Developing a Light Infantry-Robotic Company as a System

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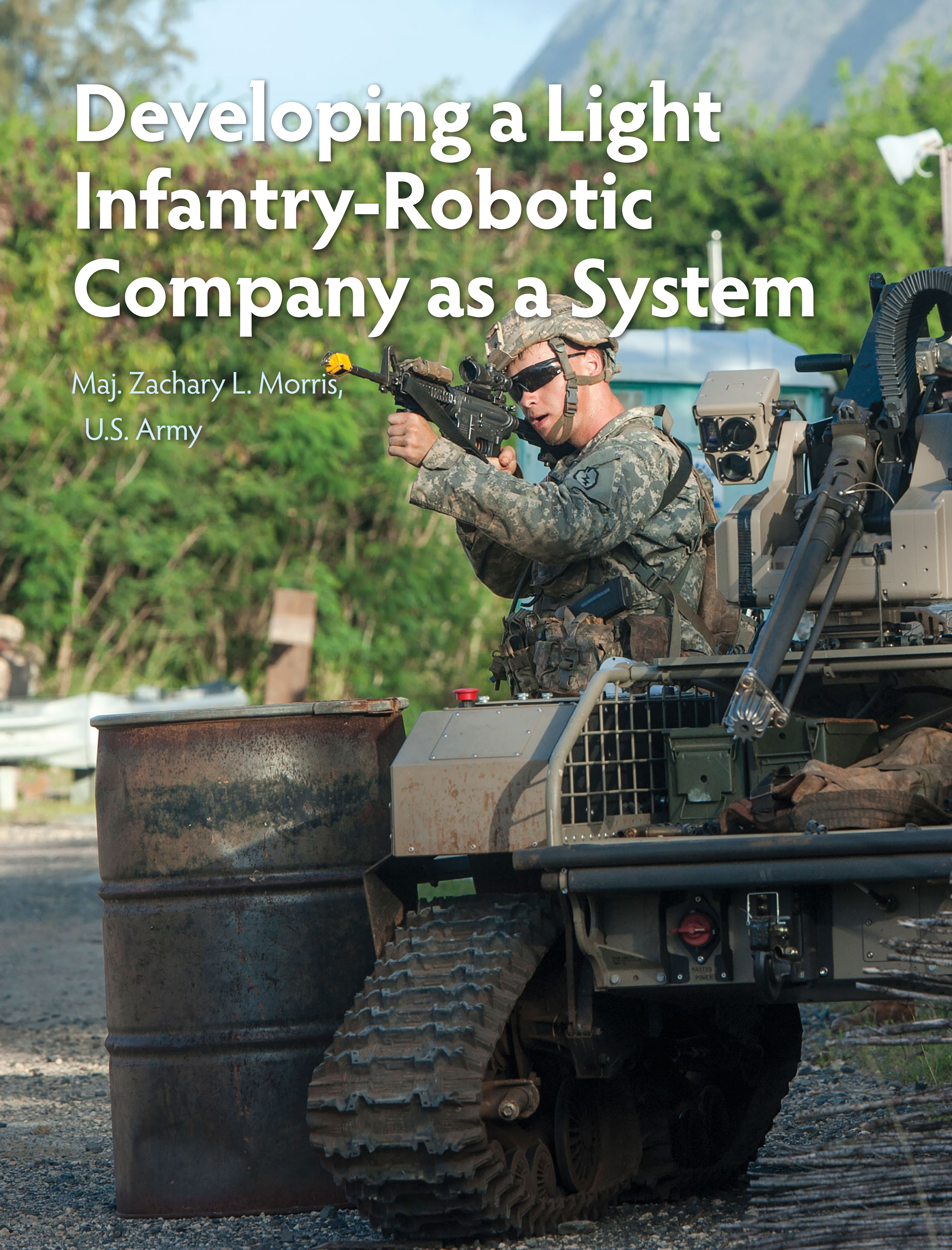

Substantial changes are altering the future operating environment. Lethal autonomous weapon systems (LAWS) are likely in a developmental phase similar to combat aviation before World War I. Within a decade, aircraft experienced exponential growth in combat capability, increasing speed, power, firepower, maneuverability, and endurance.[1] A simplified explanation of Moore's law states "processor speeds, or overall processing power for computers, will double every two years."[2] Depending on the historical accuracy of Moore's law, autonomous and robotic weapons could improve dramatically in the near future.

Gen. Mark A. Milley, chief of staff of the U.S. Army, described a potential future environment as highly lethal, requiring constant maneuver, dispersion, and speed; involving extremely capable forces in complex urban terrain; constraining U.S. frontline resupply capability; and degrading typical American advantages such as communications and networked technologies.[3] To meet the challenges of such a future environment, the *U.S. Army Robotic and Autonomous Systems Strategy* identified five critical capability areas: increase situational awareness, lighten the soldiers' physical and cognitive loads, sustain the force, facilitate movement and maneuver, and protect the force.[4] The U.S. Army should conceptually visualize how units could maximize these critical capabilities as well as organize and fight by using LAWS in a complex future environment.

LAWS could substantially increase light infantry unit capabilities. This article argues that the U.S. Army should develop a light infantry-robotic company (LIRC) as a system—integrating controlled LAWS and human capabilities—in the near future. The first section explains how the U.S. military should incrementally increase LAWS authority and capability. The second section develops a LIRC organization, conceptually based on the Stryker infantry company configuration. The final section depicts a potential LIRC tactical enabling concept using a movement to contact scenario.[5]

Previous page: U.S. Army Pacific soldiers from 2nd Battalion, 27th Infantry Regiment, 3rd Brigade Combat Team, 25th Infantry Division, move forward toward a simulated opposing force with a Multipurpose Unmanned Tactical Transport 22 July 2016 during the Pacific Manned-Unmanned Initiative at Marine Corps Training Area Bellows, Hawaii. (Photo by Staff Sgt. Christopher Hubenthal, U.S. Army)

Phase I and Phase II of Autonomous Weapons Development

Ethical considerations, primarily target discrimination and responsibility concerns, and dubious American confidence in autonomous systems are the largest obstacles confronting autonomous weapons.[6] Incrementally increasing autonomous weapons authority and capability—using iterative learning, experimentation, and fielding—is necessary to increase American confidence in these systems and to ensure the ethical application of autonomous weapons.[7]

The U.S. military is currently in the first phase of autonomous weapons development. This phase maximizes discrimination and responsibility by limiting weapons to semiautonomy; capable only of targeting weapons, projectiles, or other autonomous systems.[8] The current Department of Defense directive states "human-supervised autonomous weapon systems may be used to select and engage targets, with the exception of selecting humans as targets," in defense of a static position or "onboard defense of manned platforms."[9] This policy limits autonomous weapons by engaging "materiel targets" only.[10] It essentially approves already employed weapon systems, such as the AEGIS combat system on manned cruisers and destroyers, designed to defend against incoming high-speed projectiles and missiles.[11] Thus, semiautonomous weapons remain completely within the control of military personnel and limit violations of discrimination. However, restricting autonomous targeting authority significantly constrains development and military utility for most maneuver units.

Phase two described below is the next ethical step that advances autonomous weapons and U.S. military capabilities while maximizing target discrimination and responsibility. Phase two begins by experimenting with controlled fully autonomous weapons; autonomous weapons can engage human targets in limited situations complying with discrimination and clear responsibility. For example, commanders would arm the autonomous weapon and control engagements based on target type, time period, geographic area, rules of engagement, and weapons control status—such as hold, tight, or free (see note for definitions).[12]

In this phase, fully autonomous engagements should emphasize targets unmistakably identified as belonging to a hostile military. The primary way to achieve target clarity, based on current technology, means restricting autonomous systems to targeting military vehicles, such as armored vehicles and aircraft. For example, the Army could employ autonomous weapons for air defense, antiarmor, artillery, and other vehicle or target-specific (such as grid location) requirements because technology (such as radar, thermal and visual shape recognition, and other sensors) could enable autonomous weapons to likely identify and target enemy vehicles adequately to meet or surpass human discrimination requirements now.

On the other hand, autonomous weapons should remain heavily constrained from attacking individual humans due to current technological limitations on distinguishing types of human targets. However, by using a free-fire area within a geographic kill box or sector of fire, commanders could enable engaging human targets in a tightly constrained time and area in which only hostile military targets are known to be present. These limitations and constraints for phase two are probably achievable now, or in the near future, also ensuring discrimination and clear responsibility for autonomous weapons. Further, transitioning into phase two could radically improve combat power for maneuver formations, particularly a light infantry company.

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The Future Organization for a Light Infantry-Robotic Company

The future LIRC team should conceptually mirror the Stryker infantry company organization (see figure 1, page 22).[13] Soldiers marked "DVR" (or driver) in figure 1 are the primary operators, as needed, of the unmanned ground vehicles (UGVs) and unmanned aircraft systems (UASs).[14]

The headquarters element is designed to operate in two or more dispersed locations providing survivable command, control, communications, and intelligence across the LIRC. Each command element could include the commander, first sergeant, or executive officer, one fire support team, and one or two members of the intelligence, surveillance, and reconnaissance (ISR) team. Thus, each command section would contain two command UGVs, two ISR UASs, and one large quadcopter UAS.[15] The medical evacuation team, capable of autonomously evacuating four litter and two ambulatory casualties, could position itself as the mission requires. Organized in this manner, the LIRC headquarters could operate effectively from two (potentially up to four) locations. Further, this organization gives the LIRC commander considerable flexibility, redundancy, survivability, and targeting options.

The mortar section and heavy weapons platoon further increase the LIRC's firepower and targeting range. The mortar section now includes two 120 mm mortar UGVs, one equipment carrying UGV, and an autonomous attack UAS. The heavy weapons platoon includes four heavy weapons UGVs and an equipment carrying UGV.[16] These systems could increase the LIRC's indirect fire range out to approximately twenty kilometers, direct fire ranges to approximately three kilometers, and air defense range to ten kilometers.

The proposed LIRC includes three platoons organized as depicted in figure 2 (on page 23). The basic platoon headquarters and squad sizes are retained, because these formations are effective for light infantry operations and retain critical capabilities even if LAWS are unavailable for a specific mission. These platoons would consist of three rifle squads; however, each squad should add a small quadcopter UAV for ISR capability. The platoon headquarters would

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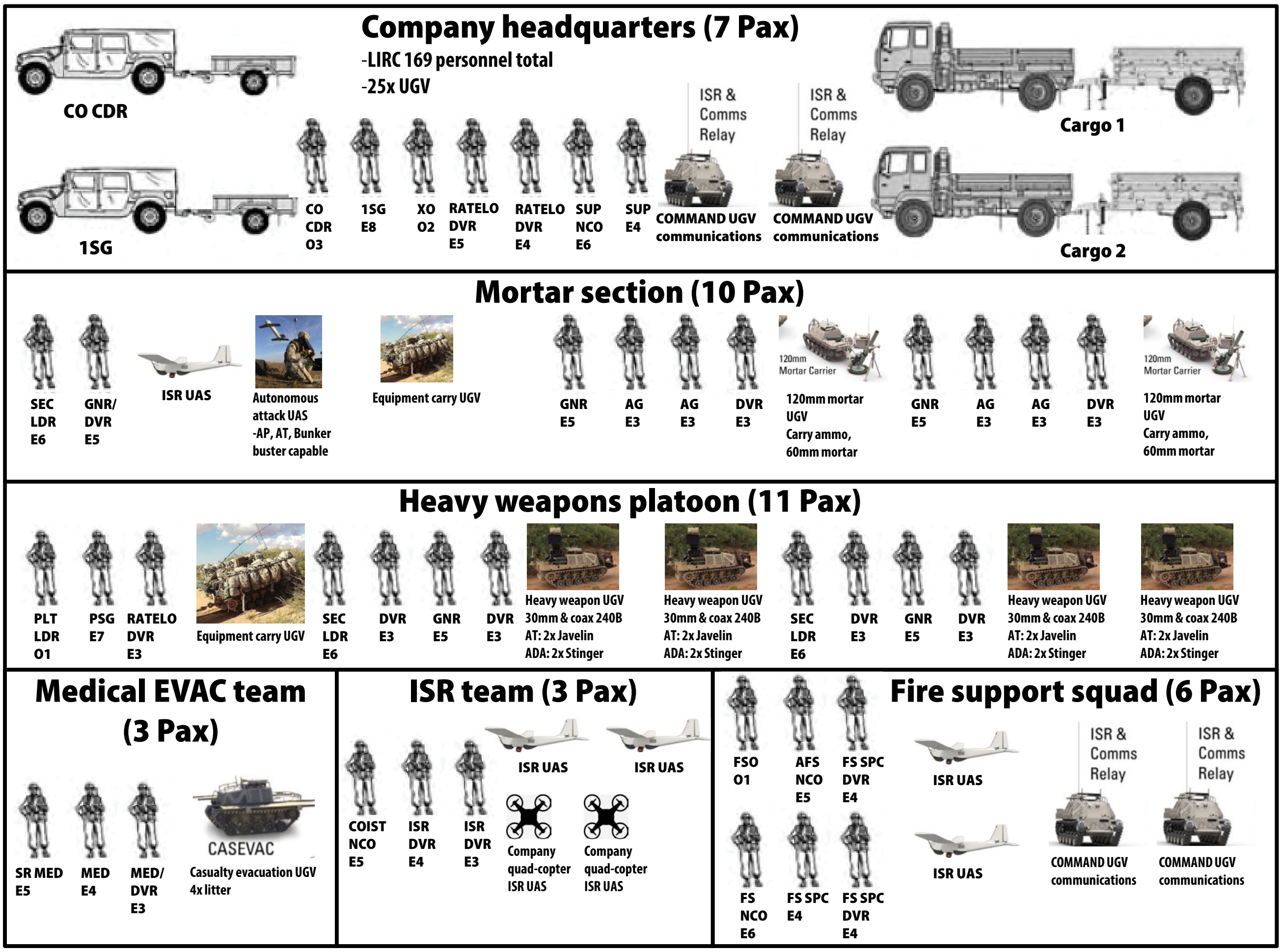


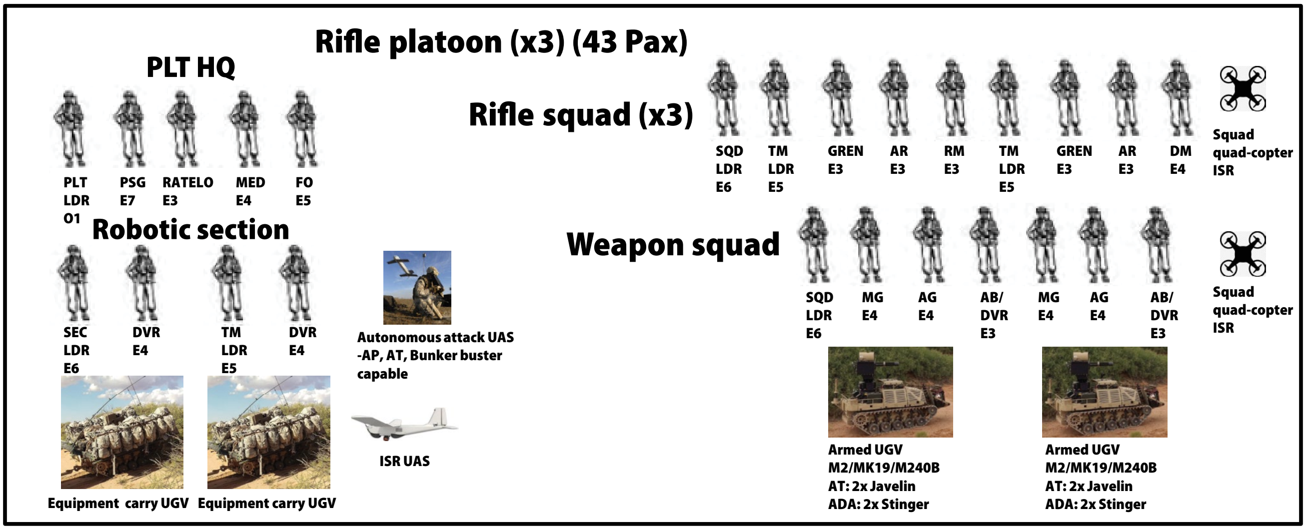
(Figure by author)

Figure 1. Organization of a Light Infantry-Robotic Company Headquarters

generally mirror most infantry platoon headquarters, but it would include a four-man robotic section to manage the platoon's two equipment carrying UGVs, ISR UAS, and autonomous attack UAS. Finally, the weapons squad would retain dismounted capability while adding two-armed combat UGVs (and in the future, as autonomy and capability increases, possibly four) capable of employing one machine gun, two antitank missiles, and two air defense missiles.[17] This organization would retain the size and capability of current infantry platoons, while greatly reducing the soldier's combat load, and increasing protection, situational awareness, and firepower.

The U.S. Army should not develop a LIRC larger than the organization described here until autonomy and artificial intelligence improves significantly for two reasons. First, a larger organization would likely exceed the command and control capabilities of many company grade officers and noncommissioned officers in a combat environment. The Stryker company is the largest current U.S. maneuver infantry company; exceeding the size of a Stryker organization would likely diminish tactical improvements due to the challenges of controlling a large organization in combat. Likewise, further increasing autonomous system numbers could reduce a unit's command and control effectiveness. Second, a larger organization could significantly reduce strategic mobility and strain maintenance and logistics for a light unit. Strategic lift, maintenance, and logistics are vital concerns for the Army, and any future unit must work within these constraints somewhat.[18] The LIRC described above would already increase mobility and logistical strains; further expansion would likely exacerbate these issues. Thus, any alterations from the organization explained above should probably reduce the size, not enlarge the LIRC.

While a smaller organization is better than a larger unit, a smaller LIRC would have several weaknesses. Smaller units would probably fail several Army autonomous objectives, such as increasing situational awareness, lightening soldiers' physical loads, facilitating movement and maneuver, and protecting the force.[19] The best way to reduce the LIRC size would likely include removing the rifle platoon's armed combat UGVs and some of the begins when an enemy force seizes Columbus, a small city in allied Baltenning, during a crisis. Enemy forces quickly reposition southward while consolidating around Columbus and attempting to use the crisis for political gain. The LIRC is part of a rapidly deployable infantry brigade, arriving at the Baltenning-held Fryar Drop Zone (FDZ) within seventy-two hours of the enemy attack. The LIRC's mission is to clear from the line of departure



(Figure by author)

Figure 2. Organization of a Rifle Platoon

ISR UASs. However, these size reductions are limited and could significantly reduce the company's situational awareness, force protection, and firepower; other reductions could have more drastic impacts. Fewer UASs would diminish the LIRC's situational awareness, intelligence gathering capabilities, and tactical and operational targeting ability. Removing the heavy weapons platoon would significantly reduce the LIRC's firepower and force protection, and limit the potential for overmatch capabilities.[20] Finally, decreasing equipment-carrying UGVs would inhibit movement and maneuver, and sustain current excessive individual soldier equipment loads. Thus, while smaller organizations are better than oversized formations, significantly smaller units could limit many potential tactical and operational improvements.

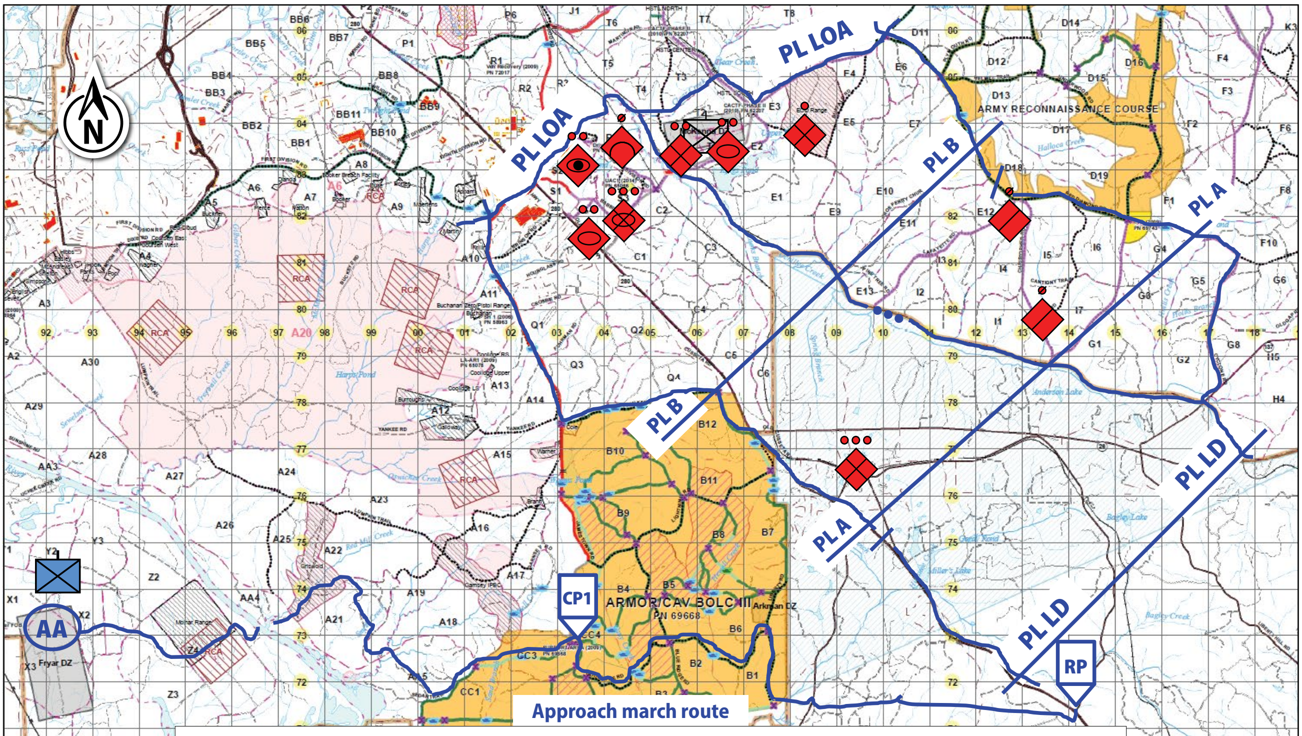
Light Infantry-Robotic Company Movement to Contact Tactical Concept

The following is a notional employment of the LIRC to illustrate a concept of employment. The situation (LD) to the limit of advance (LOA), identified as phase line (PL) LD and PL LOA, respectively, in order to secure a foothold in Columbus and protect FDZ to enable arrival of follow-on units (see figure 3, page 24).[21]

The expected enemy unit consists of two light infantry platoons; an armor platoon of four T-72B3M main battle tanks (MBTs); a mechanized infantry platoon, including three BMP-3 infantry fighting vehicles (IFVs); two self-propelled artillery vehicles; and one air defense vehicle.[22] Also, civilians are present on the battlefield, especially in the vicinity of the expected enemy main line of defense in the southern outskirts of Columbus. Further, Baltenning forces are currently unable to participate in the attack while they rebuild defensive positions.

After completing preparation and information updates, the company departs the assembly area (AA). The company uses the designated approach march route, fording the Chattahoochee River and passing checkpoint 1 (CP1) before reaching the release point (RP). (See figure 4, page 25, for a visual representation of the movement.) During the movement, units are dispersed to protect the force from enemy observation, air attacks, and indirect fire. The UGVs each carry equipment, food, water, fuel, and ammunition supplies for twenty-two soldiers. These equipment-carrying UGVs reduce the average soldier physical load from 120–150 pounds to approximately 50 pounds.[23] All UGVs use a communications are available. At CP1, within fifteen kilometers of the area of operations, the company becomes self-sufficient for ISR and information gathering.

After passing CP1, the company begins gathering organic information and targeting data. The company saturates areas of interest using autonomous UASs, capable of flying independent recon routes and tracking multiple



Legend

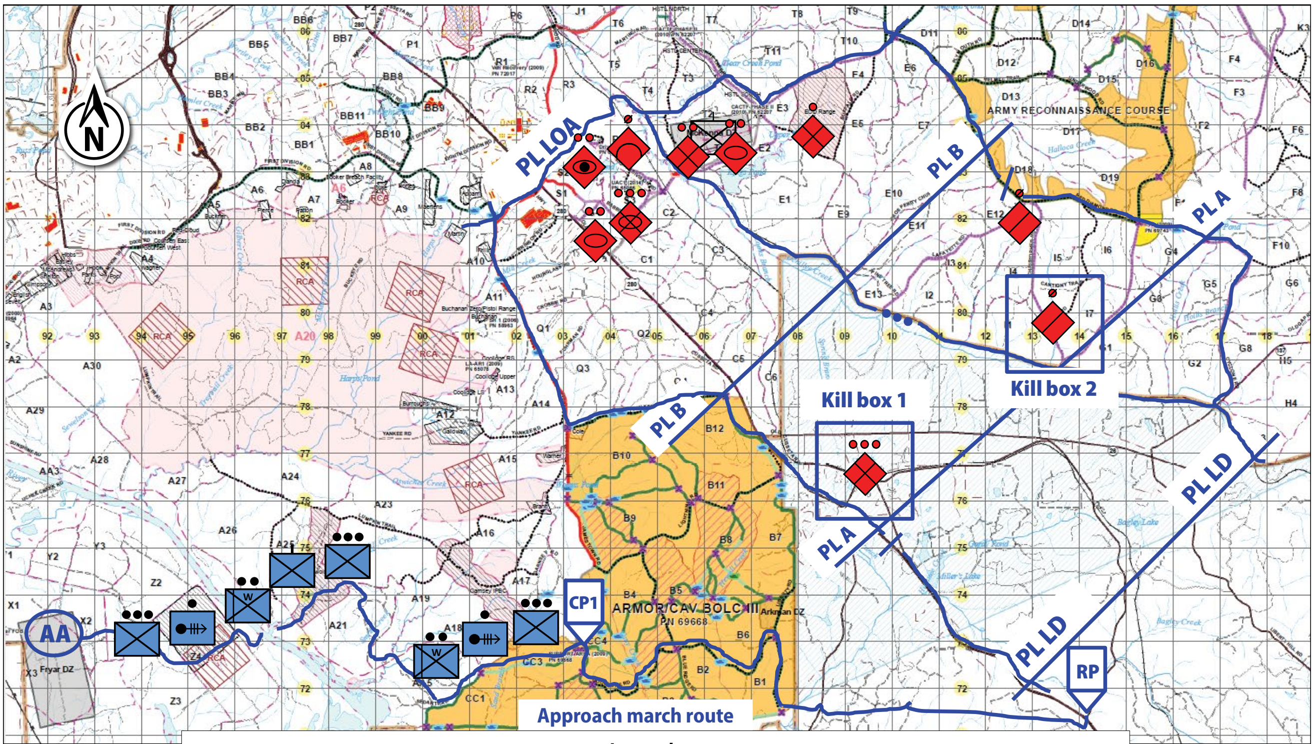
AA—Assembly area
CP—Checkpoint
PL A—Phase line alpha
PL B—Phase line bravo
PL LD—Phase line line of departure
PL LOA—Phase line limit of advance
RP—Release point

(Figure by author)

Figure 3. The Situation

leader-follower function to maintain proper formation, speed, route, and position behind a designated human operator, leaving the infantryman to find the best route and maintain situational awareness.[24]

Squads employ quadcopters around each platoon during the movement, providing 360-degree situational awareness. Autonomous ground attack weapons operate on a weapons hold status, requiring humans in the loop for any engagement. Air defense autonomous weapons operate in a weapons tight status, able to engage any enemy air platform independently within ten kilometers. From the AA to CP1, the company receives updates on the situation from higher headquarters as long as vehicles or groups of people. Platoon assets search the initial objective areas, from PL LD to PL Bravo (PL B), pinpointing enemy positions and movement. Company-level assets—the ISR, mortar, and fires section—scan for deep targets around the enemy main defensive line between PL B and PL LOA. Using small dismounted situational awareness video receivers, each element can observe any encrypted UAS video, greatly improving the company's situational awareness.[25] The ISR team uses one command UGV to manage all the ISR video links and pass critical information to higher, adjacent, and subordinate units. One critical task involves confirming zero civilians present in kill boxes 1 and 2 (see figure 4, page 25). Once



Legend

AA–Assembly area
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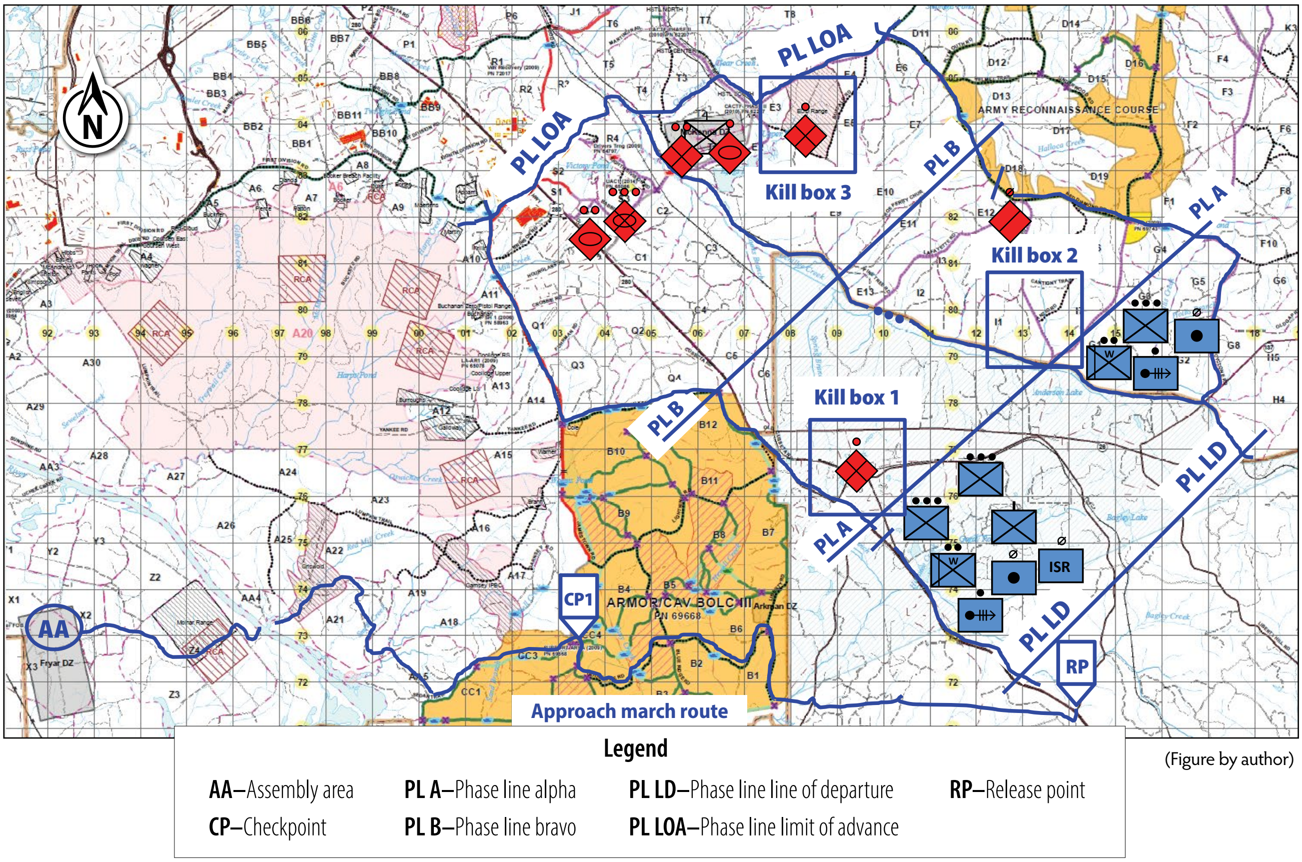
(Figure by author)

Figure 4. Movement

confirmed, the company establishes both kill boxes and authorizes independent autonomous weapons engagement against human targets within both geographic areas. After completing the approximately twenty-five-kilometer approach march and arriving at the RP, platoons disperse to their assigned zones across PL LD.

Prior to crossing PL LD, the company initiates the disruption phase of the operation. Autonomous weapons transition from a weapons hold status to a weapons tight status, able to engage any enemy military vehicle within the company's boundaries. Further, autonomous weapons may engage human targets within established kill boxes. However, autonomous weapons still require humans in the loop to engage other enemy personnel, ensuring proper target discrimination. The company fires multiple autonomous attack UASs with antitank and antipersonnel capabilities. The systems are fired from each of the three line platoons and mortar section. Attack UAS target either kill boxes 1 or 2, or areas already observed by ISR platforms during the approach march. Each weapon receives engagement priorities for enemy vehicles, such as air defense vehicles, indirect fire vehicles, MBTs, IFVs, and armored personnel carriers. These systems use thermal and shape recognition software to distinguish between enemy military and civilian vehicles. Using autonomous weapons prevents signal jamming and cyberattacks after launch because of the weapons independent nature.

Simultaneously, the mortar section engages enemy positions between PL A and PL B using precision-guided munitions and conventional warheads. After the initial strike, the company employs ISR platforms to confirm: one air defense vehicle, one artillery piece, and two IFVs destroyed; twelve enemy casualties in kill box 1; and two enemy dead in kill box 2. Approximately 50 percent of the autonomous systems fail due to enemy countermeasures, including active defenses, rapid movement, camouflage, and decoy vehicles.[26] As the LIRC crosses PL LD, a second autonomous attack UAS strike destroys one MBT, the



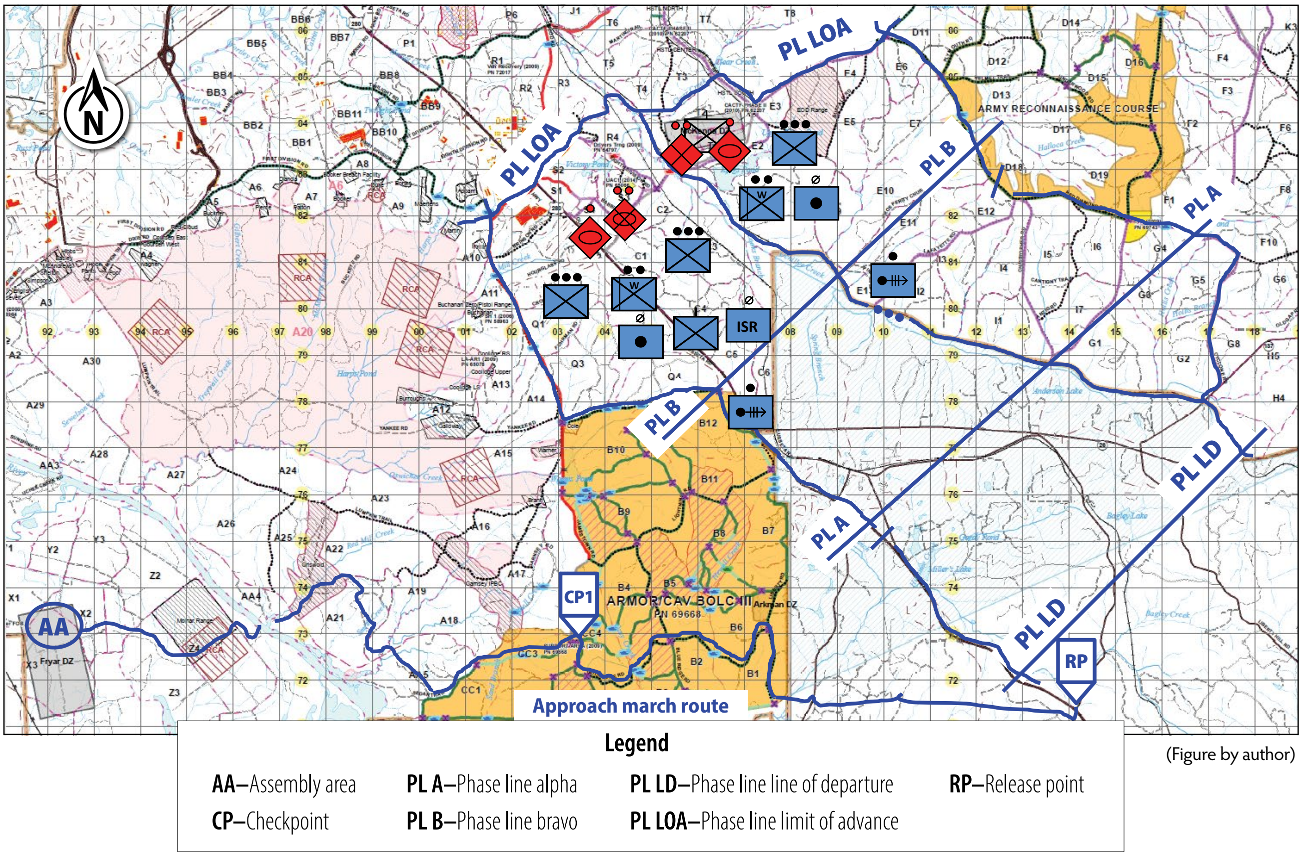
(Figure by author)

Figure 5. Assault Line of Departure to Phase Line Bravo

last artillery piece, and inflicts five additional casualties in kill box 1. See figure 5 for a visual representation and updated enemy situation.

Upon crossing PL LD, the company conducts target handover, allowing squad quadcopters to track enemy positions between PL LD and PL B. In the eastern sector, the remaining enemy recon team withdraws. Further, the executive officer confirms no civilian presence in kill box 3 and establishes it (see figure 5). Autonomous attack UASs and 120 mm mortars begin destroying the enemy squad in kill box 3 while the company advances. In the western sector, the company makes contact using the smallest element possible—usually a single UGV—because of accurate situational awareness created by the ISR network over the area of operations. Four armed UGVs enter kill box 1 to destroy or suppress remaining enemy humans while one infantry platoon envelops the position. The commander disables kill boxes 1 and 2 before any friendly humans enter the area, restricting autonomous weapons engagement authority to enemy vehicles only. Once restricted, the UGVs continue autonomously scanning sectors of fire using sensors to detect human or vehicle targets. As the UGVs lock onto sequential targets, human operators command the UGVs to either engage or move on to the next target within their sector of fire. Because of the UGVs stabilized autonomous weapons and programming, they are capable of incredible accuracy and lethality, similar to a common remotely operated weapon station (CROWS) system.[27] Thus, by the time infantrymen attack through the enemy positions, most enemy soldiers are already casualties or suppressed and unable to respond to attacking humans.

As the company crosses PL B, it employs all systems to further degrade enemy leadership and combat power. The 120 mm mortar fire and autonomous attack UASs shape the battlefield by forcing the enemy to constantly reposition, further exposing them to attacks. Long-range engagements also open seams between positions and reveal exposed flanks for the company to isolate and attack. The autonomous UGVs move forward with local infantry support and engage the remaining three MBTs and the lone IFV using antitank missiles. Three UGVs are destroyed during this engagement; however, the IFV and one MBT are also destroyed (see figure 6). The two remaining MBTs withdraw north into Columbus. Infantrymen, using suppressing fire from UGVs and information from ISR systems, isolate and destroy enemy infantry units. As air defense threats and availability allow, the company employs close-air support and close-combat attack aircraft to engage additional enemy targets. Once the enemy retreats, the company continues using indirect fire and close-air support to pursue and disrupt enemy units. The company then consolidates, moves up supply UGVs, conducts casualty evacuation, and establishes a defensive line along PL LOA.



(Figure by author)

Figure 6. Final Assault Phase Line Bravo to Phase Line Limit of Advance

Conclusion

Historian Michael Howard observed, "No matter how clearly one thinks, it is impossible to anticipate precisely the character of future conflict. The key is not to be so far off the mark that it becomes impossible to adjust once that character is revealed."[28]

Attempting to visualize the future battlefield and environment is one of the Army's sacred duties.[29] The U.S. Army should create more concrete visualizations of the future battlefield and incorporate potential LAWS. The military, and especially light infantry community, must move with a sense of urgency in the autonomous weapons field because "adversaries are developing and employing a broad range of advanced" autonomous "technologies as well as employing new tactics to disrupt U.S. military strengths and exploit perceived weaknesses."[30] In the future, adversaries' LAWS could significantly threaten American infantrymen, and U.S. systems could drastically improve the combat capability of infantry formations.

The Army should transition LAWS to phase two, thereby increasing authority and capability while maintaining ethical standards and developing U.S. confidence in autonomous systems. A Stryker company provides a good organizational model for the future LIRC. This organization could achieve the *U.S. Army Robotic and Autonomous Systems Strategy* objectives and goals. Further, the LIRC could achieve many of the *U.S. Army Operating Concept* objectives, such as improving mobile protected precision firepower, lethality and effects, protection, and situational understanding.[31] In fact, the *Army Operating Concept* recognized that "autonomy enabled systems will deploy as force multipliers at all echelons from the squad to the brigade combat team."[32] The U.S. Army must not avoid the risk of lethal autonomous weapons and develop units that recognize and leverage these potential capabilities across all levels while taking prudent risks.[33] Without developing these forces, the U.S. military may find itself at a significant disadvantage in the next conflict. ■

The views in this essay are the author's own and do not reflect those of the U.S. Army or Department of Defense.

Notes

1. T. Dugdale-Pointon, "A Brief History of Air Warfare," HistoryOfWar.org, 30 March 2007, accessed 12 March 2018, http://www.historyofwar.org/articles/wars_airwar.html.

2. "Moore's Law: Or How Overall Processing Power for Computers Will Double Every Two Years," Moore's Law, accessed 12 March 2018, http://www.mooreslaw.org/.

3. Mark A. Milley (speech, Dwight David Eisenhower Luncheon Speech, Association of the United States Army Annual Meeting, Washington, DC, 4 October 2016), Defense Video Imagery Distribution System, accessed 12 March 2018, https://www.dvidshub.net/video/485996/ausa-2016-dwight-david-eisenhower-luncheon.

4. Maneuver, Aviation, and Soldier Division, Army Capabilities Integration Center (ARCIC), *The U.S. Army Robotic and Autonomous Systems Strategy* (Fort Eustis, VA: U.S. Army Training and Doctrine Command [TRADOC], 2017), 1.

5. John F. Schmitt, "A Practical Guide for Developing and Writing Military Concepts," Working Paper #02-4 (McLean, VA: Defense Adaptive Red Team, December 2002), 10, accessed 12 March 2018, http://www.au.af.mil/au/awc/awcgate/dod/dart_guide.pdf. An enabling concept is a description of how a particular task or procedure is performed within the context of a broader functional area, such as the infantry, using a particular capability.

6. Ethical considerations for the employment of autonomous weapons are discussed extensively in other papers. See, for example, Ronald C. Arkin, "Ethical Robots in Warfare," College of Computing, 16 October 2016, accessed 12 March 2018, http://www.cc.gatech.edu/ai/robot-lab/online-publications/arkin-rev.pdf; or Zachary Morris, "A Four-Phased Approach to Developing Ethically Permissible Autonomous Weapons," *Military Review* (online exclusive, May 2018), accessed 8 June 2018, https://www.armyupress.army.mil/Journals/Military-Review/Online-Exclusive/2018-OLE/May/Four-Phase-Approach/.

7. ARCIC, *The U.S. Army Robotic and Autonomous Systems Strategy*, 23. Autonomy is defined as "the level of independence that humans grant a system to execute a given task in a stated environment." The independence of an autonomous system (or weapon) is a point on a spectrum that can be tailored to the specific mission, level of acceptable risk, and degree of human-machine teaming.

8. Department of Defense Directive 3000.09, *Autonomy in Weapon Systems* (Washington, DC: U.S. Government Publishing Office [GPO], 21 November 2012), 3.

9. Ibid.

10. Ibid.

11. U.S. Navy, "United States Navy Fact File: Aegis Weapon System," Navy.mil, 26 January 2017, accessed 12 March 2018, http://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=200&ct=2.

12. Rules of engagement are directives issued by a military authority controlling the use and degree of force, especially specifying circumstances and limitations for engaging in combat. Weapons control statuses describe the relative degree of control over weapons engagements. Weapons free: this is the least restrictive status and weapons can fire at any target not positively identified as friendly. Weapons tight: weapons may only engage targets positively identified as hostile, according to prevailing rules of engagement and hostile criteria. Weapons hold: this is the most restrictive weapon control status and weapons may not fire except in self-defense or in response to a formal order.

13. For an explanation of a Stryker Company organization, see Field Manual (FM) 3-21.11, *The SBCT Infantry Rifle Company* (Washington, DC: U.S. GPO, January 2003), 1-6. For diagrams depicting other infantry company organizations, see FM 3-21.10, *The Infantry Rifle Company* (Washington, DC: U.S. GPO, July 2006), 1-11–1-12.

14. ARCIC, *The U.S. Army Robotic and Autonomous Systems Strategy*, 25. An unmanned ground vehicle (UGV) is an electromechanical unmanned ground platform. UGVs can be operated via remote control, teleoperation, or may be equipped with some degree of autonomous behavior.

15. Command UGVs would provide blue force tracking, radio communications, retransmission capability, tactical satellite communications, other command capabilities as needed, and local electronic warfare, jamming, and direction finding capabilities. Company autonomous intelligence, surveillance, and reconnaissance unmanned aircraft systems (UASs) should be similar in size and general capability to current Puma UAS. However, more advanced systems should include greater autonomy, such as independent flight, return, target tracking, area search programming, and other capabilities, which would allow one operator to control multiple systems and reduce electronic warfare threats. Information regarding Puma capabilities can be found online at "UAS: RQ-20B Puma AE," AeroVironment, accessed 12 March 2018, https://www.avinc.com/uas/view/puma.

16. The 120 mm mortar UGV provides autonomous digital targeting, precision-guided munitions (PGMs) capability, and carries ammunition for the system. Dismounted 60 mm mortars could be carried as the mission and unit requires. Equipment-carrying UGVs provide communications capability, electric power, and transport twenty-two soldiers' equipment, and food, water, ammunition, and fuel for three to five days of operations. Autonomous attack UAS would have similar capabilities to current Switchblade systems.

However, autonomous attack systems would require: longer battery life, antiarmor warheads, antipersonnel warheads, bunker-busting warheads, autonomous targeting programming, and fire and forget capability. Current Switchblade information can be found online at "Switchblade Tactical Missile System, United States of America," Army Technology, accessed 12 March 2018, http://www.army-technology.com/projects/switchblade-tactical-missile-system/. Heavy-weapon UGVs include autonomous targeting capability based on phase-two requirements, and autonomous movement and control capabilities. Further, these systems are armed with heavy direct-fire weapons (potentially 20 mm or 30 mm cannon, and 240B coaxially mounted), antitank missiles (two Javelin-like weapons), and air-defense missiles (two stinger-like weapons). Kent Massey, "Squad Mission Equipment Transport (SMET): Lessons Learned for Industry" (annotated version of briefing, NDIA Ground Robotics Capability Conference, Springfield, VA, 2 March 2016), accessed 12 March 2018, https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2016/GRCCE/Massey.pdf.

17. These armed UGVs would retain slightly lighter weapons than the heavy weapons platoon UGVs. The primary weapon would consist of either a M2 .50 caliber, Mk-19, or M240B machine gun. Secondary weapons would include two antitank missiles and two air defense missiles. Example air defense missiles include the Stinger system, see "Stinger Man-Portable Air Defense System (MANPADS)," Army Technology, accessed 12 March 2018, http://www.army-technology.com/projects/stinger-man-portable-air-defence-system-manpads/. Example antitank systems include the Javelin, TOW, or ground launch capable hellfire missile. More information on these systems can be found online at "Javelin Portable Anti-Tank Missile," Army Technology, accessed 12 March 2018, http://www.army-technology.com/projects/javelin/; "TOW 2 Wire-Guided Anti-Tank Missile," Army Technology, accessed 12 March 2018, http://www.army-technology.com/projects/tow/; "AGM-114 Hellfire II Missile," Army Technology, accessed 12 March 2018, http://www.army-technology.com/projects/hellfire-ii-missile/.

18. TRADOC Pamphlet (TP) 525-3-1, *The U.S. Army Operating Concept: Win in a Complex World, 2020-2040* (Fort Eustis, VA: TRADOC, 31 October 2014), 42.

19. ARCIC, *The U.S. Army Robotic and Autonomous Systems Strategy*, 1.

20. TP 525-3-1, *The U.S. Army Operating Concept,* 11. Maintaining overmatch capability is a critical task in the concept.

21. For a detailed explanation of how to conduct a movement to contact, see FM 3-21-10, *The Infantry Rifle Company*, chap. 3. For an explanation of operational terms and graphics, see FM 1-02, *Operational Terms and Graphics* (Washington, DC: U.S. GPO, September 2004).

22. Dave Majumdar, "Get Ready, NATO: Russia's Cold War T-72 Tank Is Set for a Big Upgrade," *The National Interest* (website), 31 March 2016, accessed 12 March 2018, http://nationalinterest.org/blog/the-buzz/get-ready-nato-russias-cold-war-t-72-tank-set-big-upgrade-15642; "BMP-3 Infantry Combat Vehicle," Army Technology, accessed 12 March 2018, http://www.army-technology.com/projects/bmp-3/.

23. Task Force Devil Combined Arms Assessment Team, "The Modern Warrior's Combat Load: Dismounted Operations in Afghanistan April-May 2003," *U.S. Army Center for Army Lessons Learned* (2003), 113, accessed 12 March 2018, http://thedonovan.com/archives/modernwarriorload/ModernWarriorsCombatLoadReport.pdf. Weights are based on data from the study below. Numbers were compared using Emergency Approach March Load, which includes all equipment for three days of operations, and pure fighting load, which is what soldiers would carry if UGVs could carry all additional equipment.

24. ARCIC, *The U.S. Army Robotic and Autonomous Systems Strategy*, 24. Leader-Follower Function: an appliqué kit that provides a limited robotic-like capability to UGVs enabling them to follow a designated leader's route, speed, and formation.

25. "Situational Awareness Video Receiver (SAVR) RF-7800-T-HH," Harris Corporation, accessed 12 March 2018, https://www.harris.com/sites/default/files/downloads/solutions/rf-7800t-situational-awareness-video-receiver.pdf. One example of a small dismounted situational awareness video receiver currently used in the U.S. Army includes the Harris RF-7800t. This system enables dismounted soldiers, using a small eyepiece, to observe any broadcasting encrypted video feed.

26. Andrew E. Kramer, "A New Weapon in Russia's Arsenal, and It's Inflatable," *New York Times*, 12 October 2016, accessed 12 March 2018, https://www.nytimes.com/2016/10/13/world/europe/russia-decoy-weapon.html?_r=0. Multiple nations, including Russia, are developing mock decoy vehicles to deceive advanced targeting systems, and the U.S. should expect effective countermeasures for LAWS in the future.

27. "Kongsberg Contracted to Support US Army's M153 CROWS System," Army Technology, accessed 12 March 2018, http://www.army-technology.com/news/newskongsberg-contracted-to-support-us-armys-m153-crows-system-4769114.

28. TP 525-3-1, *The U.S. Army Operating Concept*, 31.

29. Ibid., iii.

30. ARCIC, *The U.S. Robotic and Autonomous Systems Strategy*, 1.

31. TP 525-3-1, *The U.S. Army Operating Concept*, 36–40.

32. Ibid., 39.

33. Ibid., v.