifications.

This report describes an experiment conducted by RAND Corporation researchers exploring the realistic incorporation of AI/ML–enabled capabilities in company-level tabletop wargames set in the Baltic states in the 2030s between Blue (U.S.) and Red (Russian) forces. Two wargames were conducted: (1) a baseline game with remotely operated (RO) robotic combat vehicles (RCVs) had distinct disadvantages that were easily exploitable relative to fully autonomous RCVs and manned vehicles.

- RCVs were used as armed reconnaissance and often explicitly as bait.
- Relatively limited intelligence, surveillance, and reconnaissance capabilities and indirect fires allowed Red to remain static.
- Postulated AI/ML capabilities can be incorporated into tactical ground combat wargames.
- Such games, by bringing together operators and engineers, could be used by the requirements and acquisition communities to develop realizable requirements and engineering specifications for AI/ML systems.
operated (RO) light- and medium-weight robotic combat vehicles (RCV-Ls and RCV-Ms) under the continuous control of soldiers (as envisioned by the Army for relatively near-term fielding) and (2) an AI/ML game in which those vehicles operated fully autonomously, executing movement and enemy engagements without human intervention but consistent with orders provided by their company commanders. This latter capability arguably goes beyond what would be permitted by current DoD policy.

We modified and augmented the rules and engagement statistics used in A Fistful of TOWs 3 (FFT3), a commercial tabletop wargame, to enable fully autonomous combat vehicles and AI/ML–enabled situational awareness to show how the vehicles perform in a company-level engagement between Blue and Red forces in Latvia (Beard and Minson, 2011). The augmented rules and statistics we developed for this wargame were based in part on the U.S. Army’s far-term plans for developing and fielding robotic and AI/ML–enabled weapon and other systems. By changing the rules, we attempted to realistically reflect the capabilities and limitations of those systems, including their vulnerability to selected enemy countermeasures, such as electronic jamming of communications. Beyond RO vehicles, we included fully autonomous combat vehicles with the ability to detect, identify, and engage targets without human intervention—which the Army does not yet envision—as an exemplar of the capabilities that might be technically feasible in the farther term.

The wargames yielded several observations that should be explored further in subsequent wargames and analyses:

- In the baseline game, the need to maintain unobstructed and unjammed line-of-sight communications with the RO vehicles imposed constraints on Blue forces, slowing the pace and complicating the management of Blue’s advance. Red’s effective use of jamming substantially limited Blue’s ability to use those vehicles. We should explore further the ability of an enemy to exploit the need for continuous communications with RO vehicles and its effects. Such exploration could involve more tactical gaming, assuming the performance of the systems as we have here. In addition, the physical systems could be field-tested to assess the practical vulnerability of the vehicles to communication interruption, as was assumed in this game.

- In the baseline game, Blue was limited in the number of RO RCVs it could commit to action at any time. Controller vehicles were able to command only two RCVs each, preventing Blue from massing RCVs against a Red position. In contrast, there was no such limit on the fully autonomous vehicles. They could be committed as desired by Blue as long as Blue did not demand that they execute overly complex orders; we assumed the system had limited ability to interpret and act on complex orders, which is in line with reasonable extrapolations of the state of technology in the foreseeable future. This assumption was
implemented in the game by limiting the bandwidth of the orders Blue could give to the autonomous vehicles. The potential performance of future RCVs, and thus the benefits of AI/ML–enabled combat vehicles, should be explored further to guide the development of these capabilities.

- In both games, RCVs were treated as being relatively more expendable than crewed vehicles. RCVs were always the first vehicles Blue moved forward and the first to take direct fire. According to player comments, it appeared that the RCVs, whether RO or completely autonomous, were used as bait because doing so did not put soldiers at risk. Moreover, loss of the RCVs seemed, at least initially, to not cause Blue substantial regret, because the RCVs’ offensive capabilities (especially those of the RCV-Ls) were limited compared with those of other vehicles. Whether RCVs would be viewed and employed consistently by players as essentially disposable could and should be examined in future games, including for situations in which the players are informed at the outset that the cost to replace the RCVs is high and their inventory is limited, or for situations in which there is a need for an RCV-equipped force to conduct multiple engagements in sequence without reinforcement.

Throughout the two games, players on both sides discussed the capabilities and limitations of the RO and fully autonomous systems and their implications for engaging in combat using such systems. These discussions led to observations about which limitations should be mitigated before commanders were likely to accept a system (e.g., the susceptibility to jamming of RO RCVs) and which capabilities needed to be fully understood by commanders so that systems could be employed appropriately (e.g., the limitations on the complexity of the orders that could be provided to fully autonomous RCVs). This research demonstrated how bringing together operators and engineers within the context of games might aid in creating requirements and engineering specifications for AI/ML systems—a development that would benefit the requirements and acquisition communities.

**Game Purpose, Setting, and Rules**

**Purpose and Setting**

This project had three objectives. The first was to experiment with concrete and meaningful representations of AI/ML in tabletop tactical wargames. For this purpose, we chose instantiations of AI/ML capabilities in ground vehicles as a counterpoint to the often vague representations of AI as a fairy-dust (i.e., unrealistic) solution to be sprinkled over the battlefield. The second purpose was to obtain initial insights into the potential value and limitations of currently pursued medium-term (i.e., potentially fielded in the 2030s) AI/ML capabilities for combat vehicles that could be explored more comprehensively via subsequent games, analyses, and testing. The third purpose was to explore how players interact with AI/ML systems.

Participants were asked to play the following two scenarios of a tactical (company-level) ground combat wargame with AI/ML capabilities embedded in autonomous platforms (ground vehicles and unmanned aerial vehicles) set in the 2030s (i.e., the relative medium term) against a near-peer adversary:

- a baseline scenario with Blue RCVs remotely controlled by human operators (only), which is consistent with the Army’s plans for fielding robotic vehicles in the 2020s. In early 2020, the Army chose contractors to build prototype RCV-Ls and RCV-Ms that will be used to determine the feasibility of integrating unmanned vehicles into ground combat operations, including the conduct of a company-level experiment with the prototypes at the end of 2021 (Judson, 2020).
- an AI/ML scenario with Blue RCVs also capable of fully autonomous operation, which could be available in the 2030s (likely at the earliest). We used the same RCV platforms in our AI/ML scenario as in our baseline scenario to focus on the differences in vehicle
command and control between the two cases rather than on other possible aspects of vehicle performance resulting from the platform itself.

Apart from Blue AI/ML capabilities, the forces on each side were identical between the two games (see Figures 1–4). In particular, the Red forces were assumed to not have AI/ML capabilities in either of the two game scenarios; for the purposes of testing Blue capabilities, all Red forces and capabilities were held constant across both scenarios. Three of the six players were RAND analysts who are former field-grade Army officers with operational experience, experience analyzing ground combat systems, and experience designing and participating in RAND wargames for the Army. Two of the players were technologists with breadth and depth in AI/ML and operational testing. The sixth player was an Army general officer who brought both technological and operational experience to the table. The Red team consisted of two RAND analysts (former Army officers) and a technologist. The Blue team consisted of the remaining players. Therefore, each team had at least one technologist and one operator. Moreover, each team had at least one player with significant wargame experience.

In addition to the forces depicted on the map with counters (Figure 2), the Blue force’s Fire Support Team (FIST) vehicle could call on a battalion of 155-mm howitzers for artillery support.

Red force artillery support included a battalion of 152-mm howitzers that could be called on by the artillery observer or its assigned unmanned aerial system (UAS) (see Figures 3 and 4). For both Red and Blue, there was a one-turn delay in implementing the call for fire.

In each scenario, a Blue mechanized company task force was attacking a Red motor rifle company task force near Gulbene, Latvia, with the objective of neutralizing the Red force and moving through the area to the east (see Figure 5). The map remained unchanged, and in both cases, Blue used the east-west road to the north and a combination of roads and open ground to the south as its avenues of advance.
follower mode trailing directly behind the OMFVs. Thus, in the base game, only four of the 12 RCVs available could engage in combat (i.e., move independently or conduct fires) at any given time. In the AI/ML game, AI/ML capabilities enabled Blue RCVs to operate autonomously, and all 12 RCVs could engage in combat. Autonomous capabilities included the ability to detect, identify, and engage Red targets without human intervention.2

Capabilities and Limitations of RO RCVs

RO RCVs had to be under positive control by human operators in the OMFVs at all times to be effective. Each OMFV could control two RCVs at a time; a controller OMFV carried two controller teams (of two soldiers each). The RO RCVs’ only autonomous capabilities were (1) leader-follower mode for movement and (2) return to a point to regain contact with human controllers. Control range was line of sight at

![Figure 2: Blue Force Order of Battle](image-url)
FIGURE 3
Red Combat Systems

T-90M
Modernized T-90 main battle tank with 125-mm smoothbore main gun, heavy passive and reactive armor protection, soft-kill APS

BMP-2M
Modernized infantry fighting vehicle with 30-mm autocannon, AT-14 ATGM launcher, light armor protection (PRP-4A is a BMP-derived forward observer vehicle)

2K22M1 Tunguska (2S6)
Air defense vehicle with 30-mm cannons and SA-19 SAMs

Small Unmanned Aerial System (UAS)
Eleron UAS shown; 30-min endurance, EO/IR sensor

SOURCE: T-90M, BMP-2M, and 2K22M1 Tunguska images courtesy of Vitaly Kuzmin (CC BY-NC-ND 4.0).
NOTES: ATGM = anti-tank guided missile; BMP = Boyevaya Mashina Pekhoty (Infantry Combat Vehicle); EO/IR = electro-optical/infrared; INF SQD = infantry squadron; SAM = surface-to-air missile.

FIGURE 4
Red Force Order of Battle

Company HQ
Artillery observer
Motor Rifle Platoon
Motor Rifle Platoon
Motor Rifle Platoon
Dismounted elements
Tank Platoon
Air Defense Section

Game counters

T-90M
BMP-2M
PRP-4A
INF SQD
2S6
UAS
up to 2.5 km, or 1.5 km if line of sight was partially obscured by terrain. The control links were assumed to be directional; they could be jammed, but only if the (backpack) jammer was in alignment to interrupt the RCV-OMFV line of sight. If communications were lost or jammed, the RCVs held in place. Because of sensor and communications limitations, the RO RCVs moved at half speed relative to human-crewed vehicles in other-than-easy terrain (i.e., easy terrain like roads or open farmland). RO RCVs fired under the continuous remote control of their human operators, and their fire was considered equally likely to hit a target as fire from human-crewed vehicles operating the same weapon system.

### Capabilities and Limitations of Fully Autonomous RCVs

In the AI/ML scenarios, Blue commanders issued orders to the autonomous vehicles each turn. This reflected the cognitive capabilities of the vehicles that the project team deemed potentially achievable by the 2030s. The assumption was that autonomous vehicles could follow simple orders (e.g., maneuver in formation, navigate in all but the most complex terrain, and engage targets following simple logic) but could not follow more-complex mission-type orders or operate independently (as human-crewed vehicles could). This sort of first-generation autonomy that is built into RCVs is potentially worth acquiring and using on the battlefield. In the game, the autonomous vehicles within communications range of the RCV headquarters (HQ), and each of the two OMFVs in the RCV HQ could issue two orders (representing two robot commanders or commander sections in each OMFV). Each order could command any number of autonomous vehicles. The order was given to game referees verbally or in writing and could include directions drawn on a map; it had to be of limited complexity to reflect limitations in the cognitive ability of the AI/ML RCVs. (We do not know what the actual command interface for the AI/ML RCVs will be. It could involve some combination of voice, text, and digital map commands.) After the orders were given, the game referees reviewed them for vagueness, contradiction, or lack of clarity. If the referees deemed an order acceptable, then the autonomous vehicles executed their moves as ordered; if not, the RCVs either continued to execute the orders given to them previously or followed misinterpreted orders as directed by the referees. (In our game, the latter never occurred because no orders given warranted that response.)

The fully autonomous RCVs were able to execute unambiguous fire orders as directed (e.g., “fire on enemy unit X,” “fire on enemy in direction Y,” “fire on enemy in geographic area Z”). Once such fire orders or permissions were given, further interaction or confirmation with humans was not necessary. Thus, once the autonomous RCVs began to advance to the east and passed the north-south road, they could fire on any Red vehicle the RCVs detected and identified. The autonomous vehicles could communicate with each other and coordinate their own fire against groups of commonly known enemy targets. Fire from fully autonomous RCVs was considered equally likely to hit targets as fire from human-crewed vehicles.

### Game Rules

To meet the objectives of (1) experimenting with representations of AI/ML in a tactical wargame, (2) developing initial insights into the value and limitation of the systems, and (3) studying how players interact with AI/ML systems, we opted to leverage existing ground combat rules to provide a coherent basis for representing and adjudicating tactical engagements. For this experiment, we adapted the basic rules developed for FFT3, a commercial game system (Beard and Minson, 2011). We used FFT3 for this experiment because it was readily available, inexpensive, and well suited to representing the common aspects of the scenario that were of secondary importance to the exploratory goals of the project. Ground combat experts on the research team determined that FFT3 represented ground combat at the required level of granularity to allow our research team to simulate RO and fully autonomous combat vehicles. Commercial games serve different purposes than serious, analytic games, and dynamics within the design may not be based on empirical research. Through several playtests and prior experience with the game, however, the authors evaluated that FFT3's
base rules represented system performance at a sufficient level to serve the project’s purposes. Because the primary question addressed by this project was command and control of RO and autonomous vehicles and because FFT3 did not contain rules for remote or autonomous vehicle operation, these game rules were written by RAND researchers.

In FFT3, each combat vehicle has statistics and rules governing its operation that represent its combat capabilities—mobility, protection, survival, and firepower (e.g., target acquisition, rate of fire, accuracy). We generally used FFT3’s rules and statistics for existing weapon systems (e.g., T-72 and M1 Abrams tanks) because these rules were shown in playtesting to perform within expected ranges based on past RAND research on tactical ground combat.

However, as noted, FFT3 does not contain rules for remote or autonomous operation of ground vehicles, or for OMFVs and RCVs specifically. Thus, the team developed new rules and statistics for those proposed systems. Weapon systems to be carried by those vehicles were rated based on comparison with existing weapon systems. Their mobility was assessed based on information concerning the concepts for the vehicles’ chassis and comparison with existing vehicles. Their protection was similarly assessed based on information concerning the protection of the concept systems.

Beyond the addition of new units into the game, the most-important adaptations we made to the existing rules concerned command and control for the RO and fully autonomous RCVs. Command and control for those vehicles—how their operations on the battlefield could or could not be directed—is the biggest difference between them and human-crewed vehicles. Such rules are the most important aspect of any rules system developed to simulate the operation of RO and fully autonomous RCVs. Issues of vehicle command and control are also central to the conclusions we draw from this work. Therefore, we worked on formulating a project that looks at the question, starting from the disruptive technologies.

**Game Sequence**

The game operated in 3-minute turns, which repeated until the game ended. Both sides could operate their game units according to the following sequence of play:

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**FIGURE 5**

The Game Map

![Game Map](image)
Attacking Player Turn

- Attacker states task and purpose for the turn and writes orders for autonomous vehicles (if present)
- Attacker resolves artillery fire
- Attacker moves (and Defender takes opportunity fire against Attacker units)
- Both sides resolve close combat (if any)
- Attacker resolves direct fire.

Defending Player Turn

- Defender states task and purpose for the turn
- Defender resolves artillery fire
- Defender moves (and Attacker takes opportunity fire against Defender units)
- Both sides resolve close combat (if any)
- Defender resolves direct fire.

Cohesion

In the basic rules, cohesion limits dictate how far away elements of a unit (such as vehicles in a platoon) may be from each other; the maximum for the highest-quality troops is 800 m. In the baseline scenario, RCVs were assumed to be able to operate at distances from their OMFV controllers that were limited only by the range of their communications links (discussed earlier). In the AI/ML scenario, the RCVs were assumed to be able to operate at any distance from the OMFVs, subject only to preset limits, if any, that might be imposed by company commanders.

Target Priorities

In the basic ruleset, target priority rules dictate that, with certain exceptions, units must fire at the closest target. These rules reflect both the assumption that human-crewed systems will give priority to preserving themselves and limitations to battlefield knowledge. In the baseline scenario, the teleoperated RCVs were made subject to these same limits. However, in the AI/ML scenario, the autonomous RCVs were not subject to target priority limits—they could fire at any target at any range their AI targeting algorithms chose, subject only to limitations, if any, imposed a priori by the company commanders.

Quality

In FFT3, troop quality is used to determine whether units survive hostile fire; this reflects an assumption that more-experienced or better-trained troops have higher morale in the face of minor casualties and the idea that they may more effectively use terrain for cover against incoming fire. RCVs ignored morale effects and thus could not be suppressed or break under fire as a human unit might. As a result, they were somewhat more resilient to fire than a comparably protected vehicle might have been if it had a human crew. However, RCVs were more likely to be immediately knocked out by direct fire than similarly armored human-crewed vehicles because they were deemed not able to use terrain for cover as effectively. Additionally, in FFT3, higher-quality troops benefit from increased accuracy and rate of fire. In the AI/ML scenario, human-crewed vehicles were provided the equivalent of a one-level increase in troop quality for lethality purposes because of assumed zero latency in detecting targets and executing fires, enabled by high-quality sensors and AI-driven information fusion, even though those vehicles were not autonomous. In the baseline scenario, no vehicles received a quality bonus.

Capabilities and Limitations of Unmanned Aerial Systems

The small UASs in both the Red and Blue companies were treated as indicated by the FFT3 rules for and treatment of helicopters, with some modifications. RAND designers saw those rules as reasonably representative of UAS capabilities in light of other RAND work involving UASs supporting tactical ground combat operations. In both scenarios, the UASs had electro-optical and infrared sensors with ranges of several kilometers.

Fire against small UASs was allowed only by dedicated anti-air weapons, such as the Russian 2S6 self-propelled antiaircraft system, or by autocannons and machine guns at very close range. FFT3 does not include separate rules for small UASs; the team implemented a modification reducing the likelihood of hit by most weapons.

In the baseline scenario, each Blue UAS had to be linked to its parent vehicle and reported information
back to that vehicle with an effective communications (slant) range of 4 km. Situational awareness by the entire company had a latency of one turn. Thus, referees did not allow the remainder of the company to fire on UAS-observed targets until the next game turn. Both the Blue and Red UASs were programmed at launch to fly a route (pattern) or were controlled directly by the crew of the ground vehicle from which the UASs were launched.

In the AI/ML scenario, the Blue UASs were given orders to fly a mission by the company commander and operated independently, by themselves or in concert with other UASs. The Blue UASs provided updates to the entire Blue force—they could automatically retransmit among themselves and to Blue force vehicles, enabling communications beyond a single-link range of 4 km.

**Baseline Scenario Gameplay—Without AI/ML**

The baseline game used RO RCVs consistent with the concepts the Army indicates that it plans to pursue for fielding in the 2020s. The Blue objective in both the baseline and AI/ML games was to break through the Red position and, if possible, exit the map on the east edge. In both games, this was a challenging objective for Blue; it was chosen to drive the action and enable us to test the performance of the RCVs. In the baseline game, the Blue players operated consistent with the task organization for a future mechanized infantry company equipped with a platoon of four Abrams tanks, mechanized infantry platoon, and RCV platoon, as displayed in Figure 2. Figure 6 displays the initial disposition of both Blue and Red forces in this baseline scenario.

Blue’s overall strategy was to use the RCVs as armed reconnaissance to find Red’s main line of defense. When it was found, the Blue company’s four Abrams main battle tanks (MBTs) would be brought forward along the east-west road in the south to break through and contend with any Red MBTs. Blue moved its units in a bounding overwatch, wherein RCV-Ls would advance first, covered by RCV-Ms and OMFVs. Then the two groups of RCVs would switch roles. Figure 7 shows a closer view of Blue’s early disposition of its forces.

**FIGURE 6**

Initial Disposition of Forces in the Baseline Scenario
Red’s overall plan (determined by the Red players) was to turn the open area in the south of the map into a kill zone (see Figure 5), concentrating its forces in firing positions in cover on the edge of the area. Infantry were used as advanced screeners, and the northern road was lightly guarded. Red kept its MBTs in reserve to the rear of its forces in the south. Knowing that Blue possessed RO RCVs, before the battle, Red distributed its jammers on what it considered to be the most likely pathways for Blue’s advance. Red’s battle plan further called for Boyevaya Mashina Pekhoty vehicles (BMPs) to fire only at OMFVs or Abrams MBTs, leaving the RCVs to be engaged by Red’s infantry. Figure 8 displays the initial disposition of Red’s forces.

In the north, Blue’s advance was stymied by Red’s screening infantry, which proved effective against RCVs, although one of the RCVs did score a kill against a BMP that was waiting to fire on a tank or OMFV. Blue’s ability to use only four of its eight RCVs in combat at any given time inhibited Blue’s ability to concentrate its forces.

In the south, Blue’s ability to operate was degraded significantly by Red’s jammers. The jammers forced Blue to bunch up its vehicles, to keep the following RCVs close enough to the control vehicle to be able to move without having their communications links jammed. The situation deteriorated after Red’s UAS called down artillery fire, which took out a Blue RCV-M and, more importantly, one of the OMFV command vehicles, the only one on that axis of advance.

The game ended with Blue still bunched up on the southern crossroads, without a functional command vehicle, and confined on the northern road. Blue did not encounter Red’s main line of defense and did not bring its MBTs into combat effectively. Red did not see any reason to move its forces substantially out of their covered positions; it also did not commit its MBTs.

**AI/ML Scenario Gameplay—with Fully Autonomous RCVs**

The AI/ML game explored the use of fully autonomous RCVs capable of executing orders of limited complexity without human intervention. For example, autonomous RCVs could be ordered to move to...
a position and engage any non-Blue vehicles they encounter. (At the time of publication, DoD has no planned capability for fully autonomous engagement of enemy vehicles.) For the AI/ML game, both sides used some elements of their approaches in the baseline game. Blue continued using the same two roads as its principal avenues of advance and leading with its robotic units as armed reconnaissance. Red continued to place the bulk of its forces in the south and keep its MBTs in reserve. Figure 9 shows the initial disposition of forces in the AI/ML scenario. However, both sides also departed significantly from their play in the baseline game.

Relative to the baseline game, Blue decided to substantially reorganize its fighting force, breaking its units into four mixed-composition platoons divided between the north and south roads. The platoons consisted of one Abrams MBT, one OMFV, and three RCVs (either one RCV-L and two RCV-Ms, or two RCV-Ls and one RCV-M), with the remaining three OMFVs held in reserve behind the two platoons on the north road. Blue believed that its RCVs had ranged too far ahead of its other units in the first game, making Blue incapable of exploiting the knowledge of Red force disposition revealed by Red’s successful attacks on the RCVs. Although this reorganization was markedly different than the task organization the Army is considering, the Blue players considered that it would enable the now fully autonomous RCVs to be supported using MBTs on both avenues of advance, enabling Blue to respond to Red attacks on Blue’s RCVs with timely and effective counterfire. In particular, Blue also believed that it could dominate the battlefield if it were able to place the Abrams MBTs in key positions and take advantage of their substantial range and firepower. The reorganized platoons were designed to enable the MBTs to achieve those positions. Blue also considered it likely that the autonomous RCVs would be able to move and fire more effectively in this scenario.
Blue advanced much more rapidly than in the first game. However, Blue quickly ran into trouble after passing the southwestern crossroads when the three RCVs of that platoon advanced beyond the Abrams and OMFV. Three Red BMPs engaged the RCVs from cover and destroyed them all in a single volley of opportunity fire. Those BMPs quickly retreated to cover in the northwest in a forested area. Figure 12 shows the location of that attack.

Blue nonetheless continued its advance in the north, encountering no substantial opposition. Subsequent artillery fire destroyed another Blue RCV-M near the southwestern crossroads. Red decided to keep its infantry in hiding despite having close-range shots against the remnants of Blue’s first platoon in the south, which now consisted only of an Abrams MBT and an OMFV. Blue then fanned out its second platoon in the south along the edge of the open area. In the north, Blue sent one platoon down the road and—after intense debate—sent the second platoon down to the south to command the edge of the tree line. Figure 13 shows the disposition of forces after the Blue move.

Red again deployed its forces to take advantage of its infantry, which could stay undetected longer than its vehicles and which had weapons that were quite effective at close range against Blue vehicles. Red ceded most of the northern area of the map, defending the main east-west road with six infantry squads placed in ambushing positions deep within Red’s side of the map. Three more infantry squads were placed far forward at the intersection in the southwestern part of the map that had previously provided an opportunity to bunch Blue’s RCVs via jamming. Red’s vehicles were arrayed in the southern kill box and kept deep in cover. Red’s MBTs were kept far in reserve on the southeastern road. Red wanted to create an overwhelming firepower advantage around the southern kill box. Red also abandoned the strategy of having BMPs withhold fire against RCVs, considering the autonomous vehicles to be potentially more effective and dangerous. Figure 11 shows a closer view of Red’s initial disposition of forces in this scenario.

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FIGURE 10
Initial Disposition of Forces in the AI/ML Scenario: Blue

Mixed-composition
platoons north and south

FIGURE 11
Initial Disposition of Forces in the AI/ML Scenario: Red
Red kept its forces arrayed on the edge of the southern open area 100 meters back in concealment. Along the northern road, Red conducted an ambush against Blue's advancing platoon. The ambush destroyed an RCV-L, an RCV-M, and the Abrams MBT. Blue return fire killed two infantry squads. At the southwestern crossroads, Blue dismounted one infantry squad, which flushed a Red infantry squad from cover. Red infantry killed the Blue infantry and the OMFV but the Red infantry was killed by the Abrams MBT.

The game ended with Blue's attack along the northern road substantially disrupted. However, Blue had three MBTs in position to command the large open area in the south, where Red’s forces were concealed. Blue was probing with RCVs to try to flush the Red forces from that concealment. Red was considering whether to send its MBTs to clear out the remains of Blue’s platoon on the northern road and then drive south to attack Blue on its left flank.

**Observations**

The two games are insufficient to yield definitive and generalizable conclusions about AI/ML systems. Nonetheless, the experiment did suggest some preliminary observations about both AI/ML and the utility of wargames employing it that could be useful to planning and executing subsequent games.

**Observations About AI/ML**

**RO RCVs Had Distinct Disadvantages That Were Easily Exploitable Relative to Fully Autonomous RCVs and Manned Vehicles**

In the baseline game, the need to maintain unobstructed and unjammed line-of-sight communications to the RO RCVs imposed significant constraints on Blue forces, slowing the pace and complicating the management of Blue’s advance. In particular, Red’s effective use of backpack jammers (placed before the battle) substantially limited Blue’s ability to use the RCVs. Blue was also limited in the number of RO RCVs it could commit to action at any time by the OMFVs’ ability to command only two RCVs each—which prevented Blue from massing RCVs against a Red position. And because Blue needed OMFVs to maintain control of the RO RCVs, Blue had to protect the controller OMFVs because Blue’s primary concern had to be keeping its OMFVs alive. If the baseline game had continued, Blue’s loss of one OMFV to artillery fire would have crippled its southern advance. In contrast, during the AI/ML game, as one player stated, “AI vehicles fight like crewed vehicles; they are just easier to lose because there are no people.” In the AI/ML game, we observed that the players never demanded that the autonomous vehicles carry out complex orders. Thus, the autonomous vehicles never failed to do what the players wanted. In different scenarios (e.g., more-dynamic scenarios or those taking place in more-complex terrain), the operation of the autonomous vehicles might have been more severely challenged. Nevertheless, more gaming of combat operations in complex terrain, for example, would be helpful to explore how the human commanders might make good use of the limited abilities of the AI.

We identified the following hypothesis for future study: The need to maintain unobstructed and unjammed line of sight to RO combat vehicles is a significant limitation subject to exploitation by an enemy.

**RCVs Were Used as Armed Reconnaissance, and Often Explicitly as Bait**

In both games, RCVs were always the first vehicles Blue moved forward and the first to take direct fire. In the baseline game, Red decided initially to not engage RCVs, thereby not revealing its forces and enabling them to wait to engage more important targets. However, in the AI/ML game, Red discarded that tactic given its view that the offensive capability of the autonomous RCVs was clearly greater than that of the RO RCVs. Based on player comments, our hypothesis is that the RCVs, whether RO or completely autonomous, were used as bait because doing so did not put soldiers at risk. Moreover, loss of the RCVs seemed, at least initially, to not cause Blue substantial regret because the RCVs’ offensive capabilities (especially those of the RCV-Ls) were limited, compared with those of the OMFVs and MBTs. When and why RCVs would be viewed and employed
by players as essentially disposable could be one question or hypothesis worth examining in future games. The cost of RCVs is uncertain; however, it seems clear that for RCVs to be used in combat as essentially disposable bait, they must be readily available in the arsenal, which in turn suggests that their cost must be low. It could also be worthwhile to conduct games in which players are informed that RCV costs or availability are not such that the vehicles should be viewed as disposable. If such games awarded points for the accomplishment of each side’s objectives, they could award points for the destruction of the RCVs to try to get the players to internalize the costs and availability of the vehicles.

We identified the following hypothesis for future study: When players are informed that RCV inventories are limited (presumably owing to relatively high RCV costs), they will be less likely to quickly expose the RCVs to enemy fire. Alternatively, they might work harder with other sensors to find the enemy before committing the RCVs.

**Relatively Limited Intelligence, Surveillance, and Reconnaissance Capabilities and Indirect Fires Allowed Red to Remain Static**

One Red player compared this game to other games conducted for the Army, which were dominated by postulated sophisticated future intelligence, surveillance, and reconnaissance (ISR) capabilities and extremely lethal indirect fires. He stated, “If there were significantly more ISR, we would be doing this very differently. Everything would be moving. But there’s not that capability, so not a huge reason to move.” The relatively limited ISR capabilities provided by Blue UASs enabled concealment for Red, and Red prevailed in several cases by being the first to fire from that concealment. Of course, the counterargument to this is that past wars (e.g., World War II) in which ISR capabilities were limited.
still saw troops advancing toward concealed enemy forces.

We identified the following hypothesis for future study: Ubiquitous, advanced ISR and readily available indirect fires will compel enemy forces to exit concealment and engage.

Observations About the Game

Playing with an Open Board Affected the Decisionmaking of the Players

The adjudicators advised the players to play as if they could not see the enemy markers. However, this advice—often given—was not always followed. Players continuously made reference to markers that they were not supposed to be able to see and made decisions that were explicable only by their knowledge of the opposing side’s disposition of its forces. For example,

- the Blue players decided to dismount infantry to flush out concealed Red infantry that they ostensibly did not know were close to

Blue’s forces. A Blue player explained that he had done so because the area was a likely spot for Red infantry. The Blue player did not explain why he did not dismount in almost identical areas that did not have Red infantry. Furthermore, the Blue players in the second game kept their UASs just out of range of a Red 2S6. They did so despite the fact that their lack of ISR prevented them from calling for indirect fires and despite the fact that their ground units advanced past their UAS support.

- Red players in the second game were content to keep their MBTs in reserve in the south. This decision was influenced by the fact that the Red players knew that Blue was diverting a second northern platoon to the south, leaving only one Blue platoon to advance along the northern road.

Playing a double-blind game would have eliminated this issue but was precluded for this effort because of resource limitations (it can take consid-
Conclusions

Using the FFT3 commercial wargame as a basis, the researchers demonstrated how postulated AI/ML capabilities could be incorporated into a tactical ground combat wargame. We modified and augmented the FFT3 rules and engagement statistics to enable (1) postulated fully autonomous combat vehicles and (2) vehicles with AI/ML–enabled situational awareness to show how the two types of vehicles would perform in company-level engagement between Blue (U.S.) and Red (Russian) forces. The augmented rules and statistics we developed for this wargame were based in part on the Army’s evolving plans for developing and fielding robotic and AI/ML–enabled weapon and other systems. However, we also included fully autonomous combat vehicles able to detect, identify, and engage targets without human intervention, which the Army does not currently envision. Our rules sought to realistically portray the capabilities and limitations of those systems, including their vulnerability to selected enemy countermeasures, such as jamming. Future work could improve the realism of both the gameplay and representation of AI/ML–enabled systems. Throughout both games, players on both sides discussed the capabilities and limitations of the RO and fully autonomous systems and their implications for engaging in combat using such systems. These discussions led to changes in how the systems were employed by the players and observations about which limitations should be mitigated before commanders were likely to accept a system (e.g., the susceptibility to jamming of RO RCVs) and which capabilities needed to be fully understood by commanders so that systems could be employed appropriately (e.g., the limitations on the complexity of the orders that could be provided to fully autonomous RCVs). This research demonstrates how such games, by bringing together operators and engineers, could be used by the requirements and acquisition communities to develop realizable requirements and engineering specifications for AI/ML systems.

Conducting a Preliminary Shakedown Game Would Have Been Useful

A shakedown game (that is, a practice game meant to familiarize players with the rules and the available systems) would have enabled the players to familiarize themselves with the terrain and understand the capabilities and limitations of the postulated future systems used in the game. (The game design team ran shakedown games to test the game rules and the scenario but without the players.) During both games, but particularly the first, there was much discussion and debate among the players and adjudicators regarding the capabilities and limitations of the RCVs, OMFVs, and AI/ML–enabled rapid dissemination of information. While valuable, this discussion slowed game progress and could have been prevented through the use of a shakedown game. However, resource limitations precluded conducting a shakedown game. Nonetheless, the game was helpful in educating players, generating insights about potential concepts of employment, and generating requirements for future weapon systems and platforms.
Notes

1 TOWs are tube-launched, optically tracked, wireless-guided missiles.

2 This capability is arguably inconsistent with Department of Defense Directive 3000.09, 2017.

3 Therefore, modeling the firepower, mobility, and protection of the OMFVs and RCVs was secondary to developing rules for vehicle command and control.

4 In our games, only the attacker (Blue) possessed autonomous vehicles.

5 This indicates a dilemma that the Red force faced when engaging the RCVs; although the RCVs presented a potentially lethal threat to some Red vehicles, they were less lethal than the heavier human-crewed fighting vehicles available to Blue. Firing on RCVs, although usually effective at knocking them out, did less to neutralize Blue combat power than firing on the OMFVs or MBTs, and, if Blue was postured well, firing on the RCVs would give up Red fighting vehicle locations and expose them to direct and indirect fire before Blue units were close enough to be engaged effectively.

6 This was in part because of a second member of the Blue team assuming command of Blue in that round.

References


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About This Report

In this report, researchers experimented with how postulated artificial intelligence/machine learning (AI/ML) capabilities could be incorporated into a wargame. We modified and augmented the rules and engagement statistics used in a commercial tabletop wargame to enable (1) remotely operated and fully autonomous combat vehicles and (2) vehicles with AI/ML–enabled situational awareness to show how the two types of vehicles would perform in company-level engagement between Blue (U.S.) and Red (Russian) forces. The augmented rules and statistics we developed for this wargame were based in part on the U.S. Army’s evolving plans for developing and fielding robotic and AI/ML–enabled weapon and other systems. However, we also portrayed combat vehicles with the capability to autonomously detect, identify, and engage targets without human intervention, which the Army does not presently envision. The rules we developed sought to realistically portray the capabilities and limitations of AI/ML–enabled systems, including their vulnerability to selected enemy countermeasures, such as jamming. Future work could improve the realism of both the gameplay and representation of AI/ML–enabled systems, thereby providing useful information to the acquisition and operational communities in the U.S. Department of Defense. The research reported here was completed in September 2020 and underwent security review with the sponsor and the Defense Office of Prepublication and Security Review before public release.

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For more information on the Acquisition and Technology Policy Center, see www.rand.org/nsrd/atp or contact the director (contact information is provided on the webpage).

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