Interdependence

Putting robots in the rifle squad

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The *Marine Corps Operating Concept* (MOC) acknowledges that, for the last fifteen years, the Corps has been engaged in combat and crisis response missions while failing to make significant strides to guarantee success in future engagements.[1] During this time, numerous concepts and technologies underwent significant advances in their capabilities and relevance to the warfighter, including *autonomous* systems. The Marine Corps and the majority of the warfighting industry refer to autonomy as the way forward for Marine Corps technologies. However, we argue that *interdependence* aligns better with the MOC, specifically regarding

> avoiding linear, sequential, and phased approaches to operations and blend[ing] maneuver warfare and combined arms to generate the combat power needed for simultaneity of action in its full range of missions.[2]

In executing the MOC, we propose changing "learn[ing] how to use unmanned systems and automation at all echelons and in every domain,"[3] to "learning how to incorporate interdependence with unmanned systems at all echelons and in every domain." These human and machine interfaces will drastically alter and enhance the way in which warfighters conduct future operations. For those interfaces to work in conjunction, it is imperative that the conversation moves away from autonomy in favor of interdependence. Marines have autonomy, but a key part of their mission success is exploiting effective teaming.

Myths about Autonomy

Recent successes in autonomous technologies have garnered attention while perpetuating misconceptions about the technology. Prior to introducing the concept of interdependence, it is important to understand these misconceptions about autonomy and their impacts on our ability to integrate unmanned systems into the MOC. One misconception of autonomy is that "the conceptualization of 'levels of autonomy' is a useful scientific grounding for the development of autonomous system roadmaps."[4] Levels of autonomy are an incomplete and insufficient model for determining the ability of a human-machine system. Using levels, which imply an ordinal structure, will stifle the growth of systems capable of enhancing future missions because the current definitions are inadequate in addressing the present problems that we face. A second misconception is that "autonomy is a widget."[5] Autonomy is not a hidden property of a platform or single piece of technology; it is a "characterization of observed or anticipated interactions between the machine, the work to be accomplished, and the situation."[6] When commanders ask for "more autonomy," they are asking for more automation or the ability of a machine to repetitively complete a single task, such as sending an unmanned aircraft

Autonomous technologies may change the conduct of combat operations. *(Photo by WO Bobby Yarbrough.)*

Autonomous systems are incapable of conducting missions without human effort. *(Photo by WO Bobby Yarbrough.)*

system out to predefined waypoints to send back video feed. What commanders should ask for are systems that can interact with their human counterparts and change tasks dynamically as the situation dictates.

Another myth is that "once achieved, full autonomy obviates the need for human-machine collaboration."[7] Machines are capable of taking over the simpler day-to-day tasks, such as factory operations; however, it is foolish to believe that autonomous systems are capable of conducting missions without combined effort from humans. When this myth is broken, the focus can shift from what the platform can do for the individual to how the individual and system can work together. Another commonly heard myth is that "'full [a]utonomy' is not only possible, but is always desirable."[8] Once a system reaches its capacity for work, it will begin to look to improve in other areas; as such, it will never be possible for an autonomous system to operate without the human's input and ability to solve problems. These myths are prevalent throughout industries; therefore, the focus should shift from autonomy to interdependence.

What Is Interdependence?

We propose that the Marine Corps shift the conversation from how autonomy can aid in addressing complex problem sets to how interdependence can address these same issues. Interdependence is the concept that the parts of an organization share some amount of dependence on one another; if one part fails, it will negatively impact the other parts.[9] Dr. Matthew Johnson, a researcher at the Institute for Human and Machine Cognition, proposed two categories of interdependence: required and opportunistic interdependence.[10] Required (hard) interdependence is one part of an organization's complete dependence on another part(s) for success. Opportunistic (soft) interdependence comes from team members' recognition that there are opportunities for higher levels of effectiveness and efficiency, and a more robust set of capabilities, through teamwork.[11] The goal of soft interdependence is to improve team performance through better decision making, which is ultimately related to situational awareness and individual/team cognition.[12]

***It is time to begin rethinking the Marine Corps rifle squad,* again.**

An example of this soft interdependence is how an infantry squad clears a house. A squad that is not interdependent would send fire teams into the house and have them clear it independently. With no coordination or awareness of the other teams, each fire team would go from room to room unsure if another team had already cleared it. However, an interdependent squad clears the house as a team. The Marines would coordinate as they moved, understanding the progress of each member of the team as well as their situational awareness. Soft interdependence is something Marines engage in every day all across the globe; now the goal is to bring unmanned systems into that equation.

A common issue that arises concerning the integration of Marines and unmanned systems is the idea that there is no trust. Why should the Marine *trust* a robot to do its job or *trust* that it will not inadvertently harm the Marine? Here, the concept of autonomy again falls short. If the Marine Corps wants to employ unmanned systems in the close fight as prescribed in the MOC, there must be trust between the systems being fielded and the Marines who will team with them. Interdependence provides the possibility for that trust to take root through observability, predictability, and directability.[13] To promote observability, predictability, and directability between unmanned systems and Marines, Marines will have to train with these systems—just as Marines train with one another now.[14] One unique aspect of training with unmanned systems is the speed with which this knowledge is passed to other unmanned systems. There is no requirement for every system to train; rather, these systems can simply share their experiences, information, and knowledge.

How Interdependence Can Help the Marine Corps

Incorporating interdependence into human-machine teaming discussions today and requirement definitions tomorrow can set the Marine Corps on a track to outpace the enemy in future battles. An example of this is the rifle

squad. It is time to begin rethinking the Marine Corps rifle squad, *again*. A systems operator, dedicated solely to employing the technology being fielded, is needed *today*. These systems require a high degree of cognition, taking that Marine's eyes out of his sights in order to employ more powerful capabilities through these technologies. The coordination cost associated with managing the technology that empowers the squad, while necessary today, is too high to ignore while moving forward. We need the cognitive power of that Marine applied directly to the fight in front of him. Interdependence can move the Marine Corps in that direction. A squad empowered by unmanned systems exercising soft interdependence will recognize the strengths and weaknesses of each member and system and will work to maximize their effectiveness. The tasks each Marine and machine perform can change from mission to mission based on the situation.

These advanced technological systems are not as futuristic as some might assume. Shield AI, a San Diego-based company, developed a powerful artificially intelligent agent to power its unmanned aerial vehicles.[15] Currently, it is capable of traversing buildings and identifying the layout and number of persons inside. However, in the near future these systems will be capable of teaming with one another to perform the same process for whole cities. This kind of coordination between other unmanned systems and humans will move toward a higher type of soft interdependence.

Unmanned ground vehicles have lagged behind their aerial counterparts, largely because of the difficulty in navigating ground terrain as well as a low demand in the private sector. These impediments notwithstanding, there have been significant advancements in unmanned ground vehicle technology. For example, Ghost Robotics has a notable platform, GR Vision, that is increasingly able to navigate difficult terrain.[16] Additionally, Ghost Robotics will be bringing a very powerful software suite onboard from Eyxn Technologies in the near future. It behooves the Marine Corps to stay apprised of these developments, as they could complement soft interdependence.

These are just two examples of what is fast approaching on the horizon. Both Shield AI and Ghost Robotics are developing impressive autonomous capabilities, but neither will be effective if not imbued with sufficient support for interdependence to enable them to seamlessly work within the Marine Corps mission framework. Thus, how does the Marine Corps move forward? We need to begin discussing these unmanned systems from a standpoint supporting interdependence. Significant gains could be realized by supplementing the capabilities of Marines with unmanned systems and eliminating the cognitive tax of a Marine looking down at a screen. The Marine Corps Warfighting Laboratory has worked to integrate the concept of interdependence with unmanned systems in the past, and some work continues at the Naval Postgraduate School.

Interdependence between Marines and unmanned systems will be difficult to implement and sustain; difficulties include mission and task definitions, ambiguous metrics, and high costs of development and implementation. Despite these obstacles, the payoff far outweighs the costs. Using unmanned systems without teaming them with Marines is the fastest way for us to become irrelevant in any future fight and the most likely way these systems will fail to deliver on the promises of future technology. From the rifle squad through all levels of the enterprise, interdependence will allow the Marine Corps to seize the initiative.

Notes

1. Headquarters Marine Corps, *The Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century,* (Washington, DC: September 2016), available at http://www.mcwl.marines.mil.

2. Ibid.

3. Ibid.

4. J. Bradshaw, R. Hoffman, D. Woods, and Matthew Johnson, "The Seven Deadly Myths of 'Autonomous Systems'," *IEEE Intelligent Systems*, (Pensacola, FL: Florida Institute for Human and Machine Cognition, 2013).

5. Ibid.

6. Ibid.

7. Ibid.

8. Ibid.

9. James D. Thompson, *Organizations in Action: Social Science Bases of Administration*, (Abingdon, UK: Routledge, 1967).

10. Matthew Johnson, "Coactive Design: Designing Support for Interdependence in Human-Robot Teamwork," (thesis, Florida Institute for Human and Machine Cognition, 2014).

11. Ibid.

12. Alan Clarke and Daniel Knudson, "Toward a Framework for Autonomous Systems Employment in Human Machine Teams," (Monterey, CA: Naval Postgraduate School, 2018).

13. M. Johnson, J.M. Bradshaw, R.R. Hoffman, P.J. Feltovich, and D.D. Woods, *Seven Cardinal Virtues of Human-Machine Teamwork: Examples from the DARPA Robotic Challenge*, (Piscataway, NJ: Human Centered Computing, 2014).

14. Louis Batson and Donald Wimmer Jr., "Unmanned Tactical Autonomous Control and Collaboration Threat and Vulnerability Assessment," (Monterey, CA: Naval Postgraduate School, 2015); and "Products," *Shield AI*, (Online), available at https://www.shield.ai.

15. "Products," Shield AI, (Online), available at https://www.shield.ai.

16. "Robots," Ghost Robotics, (Online), available at https://www.ghostrobotics.io/robots.