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Designing and Provisioning for a Consistent C2 Approach for Marine-Machine Teaming

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Monterey, California: Naval Postgraduate School

<http://hdl.handle.net/10945/69945>

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NPS NRP Executive Summary

Designing a Consistent C2 Approach for Marine-Machine Teaming
Report Date: 31 October 2019 Project Number (IREF ID): NPS-19-M286-A
Naval Postgraduate School Information Sciences Department



NAVAL RESEARCH PROGRAM
NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

Designing a Consistent C2 Approach for Marine-Machine Teaming

Period of Performance: 10/15/2018-10/15/2019

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Prepared for:

Topic Sponsor Lead Organization: Marine Corps Combat Development Command (MCCDC)

Topic Sponsor Organization: Marine Corps Warfighting Laboratory (MCWL)

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Distribution A: Approved for public release: distribution unlimited.

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EXECUTIVE SUMMARY

Project Summary

This research aimed to develop a framework that facilitates human machine teaming (HMT) between unmanned technologies and the Marines using them. Designed to promote the best attributes of both Marines and unmanned systems (UxS) in operations, HMT is a new area of research in the military. The researchers conducted a thorough literature review that expanded on command and control(C2) fundamentals and myths of automation, cognitive load, interdependence, doctrinal concepts from the Marine Operating Concept, and the Knowledge Value Added (KVA) approach. This analysis formed the backbone of the research and provided the foundation for a C2 HMT framework. The framework provides a pre-operations checklist for using UxS so that Marine HMT is effective in the next era of warfare.

Keywords: *artificial intelligence, AI, command and control , C2, human machine teaming, HMT, interdependence analysis, IA, mesh network, tablet, unmanned systems, UxS*

Background

The words innovation, autonomy, and artificial intelligence (AI) are thrown about with regularity in the Department of Defense (DoD) and in the private sector. This research hypothesized that those terms are not neatly packaged nor are definitions roundly agreed upon and that a framework or checklist for using robots in Marine Corps operations is needed. We found that the future of semi-autonomous and autonomous assets is dependent on the continued research into HMT. Designers and developers of HMT technology must understand the premise of interdependence (Johnson, 2014). Interdependence analysis (IA) determines the best ways for humans and machines to team, and make it a focal point of the design process for UxS. Humans should and will remain a part of the UxS design for the foreseeable future not only because of the limited capabilities of the machines but because humans and machines working as a team are more effective than either one working individually.

Findings and Conclusions

The research concluded USMC doctrine and concepts must match an anticipated future where units are spread out across the battlespace. The fifth epoch of warfare will look nothing like the fourth—just as the fourth looked nothing like the third. The era of warfare the U.S. is about to enter will likely feature small units operating independent of their larger parent element and conducting missions that were once reserved for battalions and regiments (Scales, 2018), usually because UxS are available to assist.

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The DoD must continue to adopt mobile ad hoc networking (MANET) technology such as TrellisWare that facilitates C2 across the battlespace and allows small unit leaders to operate independent from higher command elements. In addition, the Marine Corps must continue to refine their C2 approach to one that truly allows decentralized decision-making. This is needed to permit small units to utilize the full capabilities of the systems at their disposal without requiring continuous reach back to higher command echelons. The C2 HMT framework presented is a simple but powerful tool to help small-unit leaders effectively employ the new battlefield technology, especially UxS.

A second finding is that the DoD should analyze new capabilities through a value-added approach, not cost-savings mindset. The rapid advancement of technology has placed a plethora of highly capable systems in the purview of DoD decision makers. However, many of these systems have been developed with a focus on maximizing systems capabilities instead of filling needs of tactical units. At times this can lead decision makers to the fallacy of replacement instead of a value-added mindset. The decision tree of replacement technologies drives analysts to take a cost cutting and savings stance to produce a strong return on investment. The KVA analysis shows that technology should be analyzed through the value it adds to the warfighter (Housel and Bell, 2001). This value can come in the form of increasing time efficiencies and process throughputs instead of decreasing expenses. Return on Knowledge is not simply a way of putting positive spin on spending substantial money. It is a way to analyze processes through what is actually accomplished, and not focus on just costs saved or expenses incurred.

Recommendations for Further Research

Numerous articles have been written about the Marine Corps' future and what role it will likely perform in future conflicts. Whether countering littoral actions by great power adversaries or performing traditional mission sets such as a movement to contact, further application of this C2 HMT framework to complex scenarios is recommended. Expanding the framework to future modes of Marine Corps warfare will make the framework ever more useful. Furthermore, as technologies such as mobile ad hoc networking, situation awareness tablets, and modular multi-mission UxS are adopted, the tactics, techniques, and procedures of the Marines with this gear should be analyzed. Matching the realistic use of the gear with the Marine Corps mission sets will facilitate the learning process for both the Marines and the machine designers. The C2 HMT framework helps in adapting new ways of operating, but actual investigation should continue on new tactics, technologies, and environments.

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References

- Housel, T., & Bell, A. (2001). *Measuring and Managing Knowledge*. Monterey, California. Naval Postgraduate School. Retrieved from <https://calhoun.nps.edu/handle/10945/41074>
- Johnson, M. (2014). *Coactive design: designing support for interdependence in human-robot teamwork* (Doctoral thesis). Retrieved from: <http://humanrobotinteraction.org/journal/index.php/HRI/article/view/173/143>
- Scales, R.H. (2018, Oct. 1). Return to Gettysburg: The fifth epochal shift in the course of war. *War on the Rocks*. Retrieved from <https://warontherocks.com/2018/10/return-to-gettysburg-the-fifth-epochal-shift-in-the-course-of-war/>

Acronyms

AI	artificial intelligence
C2	command and control
DoD	Department of Defense
HMT	human-machine teaming
KVA	knowledge value added
MANET	mobile ad-hoc network
ROK	return on knowledge
USMC	United States Marine Corps
UxS	unmanned system