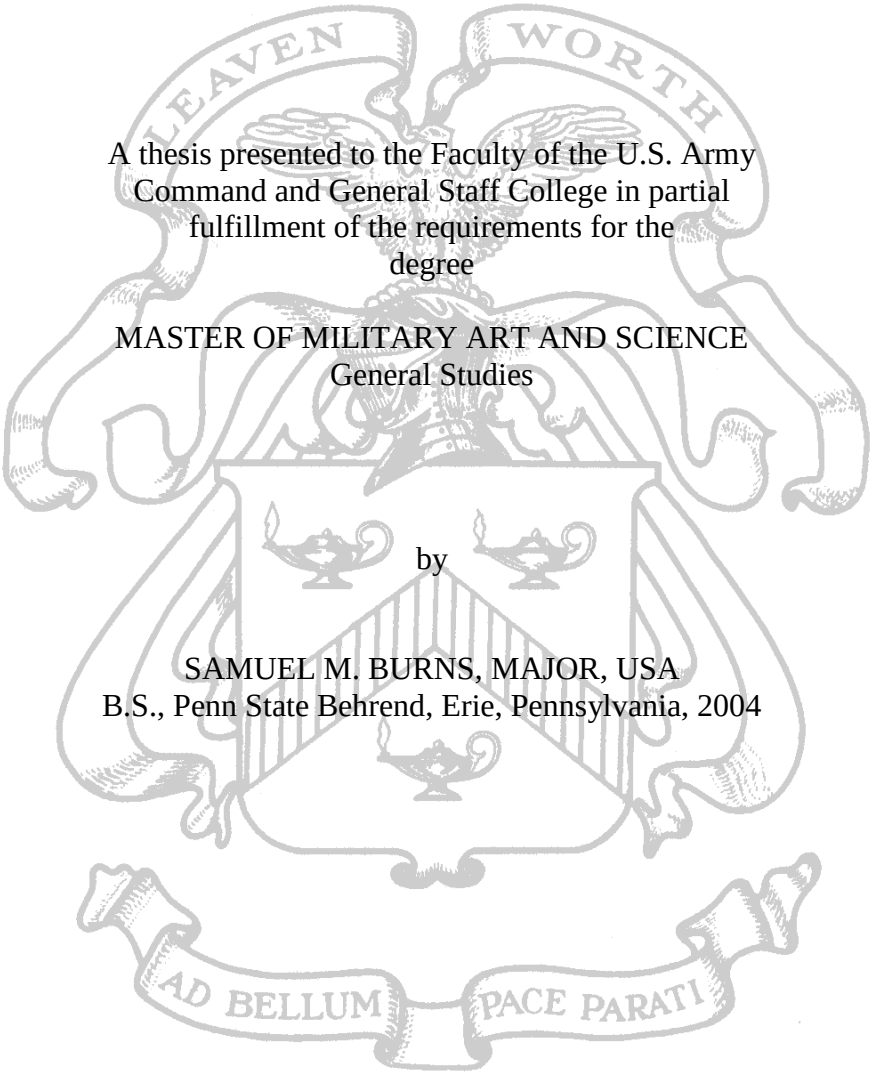
ENHANCING THE ARMY OPERATIONS PROCESS THROUGH THE INCORPORTATION OF HOLOGRAPHY



A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE
General Studies

by

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In order to dominate our opponents on the battlefield, the Army must have an agnostic technology that can quickly grow. Mission command information systems must be able to extend across multiple environments regardless of a commonality in hardware. The human dimension must be met at each domain (human, land, maritime, air, space, cyber)by an information system that augments the process. The focus needs to be on data delivery at the process in need over an approved secure based hardware. Holography is the future of mission command for the commanders, staff and soldiers allowing a distributed environment for all operations. Cognitive load is greatly reduced allowing for commanders, staff and soldiers to focus on the process and not on a computer screen. The process is no longer split between trying to take data and mentally overlaying it onto the process. Data now augments reality and is a noninvasive process to decision making.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

ENHANCING THE ARMY OPERATIONS PROCESS THROUGH THE INCORPORTATION OF HOLOGRAPHY, by Major Samuel M. Burns, 114 pages.

In order to dominate our opponents on the battlefield, the Army must have an agnostic technology that can quickly grow. Mission command information systems must be able to extend across multiple environments regardless of a commonality in hardware. The human dimension must be met at each domain (human, land, maritime, air, space, cyber) by an information system that augments the process. The focus needs to be on data delivery at the process in need over an approved secure based hardware. Holography is the future of mission command for the commanders, staff and soldiers allowing a distributed environment for all operations. Cognitive load is greatly reduced allowing for commanders, staff and soldiers to focus on the process and not on a computer screen. The process is no longer split between trying to take data and mentally overlaying it onto the process. Data now augments reality and is a noninvasive process to decision making.

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This paper would not have been possible without the help and guidance of Colonel Romano. He is deserving of a sincere and special thank you for his mentorship and commitment to the growth of my professional development. I would also like to thank my committee for their continued guidance and support throughout the research process. This research would not have been possible without the help of the entire team. A special thank you goes out to Dick and Ginny Kramer for allowing me to use their amazing artwork in the presentations. I can only hope that this is able to benefit the Army in the future and continue to give the US a competitive advantage.

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ACRONYMS

AFATDS	Advanced Field Artillery Tactical Data System
AMDWS	Air and Missile Defense Workstation
AMPS	Aviation Mission Planning System
ASA(ALT)	Assistant Secretary of the Army (Acquisition, Logistics, and Technology)
AR	Augmented Reality
BCS3	Battle Command Sustainment Support System
BS	Bachelor of Science
C4ISR /EW	Command, Control, Communication, Computers, Intelligence, Surveillance, Reconnaissance / Electronic Warfare
CGSC	Command and General Staff College
COE	Common Operating Environment
CP	Command Post
CPOF	Command Post of the Future
C-RAM	Counter-Rocket, Artillery, Mortar
CTO	Chief Technical Officer
DCGS-A	Distributed Common Ground System-Army
EECP	Early Entry Command Post
FSR	Field Service Representative
GE	General Electric
JADOCS	Joint Automated Deep Operations Coordination System
JBC-P	Joint Battlefield Command-Platform
JCIDS	Joint Capability Integration and Development
JENM	Joint Enterprise Network Management

JWARN	Joint Warning and Reporting Network
MCIS	Mission Command Information Systems
MFCS	Mortar Fire Control System
MIS	Management Information Systems
NIE	Network Integration Event
OSRVT	One System Remote Video Terminal
PBX	Private Branch Exchange
PSDS2	Persistent Surveillance and Dissemination System of Systems
RSSC	Regional Satellite Communications Support Center
SA	Situational Awareness
SDN	Software Defined Networks
SDR	Software Defined Radios
SRQ	Secondary Research Question
SU	Situational Understanding
SOSE&I	System of Systems Engineering and Integration
SWAP-C	Size, Weight, and Power Cooling
TAIS	Tactical Airspace Integration System
TIGR	Tactical Ground Reporting
TMC	Tactical Mission Command
UASGCS	Unmanned Aircraft System Ground Control Station

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CHAPTER 1

INTRODUCTION

Time, it is the most expensive commodity in the world that is difficult to buy and can never be regained.

> We don't have the luxury of time or money, so we have to use our brain power and we have to use our best assets, and that's our Soldiers," Piatt said. "Our Soldiers can think smarter, they are adaptable, and we've got to focus on what we want to do based on the real threats of the environment.[1]

Could the Army employ the use of holography based applications within the Common Operating Environment (COE) to enhance the operations process in a operational, strategic, and tactical environment (see figure 1)? A visual information environment, augmented on top of reality decreases the amount of time needed to make decisions. The elimination of handheld devices, monitors and physical computers create a noninvasive and non distracting decision making environment. Holography creates an ever present and undetected reality to the enemy for commanders, staffs, and soldiers. Would holography remove the need for a Command Post (CP) that takes significant time and emits an easily identifiable target (see figure 1)?

[1] Vanessa Flores, “Army Warfighting Assessment Informs Rapid Capabilities,” *Army News*, 7 November 2016, accessed 16 January 2017, http://rapidcapabilitiesoffice.army.mil/news/Army-warfighting-assessment-informs-rapid-capabilities/.

Figure 1. BCT Main Command Post (Isometric View)

Source: Department of the Army, *Command Post Handbook* (Washington, DC: Government Printing Office, 2015), 40.

Does the CP become virtual, and is located wherever the Commander and staff are? Will holography based application create a virtual CP and allow the Commander and Staff to be distributed across the battlefield (see figure 2)? Could this capability enhance expeditionary mission command? Does the DoD need to migrate to a holography based platform sooner than later?

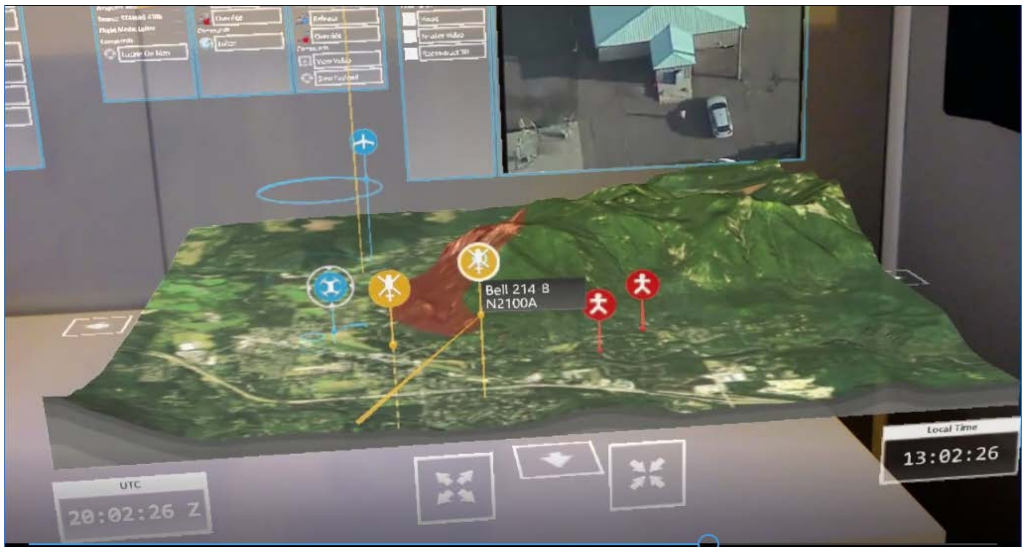

Figure 2. Commanders Common Operating Picture (CCOP)

Source: HoloLens Demo, *Situational Understanding and UAV* (Bingen, WA: INSITU, 9 February 2017), Video.

Background of the Study

I started working on computers at the age of 15 and have not stopped since. I attended Penn State Behrend College where I received a Bachelor of Science in Management Information Systems (MIS). I took many technical classes that focused on software development, hardware architecture, data warehousing, business intelligence, and information technology requirements. While attending school, I was chosen out of 3,000 applicants to work for the chief technical officer (CTO) of GE (General Electric) Rail division located in Erie, Pennsylvania. While at GE I would learn Six Sigma and use the technical skills I learned at Penn State. I specifically worked on Exchange 2000 replication issues, created a self-sustaining reportable IT system for a private branch exchange (PBX) data warehouse, and many more projects.

During 2005 the Iraq surge was happening and I did not see myself working in a cubicle for the next 10 years, so I decided to join the Army. Upon entering the Army, I was assigned to the Field Artillery for the first five years of my career. This was a very difficult time for me as I knew that I was not fulfilling my destiny of working in IT for the Army. With enormous success at GE and Penn State, I wanted to take on the most complex time sensitive IT systems in the world to dominate and win in a complex environment.

Entering into the Signal Corps excited me very much. Even though I had been serving in Artillery I would continue to stay as current as possible and learn new IT skills and technologies. I was able to successfully stand up the Battle Lab at Ft. Gordon in partnership with General Dynamics for the Officer Basic Course, Captains Career Course, and Warrant Officer Basic Course capstone exercise. Additionally, within the Signal Corp I have served as a Battalion S6, and Signal Company Commander. Prior to attending the Command and General Staff Officers Course (CGSOC) I worked for the Network Integration Branch, Mission Command Center of Excellence. I was able to go to Network Integration Exercise (NIE) 17 where I implemented the Common Operating Environment for the Brigade Modernization Command (BMC) (see figure 3). Figure 3 shows the current Army CP moving toward the COE CP. BMC is transformed to Joint Modernization Command (JMC). JMC executes operationally realistic and rigorous Network Integration Evaluation (NIE) and Army Warfighting Assessment (AWA)

exercises to provide Soldier feedback on emerging concepts and capabilities that will improve the combat effectiveness of the Joint Force.[2]

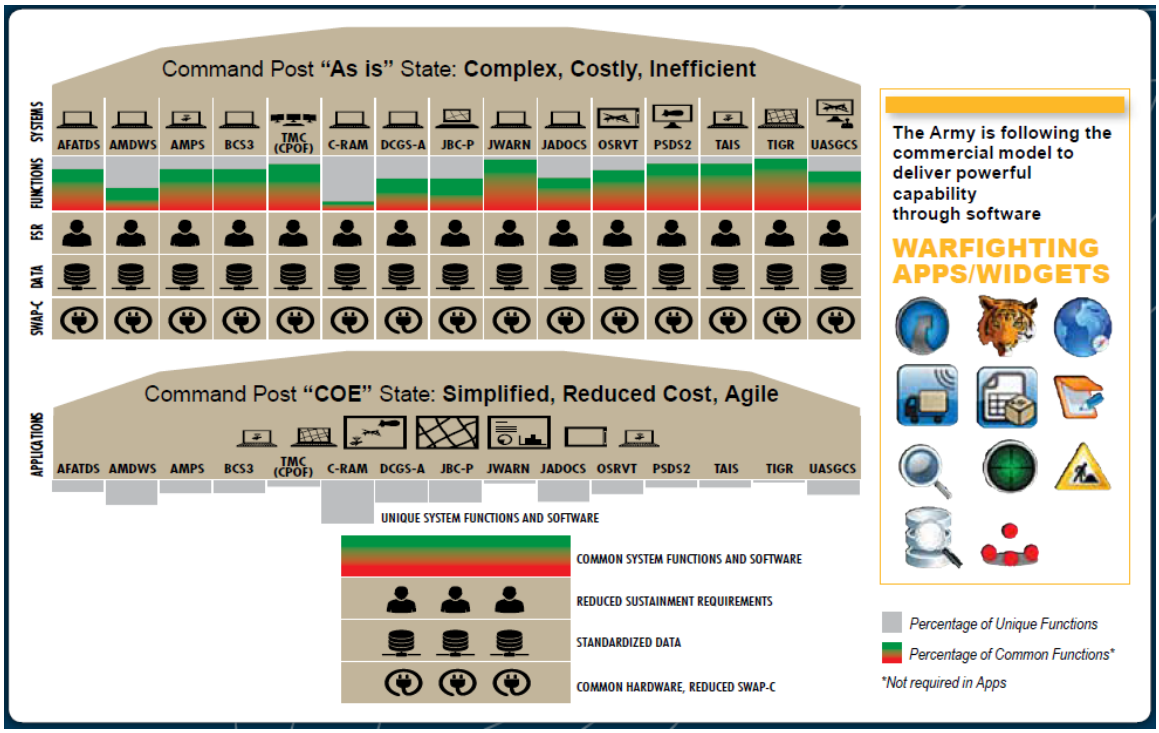

Figure 3. COE consolidation

Source: Department of the Army, *COE Flip Book Final E-Version* (Washington, DC: Government Printing Office, October 2015), 6.

The following three reasons explain why I am conducting this research:

1. Protect our country and the freedoms that we enjoy

2. Protect every Soldier and public servant / service provider in the government and public sector

[2] USA Joint Modernization Command, "Mission," Army Capabilities Integration Center (ARCIC), accessed 12 March 2017, http://www.arcic.army.mil/Directorates/JMC.

3. Personal independent financial growth and conditions for career opportunities

Imagine that you are the brigade commander for a combat aviation brigade (CAB). Your CP has the possibility of having twenty-six stove piped MCIS's. Some of these systems include (see figure 4).

1. Joint Battle Command Platform (formerly BFT)
2. Command Post of the Future (CPOF)
3. Command Web (CMD Web)
4. Global Command and Control System (GCCS-A)
5. Tactical Ground Reporting (TIGR)
6. Advanced Field Artillery Tactical Data Systems (AFATDS)
7. Distributed Common Ground Systems – Army (DCGS-A)
8. Counter – Rocket Artillery Mortar (C-RAM)
9. Tactical Airspace Integration System (TAIS)
10. Aviation Mission Planning System (AMPS)

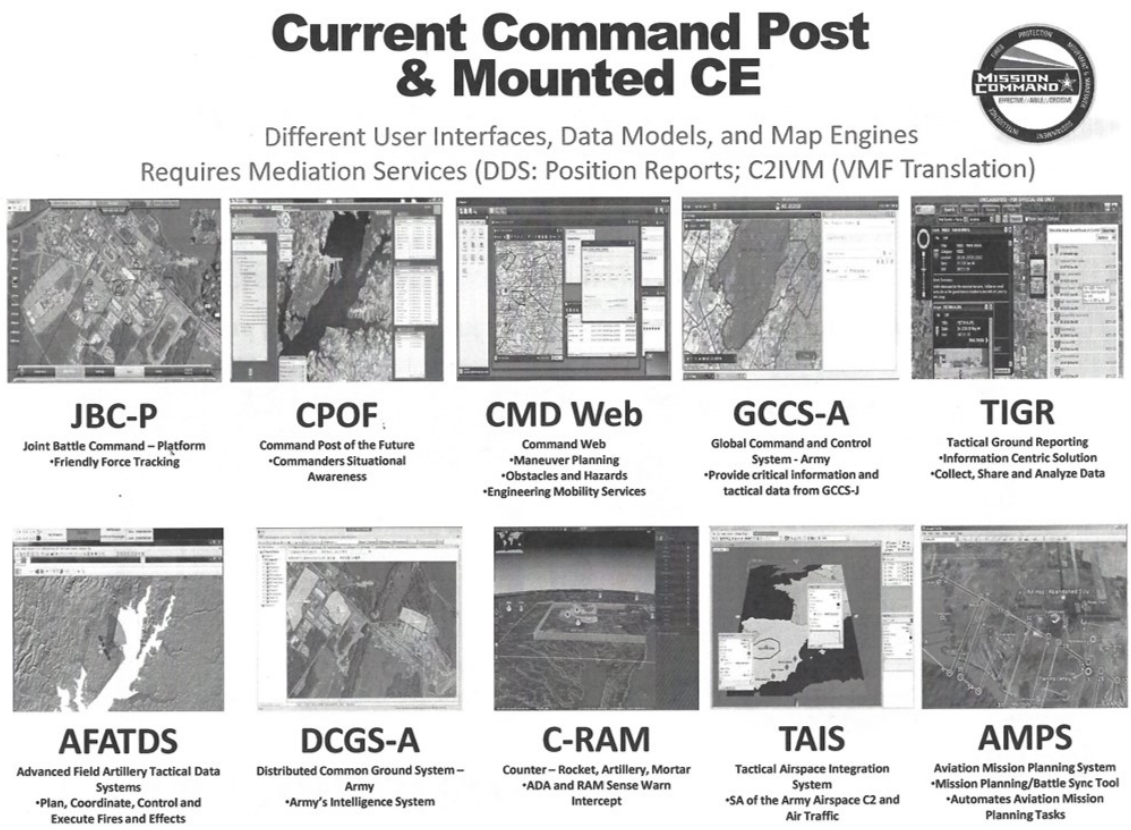

Figure 4. Current Command Post and Mounted Computing Environment

Source: Department of the Army, "Current Command Post and Mounted Computing Environment" (Mission Command Center of Excellence Command Post and Mounted Computing environment document writing team, Ft. Leavenworth, KS, 2017).

As the commander, you are expected to take portions of information if not all of the twenty-six systems and meld them together into a mental picture to create situational understanding. As the commander, you expect your staff to have situational understanding. Can your staff visualize the same mental picture that you have just created by picking from the array of MCISs? Conducting mission command in this manner is a deviation from the traditional use of an analog map board. Many CPs will employ the use

of an analog map board that is manually updated from command systems. The map board allows for the rapid buildup of situational understanding for anyone walking into the CP.

Technology has created an operational gap. The Army has been using map boards and terrain models for years and now they are expected to use a monitor, phone, or some type of physical device. A monitor that only a few people can fit behind, does not display all of the data for situational understanding, and does not have an optimal field of view. Moving to holography allows for operations to return to its original state of virtual map boards, virtual terrain models, and an interface that easily scales to thousands of users. Holography will fill the missing operational gap of allowing the commander and staff to rapidly gain situational understanding combing map boards and sensors automatically. Holography will not only affect the operations of a CP. It will change everything that the Army is using strategically and tactically. Data will augment every process in a noninvasive decision making model. All physical devices such as monitors, phones, keyboards and any physical device will cease to exist. Data will be delivered at the point of need, while the personnel and managers process data for visual augmentation. All staff elements begin to become part of the knowledge management process to deliver data at the point of need.

Microsoft has recently released a new product called HoloLens (see figure 5). Figure 5 shows an image of an option for wearable technology to display holography.

Figure 5. Microsoft HoloLens

Source: Microsoft, "Microsoft HoloLens," accessed 24 January 2017, https://www.microsoft.com/microsoft-hololens/en-us.

A new world of mixed reality experience is waiting for you.[3] With your Windows 10 PC and a compatible headset, you can enjoy familiar Windows apps, features and navigation, while discovering new apps, games and media perfect for AR, VR and everything in between.[4] This technology capability will greatly enhance applications within COE sharing information to be overlaid onto reality. If the Army does not begin to meld and overlay information onto reality. The Army will continue to struggle long term with rapid changes in battlefield conditions. Capabilities similar to HoloLens could create virtual CP's and allow the Commander and Staff to be distributed across the battlefield. Fixed command posts no longer exist and all meetings are done virtually. Holograms are

[3] Microsoft, "Amazing mixed reality experiences are yours," Upcoming Features, accessed 24 January 2017, https://www.microsoft.com/en-us/windows/upcoming-features#mixedreality.

[4] Ibid.

used as live terrain models for tracking sensors and allowing the commander and staff to rapidly develop courses of actions (see figure 6).

Figure removed.

Figure 6. Situational Understanding hologram

Source: HoloLens Demo, *Situational Understanding and UAV* (Bingen, WA: INSITU, 9 February 2017), Video.

Statement of the Problem

Mission Command Information Systems (MCIS) are not optimally designed to enable Army commanders and staffs to gain holistic understanding of the operational environment throughout the operations process.

Purpose of the Study

The purpose of this study and primary research question (PRQ1) is: *How can holography enhance the Army Operations Process?*

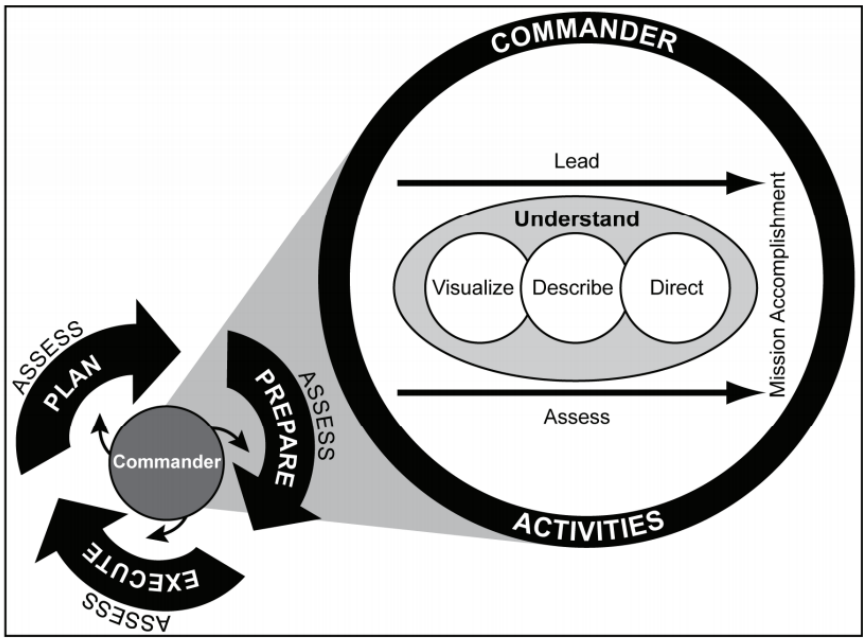

Figure 7. Army Operations Process

Source: Department of the Army, Army Doctrine Publication (ADP) 5-0, *The Operations Process* (Washington, DC: Government Printing Office, May 2012), 1.

In order to properly define the purpose of the study it is important to ask why holography would be needed. Holography based applications will allow a simplified information management environment through natural cognitive load.

Are we in a new Military Revolution or a Revolution in Military Affairs?

> The *Dynamics of Military Revolution* bridges a major gap in the emerging literature on revolutions in military affairs. It suggests that two very different phenomena have been at work over the past centuries: military revolutions, which are driven by vast social and political changes, and revolutions in military affairs,

> which military institutions have directed, although usually with great difficulty and ambiguous results.[5]

This research would like to call the next military revolution the Age of Information. This research declares the Age of Information as a military revolution because it is not driven by the military but by social, economic, and political changes. Is society correctly defining a military revolution without using technology? Has information overwhelmed the Army in the Age of Information? Are phones, laptops, and monitors the best way to look to view the information? Holography will simplify the management of information by augmenting data over reality.

Secondary Research Questions

The following secondary research questions (SRQ) were chosen based on the idea that holography would be initially implemented into the Army's planning process. Mission command would be the next process to focus on allowing the commander and staff to centrally monitor and manage. Looking at how holography would simplify mission command systems talks about a user friendly easy to learn operational environment. Lastly, looking at how holograms would look and work within warfighting functions shows the readers the realm of the possible.

[5] MacGregor Knox and Williamson Murray, eds., *The Dynamics of Military Revolution, 1300-2050* (Cambridge: Cambridge University Press, 2001), 2.

Secondary Research Question 1

SRQ1 asks: How would holograms support the planning process? Holograms will create a virtual environment during the planning process allowing the staff to better visualize and understand during war game on live terrain.

Secondary Research Question 2

SRQ2 asks: How would holograms support the execution activity of mission command? Holograms will allow commanders and staff the ability to interact with a live environment with a touch to talk capability of sensors.

Secondary Research Question 3

SRQ3 asks: How would the use of holograms in Mission Command Information Systems (MCIS) improve the exercise of mission command? Holography will allow the commander and staff to be distributed and exercise expeditionary mission command.

Secondary Research Question 4

SRQ4 asks: How would holograms be used in warfighting functions*?* Chapter 4 will include several vignettes discussing and showing how holography would benefit all of the warfighting functions.

Significance of the Study

On 14 January 2017 Lieutenant General H. R. McMaster wrote an email on the subject of ARCIC Professional Reading #126 (14 January 2017), “NATO's Land Forces: Strength and Speed Matter.” The ARCIC develops concepts, learns, and integrates capabilities to improve our Army and ensure the effectiveness of the Joint Force. This email alone drives the significance of the study of how holography can drive the

operations process. Holography will simplify the ability for the commander to rapidly gain situational understanding in order to build strength and speed within the Army and NATO. Holography will give all commanders the visualization needed to make quicker decisions. Chapter 4 will include vignettes of how holography will increase strength and speed for combatant commanders and align NATO forces. His email highlights the following points for NATO Land Forces:

1. Ensure the intelligence enterprise provides timely indicators and warnings of Aggression.[6]

2. Close the gap in current NATO Rapid Response timetables.[7]

3. Pre-position US equipment to permit rapid reinforcement.[8]

4. Develop and test effective counters to Russian A2/AD capabilities.[9]

5. Strengthen land force capabilities and modernize forces for inter-state, high intensity conflict.[10]

6. Re-examine training and doctrine to ensure land forces are capable of countering a peer competitor.[11]

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[6] General John Nicholson, *NATO's Land Forces: Strength and Speed Matter,* Reading #126 (Fort Eustis, VA: Army Capabilities Integration Center, 18 July 2016)**.**

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Ibid.

All of the following points could be greatly enhanced and allow for the command and control of rapid buildup of forces and speed through the use of holography. The Army is looking for solutions that "consider additional ways the Army can ensure readiness and interoperability to prevent conflict, shape security environments, and, if necessary, fight and win as part of a joint and multinational team." The Army has posited 20 Army warfighting challenges designed to lead intellectual discourses to derive solutions. Key issues follow:

1. #1. Develop Situational Understanding: How to develop and sustain a high degree of situational understanding while operating in complex environments against determined, adaptive enemy organizations.[12]
2. #2. Shape the Security Environment: How to shape and influence security environments, engage key actors, and consolidate gains to achieve sustainable security outcomes in support of Geographic and Functional Combatant Commands and Joint requirements.[13]
3. #8. Enhance Realistic Training: How to train Soldiers and leaders to ensure they are prepared to accomplish the mission across the range of military operations while operating in complex environments against determined, adaptive enemy organizations.[14]

[12] Ibid.

[13] Ibid.

[14] Ibid.

4. #12. Conduct Joint Expeditionary Maneuver and Entry Operations: How to project forces, conduct forcible and early entry, and transition rapidly to offensive operations to ensure access and seize the initiative.[15]
5. #14. Ensure Interoperability and Operate in a Joint, Inter-organizational and Multinational Environment: How to integrate joint, interorganizational, and multinational partner capabilities and campaigns to ensure unity of effort and accomplish missions across the range of military operations.[16]
6. #15. Conduct Joint Combined Arms Maneuver: How to conduct combined arms air-ground maneuver to defeat enemy organizations and accomplish missions in complex operational environments.[17]
7. #19. Exercise Mission Command: How to understand, visualize, describe, and direct operations consistent with the philosophy of mission command to seize the initiative over the enemy and accomplish the mission across the range of military operations.[18]
8. #20. Develop Capable Formations: How to design Army formations capable of rapidly deploying and conducting operations for ample duration and in sufficient scale to accomplish the mission.[19]

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[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid.

Holography will greatly enhance all of the listed warfighting challenges. Chapter 2 will go into greater detail listing a few of the Army warfighting challenges and discuss common information. The study of all of the army warfighting challenges and how holography would enhance them would greatly benefit the Army in the future. This research is unable to capture every requirement within the documents and fully explain how holography would augment information.

Operational Definitions of Key Terms

The following operational definition of key terms will be used for the remainder of this study:

Augmented reality: "an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (as a smartphone camera); also: the technology used to create augmented reality."[20]

Augmented reality: "augmented reality overlays digital information on top of your real world. By understanding your environment, mixed reality enables holograms to look and sound like they're part of your world."[21]

Cognitive load: "is defined as the aggregate mental load place on battle-staff personnel by a complex mission command work setting."[22]

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[20] Merriam-Webster Dictionary, "Augmented Reality," accessed 14 November 2016, http://www.merriam-webster.com/dictionary/augmented%20reality.

[21] Microsoft Webster Dictionary, "Augmented Reality," accessed 14 November 2016, https://www.microsoft.com/microsoft-hololens/en-us/why-hololens.

[22] Ibid.

Common operating environment: “Common Operating Environment (COE) is a new way of doing business. The COE is not a system or an acquisition Program of Record. Rather, COE technologies and standards bring stove piped systems onto a common foundation to allow the Army to deliver warfighting capabilities as software applications. This will provide Soldier with a vast range of tools in one user-friendly place--improving their access to information, while reducing their training and logistics burden. And it’s not just easier: COE makes the Army more efficient, more operationally effective and more cyber secure.”[23]

Early Entry Mission Command: “Once on the ground, friendly forces must be able to move immediately with communications, and expand operations as additional forces arrive. In these operations, the MC Network must adapt to rapid changes, ensuring capacity and connectivity while minimizing ‘blinks’ in communications.”[24]

Expeditionary Mission Command: “Expeditionary refers to the ability to deploy task-organized forces on short notice to austere locations, capable of conducting operations immediately upon arrival.”[25]

[23] Department of the Army, *COE Flip Book Final E-Version* (Washington, DC: Government Printing Office, October 2015), 14.

[24] Ibid., 8.

[25] Jeffrey R. Witskin, *Mission Command Network Vision and Narrative* (Fort Leavenworth, KS: Combined Arms Center, October 2015), 6.

Golden Hour: “the hour immediately following traumatic injury in which medical treatment to prevent irreversible internal damage and optimize the chance of survival is most effective.”[26]

Hologram: “a three-dimensional image reproduced from a pattern of interference produced by a split coherent beam of radiation (as a laser); also: the pattern of interference itself.”[27]

Holography: “the art or process of making or using a hologram.”[28]

Home Station Mission Command: “the MC Network applies strategic/enterprise and installation aspects of the network to fully enable expeditionary mission command and training and readiness.”[29]

[26] Merriam-Webster Dictionary, “Golden Hour,” accessed 7 March 2017, https://www.merriam-webster.com/medical/golden%20hour.

[27] Merriam-Webster Dictionary, “Hologram,” accessed 14 November 2016, http://www.merriam-webster.com/dictionary/ hologram.

[28] Ibid.

[29] Witskin, 10.

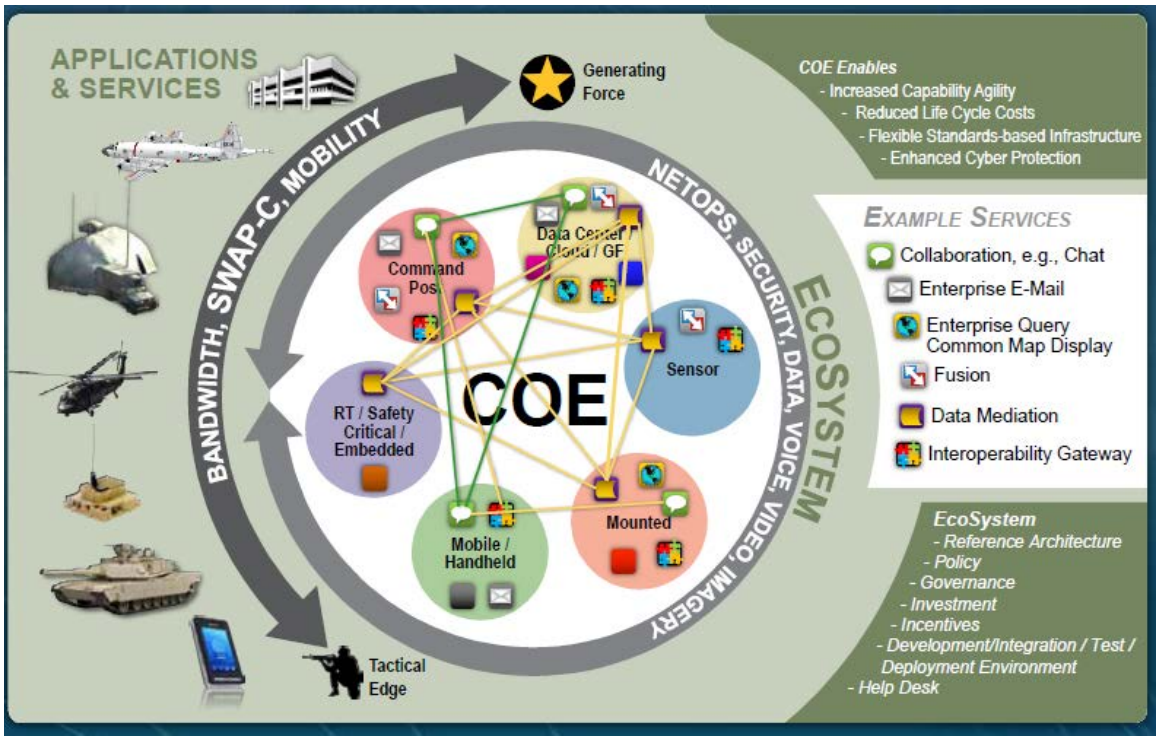

Figure 8. COE Overview

Source: Department of the Army, *COE Flip Book Final E-Version* (Washington, DC: Government Printing Office, October 2015), 14.

Human-Systems Integration: "Human-Systems Integration (HSI) encompasses the technical domains of Human Factors Engineering (HFE), manpower, personnel, training, system safety, personnel survivability, and health hazards. "[30]

[30] John Hawley and Michael Swehla, *Human-System Integration and the Network Integration Evaluations, Part 3: Mitigating Cognitive Load in Network-Enabled Mission Command* (Aberdeen Proving Ground, MD: Army Research Lab, June 2016).

Macroergonomics: “concerned with the analysis, design, and evaluations of work systems. As used here, a work system refers to a sociotechnical system consisting of both people and technology intended to accomplish a specific organizational function.”[31]

Sociotechnical systems analysis: “an approach to organizational work design and assessment that concerns the interaction of people and technology in operational work settings. Outside the Network Integration Events (NIE) few other venues provide an opportunity to asses Soldier performance effects and issues at the sociotechnical system level.”[32].

Limitation and Delimitations

This section can best be defined as “fully disclosing what the researcher intends to do and, conversely, does not intend to do.”[33] This study intends to show the users the possibility of what holography would look like within Army operations, mission command, and per warfighting function. Chapter 4 will include vignettes and scenarios that will immerse the reader into the possibility of augmented reality. Due to the nature of the study the following areas are known but outside the scope of this research:

1. Joint Capabilities Integration Development System
2. System, Application, and Network Architecture
3. Security

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[31] Ibid.

[32] Ibid.

[33] Paul D. Leedy and Jeanne Ellis Ormond, *Practical Research Planning and Design*, 9th ed. (Upper Saddle River, NJ, Merrill, 2010), 56.

4. Hardware

5. Operational Integration

6. AWFC #14, #15, #20 due to classification

Nature of the Study

The nature of this study was a qualitative research study. I am using the content analysis model. A content analysis is a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases.[34] In qualitative research, the potential sources of data are limited only by the researcher's open-mindedness and creativity.[35] This research uses data gather from the Mission Command Center of Excellence, Ike Skelton Combined Arms Research Library, industry use, and personal knowledge. Reviewing the functional needs analysis from 2013 clearly outline the missing capabilities for MCISs. The 20 Army warfighting challenges have a common them of situational understanding across the majority of the challenges. The focus of the study is to immerse the reader into the possibility of augmented reality, creating a new dimension where data integrates with reality.

Summary

Technology has created an operational gap. The Army has been using map boards and terrain models for years and now they are expected to use a monitor, phone, or some type of physical device. A monitor that only a few people can fit behind, does not display

[34] Ibid., 144.

[35] Ibid., 145.

all of the data for situational understanding, and does not have an optimal field of view. Moving to holography allows for operations to return to its original state of virtual map boards, virtual terrain models, and an interface that easily scales to thousands of users. Holography will fill the missing operational gap of allowing the commander and staff to rapidly gain situational understanding combing map boards and sensors automatically. Holography will not only affect the operations of a CP. It will change everything that the Army is using strategically and tactically. Data will augment every process in a noninvasive decision making model.

CHAPTER 2

LITERATURE REVIEW

Introduction

The literature review of holography is extremely complicated due to the lack of available resources. This review includes research that was created by the author during the course of this research. Holography as a technology is extremely new. There are minimal amounts of use cases within industry to provide data on the effects of information technology with operational technology.

Reading Lieutenant General H. R. McMaster's foreword in the *Mission Command Network Vision and Narrative* refined the focus of what literature to review.

What Does the Army Want?

> American military power is joint power. Army forces provide foundational capabilities to the joint force that are essential to securing our nation. Regionally aligned and forward positioned forces are essential to assure allies and deter enemies. When called upon, Army forces must be prepared to fight and win as part of joint, interorganizational and multinational teams. In future armed conflict, increasingly capable and elusive enemies will attempt to avoid our strengths, disrupt our advantages, emulate our capabilities, and expand operations beyond the physical battleground to battlegrounds of perception, subversion, and the cyber-electromagnetic spectrum. Army forces will have to deploy rapidly into unexpected locations and transition quickly into high tempo operations across wide areas. Joint, combined arms, air-ground formations will operate dispersed while maintaining mutual support and the ability to concentrate rapidly to take advantage of fleeting opportunities and protect against unanticipated dangers. Forces will task organize on the fly based on changes in mission variables (mission, enemy, terrain and weather, troops, time and civil considerations). Ultimately Army forces must defeat enemy organizations, control terrain, secure populations, consolidate gains, and project power across the land, air, maritime, space and cyberspace domains to preserve joint force freedom of movement and action.
>
> We are far from the realization of a network that satisfies the characteristics and design principles in this vision and narrative. Our Army's ability to conduct

> expeditionary maneuver and Joint Combined Arms Operations depends on a Mission Command Network that is assured, interoperable, tailorable, collaborative, identity based, and accessible at the point of need. Realizing our vision for the Mission Command Network will require focused and sustained collaboration across our Army as well as with the Joint Force and multinational partners. It will not be easy. We must evaluate and prioritize network-related efforts based on the degree to which they contribute to this vision and how network-related capabilities effect our ability to operate consistent with the Army Operating Concept We must analyze current and future network requirements, assess requirements against current and planned capabilities, research and develop solutions to capability gaps and implement network solutions across the force. This paper provides a vision as the start point for network design and describes the operational capabilities necessary for Army forces to win in a complex world.[36]

The statement above is extremely powerful and summarizes where the Army needs to focus. This research focuses on the word vision, which is profound within the definition of Mission Command. The word vision is found four times within the above statement, but also is listed in the title of the document that it is referenced from. Holography integrated into mission command as an augmented reality will give the Army a tangible vision of operational, strategic and tactical applications.

Army Warfighting Challenges

The Army Capabilities Integration Center (ARCIC) currently overseas the 20 Army Warfighting Challenges. The ARCIC develops concepts, learns, and integrates capabilities to improve our Army and ensure the effectiveness of the Joint Force.[37] ARCIC's intent is to innovate to ensure that Army forces are prepared to provide multiple options for combatant commanders; present multiple dilemmas to enemies;

[36] Witskin, 3.

[37] ARCIC, "Mission," Army Capabilities Integration Center, accessed 16 January 2017, http://www.arcic.army.mil/Home/About.

integrate efforts of multiple partners; and operate across multiple domains.[38] ARCIC's end state is to create resilient soldiers, adaptive leaders, and cohesive teams are capable of defeating enemy organizations, controlling terrain, securing populations, consolidating gains, and preserving joint force freedom of action in the land, air, maritime, space, and cyberspace domains.[39] Historically ARCIC has been slow to integrate new technology. On 28 December 2009, the Vice Chief of Staff, Army directed the chief information officer (CIO/G-6) to develop "as is" and "end state" network architectures to set the vision for the evolution of network procurements and enhancements.[40] This initiated the beginning of COE. Currently the Command Post Computing Environment, which is a portion of COE is scheduled to begin fielding in 1Q19. This means that from the initial discussion of COE in 2009 and the proposed fielding in first quarter 2019 (1Q19) adds up to ten years of development. This time involved in developing this solution is a decade and shows why the Army needs to begin looking at and designing holography based applications now.

While attending CGSOC many speakers have brought up the AWFC's, so it is important to include this information in this research (see table 1). I downloaded all 20 documents from ARCIC's SharePoint and read them to include documents that are currently in draft from centers of excellence. Due to the size constraints of this thesis it

[38] Ibid.

[39] Ibid.

[40] Heidi Shyu, "Common Operating Environment (COE) Directive for Program Executive Offices (PEOs)," (Department of the Army memorandum, Washington, DC: 20 December 2011).

is not possible to cover every warfighting challenge and how holography could enhance each demand. This research will extract data from the AWFC's one, two, eight, twelve, and nineteen, to focus on rapidly building speed and strength across formations. Initial review found fourteen, fifteen and twenty to be important for review. Due to the security document classification of fourteen, fifteen and twenty this research will not be able to include the challenges in the review.

As one reviews the demands within each challenge one will see a number in parenthesis. This number directly links to the numbered demand within the actual warfighting challenge document to allow the reader to quickly orient and use as a reference for later. Additionally, the learning demand numbers will be used in chapter 4 to associate what demands can be enhanced through holography. An example would be 1.1, which refers to Army warfighting challenge one, learning demand one. The reader will be able to create a mental linkage between the AWFC number and the proposed holography solution. This will set the reader up to understand how the research takes the Army warfighting challenge demands and nests them within warfighting functions.

The Army will enhance readiness and interoperability to prevent conflict, shape security environments, and, if necessary, fight and win as part of a joint and multinational team.[41] Holography will give commanders and staff a competitive edge over the enemy for gaining a holistic situational understanding. The commanders visually see how forces are arrayed across the battle space in a multi domain (e.g. land, air, space, cyber) environment.

[41] General John Nicholson, *NATO's Land Forces: Strength and Speed Matter,* Reading #126 (Fort Eustis, VA: Army Capabilities Integration Center, 18 July 2016).

Table 1. The 20 Army Warfighting Challenges		
#	Title	Document Date
1	Develop Situational Understanding	20160718
2	Shape the Security Environment	20150316
3	Provide Security Force Assistance	20160718
4	Adapt Institutional Army and Innovate	20160609
5	Counter Weapons of Mass Destruction	20160113
6	Homeland Operations	20150416
7	Conduct Space, Cyber, Electronic Warfare, and Communications Operations	20160818
8	Enhance Training	20150810
9	Improve Soldier, Leader, and Team Performance	20150721
10	Develop Agile and Adaptive Leaders	20160923
11	Conduct Air-Ground Reconnaissance and Security Operations	20150510
12	Conduct Joint Expeditionary Maneuver and Entry Operations	20160217
13	Conduct Wide Area Security	20160216
14	Ensure Interoperability and Operate in a Joint, Interorganizational, and Multinational Environment	20150416
15	Conduct Joint Combined Arms Maneuver	20160516
16	Set the Theater, Sustain Operations, and maintain Freedom of Movement	20160822
17	Integrate Fires	20150312
18	Deliver Fires	20150508
19	Exercise Mission Command	20161028
20	Develop Capable Formations	20160510

Source: Created by author

AWFC #1 Develop Situational Understanding

The first AWFC focuses on situational understanding (SU). The problem statement asks how to develop and sustain a high degree of SU while operating in

complex environments against determined, adaptive enemy organizations.[42] The following learning demands are associated with AWFC one:

1. (1.1) How do Army commanders and staffs achieve SU of complex areas of operation across all phases of operations and in all five domains?[43]

2. (1.2) How do Army units integrate relevant information from all available sources (traditional / non-traditional) to develop the COP and the SU of commanders and staffs for Mission Command?[44]

3. (1.3) How do Army elements at Brigade (BDE) and below integrate and synchronize organic/non-organic intelligence capabilities to support the development of SU?[45]

4. (1.4) How do Army units accelerate the experiential learning process in order to imbue Soldiers and leaders with the experience, judgment, and maturity necessary to develop and sustain SU in a complex environment?[46]

[42] TRADOC, "Army Warfighting Challenges (AWFC) Group," 2016, accessed 9 September 2016, https://www.milsuite.mil/book/groups/army-warfighting-challenge-awfc-group.

[43] Ibid.

[44] Ibid.

[45] Ibid.

[46] Ibid.

5. (1.5) How do Army units responsible for the execution of cyberspace and electromagnetic operations develop the SU of commanders and staffs for Mission Command?[47]

6. (1.6) How do Army units develop understanding of the political, military, economic, social, information, infrastructure, physical environment, and time (PMESII-PT) factors that affect the mission?[48]

7. (1.7) How does the introduction of technologies and changes in capacities to existing capabilities affect achieving SU for the conduct of operations across all echelons, formations, environments and domains?[49]

The commander and staff will be distributed across the battle field. Virtual meetings will allow the commander and staff to collaborate and plan based on a common situational understanding of sensors on a holographic map. Knowledge managers will support from home station mission command delivering data and views to the staff and commanders on demand. Holographic terrain models allow staffs to rapidly model and learn using MDMP with simulations for war gaming and course of action analysis. Technologies and changes in capacities are primarily done through data and not the visualization of the interface. The common interface is minimally invasive to the user and creates an environment that augments the process.

[47] Ibid.

[48] Ibid.

[49] Ibid.

AWFC #2 Shape the Security Environment

The second AWFC focuses on shaping the security environments. The problem statement asks how to shape and influence security environments, engage key actors, and consolidate gains.[50] To achieve sustainable security outcomes in support of Geographic and Functional Combatant Commands and Joint requirements.[51] The following learning demands are associated with AWFC two:

1. (2.1) How does the Army determine, develop, and sustain the cognitive competencies required to Shape the Security Environment?[52]

2. (2.2) How do Geographic Combatant Commanders access operational and institutional Army capabilities to shape the security environment in their Area of Responsibility?[53]

3. (2.3) How does the Army ensure security environment planning is sufficient and timely in support of future operations in any operational environment?[54]

4. (2.4) How must the Army synchronize NGO, OGA and joint, inter-organization, and multination efforts to shape the security environment with military operations to support shared understanding and build trust?[55]

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[50] Ibid., AWFC #2.

[51] Ibid.

[52] Ibid.

[53] Ibid.

[54] Ibid.

[55] Ibid.

5. (2.5) How is the regional security environment impacted by the Range of Military Operations (ROMO)?[56]

6. (2.6) How will future Joint and Army forces integrate and synchronize site exploitation activities to derive facts, actionable information, or intelligence to enable decisive action, targeting, or criminal prosecution in support of unified land operations?[57]

7. (2.7) How does the Army identify and increase availability of subject matter expertise in Building Partner Capacity and Civil-Military Operations?[58]

8. (2.8) How does the Army assess and develop inter-social knowledge, skills, and attitudes throughout the career lifecycle and provide tools to improve identified weak areas and sustain identified strengths?[59]

9. (2.9) What are the constraints and limitations in providing Army forces to conduct stability tasks that result in partner nation's ability to demonstrate the capability to conduct stability operations?[60]

10. (2.10) What are the Army force structure requirements that best enable sustained partner activity operations necessary to develop shared aims, goals, and objectives?[61]

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[56] Ibid.

[57] Ibid.

[58] Ibid.

[59] Ibid.

[60] Ibid.

[61] Ibid.

Holography will enhance cognitive competencies by reducing stove piped processes. Geographic Combatant Commanders access operational and institutional Army capabilities through the reach back of home station mission command. Holographic terrain models augment the staff during the MDMP process to reduce planning time as staffs are distributed across the battle space. Holography will enhance the COP that is shareable across NGO, OGA, joint, interorganizational, and multination efforts. Sensors enhance the security environment delivering data though holography and enabling ROMO. Operators use scanning from holography devices to enable positive identification of high value targets. Inter-social knowledge is accessed remotely allowing subject matter experts (SME) to assist anywhere within a strategic and tactical process.

AWCF #8 Enhance Training

The eighth AWFC, enhance training focuses on soldiers and leaders being prepared. How to train Soldiers and leaders to ensure they are prepared to accomplish the mission across the range of military operations while operating in complex environments against determined, adaptive enemy organizations?[62] The following learning demands are associated with AWFC eight:

1. (8.1) How does the Army improve and evolve the integrated training environment in order to effectively replicate all conditions of the future operational environment –creating adaptive realistic training--while also improving and evolving unit training management and readiness reporting?[63]

[62] Ibid., AWFC #8

[63] Ibid.

2. (8.2) How does the Army continue to improve its training and education development policy, requirements, processes, products, concepts, strategies, plans, and tool?[64]

3. (8.3) How does the Army continue to improve current training management systems and processes; while continuing to improve Unit Training Management (UTM), and nest Army Training Management Systems (ATMS) with Training Information Infrastructure (TII) and Army Training Information System (ATIS) efforts?[65]

4. (8.4) How does the Army improve the effectiveness of training and educational enablers to improve outcomes, return on investments and increase Soldier, Leader and unit proficiency and readiness?[66]

5. (8.5) How does the Army continue to improve the sustainment of crew and small unit collective maneuver, mission command training, home station ranges and training land, and its combat training centers?[67]

6. (8.6) How does the Army continue to improve its training information system and allow more efficient, effective, and intuitive access to training information?[68]

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[64] Ibid.

[65] Ibid.

[66] Ibid.

[67] Ibid.

[68] Ibid.

7. (8.7) How does the Army continue to improve its delivery of rigorous, relevant, and tailored distributed training and education at the point of need from a responsive and accessible delivery capability?[69]

Holography creates a learning environment that stretches across augmented reality and virtual reality. Conditions are replicated and give the commander, staff and soldier a genuine sense of realistic training. Training rapidly evolves based on scenarios and environments without the user changing location. Unit training management nests within the army training network displaying information to the soldier for individual performance as well as the commander and staff for unit performance. Outcomes drastically improve as leaders are focused on simulations and war gaming rather than format and setup times needed to perform these functions. Analytics is conducted on unit training performance to help deliver updates to applications across the Army. Training happens globally regardless of the area of operations. Data injected into holograms with a mix of virtual reality enable training competencies to be maintained across the force.

AWFC #12 Conduct Joint Expeditionary Maneuver and Entry Operations

The twelfth AWFC focuses on conducting joint expeditionary maneuver and entry operations. The problem statement asks how to project forces, conduct forcible entry and early entry, and transition rapidly to offensive operations to ensure access and seize the initiative.[70] The following learning demands are associated with AWFC twelve:

[69] Ibid.

[70] Ibid., AWFC #12

1. (12.1) What mobility and mobile-protected firepower capabilities would best enable forcible entry forces to insert at offset entry points and then rapidly transition to offensive operations.[71]

2. (12.2) What combinations of Army and Joint capabilities are required to protect early entry forces from enemy anti-access efforts?[72]

3. (12.3) What capabilities / DOTMLPF-P solutions are needed to enable Mission Command of early entry forces in order to support expeditionary maneuver?[73]

4. (12.4) How can maneuver forces leverage sea basing and the sea as maneuver space to overcome enemy anti-access capabilities and what capabilities must be developed to make this functional?[74]

5. (12.5) What training strategies will best support attaining Joint forcible entry proficiency and help assure US access into theaters around the globe?[75]

6. (12.6) What strategic deployment capabilities are required in order to allow maneuver forces to conduct initial entry at multiple points simultaneously?[76]

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[71] Ibid.

[72] Ibid.

[73] Ibid.

[74] Ibid.

[75] Ibid.

[76] Ibid.

7. (12.7) How does the Army ensure intelligence planning and dissemination is sufficient and timely to enable the conduct of entry operations in any operational environment?[77]

8. (12.8) What must we do to support situational understanding for commander's decision making and risk reduction?[78]

9. (12.9) What CONUS/OCONUS infrastructure capabilities are necessary to ensure the rapid deployment of entry operation forces?[79]

10. (12.10) How will significantly improved aircraft performance provide a capability for dispersed, mobile combined arms teams to concentrate rapidly?[80]

AWFC #19 Exercising Mission Command

The nineteenth AWFC focuses on exercising mission command. The problem statement asks how to understand, visualize, describe, and direct operations consistent with the philosophy of Mission Command to seize the initiative over the enemy and accomplish the mission across the range of military operations?[81] The following learning demands are associated with AWFC nineteen:

[77] Ibid.

[78] Ibid.

[79] Ibid.

[80] Ibid.

[81] Ibid., AWFC #19

1. (19.1) How do future Army forces, at all echelons and in all conditions, achieve continuous MC?[82]

2. (19.2) How does the Army create unity of effort to effectively implement mission command to achieve Army-wide understanding and practice of the MC philosophy leading to successful Unified Land Operations (ULO) in support of the joint force?[83]

3. (19.3) How do Army forces, at all echelons and under all conditions, achieve full MCIS interoperability to meet operational requirements with joint, interorganizational and multinational partners?[84]

4. (19.4) How do Army forces, at all echelons and under all conditions, achieve sustainable understanding, training, employment, and maintenance of automated MC information systems?[85]

5. (19.5) How do future Army forces achieve the ability to describe, plan, integrate, continuously assess, and incorporate Cyber Electromagnetic (CEM) activities?[86]

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[82] Ibid.

[83] Ibid.

[84] Ibid.

[85] Ibid.

[86] Ibid.

6. (19.6) How do Army forces, at all echelons and under all conditions, achieve shared knowledge to support consistent application of Mission Command and Knowledge Management across operational and institutional domains?[87]

7. (19.7) How does the Army in a complex urban environment continue to execute mission command?[88]

The fourteenth, fifteenth, and twentieth AWFC are not able to be used in detail for this research due to the classification of for official use only (FOUO).

Army mission command information systems

Mission Command Information Systems (MCIS) are not optimally designed to enable Army commanders and staffs to gain holistic understanding of the operational environment throughout the operations process. The systems do not reduce time to enable Army commanders and staffs to gain holistic understanding of the operational environment throughout the operations process. The design of a system within a system of systems can't be measured properly unless the Army is using Human-Systems integration architecture for change proposals. The majority of the findings on how the design and use of Army MCISs are rooted in the *Human-Systems Integration (HSI) and the Network Integration Evaluations (NIEs), Part 3: Mitigating Cognitive Load in Network-Enabled Mission Command.* The focus of this report is concrete actions for

[87] Ibid.

[88] Ibid.

mitigating cognitive load in network-enabled mission command.[89] Cognitive load is defined as the aggregate mental load placed on battle-staff personnel by a complex mission command work setting.[90]

The research includes the background information due to the importance of the findings on where current system of systems development is trending. Digital CP's can no longer be viewed as a collection of semi-independent systems that are cobbled together after the fact to support the mission command warfighting function.[91] However, physical integration does not always result in sufficient levels of interoperability.[92] Moreover, a cobbled together collection of mission command components is not necessarily a true system of systems when viewed from a cognitive performance perspective.[93] The cobbled together nature of current mission command systems tends to result in compartmentalized analyses of data, thus making it difficult to transform that data into useful information.[94] This compartmentalization also makes it difficult to share information across mission command systems and readily support battle staff processes and command decision making.[95]

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[89] Hawley and Swehla, iii.

[90] Ibid.

[91] Ibid., 7.

[92] Ibid.

[93] Ibid.

[94] Ibid., 7-8.

[95] Ibid., 8.

According the Hawley's report and research the data shows that systems are becoming larger, more complex, and harder for users to integrate information. Using the current methodology of design for future based systems will continue to add more time to commanders and staff. Systems are not integrated well, training and battle drills must be adjusted every time there is a change to the system. Commanders must look at a multitude of systems to try and create a mental picture of situational understanding. When is too much data too much for a commander and staff? How do commanders and staff efficiently conduct operations to build strength and speed where it matters? How could the Army measure the effects of new systems and technologies based on unit performance? The result of any significant change in systems and technology will be a unit performance trace similar to that shown notionally in figure 9.[96]

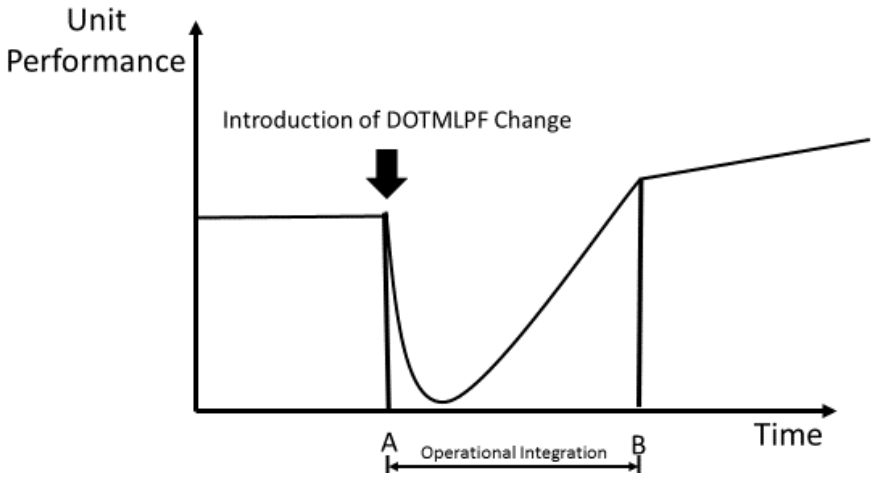

Figure 9. The disruptive effect of new systems and technologies on unit performance

Source: John K. Hawley and Michael W. Swehla, ARL-TR-7698, *Human-Systems Integration (HSI) and the Network Integration Evaluations (NIEs), Part 3: Mitigating Cognitive Load in Network-Enabled Mission Command* (Aberdeen Proving Ground, MD: US Army Research Laboratory, June 2016), 31.

[96] Ibid., 31.

Multiple and concurrent equipment changes can have a cumulative and possibly nonadditive impact on unit performance (i.e., 1 + 1 > 2). That is, multiple equipment changes requiring corresponding DOTLP changes will increase the complexity of the unit's learning and adaptation processes and increase the length of the adaptation period and possibly deepen the performance drop-off. This situation is illustrated notionally in Fig. 2. Change is disruptive, and multiple changes are cumulatively disruptive.[97]

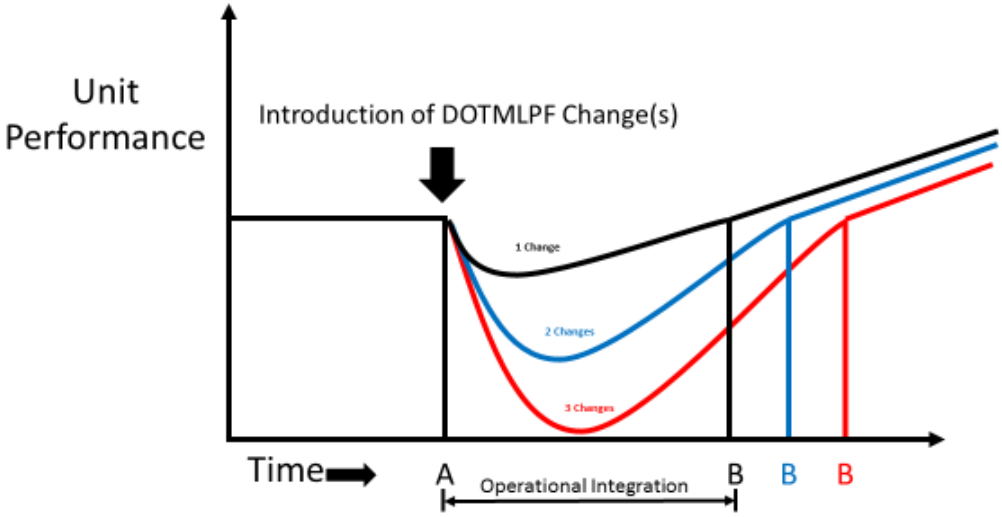

Figure 10. The cumulative effect of multiple new systems and technologies on unit performance

Source: John K. Hawley and Michael W. Swehla, ARL-TR-7698, *Human-Systems Integration (HSI) and the Network Integration Evaluations (NIEs), Part 3: Mitigating Cognitive Load in Network-Enabled Mission Command* (Aberdeen Proving Ground, MD: US Army Research Laboratory, June 2016), 31.

Dr. Hawley recommends the following for mission command information systems:

Part of the interoperability problem observed during the NIEs is the result of a lack of coordination across multiple vendors on aspects of design and component integration as basic as not having compatible software interface

[97] Ibid., 31.

> integration capabilities. Software and hardware developers often produce products without consideration of other systems that will be used as a suite, which makes it difficult for common analysis and collaboration across warfighting functions. Cognitive aspects of mission command system interoperability also must be addressed. The COE (Common Operating Environment) and CPCE (Command Post Computing Environment) represent potential solutions to mission command interoperability challenges in the mid to long term.[98]

With the lack of a common interface integration design, systems will become more complex and disjointed. The Army's systems of systems will quickly grow out of control as they move into the future and capabilities continue to aggregate. Is there a better way to visually display data in a new and improved interface? Would this interface create a better situational understanding for the commander and staff and reduce the complexity of learning multiple applications within the system of systems? Instead of searching for data and creating the optimal interface within your mind, is there a visual way to have data delivered on demand?

Why holography

> We can't have technology driving my strategy. We can't have technology driving our tactics," he said. "We have to drive technology to adapt to the tactics. We need to win this fight. [99]

> During a discussion of mission command complexity and cognitive load, a former BMC commanding general (CG) digressed at length on the issue of paper maps and the analog "wing board" versus current digital displays in NIE CPs. The CG quipped that he could stand in front of a properly laid out wing board and get the gist of the tactical situation in less than 30 s. He went on to note that he could not do that as readily with current digital displays in CPs. HSI team observations of CP operations across NIEs along with the creeping addition of analog displays

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[98] Ibid., 31.

[99] Devon Suits, "Network mission command requires seamless framework say Army leaders," 13 February 2017, accessed 14 February 2017, https://www.army.mil/article/182041/networked_mission_command_requires_seamless_framework_say_army_leaders.

> lead to a number of questions related to the CG's remarks. Is there something about a highly evolved analog tool such as a wing board that assists commanders in performing mission command that is more difficult to achieve with current digital displays? Does a wing board facilitate "cognitive fusion" of essential information in ways that are more difficult to achieve using contemporary digital displays? Admittedly, there is more terrain detail on a paper map than is apparently provided on current digital maps. Does what HSI team members have observed in NIE CPs reflect something intrinsically limiting about digital display technology or simply reflect the limits or poor design of current digital displays? Klein (1997) argues that an excessive focus on decision support technologies coupled with too little consideration of the actual cognitive mechanisms underlying expert decision making can reduce rather than improve decision-makers' performance. He asserts that improperly structured information technologies can interfere with the expression of expertise on the part of skilled commanders and staff members.[100]

Holography will simplify sociotechnical analysis for all users. Sociotechnical analysis is an approach to organizational work design and assessment that concerns the interaction of people and technology in operational work settings. Holography simplifies the user's ability to quickly make decision with information that is augmented on top of reality. Current digital displays do not easily create the gist for the commander in a tactical situation. Holography will eliminate two dimensional screens where only a few people can huddle around and piece multiple MCIS's together mentally to gain situational understanding. Holography will meld live information from sensors within the battle space and create a holographic "wing board". Additionally, primary staff and supporting staff will not need to be physically located in the CP to gain a holistic understanding. The staff will be distributed across the globe meeting the intent of expeditionary mission command.

[100] Hawley and Swehla, 24.

Monitors and devices that are used today are a temporary deviation from what the force has experienced and used for hundreds of years. Due to constraints of technology visualization had to be temporarily done on two dimensional devices, until the advent of holography. Holography will enable a virtual sand table for commanders and staff. Technology will enhance the original process of wing boards, and holography will infuse information onto an augmented reality. Chapter 4 displays vignettes that show how holography will look and work across the Army warfighting functions.

The following statement explained how MCIS were designed for the CP. The Army's strategy must look at employing expeditionary applications that support expeditionary mission command. The end state is to begin to develop MCIS's that reduce complexity and size. Holography will enhance expeditionary mission command at all echelons and across any formation through the simplicity of the interface. Holography employed correctly drastically reduces form factors minimizing the need for oversized CP's that emit easily identifiable target signatures. Form factors are defined as the size of technology and the support needed to enable the technology. Expeditionary mission command with the use of holography will meet the intent of the Army in creating a rapid situational understanding. The real question that this research generates: Do we need to migrate to a holography based platform sooner than later?

Holography will provide the user the ability to quickly analyze information and make a judgment to achieve understanding. Holography will augment Army forces that deploy rapidly into unexpected locations and transition quickly into high tempo operations across wide areas. Data will arrive at the correct time as units transition from enroute Mission Command to early entry command post (EECP) while on the move.

Army Doctrine Reference Publication (ADRP) 6-0, 28 March 2014 defines understanding as:

> To achieve understanding, commanders and staffs process data to develop meaning. A cognitive hierarchy model (illustrated in figure 11) depicts how data are transformed into understanding. At the lowest level, processing transforms data into information. Analysis then refines information into knowledge. Commanders and staffs then apply judgment to transform knowledge into situational understanding (see figure 11).[101]

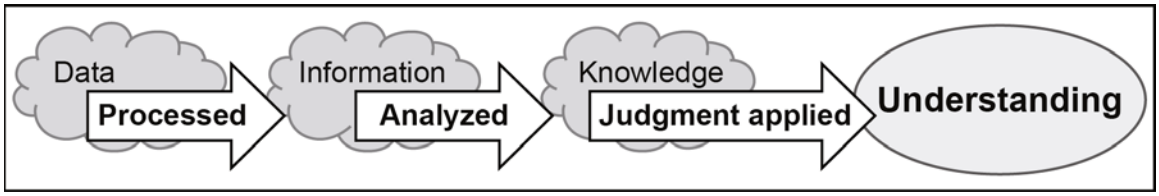

Figure 11. Achieving Understanding

Source: Department of the Army, Army Doctrine Reference Publication (ADRP) 6-0, *Mission Command* (Washington, DC: Government Printing Office, 28 March 2014), 2-36.

Moving to an environment that is augmented over reality instead of continually looking at your phone, laptop or monitor for updates will quickly increase situational understanding. Can you imagine going to war against an enemy who is still works in a CP of computers and monitors vs. an army that uses holography?

A common understanding of this interaction is navigation and driving. Global positioning system (GPS) on phones is a prime example of trying to gain situational understanding while driving (see figure 12).

[101] Department of the Army, Army Doctrine Reference Publication (ADRP) 6-0, *Mission Command* (Washington, DC: Government Printing Office, 28 March 2014), 2-36.

Figure 12. Current Process of driving with GPS

Source: Created by author.

This is not safe and temporarily disengages us mentally from driving to focusing on our smart phones. Three processes occur during this interaction which include driving, looking at a gps device, and mentally overlaying the information onto the road while driving. These three processes must occur in order to know where you are and where you are going. The process of driving and getting directions are not optimally delivered to the driver. The cognitive load of the driver is no longer focused on driving. The stove piped or disjointed process of looking at your phone and additionally staying aware during driving increases residual risk.

According to distracted driver's accidents website there are approximately 2.5 million in the U.S. who are involved in road accidents each year.[102] Of the 2.5 million accidents, 1.6 million involve a cell phone.[103] This means that 64 percent of all road accidents can be faulted due to some form of using a cell phone.[104]

Is there a better way to visualize navigation while driving (see figure 13)?

Figure 13. GPS augmented with driving

Source: Created by author.

[102] Kiernan Hopkins, "25 Shocking Distracted Driving Statistics," Distracted Driver Accidents, 23 January 2015, accessed 16 February 2017, http://distracteddriveraccidents.com/25-shocking-distracted-driving-statistics/.

[103] Ibid.

[104] Ibid.

Holography would combine the processes and eliminate the need for a smart phone. Holograms are overlaid onto the route in real-time for the driver, combining the process of navigation and driving (see figure 13). The process improvement increases the driver's ability to stay focused on the primary process of driving and the secondary process of navigating. The drivers' eyes never leave the road. The holograms are noninvasive and do not interrupt or block the driver's field of view. The design of the application must continually focus on augmenting the process and not become invasive to the process. This would occur with a poorly designed overlay that would hinder and take away from the driver's experience instead of improving through proper augmentation.

Navigation and driving is a perfect example of how we use and fight with information today on the battlefield. The blue force tracker data is on a monitor and does not easily interact with the primary process of being a Soldier and moving onto an objective. Being a Soldier is not as easy as the GPS example on navigation for driving. There are many more processes occurring. There are endless applications where holography can be used to augment the process in a tactical and strategic environment. Think of a scenario where glasses are worn and GPS is an overlay that can be dynamically updated based on the enemy situation. Holography with the right staff and sensors will help forecast and create real-time adaptable route overlays on the battle field.

Industry use

Should the Army look at investing in holography as an early adopter?

> According to a new market research report Digital Holography Market by Component (Laser, Micro display, CCD Camera), Application (Microscopy, Holographic Display, Holographic Television & Telepresence), Vertical (Medical, Commercial, Consumer, Automotive), Geography - Trends & Forecast to 2020, published by Markets and Markets, the total market is expected to reach

> USD 5.50 Billion by 2020, growing at a CAGR of 37.5% between 2015 and 2020.[105]
>
> The digital holography market has a great potential across various applications. Digital holography is expected to become a dominant technology among the upcoming 3D technologies. The increasing demand for advanced holographic displays and microscopes plays a vital role in the growth of this market. Factors such as realistic 3D visualization, high accuracy, coordinates and depth measurements, and life- sized presence would boost the demand for digital holography applications in various sectors such as aerospace & defense, automotive, medical, consumer, and commercial sectors.[106]

This data forecasts that the holography market is going to be 5.50 Billion by 2020, which is less than two and a half years from now. Microsoft is predicting that it will sell 80 million mixed reality devices similar to the HoloLens by 2020. Forrester Research estimates that 52million units of VR head-mounted displays will be used by enterprises and by consumers use in the U.S. by 2020.[107] The Army needs to begin drafting requirements now in order to start the JCIDS process to receive funding for holography based applications. Market forecasts predict that there will be a large market within the next several years. Does this data give the Army enough time with the current model of JCIDS to compete against our enemy? Does our future enemy have a reduced barrier of technological entry into their force? Can our future enemies create this capability within

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[105] PR Newswire, "Digital Holography Market Worth 5.50 Billion USD by 2020," Market Watch, 29 September 2015, accessed 31 January 2017, http://www.marketwatch.com/story/digital-holography-market-worth-550-billion-usd-by-2020-2015-09-29-7203310.

[106] Ibid.

[107] Clinton Boulton, "Microsoft HoloLens eyes enterprise adoption amid crowded field" CIO, 14 October 2016, accessed 24 October 2016, http://www.cio.com/article/3131419/virtual-reality/microsoft-hololens-eyes-enterprise-adoption-amid-crowded-field.html.

the next several years, whereas the Army took ten years to create COE? The Army cannot ignore this information and get caught behind with a potential serious adversary such as China or Russia.

Can you imagine the US fighting against a technologically advanced military that uses holography on the battle field against the US Army. The decision-making time and processing of the information in a holography environment is greatly reduced as well as SWAP-C. The enemy would have a better situational understanding, incredible mission command, and ability to tailor formations, shape the battle field, and more. See chapter 4 on mission command for several vignettes on what holography will do for combatant commanders.

According to a recent CIO article the following companies were listed as well as what they are trying and intend to do with a holography based solution using HoloLens.

> ThyssenKrupp elevator service technicians use HoloLens to triage service requests ahead of maintenance visits and getting hands-free remote guidance when on site. Technicians access Skype on HoloLens to call subject matter experts and share holographic instructions In trials, ThyssenKrupp says HoloLens has reduced the average length of it service calls by four times.[108]
>
> Volvo Cars envisions consumers using HoloLens to customize their cars in a virtual showroom. "Imagine using mixed reality to choose the type of car you want – to explore the colors, rims, or get a better understanding of the features, services and options available," says Björn Annwall, Volvo's senior vice president of marketing, sales and service. He says that HoloLens could open up new sales channels by allowing dealers to take a car configurator to pop-up stores or malls.[109]
>
> Japan Airlines (JAL) has developed two proof-of-concept programs to train engine mechanics and flight crew trainees. Thanks to the 3D capabilities in HoloLens mechanics "can study and be trained just as if they were working on the

[108] Ibid.

[109] Ibid.

> actual engine or cockpit," placing their hands on virtual engines and parts, says Koji Hayamizu, senior director of the planning group for JAL's products and service administration department. Using HoloLens, flight crew trainees access a detailed hologram that will display cockpit devices and switches that they can operate themselves, with visual and voice guidance. [110]
>
> Lowe's customers are using HoloLens to view a holographic representation of a new kitchen and customize design options for kitchen cabinetry, countertops, appliances and other home features. They may also share their designs online. "A miniature hologram kitchen allows for a bird's eye perspective of the kitchen," says Microsoft's Erickson. In-store designers and friends can view what the customer is seeing and changing in real time through a hand-held Surface tablet.[111]

Microsoft also is working with AECOM and Trimble Navigation to allow architects and engineers to view building construction and engineering schemas in 3D.[112] AECOM says engineers and designers in London, Hong Kong and Denver, are exploring 3D buildings as if they were physical models on a table.[113]

Microsoft has also offered other demonstrations that show how holography based applications reduce the time needed to get access to a subject matter expert for remote support.

> The demos that the company allowed some press to walk through were scenarios where putting virtual elements within the physical world really improves the end user experience. For example, a "father" was connected with his "daughter" via a Skype call, and the daughter was using the HoloLens while her father walked her through how to repair a plumbing issue with her sink — he was able to draw arrows basically right on top of her field of vision directing her where to put the replacement part, how to install it, what tool to use to perform each task and so on. Rather than having to rely on only words to describe the procedure, he was able to guide the daughter through the repair easily. Another

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[110] Ibid.

[111] Ibid.

[112] Ibid.

[113] Ibid.

> demonstration involved actually using one's hands to interact with the virtual objects projected into the physical field of vision.[114]

Think of hospitals revolutionizing medical and surgical training and minimizing error rates and patient deaths even further by always having a second experienced surgeon on hand virtually during difficult procedures.[115]

Summary of Existing Literature

The Army continues to look for a framework that allows for rapid deployable expeditionary mission command information systems. Systems must focus on being visually intuitive to the commander and staff. The framework must create a continuous situational understanding. The Army warfighting challenges identify requirements that enable and enhance MCIS's within every domain (e.g. land, air, space, cyber) environment across organizations. The challenges identified focus on the buildup of speed and strength across the formations. Army MCIS's that are continuously developed by different vendors causing integration complexity. Commanders are still relying on wing boards to quickly build situational awareness with their CP. HFE must be analyzed and the effect of the correct amount of cognitive load for commanders, staff and soldiers. Continually developing MCIS's in the current framework will add to the complexity of gaining situational understanding and increase training time.

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[114] Jonathan Hassell, "Why Microsoft's HoloLens Is the Next Big Enterprise Thing" CIO, 13 February 2015, accessed 24 October 2016, http://www.cio.com/article/2884133/wearable-technology/why-microsoft-s-hololens-is-the-next-big-enterprise-thing.html.

[115] Ibid.

Stove piping information technology systems creates low density operators who are vital to the operations of the CP. A low-density operator is defined as an integral piece who has a specified skill set that is critical to operations. The formation has a minimal number of operators in this capacity, which drastically increases the amount of residual risk. Information systems are not being developed to augment the process, but rather are very invasive and drive the process. Holography augments reality and replaces monitors, keyboards and physical items that are currently used for computing. Holographic applications drastically reduce process time and deliver data at the point of need. The delivery creates a non-invasive decision making model for the operator. A mixed reality allows for users to quickly visualize changes and plan based on different courses of action. Time is being returned back to operators allowing for operations, planning and integration to quickly enhance the decision-making process.

CHAPTER 3

RESEARCH METHODOLOGY

I am employing qualitative methodology, which is subjective to my opinion. In qualitative research, the potential sources of data are limited only by the researcher's open-mindedness and creativity.[116] I am using the content analysis model. I have collected extensive data and current analyses on MCIS for the Army to reference while discussing the problem statement. Regardless of the kinds of data involved, data collection in a qualitative study takes a great deal of time.[117] This research employs the use of content analysis. A content analysis is a detailed and systematic examinatio0n of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases.[118] The purpose of content analysis is to identify specific characteristics of a body of material.[119] The focus of the research evaluates any verbal, visual, or behavioral form of communication.[120] Methods of data collection include identification and possible sampling of the specific material to be analyzed.[121]

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[116] Paul D. Leedy and Jeanne Ellis Ormond, *Practical Research Planning and Design,* 9th ed. (Upper Saddle River, NJ: Merrill, 2010), 145.

[117] Ibid.

[118] Ibid., 144.

[119] Ibid., 146.

[120] Ibid.

[121] Ibid.

Research Methods

After concluding the literature review the researcher concluded that MCIS's could be studied and analyzed to identify a solution. The study was not modified and encompassed the year that the researcher worked for the Mission Command Center of Excellence. As a general rule, a content analysis is quite systematic, and measures are taken to make the process as objective as possible.[122] The literature review discovered and highlighted the research in the following order:

1. What does the Army Want?
2. The Army warfighting challenges overview
3. Army Mission Command Information Systems
4. Why holography
5. Industry use

Focusing on what the Army wants focused the research to discover a visually adaptive system that will allow systems to evolve with the process. MCIS's can no longer drive how the process works. The Army will enhance readiness and interoperability to prevent conflict, shape security environments, and, if necessary, fight and win as part of a joint and multinational team. The review of Army MCIS's show the system is becoming larger and more complex. Stove piped software does not integrate well. Training is complex and gaining situation understanding is extremely difficult. Moving to e-maps on computer screens create a different process, where the Army traditionally uses map boards. Holography review shows what it is and could be used for. A simple gps driving

[122] Ibid., 144.

scenario with figures gives the reader the ability to visually see what is research is trying to achieve. Industry use discovers early adopters of holography and how companies are augmenting data into reality for operations.

Per the thesis and supporting questions of this research, MCIS data was analyzed using *Human-System Integration (HSI) and the Network Integration Evaluations (NIEs), Part 3: Mitigating Cognitive Load in Network-Enabled Mission Command*. More often, qualitative researchers are intentionally nonrandom in their selection of data sources.[123] Instead, their sampling is purposeful: They select those individuals or objects that will yield the most information about the topic under investigation.[124]

Summary

The literature review of holography is extremely complicated due to the lack of available resources. This review includes research that was created by the author during the course of this research. Holography as a technology is extremely new. There are minimal amounts of use cases within industry to provide data on the effects of information technology with operational technology. A case study methodology could not be used due to the lack of data. Future research would be best utilized through the case study to capture objective data for improved operational results.

[123] Ibid., 147.

[124] Ibid.

CHAPTER 4

ANALYSIS

Introduction

The following tables show how holography effects operations through the designated warfighting challenges in chapter 2. The tables briefly describe the high-level effects of how holography could enhance and evolve the first AWFC SU.

Table 2. AWFC #1 Holography Features

#	Demand	Holography
1.1	How do Army commanders and staffs achieve SU of complex areas of operation across all phases of operations and in all five domains?	Holographic map boards provide commanders a view of the entire battle space across phases through the human, land, maritime, air, space and cyber domains.
1.2	How do Army units integrate relevant information from all available sources (traditional / non-traditional) to develop the COP and the SU of commanders and staffs for Mission Command?	Holographic map boards allow sharing of the commander common operational picture across traditional and nontraditional sources. Information system adapt to the process and evolve with mission command.
1.3	How do Army elements at Brigade (BDE) and below integrate and synchronize organic/non-organic intelligence capabilities to support the development of SU?	Holography allows integration of live ISR battle field capabilities through sensor sharing down to BDE and below. Radios no longer exist, elements are tap to talk on a holographic map. Numerous frequencies support failover and redundancy.
1.4	How do Army units accelerate the experiential learning process in order to imbue Soldiers and leaders with the experience, judgment, and maturity necessary to develop and sustain SU in a complex environment?	Holography utilizes the Live Virtual Constructive Integrating Architecture (LVC-IA). Enabling the Integrated Training Environment (ITE) by connecting simulation systems to conduct BDE and below combined-arms collective training.
#	Demand	Holography
1.5	How do Army units responsible for the execution of cyberspace and electromagnetic operations develop the SU of commanders and staffs for Mission Command?	Holography gives commanders the visual options needed to quickly stand up mission command enroute and early entry. Signal officers can rapidly request satellite access requests.
1.6	How do Army units develop understanding of the political, military, economic, social, information, infrastructure, physical environment, and time (PMESII-PT) factors that affect the mission?	Shodan like capabilities, provide continuous sensors and scans the internet of things feeding the data needed to visually see (PMESII-PT). The data gives the commanders the data needed to create Kinect and non-kinetic strike packages to protect, defend, or eliminate critical infrastructure.

1.7	How does the introduction of technologies and changes in capacities to existing capabilities affect achieving SU for the conduct of operations across all echelons, formations, environments and domains?	Holography uses a model that allows technology to agnostically adapt to the processes delivering data to the user at the point of need.

Source: Created by author.

The following table gives a general overview on how holography effects the warfighting functions.

Table 3. Army warfighting functions Holography Features

wff	Current Process	Holography Process
Mission Command	- Large CP - Centralized - Large Targets - Not Distributed - Array of Mission Command Information Systems	- Minimal CP - Decentralized - Small Formations - Distributed - Data delivered at point of need
Movement & Maneuver	- Blue Force Tracker (Monitor) - Radio Frequencies / Encryption - Routes hard to update in real time	- Wearable Technology - Tap to Talk , Radios Eliminated - Predictive route updates from CP
Intelligence	- Positive Identification - ISR video is complicated	- High Value Target Facial Scanner - ISR Anytime
Fires	- Joint Fires is Complex - difficult coordination and confirmation	- Joint Fires in seconds - visual coordination and confirmation
Sustainment	- Vehicle computer systems not integrated - Medevac Difficult (Time, Frequency, etc…)	- visually see vehicle data through use of integrated computer systems - medevac time greatly decreased through use of visual routes and tap to Talk
Protection	- Difficult to coordinate across organizations	- visually request outside organizations through data sharing on the holographic map

Source: Created by author.

A New Era

On 4 March 1991, the U.S. Army Operations Test and Evaluation Command (OPTEC) recommended that the final build of Version 10 MCS software (V10.03.1G) be released Army-wide.[125] This is significant to the Army and the start on how applications and software begin to try and replace map boards in CP's and much more. The decision to release the software is based on an urgent user need in Southwest Asia for the E-Map capability contained in V10.03.1G software.[126] This decision evolves the Army from an analog platform of manually updating map boards in the CP to digital map boards on a computer screen. On 4 March 1991, the Army began the transition of analog operations to digital operations.[127] The known rapidly becomes unknown and far more complex, to the point of now having twenty-six information technology platforms in the CP.

This research suggests the existence of a new era and evolution through the integration of holography. Gone are the digital days of monitors, keyboards, and the mouse. This author suggests the new name of the era to be the Object-Oriented era. Instead of looking at a physical device for data with a limited view and continuously learning new technology to adapt to the process. Data is now treated as an object. Holography creates an ever present and undetected reality for commanders, staffs, and soldiers. A simple example is to think about how complex radios are within the Army. There are hundreds of nets within a division including call for fire, command net,

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[125] Army Test and Evaluation Command (ATEC), OA-1261A, *Independent Operational Assessment of the Maneuver Control System (MCS) Field Validation* (Aberdeen Proving Ground, MD: Defense Technical Information Center, 1991), V.

[126] Ibid.

[127] Ibid.

medevac and much more. It takes a lot of practice to memorize the nets and they are different at every unit. Imagine being on a convoy and wanting to talk to the vehicle in front of you. Simply look at the vehicle tap it with your finger and talk to that specific vehicle. The Object-Oriented Era removes the memorization of numbers and treats every one and piece of equipment as an object on the battle field. The next section will help the reader get a better understanding and visualization of this era.

Holography in Operations

How can holography enhance the Army Operations Process? Figure 13 shows what sensors on a map would look like in a holographic augmented reality environment. The operator of this image are wearing a Hololens and seeing this map on a table in an office. Figure 13 is hopefully creating a visual for the reader that any type of sensor can be displayed on the map below for planning or even tracking in real-time. Remember the radio issue of trying to figure out what net to get on because you want to talk to the blue aircraft on the map. Simply take your finger touch the aircraft and talk. What about the Soldiers in the red circle? Tap each red icon to talk to them individually.

Figure removed.

Figure 14. Course of Action war gaming

Source: HoloLens Demo, *Situational Understanding and UAV* (Bingen, WA: INSITU, 9 February 2017), Video.

Imagine you are a division commanding general (CG) and about to conduct a course of action analysis brief with your brigade commanders and allies. The British are operating alongside you in coalition force effort. As the division commander, CG, you are employing the use of the Army's new concept of expeditionary mission command. It is important to discuss what expeditionary mission command is in order to help the readers obtain the correct mind set for the upcoming scenarios (see figure 14). The definitions for expeditionary mission command can be found in chapter 1 under operational definitions of key terms.

The strength of the division is seven hundred personal. Fifty personal are deployed with the assistant deputy commander maneuver (ADC-M). The remaining six

hundred and fifty are at home station command in order to provide support to the forward deployed personnel and ADC-M. The forward deployed personnel have a TAC and must be able to conduct early entry command post (EECP). All planning and execution must be able occur across both deployed, enroute, earl entry, mobile and home station networks. The CG moves back and forth from the home station to the deployed formation. Currently the CG is located in the vicinity of the home station and is ready to receive a course of action analysis brief from the forward deployed brigade commanders. The ADC-M is deployed and located with the TAC.

Figure 15. Expeditionary mission command

Source: Department of the Army, *TechNet Augusta 2015 Engagement Theater Session 3: Expeditionary Network Communications* (Program Executive Office for Command, Control and Communications-Tactical, 26 August 2015), accessed 12 January 2017, https://www.slideshare.net/afcea/expeditionary-network-communications-engagement-theater-session-3-technet-augusta-2015, slide 2.

Holography will reduce spending for force integration and proficiency training through augmented reality and virtual injects. Call for fire, evaluate a casualty, and convoy operations can be practiced through holographic training aids. Soldiers will be able to maintain proficiency and meet the demands of 350-1 training at the individual and collective task level. Planning involved to setup and forecast land will greatly be reduced as well as costs involved to make training available. Soldiers are now able to practice call

for fire on live terrain and see the visual effect of fires through holography minimizing the cost of live training. Live training is able to evolve and become more complex as Soldiers continuously practice and are proficient through the augmented virtual environment.

Research Question 1

How would holograms support the planning process? Holograms will create a virtual environment during the planning process allowing the commanders and staff to war game on live virtual terrain.

Continuing the division based scenario, all commanders and staff (US and British) are able to virtually connect using holography devices. When joining the course of action brief everyone is able to see a holographic map which is a replica of the proposed area of operations. The commander and staff array friendly forces and visually determine unit boundaries. The red team arrays the enemy's most likely course of action on the objective. ISR capabilities are seen with joint, multinational and coalition forces. A virtual score is kept validating the course of action against the determined evaluation criteria. The commander is able to move their unit across the battle space and see the effects of how their maneuver affects units in adjacent boundaries. Restricted operating zones are seen with projected on station time for the collection of intelligence assets. The brigade commanders are able to discuss actions on the objective as well as visually show how their units will conduct joint expeditionary maneuver and entry operations. Everyone is able to watch the war game occur and see where cross domain coordination needs to occur.

The CG is initially positioned in the vicinity of the home station CP, but is moving in a vehicle coming from the airport, returning from a mandatory meeting in D.C. Holography devices will enhance the commanders and staff freedom of maneuver with the ability to join briefs and track real-time situations anywhere anytime.

The need to be tethered to a physical location for important meetings is no longer needed. The network is a virtually software defined network (SDN) that has the ability to extend past the physical locations within expeditionary command. The CG and primary staff can be distributed anywhere in the world and have the ability to securely connect in using an SDN configuration.

Holography enhances the planning process through the virtual constructed terrain and the simulation environment. Virtual constructed terrain replicating the actual terrain shows a 3D model allowing commanders and staff to visually analyze the battle space. The model greatly enhances situational understanding of the upcoming mission compared to a traditional 2D map board or a constructed terrain model. The time needed to create the environment is drastically reduced, the meeting does not require physical attendance, and time is spent on the analysis of actual terrain not on the development of the terrain model. The simulation environment injects data into the battle space to visually display the enemy's most likely and dangerous course of action. Aviation has the ability to virtually fly through valleys and conduct area reconnaissance. Signal can see where communications may be degraded during certain times of the day looking at satellite coverage within restricted areas. Satellite sensor data is injected into the scenario allowing the staff to select specific satellites. A highlighted coverage of the battle space shows the coverage across time. A clock allows the operator to move time forward and

backward and evaluate the specific coverage of the satellite during the operation. Commanders are able to have an understanding on how to array CP's across the battle space to conduct uninterrupted mission command.

Research Question 2

How would holograms support the execution activity of mission command? Holograms will allow commanders and staff the ability to interact with a live environment. Sensors will be visually monitored and tracked. Virtual maps that display the live terrain of the battle space with real-time sensor analysis give the commanders and staff an evolved situational understanding. Software solutions such as Sitaware deliver sensors across all domains (human, land, air, maritime, space, cyber) and more(coalition partners, government agencies, and NGO's) to the joint operations center (see figure 16).

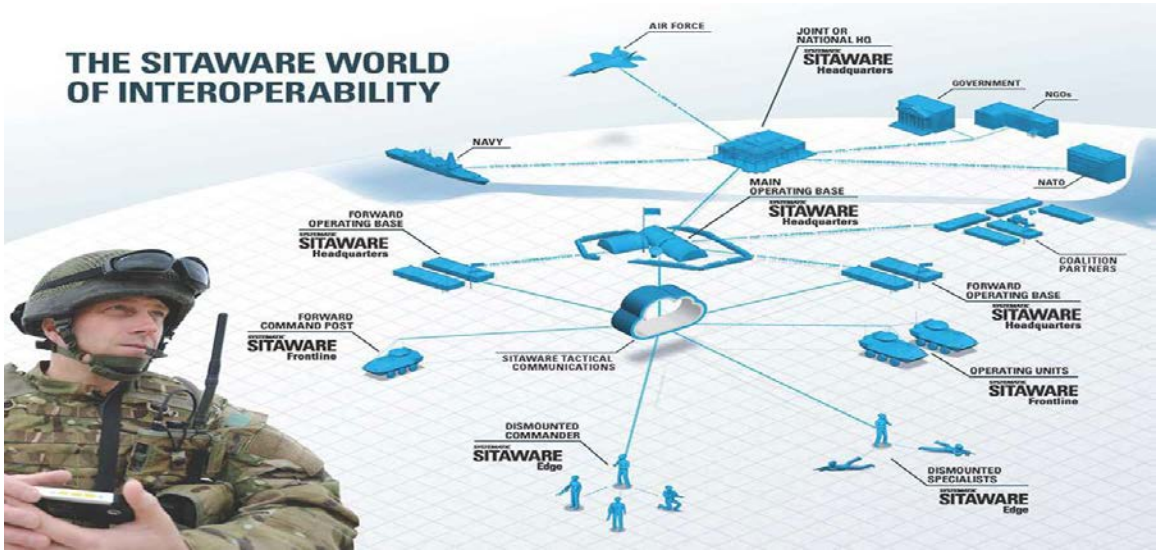

Figure 16. SitaWare headquarters real-time sensor injects

Source: Systematic, *Sitaware C4I Suite*, accessed 24 January 2017, https://www.systematicinc.com/products/n/sitaware/.

ThyssenKrupp elevator services reported that initial support calls have been reduced up to 4 times with the integration of holography. Holography will increase our situational understanding allowing the Army to rapidly build speed and combat power. Commanders and staff are able to visually track and monitor sensors across all domains that are multinational, coalition and inter organizational. Cognitive load has been drastically decreased allowing for rapid situational understanding reducing operations times. Metrics are setup and data is delivered to the users on the virtual map board to make real-time decisions in the CP.

Commanders and soldiers are able to gain a holistic situational understanding during EECP. Friendly and projected enemy positions are seen by the team as they arrive on the objective and prepare to jump in (see figure 17).

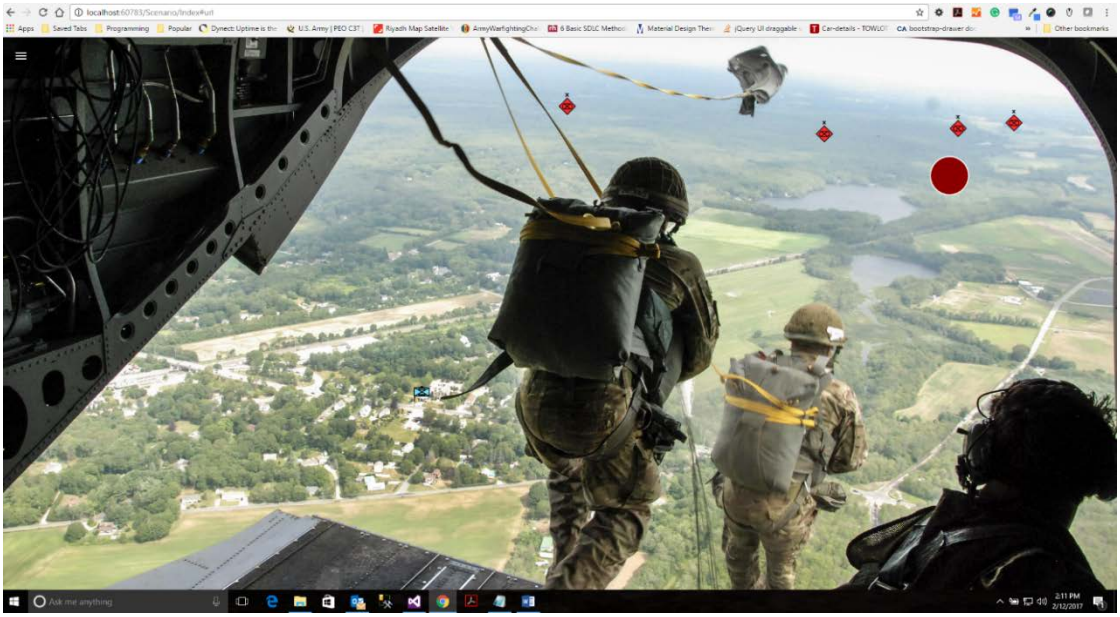

Figure 17. En Route and EECP

Source: Modified by author, Rhode Island Leap, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001599518.

The TAC is clearly marked on the left side of the figure with the array of enemy forces ahead. The enemy is not within striking distance and is over one hundred kilometers away. This allows the commander and staff to orient themselves onto the enemy. As ISR reports confirm enemy situation reports, the red positions update. Data is received and processed using FIFO (first in first out).

Research Question 3

How would the use of holograms in Mission Command Information Systems (MCIS) improve the exercise of mission command? Holography will drive the operations process through their activities of understanding, visualizing, describing, directing, leading, and assessing operations.[128] The commander and staff are distributed and exercise expeditionary mission command. The commander and staff no longer need to be physically co-located with each other in order to conduct mission command. The MCIS changes to an object-oriented environment where all sensors can be visually seen and monitored in a real-time visual environment. Commanders and staff are able to communicate with sensors on the map through tap to talk. The map board returns to the virtual CP where thousands of users can gather around the board and gain situational understanding. The use of holography creates a common picture and understanding that can be accessed across formations and echelons. The situational understanding can extend beyond the military into a multinational, coalition and inter organizational environment.

[128] Department of the Army, Army Doctrine Reference Publication (ADRP) 3-0, *Operations* (Washington, DC: Government Printing Office, November 2016), 5-13.

Mission Command as a whole becomes easier for the commanders and staff as data is continuously delivered at the point of need. The interaction and use of keyboards and the mouse cease to exist. The system does not have a steep learning curve or create low density specialized skill sets within formations. The holographic interface is common across missions, but serving different data and functionality. Command, staff and soldiers begin to use all ten fingers, their voice, vision and eyes to build the interface. Data augments the process and gives the user the sense of a noninvasive enhancement to quickly make decisions. Processes and information no longer create friction or new processes to internally meld information together to gain situational understanding. Capabilities and functionality are introduced through extensive human factors engineering and cognitive load analysis. Similar to the change process of a NASCAR pit crew. In order for a new process or capability to be introduced it must not hinder the driver or add time to the overall pit stop. A new capability that is added to the information system must not add time to the commander's decision making process and improve the overall readiness. Each technical change must be evaluated operationally to show the improvement being made and the effects across warfighting functions.

Research Question 4

How would holograms be used in warfighting functions (see figure 18)? A warfighting function is a group of tasks and systems united by a common purpose that commanders use to accomplish missions and training objectives.[129]

[129] Ibid., 5-9.

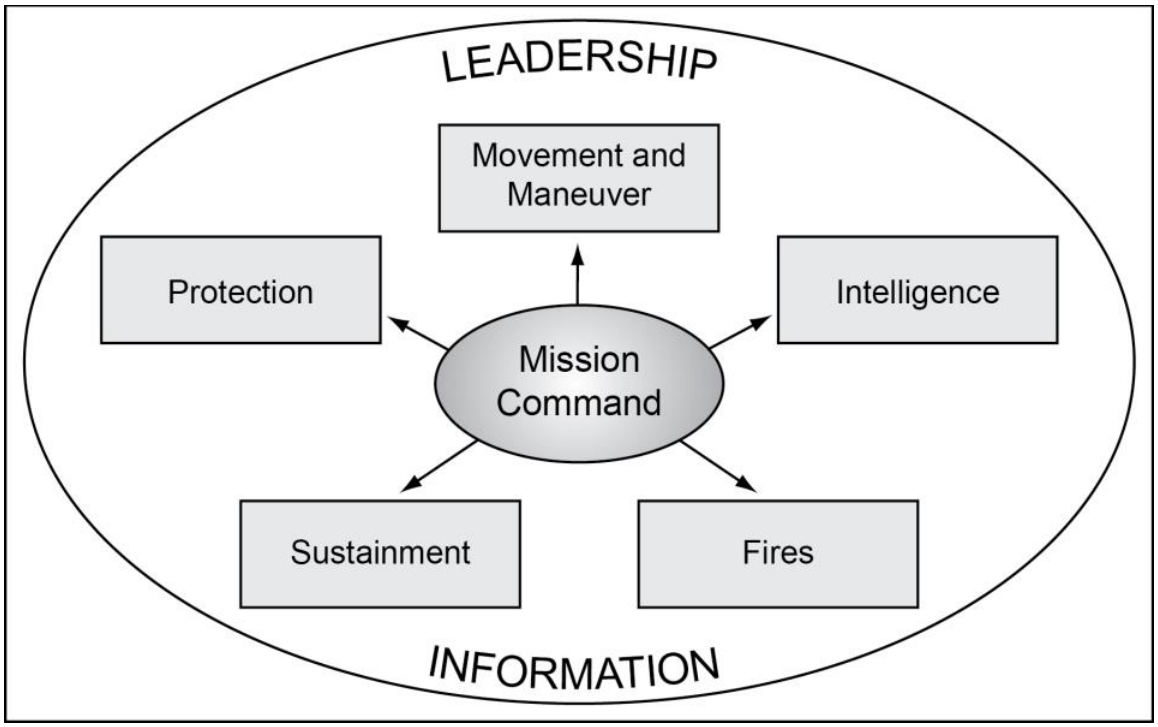

Figure 18. The Elements of Combat Power

Source: Department of the Army, Army Doctrine Reference Publication (ADRP) 3-0, *Operations,* (Washington, DC: Government Printing Office, November 2016), 5-1.

Mission Command Vignettes

The mission command warfighting function is the related tasks and systems that develop and integrate those activities enabling a commander to balance the art of command and the science of control in order to integrate the other warfighting functions.[130] Holography enhances information to give leadership the ability to rapidly make decisions and build combat power across domains. Holographic virtual map boards allow commander and staff to pick and choose sensors to evaluate actions on the

[130] Ibid., 5-11.

objective in real-time. Metrics give the commanders visual notifications to reduce risk and decrease the time needed to gain situational understanding. Commanders are able to visualize all elements of the battle space with the ability to quickly communicate and make decisions to save more lives. Expeditionary mission command can be fully employed and distributed across the globe. The commander and staff are no longer co-located. The EECP is able to make decisions and build combat speed as the primary staff at home station mission command conduct analytics. The primary staff monitors all aspects of the current phase to meet the commander intent.

Satellite access requests (SAR) give commanders the capability to schedule satellite time to conduct a mission or training. The current approval process is unacceptable for mission command and needs to be improved and adaptable to the commanders needs.

> SAR's should be submitted to FORSCOM at least 50 days prior to requested access to ensure we are able to submit to JFCOM within the 45 day window. Any request submitted less than 45 days prior to start date must be accompanied by a Letter of Lateness (LOL) in MEMO format signed by the unit S6 or higher. RSSC (Regional Satellite Communications Support Center) will normally have the SAR processed and the SAA out 1 week prior to SAR start date.[131]

This process means that the commander must have training locked in at least 45 days prior to submitting a request to get network access. This also means that if the commander decides to extend or arrive early on site then the network may not be available since the SAR is for a specific period of time. How does the Army transition to expeditionary mission command with policies that set a constraint on commanders?

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[131] Department of Defense, *Satellite Access Request Standard Operating Procedure* (Washington DC: Government Printing Office, 9 July 2008).

Imagine that you are conducting enroute mission command. Holography give you the capability to look at a holographic model and select satellites with your finger that are needed for the mission (see figure 19).

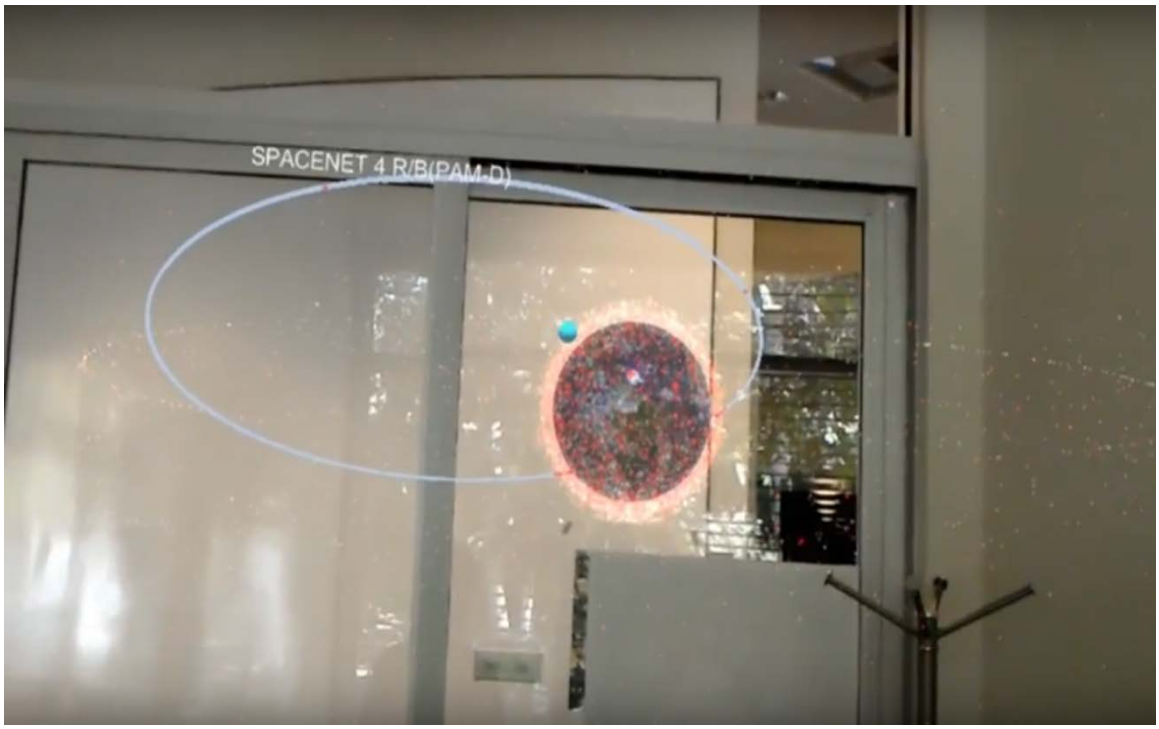


Figure 19. Rapid Satellite Access Request (Enroute MC)

Source: Richie Carmichael, Satellite Holographic Map (2 of 2), 25 July 2016, accessed 2 March 2017, https://www.youtube.com/watch?v=7cT9GlI0rzo.

A new holography based capability call rapid satellite access request (RSAR) show in figure 19 will give commander the ability to rapidly setup networks. Figure 19 gives the communication staff and planners the ability to rapidly plan and request access will be conducting enroute mission command. The requestor simply selects the satellite and analyses the coverage over the objective for the duration of the mission. If the

satellite is sufficient and provides the network needed. The planner simply selects the request and the form is automatically filled out and emailed to one of the four RSSCs. Within minutes the commander and planner know if the approval has been made.

What if the commander is conducting EECP and decides to change the location of the CP? This will require a possible satellite coverage change if the terrain is not optimally suited for the entire mission coverage required.

Figure 20. RSAR (EECP)

Source: Modified by Author using Satellite Locator iPhone App, accessed 2 March 2017.

The signal officer or planner is able to quickly see satellites in the area and select the satellite based on the mission needs. Once the satellite is selected an emergency request is sent to one of the four RSSC's for activation. RSAR gives commanders and signal planners the tools necessary to enable mission command enroute and EECP.

Movement and Maneuver Vignettes

Tactical translator will allow commanders, staff and soldiers to conduct key leader engagements without the need of an interpreter. The cloud or a distributed number of local computers will translate the host nation language through the use of blue tooth enabled devices. The host local national will wear a blue tooth earpiece and microphone will communicate with the local or cloud translation application. The US or coalition forces will be able to hear what the local national are saying in English through the wearable glasses with built in speakers. The system will also translate from English to the host national local language. This will allow for key leader engagements, planning, and missions to be conducted and reduce the need for a host nation interpreter. This type of technology will also the reduce time needed to build and maintain trust between the US and interpreters.

Language will no longer be a barrier for anyone. Signs that have the host nation language will be automatically displayed in English through the use of holography (see figure 21). Roads, mileage, and any type of marking will be able to be translated into English or the language of the operator's choice.

Figure 21. Text and voice translation

Source: Google, "Google Translate," accessed 5 March 2017, https://itunes.apple.com/us/app/google-translate/id414706506?mt=8.

Figure 21 shows a current app called Google Translate. This functionality is now built into the wearable technology giving commanders, staff and soldiers the ability to quickly read any type of sign or written language. The hologram overlays the sign and displays the translation in the selected nations language.

Chapter 2 gave the example of holography through GPS (see figure 22).

Figure 22. Predictive route monitoring

Source: Created by author.

Imagine that the staff is able to create real-time routes that are fed to convoys and soldiers who are conducting operations. The staff is continuously ensuring that sensors are confirming objectives and the enemy's disposition. As these conditions change the staff is able to update routes through predictive monitoring. This use of real-time sensors and the help of predictive analysis from good staff work reduces risk to the soldiers in the fight. Data is continuously sent to soldiers on the ground so they can safely drop off an ammo resupply. The possibilities are limitless as staffs in higher headquarters feed live

routes and emplace holographic icons onto the soldier's view. Maybe there is an emplaced improvised explosive device (IED) that a predator has detected. A holographic icon appears on the soldiers view and they are able to know the distance and direction to the IED. The view generated also allows the soldiers to see the artillery battery that is within range for an illumination request. The soldier only has to tap the artillery icon to make a request. The fires vignette goes into detail on how a soldier will conduct a call for fire.

Intelligence Vignettes

High value target scanner (HVTS) allows for soldiers on an objective to scan all of the faces to rapidly locate the person or persons of interest (see figure 23).

Figure 23. HVTS Face detection

Source: Microsoft, *Cognitive Services*, *Face API* (Microsoft, unknown), accessed 3 March 2017, https://www.microsoft.com/cognitive-services/en-us/face-api, using, Urban Exercise, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001508916.

Wearable technology with the use of holography enables soldiers to employ the use of computing technologies to scan environments for faces instead of one at a time. This system enables soldiers to rapidly identify targets through asynchronous scanning of the objective. Soldiers typically can only focus on one face at a time when looking for specific people of interests. The use of holography allows for overlays on objectives to positively identify high value targets through the use of current intelligence.

Commanders and staff now have the capability to see all sensors on the battle field through a visual common operating picture employing holography. Named areas of interest can be created within minutes and the reallocation of intelligence gathering assets. Commanders and staff are able to see a live data feed, but can also control the use of the retrans capability, evaluate collateral damage with onboard payloads, and tap to talk directly to the assets. Assets are able to share and pass video to each other through a simplified handoff and approval process through higher headquarters. Approved kinetic strike packages are sent to soldiers on the ground having the availability to talk directly to local assets. Collateral damage is evaluated on the holographic terrain map and minimizes negative effects on the local population.

Fires Vignettes

A Soldier can look up into the sky and see an AC-130 gun ship at night on the objective, touch it with their finger and request a call for fire.

Figure 24. Call for Fire holography application

Source: Modified by author, Take the Night, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001613544.

The Soldier then taps or points to the area on the ground where they want effects and the Gun Ship immediately fires, all being transmitted and watched by the commander and staff. Of course, if the commander or staff see the fire mission and disapprove they have the ability to cancel or redirect the mission to a different asset within range. This type of model employs the use of all fires assets within range. This could include the Air Force, Army, Marines, Navy, or even the host nation in a phase IV stability rebuilding environment. Giving Soldiers the ability to see an AC-130 gun ship at night through glasses or a helmet gives them the instant access to the pre-approved fire support needed.

Figure 25. Heads Up Display (HUD) target Handover

Source: Created by author.

The command post has the authority to give specific Soldiers on the ground the ability to see the AC-130 gun ship through data filter. If another asset on the ground encountered troops in contact (TIC) then the commander could redirect and enable to filter of the AC-130 to the TIC. What the author envisions is the staff and commanders acting as high level filters in providing the right products and information at the right time, given the operation.

The data in a call for fire scenario is resident to all shared sensors and can be accessed across the entire domain. Once the AC-130 is out of range to fire on the objective, an Apache air weapons team (AWT) is in the area. The AWT receives through their heads up displays (huds) in a capability called hud handover. They pass over the

objective delivering effective fires onto the target. As the AWT circles back around for a second pass the nearby gun battery immediately fires onto the objective.

Figure 26. Artillery call for fire

Source: Modified by author, Paladin Power, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001556355.

The call for fire application shows how fires can be massed onto an objective within minutes across the domain using the Air Force, Army and Marines in this example. The application could just as easily include the Navy and use some Naval gunfire. Holography will enable soldiers on the ground when conducting a call for fire to:

1. Quickly coordinate with higher headquarters to get approval and clearance of fires

2. Visually select the area they want to mass effects on

3. Visually see all domain fires assets

4. Tap to talk to any of the fires assets

5. Rapidly combine and mass fires onto a target or objective through the rapid clearance of the battle space.

Sustainment Vignettes

What if you are the executive officer (XO) for a battalion and can quickly find out the maintenance status of your vehicles (see figure 27).

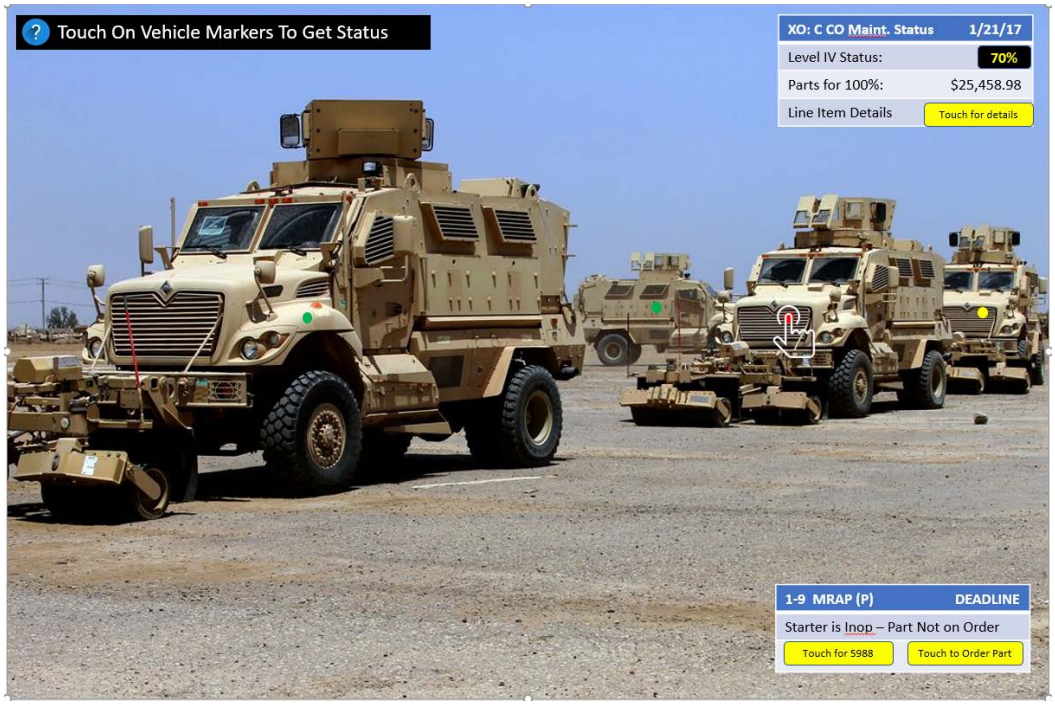


Figure 27. Command Maintenance holography application

Source: Modified by author, MRAPS Arrive, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001268151.

Holography enables the XO to visually look at equipment and check the real-time status. The figure shows that the level IV status is currently at 70%, meaning that only seven of the ten vehicles would be able to make it out of the motor pool during an emergency alert. Level IV status is defined as being able to drive your equipment out of the motor pool and accept a mission. A visual report combined with the physical updates the XO on the amount of money needed to get the status of the company to 100 percent operational vehicle readiness. Hovering a hand over a vehicle allows for the user to select the piece of equipment to get further details. Command maintenance time is now focused on fixing the problem and not trying to trouble shoot the vehicle or creating the correctly filled out 5988 (maintenance form). The 5988's are automatically updated through the diagnostics computer in each vehicle. Operators are able to easily check the status of parts on order. The Army begins to transition from managing paperwork and locating problems to fixing issues and ensuring parts are delivered in a timely manner. The data is an aggregate reported to higher headquarters to allow for the accurate forecasting of budget allocation to reach the unit's readiness goals.

This research needs to display how holography evolves the decision-making process in a strategic environment. Data is delivered to the XO in order to get the unit to a certain level of readiness, which would normally a long time to compile and is not real-time data at that given point. Mechanics are able to remote in and virtually assist soldiers in repairing vehicles to ensure parts are installed correctly. A single mechanic can oversee as many jobs as they can at one time through multiple remote live sessions. Soldiers will never be stranded again without roadside remote assistance.

Imagine the worst has just happened in a tactical environment. Your battle buddy has just been shot in the leg, grazing the femoral artery. The wound needs a tourniquet most likely resulting in loss of the limb if not treated within the golden hour. Holography can eliminate the golden hour through the use of real-time treatment from advanced medical teams and noninvasive devices that enable soldier health monitoring. The following scenario employs the use of a pulse oximeter which delivers noninvasive soldier health monitoring to the holography environment. A pulse oximeter is a small tool that analyzes oxygen saturation in areas of the body (see figure 28).

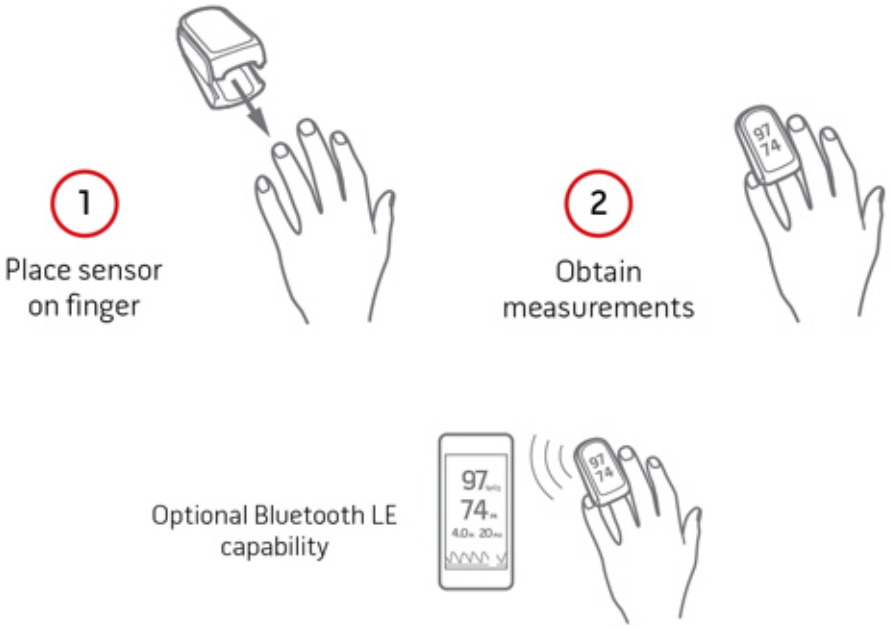


Figure 28. Pulse Oximeter

Source: Masimo, *MightySat Rx Fingertip Pulse Oximeter*, accessed 7 March 2017, http://www.masimo.com/pulseOximeter/mightysatRx.htm.

This type of technology combined with holography give the first responder or combat life saver the ability to know how tight to make the tourniquet. Is there a better way to know how to find the careful balance of stopping the bleeding but maintaining circulation to the limb?

Immediately following the gunshot wound, the squad leader presses the medevac button on the holography interface. Data is automatically sent to the medivac team for an immediate mission. The Medevac team joins the already support call between the surgical team and the first responder to see if special equipment is required. The surgical team primary (Surgeon) is assisting the first responder on caring for the wounded soldier. The surgeon is seeing the same picture as the first responder and is able to look at medical data that is provided from the soldier's noninvasive medical sensor. The surgeon is also able to draw on the patient to help the first responder carefully prep the soldier for movement to the medevac pickup point. The surgical team that is closest to the soldiers' pickup point is prepping for the arrival and preparing the operating room.

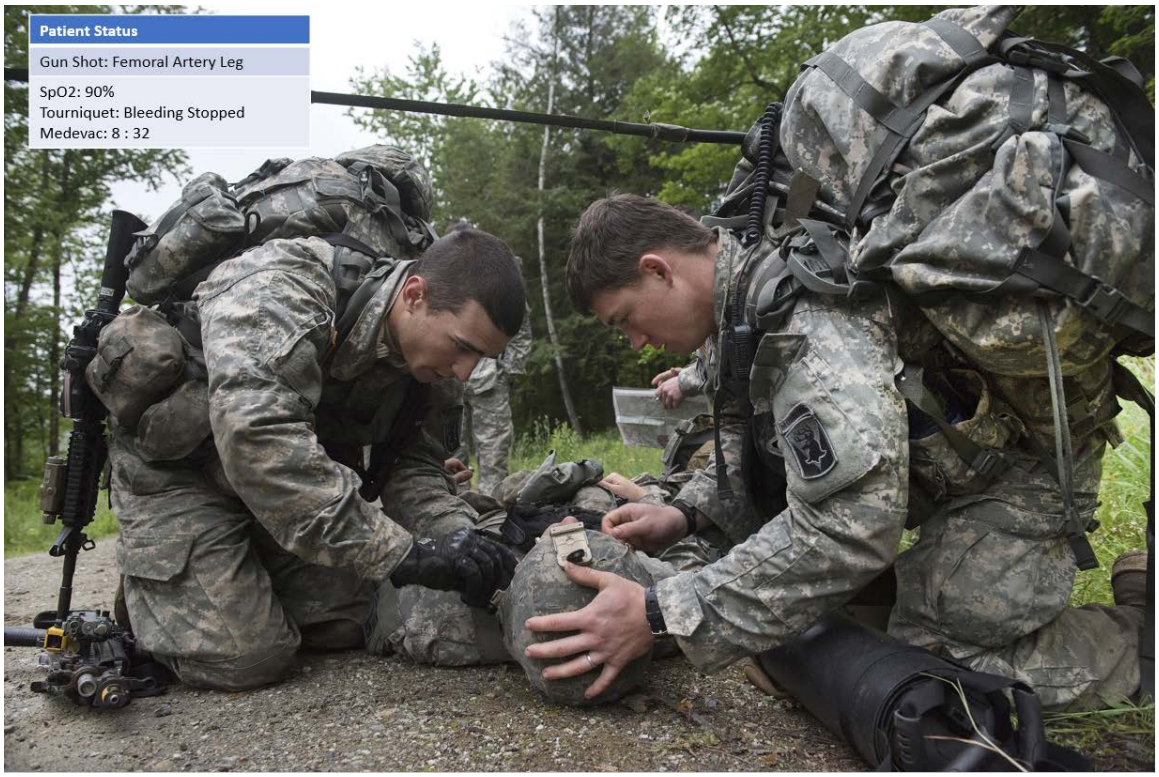


Figure 29. Soldiers treating wounded soldier

Source: Modified by author, Treatment Talk, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001557333.

The CP is monitoring all movements and reallocating intelligence surveillance reconnaissance (ISR) to the area to assist the troops in contact. The commander and staff are able to monitor all progress as they watch a helicopter move across a holographic map counting down the time to pick up. The first responder and security team have prepped the wounded soldier and are now ready to move to the pickup point. The commander and staff have selected an area that is close enough that doesn't take over ten minutes and is far away from the TIC, so the medevac is not affected. All routes are updated for the pickup point to the security transport team on the ground and the medevac pilot and team enroute.

Figure 30. Moving soldier to medevac pickup point

Source: Modified by author, Evacuation Training, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001557316.

The transport team is able to have an overlay directing the route and the number of meters to the pickup point. The medevac icon appears within their view even though the aircraft is out of range, the transport team has the ability to tap to talk to the pilot. The transport team additionally shows up on the pilots Hud. This gives the pilot the capability to contact the transport team enroute.

Figure 31. Medevac pickup

Source: Modified by author, Medevac Training, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001177988.

The pickup is successful and the flight moves to the closest capable treatment facility. The surgical team is on standby getting a brief from the surgeon and preparing to receive the wounded Soldier.

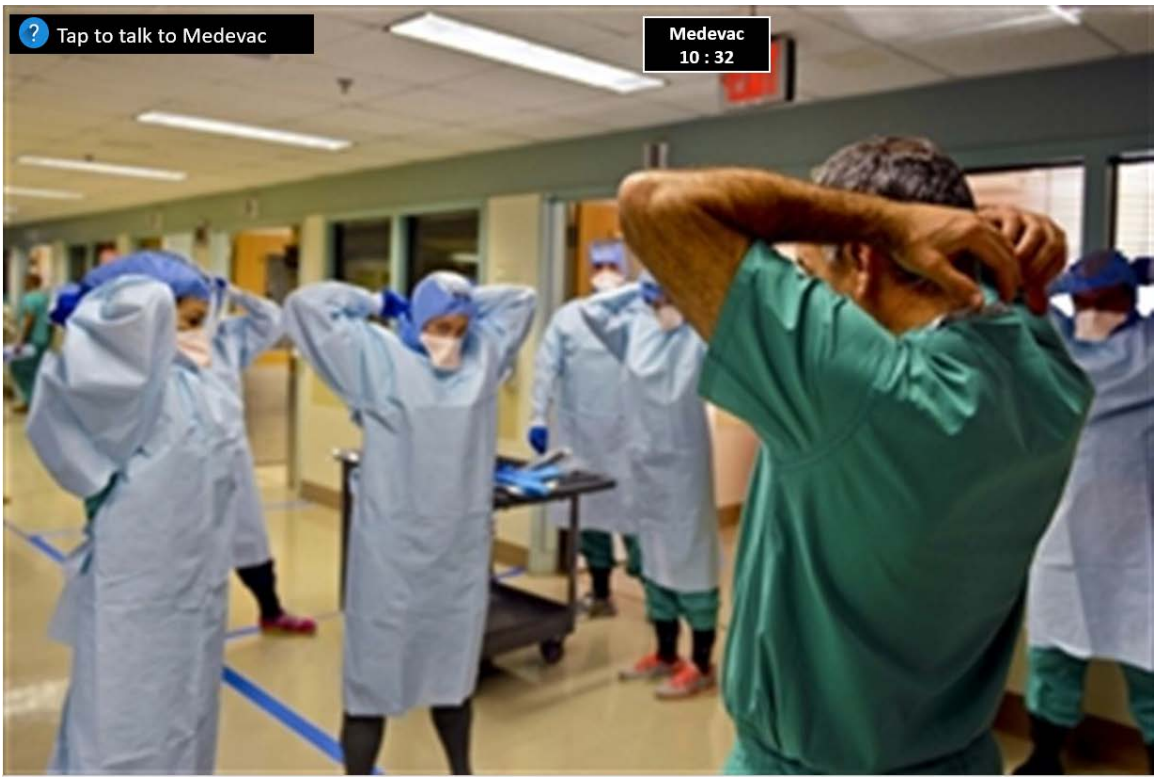


Figure 32. Surgeon prepares surgical team

Source: Modified by author, Protective Gear Training, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001205675.

The surgical team is able to tap the medevac icon and talk directly to the pilot or if on board, the flight nurse. Data continues to stream to the team to monitor the status of the wounded soldier. The surgeon speaks what the team needs and wants to know as the system returns the information. The soldier has safely reached the medical team and is now in surgery, but there seems to be complications occurring. The surgeon allows a specialist to remote into the surgical procedure to view the situation and assist in saving this soldiers life.

Figure 33. Specialist assist

Source: Modified by author, Protective Gear Training, U.S. Department of Defense, accessed 1 March 2017, https://www.defense.gov/Photos/Photo-Gallery?igphoto=2001201233.

The Specialist is able to rotate the view and look at the patient in any angle while in surgery. The specialist is able to help save the soldier, who has a full recovery and maintains full use of their leg.

Protection Vignettes

Military police have the ability to use holography through the windshields of their vehicles. Fiscally constrained posts have the ability to quickly integrate and talk with local and federal law enforcement. Situational understanding is resident across the F.B.I. and local military police during a hostage rescue situation. The military police have the

ability to integrate with the FBI to ensure a smooth transition and utilize assets that are resident to the home station mission command. Windshields in patrol cars are constantly scanning vehicles and personnel on post and sharing data with off post agencies. Home station mission command has the ability to talk directly to federal and local agencies when needed. Agencies make themselves available upon request and assist protecting home station command. Communications are visual allowing for touch to talk and request of ISR assets. Federal agencies request use of army aviation in emergency situations to transport hostage rescue teams on site. The local FBI Headquarters CP is able to link to and share with the military home station mission command and vice versa. Situational understanding is shared across all participating agencies and law enforcement.

Summary

Holography drastically reduces the time needed to make decisions in a complex environment. Commanders, staff and soldiers are able to visually analyze data on a holographic map. The CP drastically reduces in size minimizing constraints from SWAP-C. The commanders common operating picture allows for a distributed decentralized environment. Data augments the process and overlays data onto reality. The visualization enhancement drastically reduces the time needed to create a shared understanding across the domain. Commanders are no longer tethered to the CP. The CP is virtually resident across the expeditionary mission command formation.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

My conclusion are based on the theory of diffusion of innovations. This "is a theory that seeks to explain how, why, and at what rate new ideas and technology spread."[132]

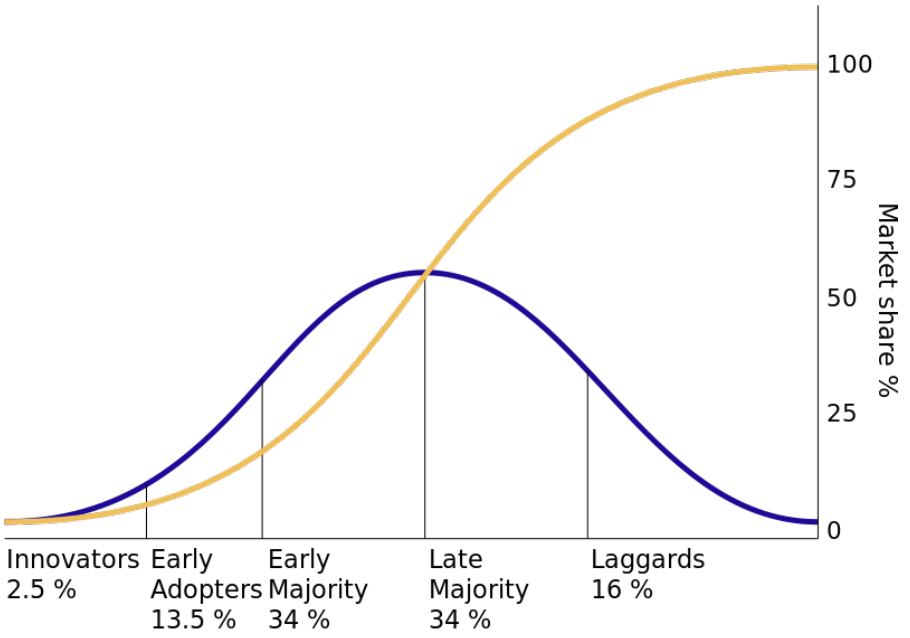


Figure 34. Diffusions of Innovations according to Everett Rogers

Source: Everett Rogers, *Diffusions of Innovation* (London, NY: Free Press, February 2011), accessed 7 February 2017, https://en.wikipedia.org/wiki/Diffusion_of_innovations.

[132] Wikipedia, "Diffusion of innovations," Free encyclopedia, 12 March 2017, accessed 7 February 2017, https://en.wikipedia.org/wiki/Diffusion_of_innovations.

Holography evolves the operations process and gives commanders and staff an enhanced situational understanding throughout the operations process. A visual information environment, augmented on top of reality decreases the amount of time needed to make decisions. The common operational picture is virtual and can be employed with expeditionary mission command. The elimination of handheld devices, monitors and physical computers creates a noninvasive decision making environment. Holography creates an ever present and undetected reality for commanders, staffs, and soldiers. Commanders and staff are distributed across the battle space, home station, enroute, and conducting early entry sharing a common situational understanding. Form factors are greatly reduced shrinking a CP to a single person. SWAP-C is no longer a constraint as holography augments teams as small as one scaling to Joint Task Forces.

Virtual constructed terrain replicating the actual terrain shows a 3D model allowing commanders and staff to visually analyze the battle space. The model greatly enhances situational understanding of the upcoming mission compared to a traditional 2D map board or a constructed terrain model. The staff can walk around the map and look at different angles of the landscape to better prepare avenues of approach, plan main supply routes, develop named areas of interest, and more. The time needed to create the environment is drastically reduced, the meeting does not require physical attendance, and time is spent on the analysis of actual terrain not on the development of the terrain model. During war gaming, simulations are able to inject the enemy most likely and dangerous course of action. This allows commanders to deconflict battle space by visually seeing areas of operation and unit boundaries. Other services and agencies are able to virtually connect in and help work out any issues within the battle space.

Mission Command evolves allowing for a multitude of sensors to be tracked on a virtual map anywhere. Virtual maps that display the live terrain of the battle space with real-time sensor analysis give the commanders and staff an evolved situational understanding. Commanders are able to deconflict fires and airspace in minutes. Every soldier and piece of equipment can be accessed through tap to talk from the common operating picture. Commanders can quickly tailor formations and focus combat and asset strength to designated areas of concern. Adaptive formations are created on the fly with the ability to meet the situation of concern.

Commanders can look across formations and utilize subject matter experts anywhere in the world through remote access. Soldiers utilize remote roadside assistance to quickly fix broken down vehicles minimizing the amount of recovery teams needed. The possibilities for remote assistance in combat are limitless. Remote assistance will be analyzed and provided by a distributed home station mission command team. Mission Command evolves from data tracking and problem detection to data arriving at the right moment. The force moves toward becoming data analytical looking for predictive models allowing for the creation of an adaptive force.

MCISs are greatly enhanced and overlay data onto the process. The ad-hoc creation of low density skill sets to operate current MCIS's cease to exist. Information systems augment the environment in an operational, strategic, and tactical setting. Commanders, staffs and soldiers are able to quickly orient themselves and use the information needed for the process or mission. Data can be generated through voice and motion. Knowledge managers help forecast information within MCIS's to build the correct views for and adaptable mission. Composable views reduce the time needed to

develop and add capabilities to the MCIS system of systems reducing the overall force need to integration timeline. Time is reduced and gives operators the ability to focus on solving the problem and not searching for data or memorizing radio nets. Data is no longer a digital view, and has evolved to an object-oriented view. All equipment and personal are sensors creating a live MCIS everywhere you look and operate. Views are now designed to augment the process and tested against user cognitive load in the eco system. Systems are no longer developed in a stove piped environment. Additions to the system must reduce time and improve the overflow of the process.

Army warfighting functions tightly nest and integrate well within holography. Mission command crates a visual environment for the commander and staff that allows for coordination of cross boundary areas of operations. Views replace applications and data seamlessly integrates with the operations process. Systems are no longer separated requiring users to understand or select a combination of platforms to gain a holistic shared understanding. Expeditionary mission command is achieved and now measured in seconds, with rapid transitions between enroute and EECP. Planning for satellite access can be done on the move through holography based views allowing commanders the flexibility needed to conduct mission command.

Movement and maneuver views provide commander, staff and soldiers the flexibility needed to adapt routes based on sensor forecasting. Language barriers are broken allowing any soldier to translate host nation signs and words to the native language of choice. The need for interpreters reduces as devices translate for commanders engaged in key leader engagement and vice versa. The traditional human process only allows us to scan one person at a time. Holographic augmentation allows to

rapidly scan objectives to gain valuable intelligence or positively identify high value targets. Named areas of interest can be quickly reallocated based on the intelligence gathering need of the commander through the holography based COP.

Fires dominates the battle field integrating all domains to create mass effects on the objective. The COP is able to rapidly deconflict fires across the Army, Marines. Air Force and Navy in a multi-domain battle. Call for fire is point to target with your hands and eliminates the need for carrying radios. Virtualized SDR provides the waveform of need at the soldier level. Once headquarters has approved the firing order, ground units see the assets supporting appear as a holography icon. Simply tap to talk to communicate with any of the fires capabilities.

Sustainment provides view in a strategic environment to quickly analyze readiness. Commander, staff, and soldiers are able to select any piece of equipment to check the status. Data is aggregated to give XO's the data necessary to rapidly prepare readiness decisions for the commander and funding requirements. Data is always displayed in real-time eliminating the need for power point and stale statistics. Protection is integrated with off post agencies for the rapid buildup and integration of protection of the home station. FBI and the home station mission command use similar platforms and can quickly enter decision briefs to coordinate assets. Rapid scanning is available in all military police equipment for vehicle scanning on and off post. Hostage rescue teams augment command posts with limited funding to ensure protection when needed.

Recommendations

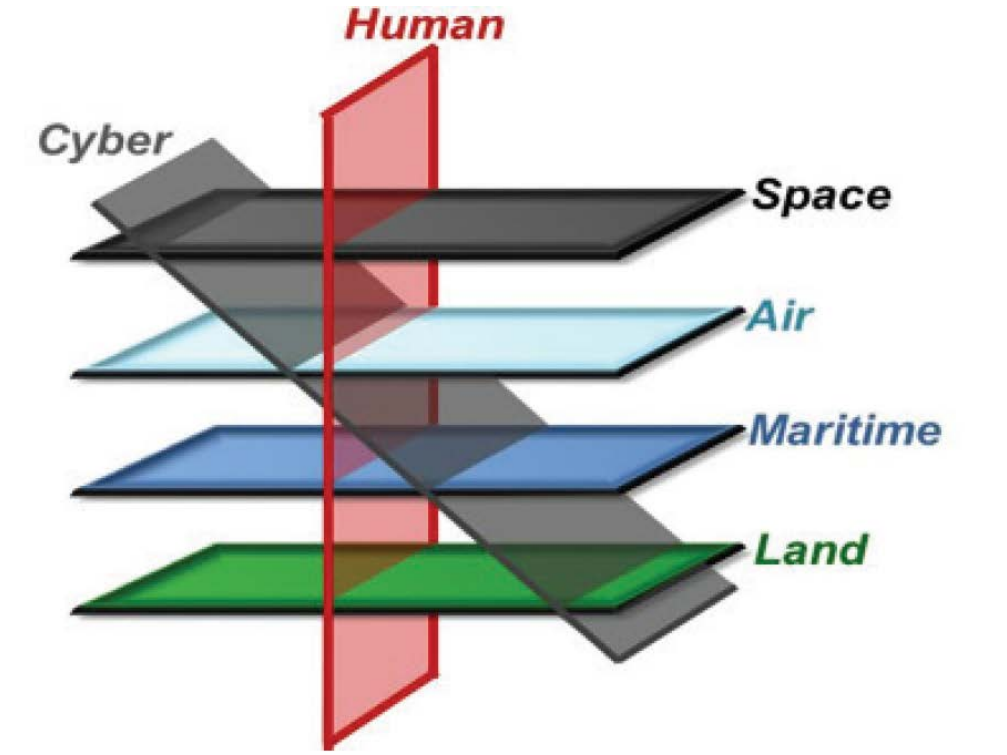
This research suggest that holography is ready to begin implementing at the commander and staff level for the common operating picture. Due to the amount of time

needed to develop capabilities it could take over a decade. It is critical that the Army begins doing the capability development now. Microsoft estimates that the holography market will be around 5.5 billion by 2020. Does that include our adversaries? Are the future enemies of the US developing applications with similar technology right now? Can the Army mitigate risk and stay the current course and take another decade to develop this capability? Data shows that with the integration of holography in operations shows a significant reduction in time and ability to gain situational understanding. Visual peripherals such as monitors were a deviation from what the Army was used to using. Searching for data and working in stove piped environment creates fog among the staff and friction during integration to gain a shared understanding.

The research suggests that following this thesis the next steps involve extensive testing and development. The domains include areas that are able to integrate with night vision, above water, under water, and a space capability. The focus should be how to mitigate cognitive load across domain, but ensure that they are able to function at different times and weather within the domain. Simultaneously cognitive load is reduced for the human dimension integrating all domains.

Summary

In order to dominate our opponents on the battlefield, the Army must have an agnostic technology that can quickly grow. Holography will increase our situational understanding allowing the Army to rapidly build speed and combat power. Mission command information systems must be able to extend across multiple environments and domains regardless of a commonality in hardware. The human dimension must be met at each domain by an information system that augments the process (see figure 35).



Cross Domain Synergy: Campaign planners can understand the complex environment by considering each domain and its effects on others.[20]

Figure 35. Cross Domain Synergy

Source: Charles Cleveland, James T. Linder, and Ronald Dempsey, "Special Operations Doctrine: Is it Needed?" *PRISM* 6, no. 3 (2016): 4-19.

The focus needs to be on data delivery at the process in need over an approved secure based hardware. Holography is the future of mission command for the commanders, staff and Soldiers allowing a distributed environment for all operations. Cognitive load is greatly reduced allowing for commanders, staff and soldiers to focus on the process and not on a computer screen. The process is no longer split between trying to take data and mentally overlaying it onto the process. Data now augments reality and is a noninvasive process to decision making.

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