

# Mission Command and Armed Robotic Systems Command and Control

## *A Human and Machine Assessment*

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## Preface

For almost 20 years, mission command has been a key component of command and control (C2) in the U.S. Army. However, with the advancements in the realm of artificial intelligence and the resultant utilization of autonomous and semiautonomous weapon systems in warfare, it is necessary to examine the extent to which these machines can cooperate within this construct.

Mission command, properly understood, empowers subordinate decisionmaking and decentralized execution appropriate to any given situation. It is solely meant for human-to-human C2. Like war itself, it is an inherently “human endeavor . . . not a mechanical process that can be precisely controlled by machines [or] calculations.” Systems that use machine algorithms for their decisionmaking processes are in direct variance to the emotive- and moral-seeking components of human cognition. Humans experience love, fear, camaraderie and hate—machines do not. Nor do they understand honor, integrity or self-sacrifice. Faced with this conflict, how can the deployment of machines work in concert with the Army’s C2?

## **Mission Command and Armed Robotic Systems**

### **Command and Control: A Human and Machine Assessment**

#### **Introduction**

Since August 2003, mission command has been a key component of the command and control (C2) of U.S. Army forces.<sup>1</sup> It has since gone through two doctrinal iterations.<sup>2</sup>

First, the July 2019 Army Doctrine Publication (ADP) 6-0, *Mission Command: Command and Control of Army Forces*, has the most up-to-date definition of this term: “*Mission command* is the Army’s approach to command and control that empowers subordinate decisionmaking and decentralized execution appropriate to the situation.”<sup>3</sup> It is solely meant for human-to-human C2; mission command, like war itself, is an inherently “human endeavor . . . not a mechanical process that can be precisely controlled by machines [or] calculations.”<sup>4</sup>

The second iteration is the Pentagon’s Third Offset Strategy. As described in April 2016, “It is combinations of technology, operational concepts, and organizational constructs—different ways of organizing our forces, to maintain our ability to project combat power into any area at the time and place of our own choosing.”<sup>5</sup> Per then Deputy Secretary of Defense Bob Work, “[T]he technological sauce of the Third Offset is going to be advances in Artificial Intelligence (AI) and autonomy.”<sup>6</sup> However, systems that use machine algorithms for their decisionmaking processes are in direct variance to the emotive- and moral-seeking components of human cognition. Humans experience love, fear, camaraderie and hate—machines do not. Nor do they understand honor, integrity or self-sacrifice.

The U.S. Army—and all of DoD—has two fundamentally important attributes of its war-fighting capacity: one focusing on decentralizing human-soldier C2 and the other on deploying armed autonomous machines in the middle of the 21st century. These attributes are seemingly at odds with one another. The U.S. Army War College’s *Key Strategic Issues List 2018–2020* identifies this juxtaposition of human and machine for its strategic significance, specifically in one of Theme 2’s issues, which directs the following:



Assess the Army's ability to execute mission command and control on a multi-domain battlefield that includes: friendly and adversary unmanned systems, semiautonomous (human in the loop) robotic systems, and autonomous (no human in the loop) robotic systems.<sup>7</sup>

While human *in* the loop is representative of semiautonomous robotic systems' C2 (waiting for human input), it is also descriptive of nonautonomous robotic systems' C2 (direct human control).<sup>8</sup> Given the highly-dynamic and futures-oriented aspects of the requests in the *Key Strategic Issues List*, this paper should be considered exploratory rather than authoritative as it looks at the following questions:

- Can the U.S. Army construct, which views mission command as a solely “human endeavor,” be able to effectively incorporate armed robotic systems?
- When does the mission command construct—as defined by the seven principles and Seven Cs (defined later in this paper)—properly function with the amoral, nonemotive and logic-based approach that machine algorithms take, and when does the construct's humanity start to be at odds with that approach?
- Will mission command ultimately prove flexible enough for armed robotic systems' C2?
- Will a more inclusive definition of mission command—to include machine algorithms, or at least two types of mission command that account for both human intelligence and machine processing—need to be developed?
- While human *in*, *on* and *off* the loop machine C2 interactions are presently the focus of military interest, an inverse relationship is also starting to emerge due to machine-derived battle management considerations. How then do we account for inverse machine *in*, *on* and *off* the loop human C2 interactions, and how do they relate to the contemporary mission command construct?

## **Mission Command Overview**

Mission command as a C2 construct—initially grounded in the experiences of the Prussian general staff—is over 150 years old. The basis of the approach was first seen in 1866 during the Königgrätz campaign that Prussia initiated against Austria. The campaign represents the earliest example of the general staff, with hundreds of thousands of widely dispersed troops coming together over a two-mile front at a crucial time. The Prussians used five railroads to move troops and the telegraph for communication; a decentralized C2 system (*Auftragstaktik*) provided the conceptual means to coordinate the maneuver operations.<sup>9</sup>

From a robotics perspective, the cotton gin and other industrial machinery represented state-of-the-art technologies at the time. No military theorists imagined armed robot systems. As a result, mission command is solely focused on humans waging war; this is how war is still fought today.

However, battlespace is getting far larger, deadlier and more complex. Machine warfighting capability is emerging. This capability—one step beyond that which is presently used in teleoperated systems (human in the loop and nonautonomous)—will increasingly coexist with the traditional human-based capability because of the evolving technological level of warfare, stemming from advances in robotics, computer programming, big data analytics and the related hard sciences.

### *Increasing Need for Decentralized C2*

Beginning with the Napoleonic era and industrialization, the size of armies dramatically increased, with all the resources of nations at war—men, materiel and capital—being directed at one another. This resulted in an ever-expanding physical battlespace and an increasing speed and tempo of operations.

Concurrently, maneuver warfare became more sophisticated and complex while fires became more precise, extended and deadly. The military systems that could effectively adapt to this environment of less centralized armies would be the victors. The successes of the Prussian (later German) army, attributed to its mission command system, portrayed its mastery of decentralized C2 at the operational level of war throughout the 19th and 20th centuries.

### *Contemporary Perspectives*

Mission command—as a decentralized C2 human-soldier-focused doctrine applied to maneuver warfare and AirLand Battle operations—first appeared in Army Field Manual (FM) 100-5, *Operations*, in 1982.<sup>10</sup> It was followed by the 2003 original FM 6-0, *Mission Command: Command and Control of Army Forces*.<sup>11</sup> It has been increasingly elevated in stature within U.S. Army doctrine and other military-focused writings, as well as in the joint force and other services, most notably in the Marine Corps.<sup>12</sup> The military has definitively recognized the need for it since incorporating it in the 1970s and 1980s as a way to face Soviet armored and mechanized forces threatening Western Europe, while some theorists argue that it has been evolving with the Army since 1905.<sup>13</sup>

There are criticisms of the U.S. Army's adaptation of mission command. Donald Vandergriff and Stephen Webber have been most vocal in this regard, publishing two volumes of *Mission Command: The Who, What, Where, When and Why: An Anthology* in 2017 and 2018 and *Adopting Mission Command: Developing Leaders for a Superior Command Culture* in 2019. The basis of this criticism, which initially emerged in 2013, is focused on the Army's more technocratic approach to using the construct:

The U.S. Army continues to worship at the technological and management science altar by combining Mission Command with emerging communications technology. . . . Thus, Mission Command, as it did in the 1980s, is becoming a method of orders and control rather than a cultural philosophy that can greatly enhance a leader's ability to make rapid and sound decisions without waiting for permission.<sup>14</sup>

A tension seems to exist between the Army's adaptation of mission command to its corporate culture and its origins as a cultural philosophy.<sup>15</sup> Army leaders appear to recognize this tension and are attempting to provide a better doctrinal synthesis.<sup>16</sup>

### *Assumption of Morality and Emotive Processes*

Humans are driven by both logic and emotion. They also have moral and spiritual components. Humans engaging in war do so as a process of engaging in collective and legitimate violence directed by one sovereign entity against another. War—at least as defined by its Western and institutionalized rules of conduct—is not meant to be a collective act of mass homicide or criminal enterprise. Morality in war is dictated by mandated rules of behavior and engagement. War as a human endeavor thus forms the centerpiece of this discussion, which also extends to the C2 of soldiers on the battlefield.



## Armed Robotic Systems' C2 and Machine Algorithms

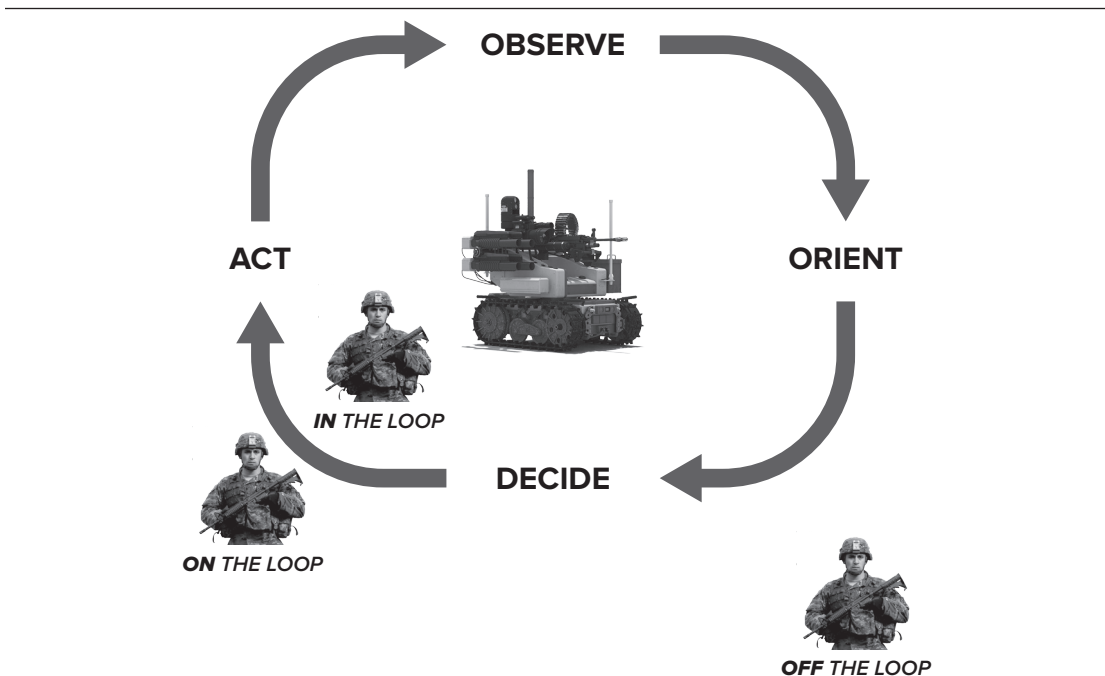
While a human-centric focus exists for the U.S. Army leadership model (and its mission command C2 element),<sup>17</sup> armed droids and drones—in effect, “machine soldiers”—are beginning to appear on the battlefield. Presently, such armed robotic systems operate under what is known as DoD Directive 3000.09. This directive, updated on 8 May 2017, pertains to autonomy in weapon systems.<sup>18</sup> It: establishes DoD policy and assigns responsibilities for the development and use of autonomous and semiautonomous functions in weapon systems; and establishes guidelines designed to minimize the probability and consequences of failures in these weapon systems that could lead to unintended engagements.<sup>19</sup>

The policy is proactive, nuanced and battlefield situational in its application, especially since fully autonomous armed systems are not mature enough to be responsibly fielded. However, “contrary to a number of news reports, U.S. policy does not prohibit the development or employment of [lethal autonomous weapon systems (LAWS)],”<sup>20</sup> but rather emphasizes the critical role of the human operator from a C2 perspective in regard to these weapon systems.<sup>21</sup>

A basic typology of armed robotic systems characterizes them from a C2 perspective as residing within human *in*, *on* and *off* the control loop positions (see Figure 1 and Table 1).

Figure 1

### Human *In*, *On* and *Off* the Loop Positions



### Human *in* the Loop C2

This represents command by directive in which a teleoperated or semiautonomous system is dependent on its operator. It does not have independent targeting, engagement or any other decisionmaking capability, although it may reduce some direct human functions via limited autonomous actions. Variants of this type of C2 are nonautonomous (human remote control) systems and semiautonomous (requiring human input before acting) systems.<sup>22</sup>

A basic example of a lethal *in the loop* system would be a teleoperated bomb disposal robot outfitted with a shotgun and used in an antipersonnel rather than an explosive device disruption manner. A more advanced example would be the SWORDS (Special Weapons Observation Reconnaissance Detection System) robot, which is a variant in the Talon family of robots mounted with various types of small arms, meant for dedicated antipersonnel use.<sup>23</sup>

*Human on the Loop C2*

This form of C2 is a machine following its programming while a human can intervene in real time. Such armed robotic systems with a human *on the loop* are viewed as supervised autonomous ones. Rather than being constantly teleoperated or having only semiautonomous capabilities (without the ability to engage in lethal fires or actions), these systems can engage in their taskings independently with remote mission plan inputs and updates as required. These systems generally perform more quickly than humans (they have a faster OODA—observe, orient, decide, act—loop) as they typically operate in machine-control mode.

From an ethical perspective, they can be considered semi-moral because they follow algorithmic parameters, and because a human controller is the arbiter of their actions when they face complex situations for which they do not have an onboard solution set. This latter is an imperative when fuzzy ethical and return-on-equity decisions are required regarding the application of lethal force.<sup>24</sup> It is thought that the more complex an environment is, the fewer supervised autonomous systems a human can responsibly monitor due to the additional cognitive burdens it would entail.

An example of a human *on the loop* armed robotic weapon system is the South Korean SGR-A1 produced in 2006, used as a robotic sentry to cover the demilitarized zone between North Korea and South Korea.<sup>25</sup>

Table 1  
**Armed Robotic Systems C2**

Loop Relationship (C2)	Human <i>in the loop</i>	Human <i>on the loop</i>	Human <i>off the loop</i>
<b>Robotic Systems</b>	nonautonomous and semiautonomous	supervised autonomous	fully autonomous
<b>Thought Process</b>	human cognition	blended	machine algorithm
<b>Human Loop Actions</b>	direct control and human input required	supervisory; override controller	none; failsafe kill switch
<b>Battle Management</b>	follow orders/dependent	follow task or plan	follow intent
<b>Decisionmaking Speed</b>	low	medium	high
<b>Human Cognitive Load</b>	high	medium	low (to none)
<b>Morality</b>	moral	semi-moral	amoral

*Human off the Loop C2*

Autonomous in nature, this is defined as “a weapon system that, once activated, can select and engage targets without further intervention by a human operator. This includes human-supervised autonomous weapon systems that are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation.”<sup>26</sup> The earlier *on the loop* type of C2 (for supervised autonomous systems) is included as well as the *off the loop* type of C2 (for fully autonomous systems) within this definition. These systems, due to their artificial intelligence (AI) capabilities, have the

fastest OODA loop processing and reaction cycles, making them very formidable. They also could follow a commander's intent and engage in mission command-led operations; the assumption is that this would occur only within noncomplex and more logical (as opposed to subjective) endstate-based ones.

Fully autonomous systems are inherently amoral due to their reliance on machine algorithms that attempt to engage in ethical rule-based actions. These systems require the lowest (or even no) human cognitive load because they are unsupervised. At best, some sort of failsafe kill switch may be embedded in them that a human could remotely trigger via an encrypted signal if they should malfunction, go rogue or somehow be taken over by an opposing force—although providing such a backdoor kill switch creates a new vulnerability.

An example of a human *off* the loop autonomous weapon system would be the science fiction Terminator. However, from a practical perspective, any form of autonomous close-in defense system under certain conditions could conceivably become one. For example, consider the use of a Phalanx 20mm close-in weapon system mounted on a U.S. warship in the heat of a full-scale defensive engagement against incoming missiles—especially hypersonic (Mach 5+) Chinese ones.<sup>27</sup> While a human *on* the loop abort button option exists, the extreme speed of the OODA loops taking place forces such scenarios to become human *off* the loop engagements.

### *Logical Considerations*

Machine logic is very different from human-based cognition; machines do not possess empathy, morality and subjectivity—those essential qualities that make humans what they are. Machines are also devoid of any form of spirituality or anthropomorphic yearnings or tendencies and “do not dream of electric sheep.”<sup>28</sup> As manufactured and fabricated products—as tools or weapons of war—machines are neither sentient nor living. Whether they can or should be allowed to achieve intelligent existence (self-awareness and subjective capacity) remains the great unknown. Presently, machines must be considered solely as logic-based devices in how they carry out their tasks and actions.

Higher-level systems are going down the path of fuzzy and quantum forms of logic with capabilities derived from superposition (space-time distortion) and entanglement (quantum object linking) offering advanced new processing potentials.<sup>29</sup> Quite likely, it will be from these higher-level logic systems that increasingly advanced forms of AI placed on human *off* the loop autonomous weapons will emerge. No reason exists that this AI must be robot-body dependent—such machine intelligence could be optimized as a collective intelligence across autonomous droids and drones to form a hivemind or swarm type of combat entity. For now, the Army has to be merely concerned with pretty basic forms of machine intelligence—exhibiting “silo intelligence” that can repeatedly beat all humans in a game of go or chess as a result of their highly-structured, rules-based algorithms and sheer processing power<sup>30</sup> but with functional intelligence not even equivalent to that of a worm or a cockroach.<sup>31</sup>

## **ADP 6-0 Mission Command and Machine Logic**

### *Seven Principles of Mission Command*

Mission command is guided by seven principles; in the following table, each principle is defined, and each principle's ability to be applied to machine function is noted. Further analysis of each principle is addressed in the paragraphs that follow. For more detailed definitions of each principle, refer back to ADP 6-0.<sup>32</sup>

Table 2

## The Seven Principles of Mission Command and Machine Applicability

Principles	Definitions	Machine Applicability
1. Competence	"The ability to do something successfully or efficiently." <sup>33</sup>	Yes
2. Mutual trust	<i>Mutual</i> : "(of a feeling or action) experienced or done by each of two or more parties towards the other or others;" <sup>34</sup> <i>trust</i> : "firm belief in the reliability, truth, or ability of someone or something." <sup>35</sup>	No
3. Shared understanding	<i>Shared</i> : "distributed between members of a group;" <sup>36</sup> <i>understanding</i> : "the ability to understand something; comprehension." <sup>37</sup>	Yes and no
4. Commander's intent	<i>Commander</i> : "a person in authority, especially over a body of troops or a military operation;" <sup>38</sup> <i>intent</i> : "intention (a thing intended; and aim or plan) or purpose." <sup>39</sup>	Yes and no
5. Mission orders	"[D]irectives that emphasize to subordinates the results to be attained, not how they are to achieve them." <sup>40</sup>	Yes and no
6. Disciplined initiative	"...when subordinates have the discipline to follow their orders and adhere to the plan until they realize their orders and the plan are no longer suitable for the situation in which they find themselves." <sup>41</sup>	Yes and no
7. Risk acceptance	<i>Risk</i> : "a situation involving exposure to danger;" <sup>42</sup> <i>acceptance</i> : "the action of consenting to receive or undertake something offered." <sup>43</sup>	Yes

Competence is efficient tasking and processing, i.e., it is a logical function. It is achieved by using the proper algorithms (training and education substitutes), access to data sets (assignment experience substitute) and their continual upgrading and refinement (professional development substitute). In the strictest sense, being tactically and technically competent is not an emotive or moral human function.

Trust, which is emotive, is not the same thing as reliable or validated information, which by nature is derived logically. Trust is derived from shared human experiences over time—resulting in the creation of shared confidence—and is part of the human bonding process. Trust develops between human commanders and human subordinates as a result of the experiential nature of shared training, field deployments and combat tours. It is based on belief, which is an emotive human function.

Understanding indicates logical comprehension, but it does not guarantee moral comprehension. Comprehension as a logical function is understood by machine algorithms; comprehension as a moral function, given its organic human basis, is not understood by them. A machine cannot use an algorithm to provide a solution set to a moral or ethical problem. Rather, when ethical code is used, it is inherently amoral and typically based on cost and benefit (and, to a limited extent, culpability).<sup>44</sup>

In the context of commander's intent, the expression of purpose means communicating the desired military endstate. This expression of purpose cannot always be clearly communicated in an insurgency or complex environment. While the simple outcome of winning or losing is logical and algorithmic, reality usually has enough variables that subjectivity comes into play. For machine logic, comprehending a commander's intent in a simple battlefield—such as in conventional force-on-force-based conflict—is achievable. However, comprehending it in a complex one with subjective outcomes—such as addressing local grievances fueling an insurgency—is derived from too many intangibles. In the former condition, "win" derived from an algorithm focused on wearing down an opposing force through fires is a logical expression of machine intelligence. In this instance, however, mission orders are substituted for intent. A

machine may be able to recognize hostile or nonhostile intent in a human (based on their biometrics and possession of a weapon) but not a commander's intent related to subjective and nuanced endstates.

Mission orders, in the context of machine applicability, are similar to commander's intent. For simple results, the metrics to be achieved can be accomplished through logical tasks; complex results are achieved via subjective tasks. As long as the mission order parameters and metrics can specifically characterize the conditional and relationship-based algorithmic results to be achieved, a machine can fulfill such tasking. On the other hand, more subjective complex endstates cannot be achieved by conditional and relationship-based algorithms.

Similarly, when initiative means changing a directive or tasking to maximize a strategy within a *simple* environment, it is logical; when it occurs in a complex environment, it requires subjectivity. For machines, the applicability of following the disciplined initiative principle is derived from the operational environment in which they are deployed. Relatively simple environments have basic programming conditionals to be met, while more complex ones, which are fuzzy in nature, have conditionals beyond the means of most present autonomous systems, as well as those in the foreseeable future.

Risk assessment means determining the probability of success and failure and modifying it by expected costs and benefits, so as to maximize a course of action. This can all be done with logic. A machine does not have to be psychologically willing to accept risk like a human commander does (that is an emotive trait). Rather, it has to be tasked to undertake necessary calculations and to communicate the resultant best course of action.

#### *Seven Cs to Execute Mission Command*

Brown's foreword in *Mission Command in the 21st Century* contains what he calls the "Seven Cs" required for successful execution of the C2 construct.<sup>45</sup> These Cs are inherently human-centric and demonstrate Brown's appreciation of the Army's core leadership values, including its emphasis on human-human relationships.<sup>46</sup> Although he considers them to be self-evident,<sup>47</sup> examining them in a parallel manner to the above examination of the seven principles of mission command can be equally helpful.

Character means the qualities that make up human individuality. Machines simply do not have these qualities, despite whatever attempts humans make to anthropomorphize them. Some of this anthropomorphizing has resulted in U.S. soldiers risking their lives to save their robot companions in combat, making sure that the exact same robot is returned to its unit after major repairs are completed and even holding military funerals for their fallen comrades who have "died" in battle.<sup>48</sup> Unfortunately, robots do not appreciate such sentiments or consider themselves "armed little buddies."

Courage means overcoming the emotion of fear, something that machines cannot experience. Only organic things that are sentient and seek to avoid threatening stimuli possess fear. Courage requires the capacity for fear and a willingness to subject oneself to such a threat situation for some purpose—typically combat-related when placed within the context of the actions of human soldiers. Hence, machines are incapable of acting in a courageous manner.<sup>49</sup>

Competence in the context of the seven Cs is the same as that of the seven Ps, discussed above on page 7.

Table 3

## The Seven Cs of Mission Command and Machine Applicability

Principles	Definitions	Machine Applicability
1. Character	"The mental and moral qualities distinctive to an individual." <sup>50</sup>	No
2. Courage	"The ability to do something that frightens one; bravery." <sup>51</sup>	No
3. Competence	"The ability to do something successfully or efficiently." <sup>52</sup>	Yes
4. Communication	"The imparting or exchanging of information by speaking, writing, or using some other medium." <sup>53</sup>	Yes
5. Commitment	"The state or quality of being dedicated to a cause, activity, etc." <sup>54</sup>	No
6. Compassion	"Sympathetic pity and concern for the sufferings or misfortunes of others." <sup>55</sup>	No
7. Confidence	"The feeling or belief that one can have faith in or rely on someone or something." <sup>56</sup>	No

Communication is an information exchange, which is logical; for machines, this is their data transfer function. Machines can engage in direct digital communication far more quickly than humans can communicate, either by speaking or visually processing (e.g., writing). For human-to-machine battlefield interface purposes, voice commands are being tested. "Soldier teammates are able to give verbal commands to the robot using natural human language in a scenario." This program is a component of "ARL's Robotics Collaborative Technology Alliance . . . as part of the work focused on state-of-the-art basic and applied research related to ground robotics technologies with an overarching goal of developing autonomy in support of manned-unmanned teaming."<sup>57</sup> Additionally, in 2020, live-fire tests are slated for armored robotic vehicles by means of digital controllers and interfaces.<sup>58</sup>

Commitment is dedication, which is an emotive human trait, derived from a sense of personal commitment to a cause. Machines, however, have neither commitment nor a lack of it—rather they are programmed to perform a task and will do so until they are no longer able. This is vividly demonstrated during the "crawling Terminator" scenes in the science fiction franchise when T-series hunter-killer robots are partially destroyed but do not give up their missions to eliminate their assigned human targets.<sup>59</sup>

Compassion is empathy, which is also an emotive human trait that machines do not feel or have. Machines are amoral—the very construct of morality is alien to their inherent "thought" process. If a machine is programmed to do so, it will engage in the torture of a human or execute them without the ability to feel remorse or any other emotion.

In this context, confidence is an emotive feeling, belief or faith; it does not refer to confidence in a piece of information, which is logical rather than emotive. Soldiers who have bonded as a combat team have confidence in one another's abilities, judgment and integrity. Machines are unable to bond with humans in an emotive sense. At best, they can recognize human biometrics (such as fingerprints and facial recognition) and allow them to access and control them or determine if they are "a friend" (in the case of an automated identification, friend or foe, weapon systems turret) and so not engage them with deadly force.<sup>60</sup>

### *A Comprehensive Analysis*

Aggregating the analyses above suggests that the Army's present conceptualization of mission command is at times both favorable and unfavorable in its application to autonomous



armed robotic systems, or for the utilization of mission command for autonomous systems (MCAS). Mission command is applicable when it is viewed from the perspective of being nonhuman-centric, as a strict form of C2 with a focus on logical C2 directives and as means of communication (the C3 attribute) between commander and subordinate. It appears to be readily applicable via the principles of competence and risk acceptance (as logical functions) and communication (as a data transfer/C3 function), but it is only applicable in noncomplex (simple conditional) environments that are related to the principles of shared understanding, commander's intent, mission orders and disciplined initiative.

Mission command is not applicable when it is viewed from a human-centric perspective or solely as a cultural philosophy (modified *Auftragstaktik*). Human emotion, morality and subjectivity are alien to machine logic and programming. Even if algorithms are created to mimic such behaviors, they represent nothing more than scripted rules. Algorithmic rules of engagement (ROE) could attempt to follow the Western rules of warfare and certain UN conventions and guidance, but would be followed by machine soldiers with no understanding of empathy or morality. These machine ROEs would only be as good as the algorithms and limited AI capabilities developed.

While this representation of mission command functions well within the U.S. Army's perspectives on leadership and leadership traits, it does not equate well with the fielding of autonomous human *off* the loop machine soldiers. Such direct variance is seen with the Cs (or enablers) of mission command; five of them—character, courage, commitment, compassion and confidence—are not applicable for autonomous robotic systems. In the case of the principles, variance occurs when emotive considerations are viewed, such as that of mutual trust, within complex environments related to shared understanding, commander's intent, mission orders and disciplined initiative. This is primarily due to the subjective nature of the endstates and tasking required to effectively operate within these environments.

## Implications

### *Operational Environment*

Within noncomplex and structured environments, mission command performs well. However, in more complex and subjective environments, it is not applicable for autonomous machine use. Drawing upon the “silo intelligence” approach, a Patriot battery can do massive numbers of calculations concerning missile trajectories and firing solutions to defeat incoming ballistic missiles. This is because it is operating within a highly-bounded and rules-based scenario. Commander's intent—provide force protection—can thus be reduced to a logical algorithmic exercise in such an environment. However, handing down mission orders in an undefined and loosely-structured environment with a subjective endstate would result in a fully autonomous (human *off* the loop) robot being unable to carry out its assigned task. This is too far outside a robotic machine's siloed analytic capabilities.

### *Cultural Philosophy*

This form of mission command has little utility for supervised autonomous (human *on* the loop) and even less utility for fully autonomous (human *off* the loop) robotic systems—hence the criticism voiced by Donald Vandergriff and Stephen Webber that the U.S. Army has strayed from the original intent of mission command as *Auftragstaktik*, or that a Prussian cultural

philosophy should be taken as a positive statement. Leadership development and the selection of officers with the qualities of knowledge, independence and responsibility is totally inapplicable to the creation, fielding and activities of autonomous machines. At best, such machines can be provided with access to the proper large data sets (as a knowledge base) and tasked to engage in independent operations until informed otherwise. However, the machine would have no leadership capability in a human sense.

#### *Mission Command Applicability as a Form of C2*

When mission command is stripped to a basic form of C2—that is, as a C2 function for the decentralized actions of subordinate echelons of a larger military entity—it has greater utility for machine applicability, but these functions are still human-oriented and hierarchical. Autonomous machines would be more efficient when fielded within a flatter and more interlinked network structure (for faster and increased information flows between the systems), but then the danger of losing human oversight and control is greatly magnified. At some point, there would also no longer be a mission command construct with a human-focused endeavor. At that point, responsibility for war could be ceded to machines, turning it into an automated process. This immediately brings various dystopian scenarios to mind that would be unacceptable to the liberal democratic governmental system.

#### *Mission Command Applicability to Human **in** the Loop Systems*

Mission command at this level of armed robotic system C2 development is fully applicable because it is still human-centric. The human is the C2 system with either no autonomy (the human is constantly in teleoperated or virtual control of the weapon system) or semiautonomy (the human still retains complete remote control of the actual firing of the system). Such human *in* the loop interactions should be considered from a mission command perspective as essentially the same as human-human interactions. Think of it as a human commander delegating a mission command to a human controller of an armed robot, with the robot simply a virtual extension of that soldier in the physical world—much like a virtual avatar in a computer game.

#### *Mission Command Applicability to Human **on** the Loop Systems*

The applicability of mission command for this level of robotic systems C2 development is at best mixed. This is because human *on* the loop C2 of armed robotic systems is transitional. As previously discussed, human *in* the loop C2 squarely exists as a human-centric activity; human *off* the loop C2 exists principally within the domain of machine activity. While autonomous systems attempt to follow mission command orders, inapplicability of the construct would dominate, and when human controllers engage in *on* the loop decisions and possibly even directly control activities, the construct would be more applicable. Overall, this means that mission command applicability at this level is marginal; the systems are supposed to predominately operate in an autonomous mode, not be constantly corrected for not following or even understanding the commander's intent with which they have been provided.

#### *Mission Command Applicability to Human **off** the Loop Systems*

This level of armed robotic C2 development—given its autonomous actions derived from machine thinking—is in direct variance to most of the mission command construct. This is due to mission command's emotive, moral and subjective qualities. Only when the logical and C3 components of mission command are stripped and applied to machines operating in

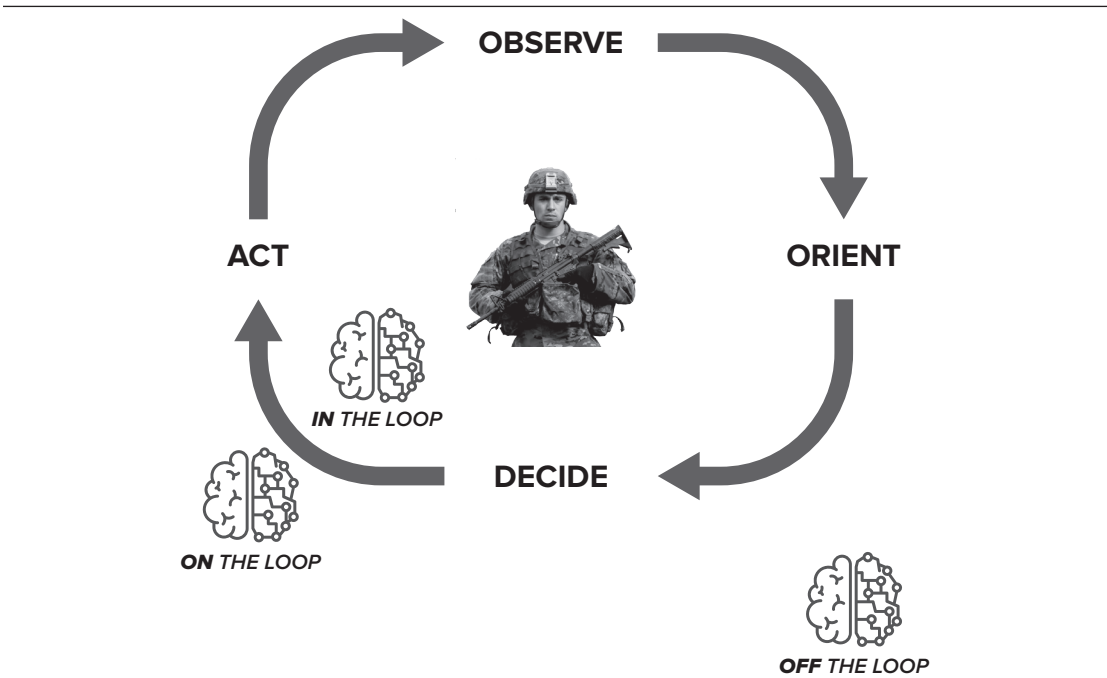
noncomplex and highly rule-based environments does it appear to be applicable. This could change if AI systems were fielded in autonomous robots derived from quantum (Q bit) computing principles that could conceivably understand gray area mission requirements.

*Mission Command's Overall Applicability*

Mission command's future applicability as an unmodified and human-centric construct will be increasingly challenged as the inverse trend of machines interacting with humans in a parallel OODA loop must be considered for future warfighting. Unlike the human-to-machine loop interaction with humans moving from the *in* to the *on* to the *off* loop C2 positions, armed robotic systems' autonomy is gradually being gained such that the machine-to-human loop interaction is moving from the *off* to the *on* to the *in* loop C2 positions, with an increase in machine battle management capacity (see Figure 2). This new development can be termed *machine C2 positions related to the human loop*.

Figure 2

**Machine Off, On and In the Loop Positions**



This ultimately refers to battle command AI used to support commanders in their decision-making activities. However, the human is always viewed as the principal decisionmaker. Work writes:

And there will be joint and combined collaborative human-machine battle networks. The human is always first because our conception of these battle networks is that AI and autonomy will be used only to empower humans, not to make individual or independent decisions on the use of lethal force.<sup>61</sup>

While Work only viewed this relationship as human-empowering, the longer-term trends suggest that the convergence of human physiology—even cognition—and machine algorithms

via wetware, biohacks and related human soldier enhancements may also take place.<sup>62</sup> This would go far beyond the human-machine interfaces of pacemakers, cochlear hearing aids, insulin pumps, microchips and related implants and would raise a host of further ethical implications.<sup>63</sup> A machine-empowering component of the human-machine relationship has to at least be considered, with machine intelligence interfering with the human decisionmaking loop. As previously discussed, machine algorithms will not necessarily approach this symbiosis from a mission command orientation.

## Recommendations

It is clear that the mission command construct—while intended for decentralized C2—is a human-focused approach to warfighting, developed long before the advent of 20th century informational technologies such as computers, networked interfaces and cloud storage. It represents a C2 approach that still operates in a modified hierarchical manner, with orders being passed down from one echelon to the next. It is in variance with the C2 requirements of emerging autonomous and armed robotic systems—systems that use logic-based algorithms devoid of emotion, morality and subjectivity. While the modified construct of MCAS has been offered as a solution to their rise and synthesis with AI, it appears to be at best a “bolt-on” approach, a solution that faces daunting human-and-machine interoperability challenges.<sup>64</sup> Thus, it is evident that the answer to assessing the Army’s ability to execute C2 on a multi-domain battlefield vis-à-vis autonomous (human *off the loop*) systems is that *the present construct will be unable to do so except under extremely limited circumstances*.

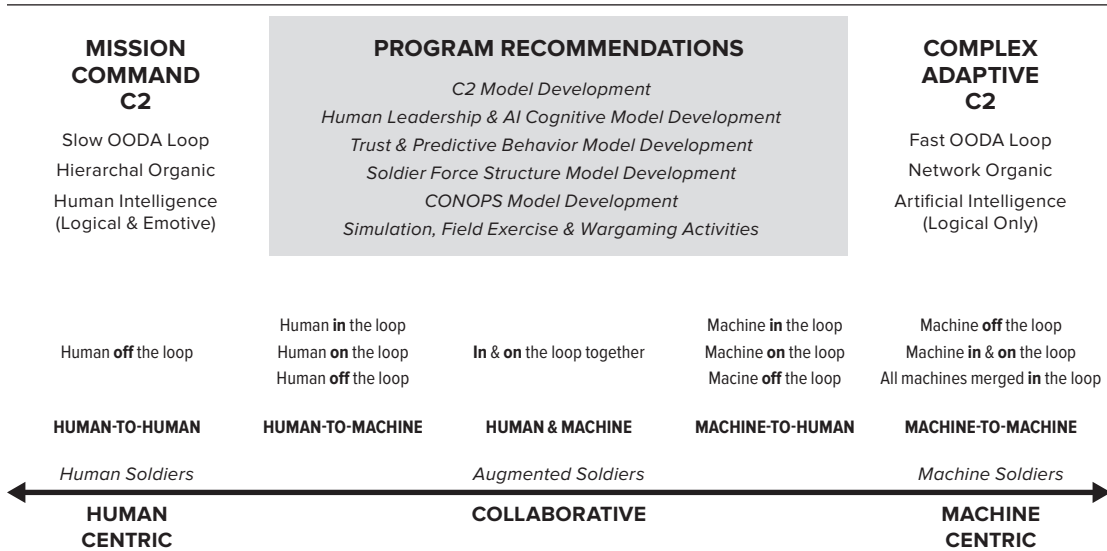
### *The Third Offset Strategy and the 2050 Soldier Program*

U.S. Army senior leadership should conduct a full-on review of the mission command construct within the larger context of the Third Offset Strategy—or more precisely, within the technologies (AI, autonomous systems, human-machine collaboration and combat teaming, etc.) identified within that strategy. Further, the mission command review should exist within a larger Army initiative—termed the *2050 Soldier Program*<sup>65</sup>—that U.S. Army Training and Doctrine Command (TRADOC) (linked to its Mad Scientist Laboratory), Army Futures Command (AFC) or some other joint or collaborative group should oversee. Figure 3 on the following page offers a conceptual model of the program’s focus and recommended activities.

The model recognizes that three types of soldiers will exist in 2050: human soldiers, machine soldiers and augmented human soldiers. The former two types are representative of a form of human and machine centrism, while the augmented soldiers are more indicative of a more collaborative or synthesized perspective. Human soldiers, in their baseline environment, engage in human-to-human interactions under the mission command construct. This environment is characterized by relatively slow OODA loops, and hierarchical information flows derived from human intelligence, which is both logical and emotive. The mission command construct is meant to decentralize human C2 processes as much as possible within military organizational hierarchies. This has allowed for commanders to subordinate leader (human-to-human) interactions to remain *off the loop*, since decisionmaking is derived from intent rather than orders.

Machine soldiers, in their baseline environment, engage (or will engage) in machine-to-machine interactions under a different type of C2 construct. One identified construct is complex adaptive C2. Its characteristics, per Aaron Bazin, are derived from its ability to:

Figure 3  
2050 Soldier Program Model



self-organize; exist in nonequilibrium; evolve by the transformation of internal models; be composed of semiautonomous agents; adapt by changing rules; display creativity that was not programmed; and change through interconnectivity, diversity and experimenting with alternative rules and structures.<sup>66</sup> The baseline environment is characterized by relatively fast OODA loops and network-based information flows, coupled with AI that is logical without subjective or emotive capacity. Machine-to-machine interactions can be one of three types: *off* the loop interactions between two equally developed AI, with one subordinate to the other; *in* and *on* the loop interactions, where a more capable AI controls a less developed or even nonintelligent weapon or transport systems; or where one AI system is distributed across a network—much like a distributed network of one intelligent thing—in its own loop.<sup>67</sup>

Then there are human-to-machine and machine-to-human C2 interactions. The human-to-machine interactions—with humans *in*, *on* and *off* the loop—form most of the focus of this paper. The attempt has been to apply mission command from the human-centric side with increasingly inapplicable utility as human C2 increasingly moves away from the interior of the machine's OODA loop. The other consideration is the machine-to-human interaction—with machines *in*, *on* and *off* the loop. From the initial Third Offset Strategy perspective, this is both highly undesirable and the antithesis of humans exercising their judgment over the force (per DoDD 3000.09) at the point where machines are allowed to be *in* or even *on* the control loop for human decisionmaking and actions. For certain human interactions with machines, the *on* the loop condition is already taking place—most commonly from a self-fratricide or fratricide perspective, such as munitions not arming until a certain failsafe distance is achieved, or with newer vehicles possessing anticollision capabilities.

The final human-and-machine-centric continuum position is that of a balance in which human and machine decisions are collaborative (via manned-unmanned teaming and centaur systems) and/or have achieved a synthesis via wearable tech, implants, wetware and biohacks. Humans and machines are mutually *in* and/or *on* the loop with one another for C2

support purposes. This takes us down the path of human soldier augmentation and enhancement (bioconvergence) that represents an acceptable eventuality based on a Third Offset Strategy endstate.

To better understand the large groupings of C2 loop potential interactions and the future applicability of mission command and complex adaptive processes both merging toward the center of the model's continuum, a number of initial recommended model developments and program activities are provided in what follows.

### *C2 Model Development*

The first recommendation focuses on research being conducted on current and evolving C2 approaches. The intent is to either draw upon pre-existing C2 models or to engage in the development of new ones that can be tested against the array of C2 loop interactions that exist. Contending C2 models include one of a dominant human-centric mission command, which currently represents the centerpiece of U.S. Army doctrine, as well as the variant MCAS that has been proposed and an outlier form of mechatronic mission command.<sup>68</sup> Additionally, flexive command has been offered as a contending C2 approach:

Flexive command prompts us to identify where the greatest situational understanding resides at a given decision point and encourages us to devise ways to connect that understanding to the decision itself. Under flexive command, mission command (as a delegation of increased decision authority) becomes one of many command approaches to a problem, and therefore is an element (a “way”) of command.<sup>69</sup>

### *Human Leadership and AI Cognition*

The second recommendation focuses on research on current and evolving human leadership and AI cognitive models. The intent is to either draw upon pre-existing human leadership and AI cognitive models or engage in the development of new ones that can be tested against the array of C2 loop interactions that exist. The *Army Leadership Development Strategy 2013*<sup>70</sup> “contains a model that basically consists of three domains of development—operational (training), institutional (educational), and self-developmental (experience).”<sup>71</sup> This model is inherently human-centric, resulting in the following requirement:

The Army must begin a discussion on how it will train AI-enabled systems to be smarter and more capable. By its nature, AI learns and gets better with experience—just as humans do. In order to best develop and prepare our force—both human and machine—the Army should begin curricular and pedagogical experimentation that teaches leader development across a range of human-to-machine interaction.<sup>72</sup>

To aid in AI cognitive development, the Defense Advanced Research Projects Agency has initiated the Machine Common Sense (MCS) program to develop new capabilities: “MCS will explore recent advances in cognitive understanding, natural language processing, deep learning, and other areas of AI research to find answers to the common sense problem.”<sup>73</sup>

### *Trust and Predictive Behavior*

The third recommendation focuses on research on current and evolving trust and predictive behavior models. The intent is to either draw upon pre-existing trust and predictive behavior models or to engage in the development of new ones that can be tested against the array of C2



loop interactions that exist. Trust between commander and subordinate is a major component of the decentralized delegation of decisionmaking in combat operations. As human and machine soldiers interact on the battlefield, issues of humans trusting machines to carry out their intent or even to not malfunction is of major concern.<sup>74</sup> At the same time, an AI could conceivably not entrust a mission to a human soldier because their predictive behavior model scoring suggests a high probability of failure.

Models and studies of human vertical trust need to be developed and reconciled with machine interactions; at the same time, similar research related to algorithmic and AI vertical predictive behavior modeling needs to be developed and reconciled with human interactions. While Dietz's Trust Process—applicable for vertical commander to subordinate interactions—has been applied to mission command trust analysis, the extension of this analysis to autonomous systems and AI has not been undertaken.<sup>75</sup>

### *Soldier Force Structure*

The fourth recommendation focuses on research on current and evolving soldier force structure models. The intent is to either draw upon pre-existing soldier force structure models or to engage in the development of new ones that can be tested against the array of C2 loop interactions that exist. The continuum of human-to-human, human-to-machine, human-and-machine, machine-to-human and machine-to-machine relationships will need to be studied and analyzed during this experimental weapon systems life-cycle phase of machine and augmented human soldier fielding. Numerous notional and projected force structure mixes—based both on friendly and opposing forces—are already being proposed and debated, including Russian robotic infantry and weapon units from the year 2030,<sup>76</sup> armed robotic “hyenas, buffalos, and boars” fighting in the African veld in 2037<sup>77</sup> and AI battle command “decision aids” supporting human commanders.<sup>78</sup>

### *CONOPS*

The fifth recommendation focuses on research on current and evolving concept of operations (CONOPS) models. The intent is to either draw upon pre-existing CONOPS models or to engage in the development of new ones that can be tested against the array of C2 loop interactions that exist. Proposed CONOPS such as swarming,<sup>79</sup> cybermaneuver<sup>80</sup> and mechatronic maneuver<sup>81</sup> offer autonomous systems new approaches to warfighting that can be mixed and matched with proposed robotic force structure articulations. New approaches to delivering precision lethal fires—such as machine-on-machine-only targeting<sup>82</sup>—as well as less lethal ones—such as bond-relationship targeting<sup>83</sup> and effects-based targeting (and ops)<sup>84</sup>—also need to be explored, along with the development of countermeasures to the A2/AD capabilities that peer and great-power competitors such as China and Russia use.

### *Simulation, Field Exercise and Wargaming*

The sixth recommendation focuses on research on current and evolving simulation, field exercise and wargaming activities. The intent is to either draw upon these pre-existing activities or to engage in the development of new ones that can be tested against the array of C2 loop interactions that exist. The Army Red Team and related agencies have in the past conducted field exercises with unmanned aerial systems—simulating armed capabilities—at the Muscatatuck Urban Training Center in Indiana and related venues. Other Army entities, such as the U.S. Army Combat Capabilities Development Command's Ground Vehicle Systems

Center—now part of AFC—are even more invested in these experiments related to their autonomous systems capabilities. Such forms of armed robotic systems field experimentation activities need to be better integrated with one another across the Army command structure, as well as further linked to wargaming at the U.S. Army War College<sup>85</sup> and the Association of the United States Army’s industry support (such as the Army Autonomy and Artificial Intelligence Symposium and Exposition series).

## Conclusion

The future fielding of autonomous armed robotic systems endowed with AI capabilities (as well as that of augmented human soldiers) will significantly impact the human conduct of war in the mid-21st century. Now is the time for the U.S. Army to better prepare for such an eventuality. As a component of this preparation—related to the suggested 2050 Soldier Program—the Army cannot be allowed to be wed to the current mission command construct as it has to the 20th century-derived main battle tank or armored fighting vehicle. Such military artifacts and constructs should only be embraced because of their present institutionalized warfighting utility, not as a ritualized element of past military prowess. Failure to change with advances in military technology and the CONOPS supporting them—most importantly C2—will yield the same result as the knighthood of chivalry dying under barrages of musket shot, advancing waves of infantry being cut down by machine gun fire and contemporary armored and mechanized forces being increasingly decimated by precision-guided munitions. This would be a catastrophic fate—one that U.S. soldiers must never be allowed to experience.



## Disclaimer

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## Notes

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- <sup>37</sup> *Lexico*, s.v. “understanding.”
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