HOW TO MAINTAIN THE TACTICAL COMMUNICATIONS EDGE WITHIN THE MODERN INFORMATIONAL TECHNOLOGICAL ENVIRONMENT

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The US Army has transitioned its main mission focus from counter insurgency to Unified Land Operations; this shift causes the US Army Signal Corps to pivot its tactical communications coverage. Existing counter insurgency based operational networks will not function to the new mission's standards. An effective way must be found to quickly get tactical communication capabilities into the warfighters possession and have America's Information Technology industry to work in favor of the US Army Signal Corps. The Problem is that the military must balance between the interoperability risks of urgent acquisition and the obsolesce risks of a methodical approach. Research has shown that the solution must also meet the challenges imposed by the exponential growth of technology and be adaptive enough to operate in a communication degraded environment, while utilizing a "fail fast" business model. An "adopt, adapt, and author" strategy should be implemented to create a joint standardized tactical hardware architecture and implement a modular technical solution utilizing commercial off the shelf acquisition models.

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ABSTRACT

HOW TO MAINTAIN THE TACTICAL COMMUNICATIONS EDGE WITHIN THE MODERN INFORMATIONAL TECHNOLOGICAL ENVIRONMENT, by Scott M. Noland, 80 pages.

The US Army has transitioned its main mission focus from counter insurgency to Unified Land Operations; this shift causes the US Army Signal Corps to pivot its tactical communications coverage. Existing counter insurgency based operational networks will not function to the new mission's standards. An effective way must be found to quickly get tactical communication capabilities into the warfighters possession and have America's Information Technology industry to work in favor of the US Army Signal Corps. The Problem is that the military must balance between the interoperability risks of urgent acquisition and the obsolesce risks of a methodical approach. Research has shown that the solution must also meet the challenges imposed by the exponential growth of technology and be adaptive enough to operate in a communication degraded environment, while utilizing a "fail fast" business model. An "adopt, adapt, and author" strategy should be implemented to create a joint standardized tactical hardware architecture and implement a modular technical solution utilizing commercial off the shelf acquisition models.

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TABLE OF CONTENTS

Page

MASTER OF MILITARY ART AND SCIENCE THESIS APPROVAL PAGE iii

ABSTRACT iv

ACKNOWLEDGMENTS v

TABLE OF CONTENTS vi

ACRONYMS viii

ILLUSTRATIONS x

TABLES xi

CHAPTER 1 INTRODUCTION 1

Overview 1
Research Question 1
Assumptions 2
Definition and Terms 3
Scope—Delimitations 7
Initial Personal Recommendation 7
Background 9

CHAPTER 2 LITERATURE REVIEW 12

Introduction 12
Speed of Technology 14
The Theory of Interdependence and Modularity 19
Failing Fast vs Waterfall Business Models 20
What to Do: The Operational Approach 21
Situational Template 25
Network Development 26
Warfighter Information Network-Tactical 28
Unified Land Operations Challenges 30
Conclusion 34

CHAPTER 3 RESEARCH METHODOLOGY 36

R3 Criteria 40
Stakeholders Defined 40
Tactical Battalion Commander 40

Army Chief Information Officer of Signal Corps....................................42
Chapter Summary 43

CHAPTER 4 DATA PRESENTATION AND ANALYSIS 44

Case Studies.. 44
Warfighter Information Network-Tactical... 45
Commercial off the Shelf.. 46
Hardware Regulatory Compliance.. 49
R2 Informed Position.. 51
R3 Stakeholder Perspectives... 54
Battalion Commanders Remaining Concerns.. 56
Army Chief Information Officer Remaining Concerns............................ 58
Conclusion 58

CHAPTER 5 CONCLUSIONS 60

The Way Forward 60
Beyond the Scope 63
Lessons Learned 66
Conclusion 67

BIBLIOGRAPHY...68

ACRONYMS

C2	Command and Control
CBA	Capability-Based Assessment
CHESS	Computer Hardware, Enterprise Software and Solutions
COA	Course of Action
COTS	Commercial off the Shelf
DoD	Department of Defense
DOT&E	Director, Operational Test, and Evaluations (The Office of the)
DOTMLPF-P	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, Policy
FAA	Functional Area Analysis
FNA	Functional Needs Analysis
FOB	Forward Operating Base
FSR	Field Service Representative
G-6	Army Chief Information Officer
HRC	Hardware Regulatory Compliance
IT	Information Technology
JC3	Joint Communications Capability Components
JCT-T	Joint Communications Tactical-Terminal
JTA	Joint Technical Architecture
LOE	Lines of Effort
R1	Initial Personnel Recommendation
R2	Researched Position
R3	Stakeholder Position

R&D	Research and Development
RCA	Regulatory Compliance Architecture
ULO	Unified Land Operations
US	United States
VICTORY	Vehicle Integration for C4ISR/EW Interoperability
WIN-T	Warfighter Information Network-Tactical

ILLUSTRATIONS

Page

Figure 1. Microprocessor Growth and Moore's Law....16

Figure 2. Research Model....40

Figure 3. Recommended Solutions....53

Figure 4. Lines of Effort....61

Figure 5. Joint Node Network Acquisitioned History....63

TABLES

Page

Table 1. Research Approach 39

Table 2. Maneuver Battalion Commander Weighted COA Selection Criteria..........41

Table 3. Chief Decision Makers Weighted COA Selection Criteria 43

Table 4. FFNA Capability Gap Metrics..........45

Table 5. Battalion Commanders Prospective..........54

Table 6. Army Chief Information Officer Prospective..........57

CHAPTER 1

INTRODUCTION

Overview

The purpose of this thesis is to find the most effective way to get tactical communications capabilities into the warfighter possession and get the United States (US) information technology industry to work in favor of the US Army Signal Corps. This thesis will apply the Joint Capabilities Based Assessment Process, across the Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, Policy DOTMLPF-P spectrum, but by focusing on the material and organizational solutions. This document will identify gaps and assess current capabilities within the three case studies provided, and offer options to advance pre-existing platforms, further develop the technological enterprise, and provide the opportunity to apply an operational approach to ensure that Department of Defense (DoD) has the technological edge over the enemy.

Research Question

The primary question that this research seeks to answer is: What is the most effective way to quickly get tactical communications capabilities into the warfighter possession and get the United States Information Technology (IT) industry to work in favor of the US Army Signal Corps

The secondary research questions are:

1. What is the current cost in research and development time on the current primary Tactical Communications network (WIN-T)?

2. How can the Army invest in the right technology for a higher investment value?

3. What is the current cost in research and development time to implement a Commercial off the shelf (COTS) Solution?

4. What would be the cost in research and development time on publishing a Regulatory Compliance Communications standard?

5. What does technical growth consist of and where can the Army's technical needs fit into the technological growth?

Assumptions

The following assumptions were made during this research:

1. The US Army G6's mission sets will remain:[1]

a. Enterprise Information Environment Mission Area;

b. Intelligence Mission Area;

c. Business Mission Area;

d. Warfighting Mission.

2. Unified Land Operations will continue to be the Army's focus for the next 10 years.

3. The US Army Signal Corps will not restart the Project Manager Warfighter Information Network-Tactical (WIN-T) Program of Record.

[1] Brigadier General Bruce T. Crawford, Statement Before the Subcommittee on Tactical Air and Land Forces, Committee on the Armed Services, on the Unites States Army Network Modernization Strategy, 115th Cong. 1st sess., September 27, 2017.

Definition and Terms

Adopt-adapt-author: refers to adopting an architecture standard, then adapting your practices to the adopted standard and finally authoring additional refinements and making the standard your own. It is a methodology to establish a set of common open architectures for use within the vehicle and mission system communities. The vehicle standard architecture will be independent of specific hardware, software or firmware solutions, meaning they refer to the base assemblage its self not any additional technical items attached.[2]

Commercial off-the-shelf (COTS): or commercially available off-the-shelf satisfies the needs of the purchasing organization, without the need to commission custom-made or modified solutions. In the context of the US Government, the Federal Acquisition Regulation has defined "COTS" as a formal term for commercial items, including services, available in the commercial marketplace that can be bought and used under government contract.[3]

Fight Tonight: This term refers to maintaining a state of readiness with the ability to sustain offensive actions against any adversary at any time.

Law of Accelerating Returns: Technical Evolution applies positive feedback in that the more capable methods resulting from one stage of evolutionary progress are used to create the next stage. As a result, the rate of progress of the technical evolutionary

[2] Tardec External Business Office (EBO), *Tardec 30 Year Value Stream Analysis,* July 2015, 5, accessed April 25, 2018, https://www.army.mil/e2/c/downloads/451990.pdf.

[3] Chapter 1 subsection 12.000, Title 48 of the Code of Federal Regulations, 40 U.S.C. 121(c); 10 U.S.C. chapter 137; and 42 U.S.C. 2473(c).

process increases exponentially over time. Over time, the “order” of the information embedded in the evolutionary process increases, technological evolution is an outgrowth of–and a continuation of–biological evolution. A specific paradigm provides exponential growth until the method exhausts its potential. When this happens, a paradigm shift occurs, which enables exponential growth to continue.[4]

Modularity—Theory of Interdependence and Modularity: Is a framework for explaining how different parts of a product’s architecture relate to one another and consequently affect metrics of production and adoption. Terms often associated with modularity is standardization of components and independent operating parts. Terms associated with interdependent technical architectures are unique components, optimized for a specific function and slow adoption.[5]

Moore’s Law: A simple observation, made over 50 years ago, by G.E. Moore, co-founder of Intel. The predictive law focuses on the growth in the number of devices per silicon die has become the central driving force of one of the most dynamic of the world’s industries. Even the policy implications of Moore’s Law are significant: it is used as the baseline assumption in the industry’s strategic road map for the next 15 years.[6]

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[4] Ray Kurzweil, “The Law of Accelerating Returns,” March 7, 2001, accessed February 23, 2018, http://www.kurzweilai.net/the-law-of-accelerating-returns.

[5] Clayton Christensen Institute for Disruptive Innovation, “Interdependence and Modularity,” accessed April 16, 2018, http://disruptiveinnovation.org/concept/interdependence-and-modularity.

[6] Gordon E. Moore, “Lithography and the Furture of Moore's Law,” *SPIE* 2440 (February 1995): 2-17.

Open System Interconnection Model: defines a networking framework to implement protocols into seven layers. It is a conceptual model conceived to assist in understanding the complex networking interactions. The Lower layers (1 through 4) are primarily for moving data. The Upper layers (5 through 7) deal primarily with interactions with applications. Each layer passes information to the next layer.[7]

Layer 7—Application (end user processes)
Layer 6—Presentation (encryption)
Layer 5—Session (applications)
Layer 4—Transport (flow control)
Layer 3—Network (switching/routing)
Layer 2—Data Link (gain access and synchronization)
Layer 1—Physical (Hardware)

R1—Initial Personal Recommendation: The Authors professional opinion on the subject matter prior to starting research.

R2—Author's Researched Perspective: The Author's researched solution to the primary research question, after cross referencing the R1 findings against the literary reviewed body of information

R3—Stakeholder Position: The Author takes the findings in R2 and applies stake holder perspectives on the primary research question.

Regulatory Compliance: Describes the goal that organizations aspire to achieve in their efforts to ensure that they are aware of and take steps to comply with relevant laws, polices, and regulations. Due to the increasing number of regulations and need for operational transparency, organizations are increasingly adopting the use of consolidated and harmonized sets of compliance controls. This approach is used to ensure that all

[7] Ronald Schlager, *The OSI Model: Simply Explained* (CreateSpace, 2013).

necessary governance requirements can be met without the unnecessary duplication of effort and activity from resources.[8]

Technical Compliance Architectures: There are three areas of technical compliance, in relevance to warfighter operations: Operational, Technical, and Systems Architectures.

1. Operational Architecture, identifies the warfighter information requirements and the standards of informational transference covered in the Joint Technical Architecture (JTA) this deals mainly in the Layer 7 (end user processes) within the Open System Interconnection Model.

2. Technical Architecture, is the compliance that deals mainly in Layer's 1through 4 of the Open System Interconnection Model. This standard characteristic is the interoperability between the physical characteristics of IT infrastructure with in the technical environment.

3. Systems Architecture, involves the fifth layer of the Open System Interconnection Model (applications), this compliance architecture focuses mainly on the conversations and functionality between applications.[9]

Unified Land Operations (ULO): Defines how the Army seizes, retains, and exploits the initiative to gain and maintain a position of relative advantage in sustained land operations through simultaneous offensive, defensive, and stability operations in

[8] Tom C. W. Lin, "Complaince, Technology, and Modern Finance," *Journal of Corporate, Financial and Commercial Law* 11 no. 1 (2016): 159-182.

[9] John D. Bard, *Joint Tactical Radio System* (Melbourne, FL: Space Coast Communication, 2003).

order to prevent or deter conflict, prevail in war, and create the conditions for favorable conflict resolution (Army Doctrine Publication 3-0). ULO is the Army's operational concept and the Army's contribution to unified action.

Warfighter Information Network-Tactical (WIN-T): is an extensive tailorable suite of integrated tactical network communication and network (cyber) management capabilities to support today's complex Joint, Coalition and Civil missions worldwide.[10]

Scope—Delimitations

The focus of this study is on the acquisitions (material) solution issues facing the US Army Signal Corps tactical communications platforms and will not be addressing the readiness issues that have also been raised during the scope of this research. Additionally, in regard to DOTMLPF-P analysis, this research will focus specifically on the organizational and material needs required to answer the research question.

Initial Personal Recommendation

This section of the study will cover the author's initial personal recommendations prior to the start of research. This R1 section will cover the "so what" of the thesis; in other words, why a reader should care about this work and how the findings relate to the US Army as a whole. Second, this section will describe the area of importance and what are the drawbacks for not having this information. Third, this section will cover the scope of answers and what can be conscribed from this study. Fourth, the method of study and data analysis is briefly covered, with a breakdown occurring in chapter 3. Lastly, this

[10] Program Executive Office Command Control Communications-Tactics, "PM Tactical Network," August 2017, accessed May 14, 2018, http://peoc3t.army.mil/wint/.

section informs the reader on the author's initial unresearched answer (R1) to the primary research question.

The reader should care about this study because the US Army Signal Corps is currently unprepared to meet the challenges of a near peer competitor and is unable to follow the "fight tonight" concept of operations. The way the Army has fought for the last 15 years will not work in the Army's future concept of operations; without a common operating picture, proper data transfer methods, and digital communications, the military will be unable to conduct Joint combined arms warfare, neutralizing its asymmetric advantages.

The answers that can be attained from this research is a material acquisition strategy that can modernize the US Army Signal Corps in order to meet the ULO doctrinal requirements found in Field Manual 3.0. This study will answer this acquisition problem by analyzing the current—future trends within the IT realm and cross leveling that information against what is and what is not working within the US Army Signal Corps, which is discussed in depth during chapter 4.

Finally, to reach the initial answer to the primary research question and delve into the author's preexisting perspective, the author's history with this subject matter is required. The author had the unique experience of serving as a tactical communication officer in both the Regular Army (seven years) and in Special Operation communications units (five years), which gave him an exclusive perspective of experiencing multiple acquisition methods (Program of Record and COTS) and two different programs of record (WIN-T and SOF Deployable Node). When the author started this study, he had a preexisting bias against WIN-T, having experienced its limitations for seven of the

12 years he served as a tactical communications officer. The author had a favorable disposition towards COTS. COTS acquisitions are flexible, elegant solution to communication problems as they happen. During the author's multiple Afghanistan deployments as a member of 3d Battalion, 160th Special Operations Aviation Regiment and 112th Special Operation Signal Battalion (Airborne), COTS solutions provided answers to unique issues that needed immediate material technical solutions. The author's initial answer (R1) to the primary research question was to replace WIN-T completely with COTS purchased equipment Army-wide.

Background

> From flag and torch in the Civil War, to signal satellites afar, we give our Army the voice to give command on battlefield of global span, in combat, we're always in the fight we speed the message day or night, technicians too, ever skillful, ever watchful, we're the Army Signal Corps.[11]

Founded in 1860, by Major Albert J. Myer and has played an integral role in military operations from the American Civil War through the present day.

> Support for the command and control of combined arms forces. Signal support includes network operations (information assurance, information dissemination management, and network management) and management of the electromagnetic spectrum. Signal support encompasses all aspects of designing, installing, data communications networks that employ single and multi-channel satellite, tropospheric scatter, terrestrial microwave, switching, messaging, video-teleconferencing, visual information, and other related systems. They integrate tactical, strategic and sustaining base communications, information processing and management systems into a seamless global information network that supports knowledge dominance for Army, joint and coalition operations.[12]

[11] U.S. Signal Corps, "Motto," accessed February 10, 2018, https://signal.army.mil/.

[12] U.S. Signal Corps, "Mission Statement," accessed February 10, 2018, https://signal.army.mil/.

The Signal Corps Mission has drastically changed from its founding during the Civil War, technology has greatly enhanced and transformed its individual mission sets, but its core principles have always remained the same; to provide robust communication in support of the Army's war fighting principles. As time progressed, several key events impacted lasting changes within its ranks. First, the Signal Corps scope was greatly enhanced during World War II, growing from an estimated 25,000 to 350,000 men and women post 1945, truly establishing signal as an integral part of US Army operations. Second, radio technology grew during the Korean and Vietnam Wars. The emergence of three distinct types of communicators occurred, specific base signal operators (S-6), field radio operators, and signal only operators. This distinct separation of communicators will continue to modern day. Specific base operators consist of an officer (S-6) and a relative small signal shop to support a Brigade or Battalion headquarters also known as tactical communicators. Field radio operators, or as they are termed today, radio operator maintainers, are signal personnel directly assigned to individual units to support Frequency Modulation (FM) communications; they are the most forward operating communicators. Signal only operators are communicators that are part of a signal only organization that supports echelons above regiment, these communicators support large organizations and typically have very little interaction with tactical units. Third, in 1965, satellite communications became active and grew in scope until it would become the primary means of tactical Command and Control (C2). Fourth, in 1988 the mobile-subscriber equipment system was issued and used as the primary tactical communication system, this system was formed to be a mobile telephone operating system on the battlefield. The limitations of mobile-subscriber equipment would be greatly exposed during Operation Desert Storm. Mobile-subscriber equipment could not maintain the speed of operations during the offensive and was deemed a failure for large scale land operations.

The Fifth key factor occurred in 1996, Fiber optic lines where developed for communications, drastically increasing the speed and throughput of technical data. Fiber optic communication is the superior method of data transportation, immediate transfer data rate (100 petabit x kilometer per second) and enormous data throughput (up to 10 Gigabits). Lastly, in 2004 the Signal Corps replaced mobile-subscriber equipment with WIN-T this system was augmented with a fiber optic backbone and Commercial off the Shelf (COTS) purchases to provide the robust technical operations required for the counterinsurgency operations battlefields in Iraq and Afghanistan.

CHAPTER 2

LITERATURE REVIEW

Introduction

Determining the answer to the primary research question, "What is the most effective way to get tactical communications capabilities into the warfighter possession and get Americans Information Technology industry to work in favor of the US Army Signal Corps" requires a literature review. The purpose of this literature review is to lay the groundwork for the structure of this study. "It provides the basic rationale for the research."[13] This information will be subsequently scrutinized and used to answer the primary research question within chapter 4: Data Presentation and Analysis.

Of primary importance is the constant acceleration of communication technology. The review will cover Moore's Law, a pivotal observative law outlining the speed of technology. This rule was expanded upon by The Law of Accelerating Returns. Furthermore, the counterpoint of Doctor Jonathan Huebner will be covered; his research suggests a slowing of humanity's innovative potential. The Theory of interdependence and modularity will be discussed in depth as it is important that the reader understands the difference between a modular technical architecture and an interdependent framework.

The US Army Signal Corps is looking to move away from its traditional developmental business model termed "Waterfall" and shifts towards a "fail fast" concept

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[13] Adriana Galván, "The Teenage Brain: Sensitivity to Rewards," *Current Directions in Psychological Science* 22, no. 2 (April 2013): 88-93.

that has been embraced in Silicon Valley technical developmental industries. This literature review will compare and contract these two schools of developmental concepts.

After addressing the developmental business models, the literature review moves on to examine a way to depict how the objectives and end states could be achieved. Termed "operational approach," this depiction of objectives and end state arises from three case studies. These objectives and end states are similar, but with three drastically different approaches. The three methods are Project Manager WIN-T, Commercial off-the-shelf or commercially available off-the-shelf (COTS), and the publishing of Regulatory Compliance Communications standards.

An understanding of the current operating environment of the US Army Signal Corps is required to properly frame the Operational Approach that will be published in chapter 5. On September 27, 2017, Brigadier General Bruce T. Crawford, Army Chief Information Officer (G-6), addressed the congressional subcommittee on Tactical Air and Land Forces of the Armed Services on the US Army's network modernization strategy. "Our current Network does not meet our Warfighting needs now or in the projected future."[14] Crawford's opening statement projected major problems within and outside the Army's communications organization. This chapter will examine how the US Army's network architecture grew into its current situation, a stationary architecture with fiber optic dependence.

Furthermore, this chapter will describe the US Army Signal Corps' primary tactical communication architecture, WIN-T.

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[14] Crawford.

Finally, the Army has transformed its mission and now the communications architecture must transform with it. "The character of war does change on occasion. And one of the drivers–not the only driver–is technology."[15] The US Army now shifts its focus to a potential near-peer adversary involved in ULO. In anticipation of ULO, a term fight tonight has gained traction; the term is synonymous with aggressive readiness. To support ULO and a fight tonight posture, the US Army must be able to communicate. This chapter will cover the challenges that the US Army Signal Corps faces transforming to meet the new requirements. The problem areas of focus are network governance, integration, requirements, acquisition, and innovation. The section is termed Unified Land Operations challenges.

Speed of Technology

To answer the primary research question, "What is the most effective way to get tactical communications capabilities into the warfighter possession and get Americans Information Technology industry to work in favor of the US Army Signal Corps?" some of the parameters of the question must first be framed. To enable the US IT industry to work in the Signal Corps favor, the US Army must plan for the speed of technological growth and utilize a procurement method that enables the best technical lifespan of its investment. This plan directly relates to the first part of the primary research question: "streamline the developmental process." This section of the literature review should answer the second and third research questions: What does technical growth consist of

[15] General Mark A Milley, Statement Before the Senate Armed Services Committee on the Posture of the United States Army, 115th Cong., 1st sess., May 25, 2017.

and where can the Army fit into that growth? How can the Army invest in the right technology for a higher investment value?

The documentation involving the speculations on technology growth is vast. To scope down the subject, this research focused on a select few highly respected theorists in the field. The first theorist to recognize and successfully predict the speed of growth was Gordon Moore, the co-founder of Intel, who wrote a paper in 1965 describing a doubling every year in the number of components per integrated circuit within the microprocessor. This observation provides the basis for Moore's Law, a formula that predicts the doubling of computer processing power every two years. Moore's Law has successfully predicted computation power doubling for the last 50 years, but many experts believe that the physicality of Moore's Law will not last past 2019.

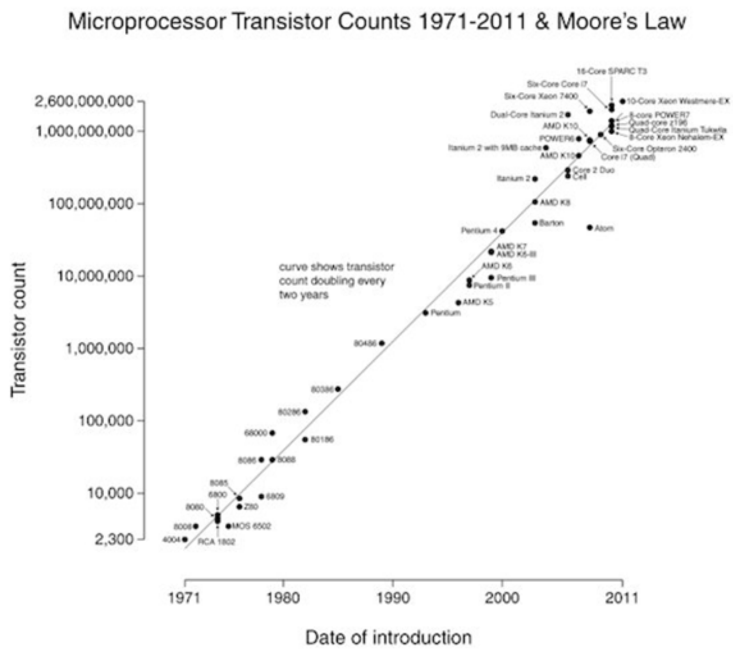

Figure 1. Microprocessor Growth and Moore's Law

Source: Peter Carey, "Silicon Valley Marks 50 Years of Moore's Law," *San Jose Mercury News*, April 24, 2015, accessed February 10, 2018, https://phys.org/news/2015-04-silicon-valley-years-law.html.

Theorists believe there will come the point that the silicon transistor will be unable to get any smaller. Ray Kurzweil proposed in his book, *The Law of Accelerating Returns* that Moore's Law was impressive, but not special. According to Kurzweil, Moore's Law is only the latest in a series of five indicators of technological expansion "from the mechanical calculating devices used in the 1890 U.S. Census, to Turing's relay-based 'Robinson' machine that cracked the Nazi Enigma code, to the CBS vacuum tube computer that predicted the election of Eisenhower, to the transistor-based machines used in the first space launches."[16] Kurzweil states that technology will continue to

[16] Kurzweil.

expand at an exponential rate, but a new technology will supplant the microprocessor in Moore's Law. Kurzweil continued to expand on Moore's Law showing that the exponential growth not only in processor speed, but also magnetic data storage, growth in DNA sequencing, internet backbone bandwidth, and wireless data devices. Kurzweil further states in *The Law of Accelerating Returns* that all technological growth is "exponential, contrary to the common-sense 'intuitive linear' view. So, we won't experience 100 years of progress in the 21st century—it will be more like 20,000 years of progress (at today's rate)."[17] Kurzweil's work is extreme in its calculations with the concept of Singularity being the focus of his book. "Within a few decades, machine intelligence will surpass human intelligence, leading to the Singularity—technological change so rapid and profound it represents a rupture in the fabric of human history."[18]

This extreme viewpoint of Singularity has drawn numerous criticisms from several scholars in the field. Dr. Jonathan Huebner disagrees with Ray Kurzweil's exponential growth theories stating that there are both physical and economic limits to technological revolutions. Huebner further asserts that humanity is currently at 90 percent of its innovative potential and will peak at 100 percent sometime in the year 2038. "The history of technological innovation from the end of the dark ages to the present time is examined, and evidence is provided that we are closer to the technological limit than many people realize."[19] Huebner speaks of two further limitations, a physical limitation

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[17] Ibid.

[18] Kurzweil.

[19] Jonathan Huebner, "A Possible Declining Trend for Worldwide Innovation" *Technological Foecasting and Social Change* 72, no. 8 (October 2005): 980-986.

such as science's inability to create a perpetual motion clock, and an economic limitation such as the infeasibility of the United States building a canal connecting the Atlantic and Pacific oceans, despite the physical capability. Huebner's research suggests that an economic technological slowing will occur before the physical threshold is achieved. Huebner's research places this slowing sometime in the middle of the 21st century.

The true potential of future technological growth can never be certain, but both sides of the argument agree that technology will continue to transform and grow until at least 2050. This research disregards the theological debate of singularity; the fact remains that Moore's Law continues to predict the doubling of computer processing speed. Moore's Law's predictive observations have been synthesized into The Law of Accelerating Returns, further expanding the scope of Moore's Law. It is this literature review finding, that technology will continue to grow and transform until at least the middle of the 21st century at an exponential rate.

The secondary research question is, what does technical growth consist of and where can the Army fit into the technological growth? Based on the literature review findings, the growth predicted in information technology needs to be accounted for in any solution that the US Army seeks to implement. Technological lifespans should be considered in the Army's procurement process, with the understanding that all equipment is not the same. Long procurement processes will place obsolete technical equipment into the hands of the organization.

How can the Army invest in the right technology for a higher investment value? Based on the literature review's findings; technological solutions that the US Army implements should be flexible and upgradable. Understanding the rapidly evolving technological atmosphere and purchasing technical platforms accordingly will increase the lifespan and investment value of technical architecture. The speed of acquisition is also a factor in answering this question; with computing power doubling every two years, the pace of acquisition is vital to maximizing technical lifespans.

The Theory of Interdependence and Modularity

The theory of interdependence and modularity describes how parts of a technical architecture relate and affect the quality of production and interoperability. Either an architecture is dependent on other parts with in its architecture or works independently of those parts. The interdependent architectures are optimized for performance in functionality and reliability, but suffer when attempting to upgrade (change) a product. The change creates an unpredictable relationship between the interdependent parts so to ensure operability both systems need to be changed. By contrast, in a modular architecture, there are no unpredictable interdependencies in the process. Modular parts fit and interact together in predesigned ways. A modular architecture specifies the design and functionality of all components so that multiple venders can fabricate components if they adhere to the prescribed standards.[20]

> [C]onsider the 'architecture' of an electric light. A light bulb and a lamp have an interface between the light bulb stem and the light bulb socket. This is a modular interface. Engineers have lots of freedom to improve the design inside the light bulb, as long as they build the stem so that it can fit the established light bulb socket specifications.[21]

[20] Clayton Christensen Institute for Disruptive Innovation.

[21] Ibid.

In modular architectures the same company is not required to design and produce the light bulb, the lamp, the wall sockets, and the electricity generation (distribution) systems. Because standard interfaces exist, varying companies can produce products for each individual part of the architecture.

Failing Fast vs Waterfall Business Models

Fail fast is a business model that focuses on incremental development testing to decide whether a concept holds value. The conceptual goal of the philosophy is to pivot away from a concept when testing is showing negative results and quickly move to a different solution. "An important goal of the fail fast philosophy is to avoid the sunk cost effect, which is the tendency for humans to continue investing in something that clearly isn't working because it's human nature for people to want to avoid failure."[22] The business model tries to take the stigma out of the term "failure" and focus on the lessons learned and adapting from the misstep. This business model has been embraced by organizations that want to develop a new product but want to face less financial risk than the waterfall methodology.[23]

The waterfall concept is considered the opposite of the fail fast methodology. Waterfall strives to complete a project completely prior to turning the project over to the customer. The Waterfall is a complete and methodical approach and tends to avoid the

[22] Eric Ries, *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses* (New York: Random House, 2011).

[23] Ibid.

"piecemeal effect," which is error that can happen when pieces of a system are added haphazardly, where they may fit partially or not at all.[24]

Waterfall concept has been the Signal Corps' primary contractual investment strategy for the past major technical contracts, (mobile-subscriber equipment and WIN-T). There has been a move at US Army Signal Corps' higher command echelons to move towards a fail fast business methodology and any new technological solution should embrace the tenants of the fail fast methodology.

What to Do: The Operational Approach

An operational approach, which includes identifying a desirable end state and objectives organized along lines of effort, answers the secondary research questions:

1. What is the current cost in research and development time of the current Program of record for the tactical communications network (WIN-T)?

2. What is the current cost of research and development time for implementing a Commercial off the shelf Solution (COTS)?

3. What would be the cost of research and development time on publishing a Regulatory Compliance Communications standard?

As stated in Doctor Jack Kem's book *Planning for Action: Campaign Concepts and Tools*, "an operational approach is not meant to be a 'developed plan of action or course of action,' but rather a broad concept."[25] The inequalities that occur when associating current conditions and desired end state serve as the location to establish

[24] Ibid.

[25] Jack D. Kem, *Planning for Action: Campaign Concepts and Tools* (Fort Leavenworth, KS: Combined Arms Center, 2012).

Lines of Effort (LOEs). LOEs will link all goals towards specific activities to focus efforts towards the desired endstate. The operational approach needs to be placed into the military perspective because this study focuses on a tactical military communication solution through the US Army Signal Corps aperture. Further descriptions of the concept of operational approach and its benefits to this study will be expanded upon in chapter 5. Understanding the current operating situation is critical to understanding the current state of the US Army Signal Corps and the context for this research. On September 27, 2017, Brigadier General Crawford, G-6, addressed the congressional subcommittee on Tactical Air and Land Forces of the Armed Services on the US Army's network modernization strategy. This congressional testimony is covered in depth below in the section termed Situational Template. The key takeaway from this subcommittee hearing was that Crawford announced the cancellation of the US Army Signal Corps Primary Tactical Communications Program of record, WIN-T, without naming a replacement. The results of this testimony left the subcommittee members and US Army with many questions involving the future of Army tactical communications. This announcement leaves the US Army Signal Corps without a tactical communication asset to support ULO doctrine. ULO pertains to the US Army ability to fight anytime, anywhere, and a moment's notice. "Simultaneous offensive, defensive, and stability or defense support of civil authority's tasks to seize, retain, and exploit the initiative and consolidate gains to prevent conflict, shape the operational environment, and win our Nation's wars as part of unified action."[26]

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[26] Kem.

Project Manager WIN-T, COTS, and the publishing of Regulatory Compliance Communications standards are the US Army Signal Corps' three primary methods of providing the Army with Communications Networks. WIN-T started with a six-billion-dollar contract awarded in 2004, delayed from a 2001 planning projection. The contract was established through an Independent Variable Acquisition Method as an Acquisition Category 1. Both processes will be covered more in depth in chapter 5. The critical takeaway from the acquisition process is that between all the standard governmental acquisition requirements and the additional reshuffling of the contract to three phases, phase one was not fully fielded until 2012. The contract has undergone considerable shifts from its original 2001 planned awarding date. Technology matured, exterior requirements shifted, and WIN-T went from a single-phase operation to a three-tiered deployment operation. The three-tiered concept lengthened the cost and deployment timelines. Planned future technologies failed to mature and struggles with phase two interoperability resulted in contract cancellation. Further conceptual challenges involving WIN-T will be covered in detail in chapter 4.

The Secondary Research question is: What is the current cost of research and development (R&D) time of the current program of record for the tactical communications network (WIN-T)? Initial estimates on cost were six-billion dollars, but with changes in mission and phases of operation the costs moved from 15 to 20 billion dollars. It is unclear exactly how much of that funding went to R&D as the 20 billion dollar price includes the tactical communication assemblages. The sources referenced used the six-billion-dollar initial funding contracts as the cost of R&D. The contract was initially set to be issued in 2001 but was not awarded until 2004 with a Phase one fielding date starting in 2006 and finishing in 2012, giving WIN-T an 11-year timeline from concept to final issue date.

The second case study considered is Commercial off the Shelf. COTS is commercially available items that are available quickly and conveniently from vendors and meet some or all military requirements. This process bypasses all R&D costs as well as potentially lengthy government procurement processes. The downsides of this process include additional costs on the integration side of procurement, and potential issues involving security, obsolescence, and continuity of operation. The key points of understanding to this process are that COTS has a high speed of acquisition with significant drawbacks in interoperability and security with possible vender dependency included.

What is the current cost of research and development time on implementing a Commercial off the shelf Solution (COTS)? COTS equipment requires no R&D costs. COTS typically require modification as most commercially available equipment does not entirely meet military needs. Most material needs to be hardened for military use. Military equipment lifespans are usually much longer than civilian hardware which can lead to the equipment no longer being serviced by the private sector. COTS equipment is usually purchased through a list of approved vendors kept in a Computer Hardware, Enterprise Software, and Solutions (CHESS) database. CHESS database approval, funding process completion and physically delivery can be made available within 90 days.

The final case study considered is Regulatory Compliance Communications standards. Regulatory standards do not procure equipment, but are required for consideration in the operational approach as they provide unity of effort within the technological realm by emplacing a set of compliance-driven standards, policies, laws, and regulations. This process is in its infancy and is currently in use on the Joint Tactical Radio System and the Vehicle Integration for C4ISR/EW Interoperability. Both standards will be covered in detail in chapter 5. The cost of bringing all technical infrastructure up to a compliance standard; can be significant. The type of Regulatory Compliance Standards in this research pertains to a set of standards imposed on contractors and vendors to dictate the equipment they are constructing for the US Army via either program of record, Government Contract, or COTS is technically compliant, synergistic and interoperable across the entire DoD environment. What would be the cost of research and development (R&D) time on publishing a Regulatory Compliance Communications standard? Cost of Regulatory Compliance R&D would consist of the staff hours invested and oversight infrastructure created to generate and enforce the regulations. A substantial cost could occur by bringing any aging equipment up to the new compliance standards imposed.

Situational Template

The purpose of this thesis is to determine the best way to streamline the tactically based technical requirements process and get Americans Information Technology industry to work in favor of the US Army Signal Corps. To accomplish this, an understanding of the current operating environment of the US Army Signal Corps is required to properly frame the Operational Approach that will be published in chapter 5. On September 27, 2017, Brigadier General Crawford, G-6, addressed the congressional subcommittee on Tactical Air and Land Forces of the Armed Services on the US Army's network modernization strategy. "Our current Network does not meet our Warfighting needs now or in the projected future."[27] Crawford's opening statement projected major problems within and outside the Army's communications organization. This chapter will examine how the US Army's network architecture grew into its current situation, a stationary architecture with fiber optic dependence. Second, this chapter will describe the US Army Signal Corps' primary tactical communication architecture, WIN-T.

Finally, the Army has transformed its mission and now the communications architecture must transform with it. "The character of war does change on occasion. And one of the drivers–not the only driver–is technology."[28] The US Army shifts its focus to a potential near-peer advisory in ULO. In anticipation of ULO, a term fight tonight gained traction. To support ULO and a fight tonight posture, the US Army must be able to communicate. This chapter will cover the challenges that the US Army Signal Corps faces transforming to meet the new requirements. The problem areas of focus are network governance, integration, requirements, acquisition, and innovation. The section is termed Unified Land Operations challenges.

Network Development

Over the last 15 years, the Army's network has evolved to suit the static warfighting environments of Iraq and Afghanistan. The problem with the network is that it is completely unprepared for the next mission, ULO. Network Operations in Iraq and Afghanistan consisted primarily of static Forward Operating Base (FOB) operations. The

[27] Crawford.

[28] Milley.

FOB centric network existed in a relatively uncontested environment that led to an unrealistic sense of information dominance across all spectrums.[29] "Unfortunately, our current network is too complex, fragile, not sufficiently mobile nor expeditionary, and one that will not survive against current and future peer threats, or in contested environments."[30]

The FOB technical working environment consists of a stationary base of operations where a network can operate solely from fiber optic lines. A fiber optic mode of transportation is vastly superior to a satellite communications link, which is the US Army's normal transportation method. Fiber optic lines operate using pulses of light sent through an optical fiber. Fiber optic transportation is the superior method of data transportation as it is immune from electromagnetic interference, zero length degradation, near instant transfer data rate (100 petabit x kilometer per second) and immense data throughput. The only drawback to fiber optic communication from the US Army perspective is that it requires on a huge amount of infrastructure to maintain fiber optic lines of operation. Fiber optic lines usually require host nation infrastructure or for the US Government to install the lines requiring millions of additional dollars. Fiber optic lines are glass based and susceptible to impact, require special training, and are expensive to maintain. Fiber optic lines are deemed unsuitable for unified land operations.

Within the counterinsurgency enviroment the Army's network was able to grow with the support of a nearly unlimited bandwidth, of a fully mature fiber network. COTS

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[29] Crawford.

[30] Ibid.

options where used to add additional computing power and added massive data archives as the Army found more and more technical solutions to fight the war on terror. The technical common operating picture grew in size and scope then was digitally published to all formations at echelon requiring huge amounts of processing power and bandwith allocation. The Army Battle Command Systems warfighting systems were added and integrated into the common operating picture. Warfighting partner nations and sister services were integrated and a host of situational awareness tools were added across the entire operating spectrum. The network that evolved became static and bloated with high data processing requirements. The reliance on fiber optic lines made the network undeployable and unrealistic for anything other than FOB operations. G-6 of the Army, Crawford, summed up the results of the network evolution to the congressional subcommittee as, "We find ourselves in a position now, within a new environment and facing new challenges, where our network is not user-friendly, intuitive, or flexible enough to support our mission in the most effective manner and demands a heavy reliance on industry field service representatives to operate and sustain these systems."[31]

Warfighter Information Network-Tactical

To answer the primary research question, one must first understand the current network challenges and the risk faced due to emerging threats. In 2008, the US Army Signal Corps awarded six-billion dollars to Project Manager WIN-T, tasked to deliver an extensive tailorable suite of integrated tactical network communication and network (cyber) management capabilities to support today's complex Joint, Coalition and Civil

[31] Crawford.

missions worldwide. The system was to consist of "One Network" and advertised as an agile, modular "toolkit" of unified network capability to enable commanders to best support their missions at every stage of operations. According to Program Executive Office Command Control Communications-Tactical, "WIN-T is the Army's tactical communications network backbone that enables mission command and secure reliable voice, video, and data communications anytime, anywhere. Leveraging both satellite and line-of-sight capabilities for optimum efficiency, effectiveness and operational flexibility."[32] Internal and external assesments have found that WIN-T does not meet its advertised capabilities. The primary deficiencies include a lack of real-time feedback from Soldiers on the ground and no ability to address jamming, cyber, electronic warfare, power and spectrum consumption, joint and interagency interoperability, and air-to-ground communications shortfalls. Furthermore, the Signal Corps has found the WIN-T too complex and not user friendly, needing to free up communication soldiers for warfighting tasks and less on integrating information technology requirements. [33]WIN-T has been the primary tactical communications asset and was currently amid phase two deployment when Crawford announced its termination. "The Army will also halt procurement of Warfighter Information Network-Tactical (WIN-T) Increment 2 at the end of FY18; however, there are purposed capabilities and elements of the overall WIN-T program that can be used and will be fielded to some of our formations through FY21."[34]

[32] Program Executive Office Command Control Communications-Tactics, "PM Tactical Network," August 2017, accessed May 14, 2018, http://peoc3t.army.mil/wint/.

[33] Crawford.

[34] Ibid.

The exact nature of what capabilities and planned elements is currently unknown. WIN-T is a stand-alone peripheral technical architectural and will likely be used as a gap filler for the next "adapt and buy" strategy. The Army Signal Corps has moved into a new network modernization path forward and has stopped all programs that do not move the Army's communication network towards ULO and the ability to fight tonight.[35] Current WIN-T tactical communications assets will continue to be used in the near future.

Unified Land Operations Challenges

The US Army has recognized that changes need to be made in its network infrastructure. Army Chief of Staff General Mark Milley stated, "Shifts in the character of war offer an opportunity. If we can anticipate or at least recognize them, we can adapt proactively, maintaining or regaining overmatch and forcing competitors to react to us."[36] In order for the Army to fight tonight, it must be prepared to conduct offensive actions against any adversary at any time and reflecting an army posture prepared for the future fight. The tactical network remains a critical enabler for the Army to project forces to fight tonight and conduct unified land operations from the garrison environments to the most remote and disadvantaged locations in the world. "To counter these challenges, the U.S. Army needs a proponent, focused on the fight tonight, to lead, and quickly move concept to doctrine in a way that guides technologically advanced weapons, systems, and

[35] Ibid.

[36] Mark A. Milley, "Changing-Nature-War-Wont-Change-Our-Purpose," Association of the United States Army, October 1, 2016, accessed February 27, 2018, https://www.ausa.org/articles/changing-nature-war-wont-change-our-purpose.

modernized facilities with which to train."[37] In order for the communications entity to prepare for transformation, the Signal Corps had to know its current state of operations. The Signal Corps conducted several internal and external tests; these tests were confirmed via the congressionally mandated Institute for Defense Analyses testing. Furthermore, the results were echoed across the DoD testing agencies, combat training center rotations, joint exercises, and feedback from operational commanders. The combined assessments found four major challenge areas as network shortfalls. "The internal and external assessments have revealed high-risk challenges that we feel must be mitigated to enable our Army to fight tonight against peer adversaries. These findings documented significant challenges across five broad areas of network governance, integration, requirements, acquisition, and innovation."[38]

Network governance is "the processes that ensure the effective and efficient use of Information Technology (IT) in enabling an organization to achieve its goals. Information Technology Demand Governance is the process by which organizations ensure the effective evaluation, selection, prioritization, and funding of competing IT investments; oversee their implementation; and extract (measurable) business benefits."[39] In the domain of governance, the internal and external assessments revealed that there

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[37] GEN Robert B. Brown and GEN David G. Perkins, "Multi-Domain Battle Tonight Tomorrow and the Future Fight," *War on the Rocks*, August 18, 2017, accessed January 20, 2018, https://warontherocks.com/2017/08/multi-domain-battle-tonight-tomorrow-and-the-future-fight/.

[38] Crawford.

[39] Gartner, "IT Governance (ITG)," accessed April 15, 2018, https://www.gartner.com/it-glossary/it-governance/.

was no single Army network integrator resulting in multiple "stove-piped" mission command systems and networks, with multiple, duplicative, and non-integrated information technology programs.

Integration refers to "architectural techniques and tools for achieving the consistent access and delivery of data across the spectrum of subject data areas and data structure types in the enterprise to meet the data consumption requirements of all applications and business processes."[40] Assessments found a lack of centralized integration that led to inadequate integration, and poorly conceived network architectures, resulting in inadequacy and unproductive integration of network priorities. "The assessments found that the Army is not capitalizing on industry best practices and must increase integration between developers and operators."[41] The communications corps has lacked in its direct conversations to gather customers' actual communications requirements, and therefore failed to take those requirements to the acquisitions community to improve network challenges.

Requirements are "Requirements definition and management (RDM) tools streamline development teams' analysis of requirements, capture requirements in a database-based tool to enable collaborative review for accuracy and completeness, ease use-case and/or test-case creation, provide traceability, and facilitate documentation and versioning/change control."[42] The Current requirement processes are not synchronized or

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[40] Ibid.

[41] Crawford.

[42] Gartner.

integrated to ensure capabilities delivered adequately meet the operational needs of the users. Additionally, external investigations identified the Signal Corps' self-limiting, and over-prescribing requirements that reduced the Army's ability to maximize use of available spectrum and the innovating power of American Informational Technological Industry.[43]

Current acquisitions processes remain static when the pace of IT continues to grow exponentially. In FY2016 the Army conducted an internal assessment in parallel with the study directed by Congress in National Defense Authorization Act on the Army's tactical network, which was carried out by the Institute for Defense Analyses. "The assessments noted an emphasis on technical specifications, rather than defined operational requirements leading to disconnects between the acquisition community and the operational force. Our current acquisition process does not allow the Army to rapidly acquire and integrate emerging capabilities, allowing the warfighter to keep pace with technology and stay ahead of the evolving threat."[44]

The US Army's acquisition process does not allow for the exponential speed of information technology and continues to treat all equipment the same. "The current acquisition processes' traditional emphasis on a legacy program of record approach for developing, testing, and procuring mission command systems and applications has limited our ability to anticipate and rapidly integrate Joint and industry solutions through

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[43] Crawford.

[44] Ibid.

non-traditional acquisition models."[45] The inability to shift within the acquisition process has prevented the communications corps from leveraging the commercial industry's robust research, development testing and evaluation capabilities.

Innovation, recent internal and external assessments have assisted the Army better access their operational posture and the conclusions that have been addressed is that change is required. According to Brigadier General Crawford:

> The Army tactical network has not sufficiently evolved over the past 16 years while the United States have fought counterterrorism and counter-insurgency wars in Afghanistan and Iraq. Therefore, the Army must adapt and change its mission command tactical network path forward to enable it to fight and win the current fight while pivoting to a new modernization path that better postures our soldiers to be successful in the future fight.[46]

Conclusion

The review of the literature provides insight into the secondary research questions. The first two secondary research questions were answered in the course of this chapter during the presentation of the speed of technology. Technology will continue to increase exponentially until at least the mid-21st century. Moore's Law remains valid, and new technology will replace the microprocessor as a predictive element as stated in the Law of Accelerating Returns. The Army needs to plan for continued technological exponential growth and streamline acquisition processes for maximum return on technical investment dollars. Modular technological architectures fit with the Army's Signal Corps' requirements to stay abreast with modern technologies allowing systems to upgrade without total replacement costs. "Failing fast" business models are the preferred

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[45] Crawford.

[46] Ibid.

models, with the uncertainties of constantly evolving new technologies, the ability to pivot to a new trend at low cost is essential to the continued success of the Army Signal Corps. The answers to the third through fifth secondary research questions were presented in the operational approach. Program of Record WIN-T has a six-billion-dollar cost in R&D and a six-year turnaround from concept until initial deployment. COTS has zero R&D requirements and a very low delivery timeline, but additional risk assumed in integrating commercial technology, security, and interoperability requirements. Regulatory Compliance Communications Standard's R&D requirements consist of staff hours involved and compliance infrastructure implemented. Substantial additional costs can be avoided by proactive implementation of the standards.

The US Army network has grown to support a static nondeployable architecture and is not suited to meet the adapting complexity of ULO. The primary tactical support system, WIN-T, has been canceled and is filling the gap until an adapt and buy solution can be formulated. Finally, five centrally focused themes are currently the Signal Corps' primary concerns to fix the future of Army communications. The five themes are network governance, integration, requirements, acquisition, and innovation. chapter 3 will define the parameters of the research methodology.

CHAPTER 3

RESEARCH METHODOLOGY

This study will be using Long's case study methodology, it is a special form of case study research that leverages and accounts for the professional body of knowledge and best professional practices concerning the research question. The evolution from initial personnel prospective (R1) to the stakeholder evaluation (R3) is a construct of this method that allows all parties to identify initial biases and assumptions so that the author can design readings and research questions that challenge those assumptions. This method enables the incorporation of the author's significant expertise, experience, education and reflection in a disciplined, organized and systematic way. This method generally follows in the Army Staff Study methodology described in Field Manual 6.0, CH 5, but refines the process by cross leveling the advancing perspectives (R1, R2 and R3) against the back drop of a modified capabilities-based assessment as depicted in table 1 and figure 2 below[47]. To prepare for this methodology, the author has conducted a review of:

1. Available sources about the doctrinal use of tactical communication architecture to understand the role of the US Signal Corps in Unified Land Operations (ULO).

[47] Kenneth Long, "Emerging Best Practices from Professional Applied Case Study Research" (Lecture, US Army Command and General Staff College, 2016).

2. Relevant sources on the speed and growth of informational technology to understand the economic and physical barriers challenging the US Signal Corps.

3. The Army Chief Information Officer, address to the congressional subcommittee on Tactical Air and Land Forces of the Armed Services on the US Army's network modernization strategy, to understand the current state of the US Signal Corps.

To identify the significant capability gaps that limit the ability of US Army communicators to execute their roles in providing communications for ULO, the author has studied three separate communication techniques WIN-T, Commercial off the Shelf (COTS), and Regulatory Compliance Architecture (RCA). While the methods do not directly compare because of the size and scope of the operations, WIN-T was an Army-wide Program of Record while COTS and RCA were used in small specific instances. The three methods and a fourth hybrid process are evaluated as Courses of Action (COAs) through the aperture of the primary stake holders, the results will be published in chapter 4 as the R3 findings. The COA evaluation criteria are discussed in depth below, under stakeholders defined.

This research is an applied qualitative professional case study with an altered capability-based assessment (CBA) that considers the professional body of knowledge (table 1). The product of CBA is a practical applied case study that uses the capabilities-based assessment process, using DOTMLPF-P analytical lens to identify solutions. A modified CBA was applied to the WINT, COTS, and RCA to identify potential capability gaps regarding Communicators executing their roles in providing communications for ULO.

The first analytical phase of the CBA process, the Functional Area Analysis (FAA), describes how the force will operate, the timeframe and environment in which it must operate, its required capabilities (regarding missions and effects), and its defining physical and operational characteristics.[48] FAA was conducted through chapters 1 and 2, with the situational template of the US Army Signal Corps and placed against the backdrop of situational variables within information technology. The FAA was evaluated through the lens of the current and future required capabilities and tasks of ULO on communicators.

The second phase of the CBA process is the Functional Needs Analysis (FNA), which is used to assess the capabilities of the current force to meet the objectives identified in the FAA. The main purpose of the FNA is to identify capability gaps and then prioritize them in operational terms. The primary input is the FAA and the output analysis is a list of capability gaps, redundancies, shortfalls, and an estimate of the timeframe of when a solution is required.[49]

The last phase of the CBA process is the Functional Solution Analysis, where the capability gaps and needs specified during the FNA are accessed across the DOTMLPF-P

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[48] Department of the Army, *Capabilities Development And System Acquisition Management: Executive Primer* (Fort Benning, GA: Army Force Management School, 2013).

[49] Command and General Staff College, F100: *Managing Army Change*. F102RA-14 (Fort Leavenworth, KS: Command and General Staff College, 2017).

spectrum. For this research, the potential resolutions are evaluated only through material domains.

The following approach to conduct the research was developed by the author.

Table 1. Research Approach

CHAPTER 1	CHAPTER 2	CHAPTER 3	CHAPTER 4	CHAPTER 5
Background and Starting Position R1	Literature Review	Methodology	Analysis R2	Recommendation for the CDM R3
MODIFIED CAPABILITIES BASED ASSESSMENT				
PHASE 1 Functional Area Analysis			PHASE 2 Functional Needs Analysis	PHASE 3 Functional Solution Analysis
MODIFIED DOTMLPF-P ANALYSIS				
	Review of Informational Technology growth across the M/0 elements		Analysis of required Communications capabilities across M/O elements	Proposed solutions for ULO Operations across the M/O elements
	Review of the ULO requirements across M/O elements		R2 improved by stakeholder analysis–basis for R3	

Source: Created by author.

In chapter 4, the Personal Initial Recommendation (R1) will be evaluated according to the following model with the output (R2) as the Informed Position. R3 will then be evaluated through the lens of the Chief Decision Maker and stakeholders to detemine the Recommended Solution.

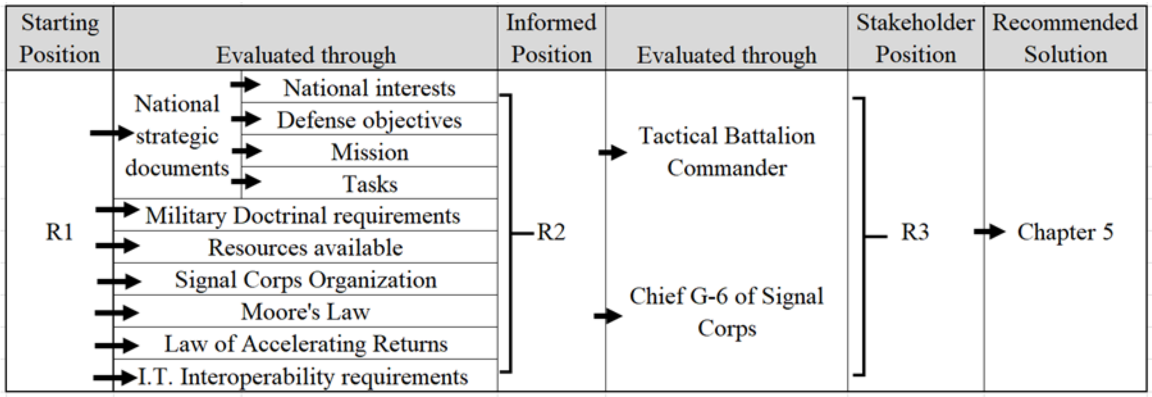

Figure 2. Research Model

Source: Created by author.

R3 Criteria

Stakeholders Defined

To answer the primary research question in chapter 4 (R3) the study looks at the subject matter through the lens of the primary stakeholders, Maneuver Battalion Commander and the G-6 of the Signal Corps. The logic behind using these two stakeholders is the reasoning that the Battalion Commander will be the chief benefactor (consequence recipient) of a successful—unsuccessful tactical communication asset. The G-6 of the Signal Corps is overall in charge of the wellbeing of the Signal Corps and is therefore the logical choice for chief decision-maker stakeholder.

Tactical Battalion Commander

The Tactical Battalion Commander's key concerns used for this research are listed in table 2. The Concerns below are listed in order of importance and used as assessment criteria for COA selection criteria. Communications reliability equaling 10 points and tailored communication solution equaling 4 points, the point scores lower by 1 per concern. The highest combined point total will then decide the recommended COA.

Table 2. Maneuver Battalion Commander
Weighted COA Selection Criteria

Point Total	Stakeholder Concern
10	Communications Reliability
9	Coverage/Set up Time and Availability
8	Bandwith Availabilty/Latency
7	Interoperabilty
6	Training Requirements/FSR Support
5	Servicability
4	Tailored Communications Solution

Source: Created by author.

Communications Reliability is the attribute that states a network consistently performs according to its specifications. One of the three related attributes that must be considered when selecting a solution. Reliability, availability, and serviceability are important aspects to design into a tactical communication solution. In theory, a dependable tactical asset is completely free of technical errors; in action, however, program managers frequently advertise a solution's consistency quotient as a percentage. The commercial standard for operations is 99 percent operability, this will also be the standard for this study.

Communications Availability is used in this study a number of ways, including set up time and mode of transport. Set up time is used as the amount of time required to achieve full capability. Mode of transport entails whether the communications are required to be static or can be used on-the-move; the standard for this study is on-the-move communications based upon ULO doctrinal requirements.

Bandwidth Availability (Latency) refers to the type of waveform used, or mode of transport utilized. The Battalion commander aperture requires the integration of all secondary and tertiary systems and sufficient overhead for additional network growth.

Network Interoperability is the constant capability to send data among all interconnected networks, at the quality level anticipated by the end user without any adverse impact to the containing networks. Specifically, network interoperability signifies to the functional interworking of data services across multi-vendor, multi-carrier inter-connections working under degraded conditions.

Training requirements are defined as what additional technical training will be required to implement the solution and if contractor support is required.

Serviceability is the ease and speed with which a tactical assemblage can be repaired or maintained. Warranty status and length of service contract will also be covered in this concern.

Tailored communication solution refers to whether the communication asset can be scaled to the units required needs. Specific units have unique requirements such as airborne drop or air assault portability. This concern encompasses the scalability of the tactical communication assets to deploy as the unit requires.

Army Chief Information Officer of Signal Corps

The G-6 key concerns used for this research are listed below. The G-6's primary concerns are discussed in detail in chapter 2: Unified Land Operation challenges. The concerns in table 3 are listed in order of importance and used as assessment criteria for COA selection criteria. With integration equaling 10 points and network governance equaling 6 points, the point scores lowers 1 per concern. The highest combined point total will then decide the recommended COA.

Table 3. Chief Decision Makers Weighted COA Selection Criteria

Point Total	Stakeholder Concern
10	Innovation
9	Requirements
8	Acquistion Process
7	Integration
6	Network Governance

Source: Created by author.

Chapter Summary

Chapter 3 describes the practical applied case study methodology and other methodologies that were used to obtain, analyze, and organize information required to answer the research questions. R2 and R3 prospective were framed with R1 being expressed in chapter 1: R1 Findings. This chapter also provides insights into how the information is analyzed using the DOTMLPF-P construct and into the screening criteria used to determine the validity of courses of action. In chapter 4 Functional Needs Analysis will be applied on the individual case studies against a ULO mission set. The R2 and R3 findings will also be presented.

CHAPTER 4

DATA PRESENTATION AND ANALYSIS

The purpose of this study is to identify the main capability gaps that limit the US Army Signal Corps' acquisition process and setting the environment to have US Technological Industry work in favor of the Army Signal Corps. Chapter 2 presented the functional area analysis of the capabilities-based assessment. The FAA created the situation and the outline, which is necessary to conduct the functional needs analysis; this will be the focus of this section. In this section, the facts presented in the earlier chapters will be analyzed against ULO mission set to answer the research questions.

Case Studies

In the case study analysis of this research, the Functional Needs Analysis will be covered. The FNA is used to assess the capabilities of the current force to meet the operational requirements identified in ULO and described in depth in table 4 below. The FNA's primary output analysis is a list of capability gaps, redundancies, shortfalls, and an estimate of the timeframe of when a solution is required.[50] In this Case Studies section of the analysis will focus on capability gaps and shortfalls, timeframes will be identified in a suggested COA covered in chapter 5 recommendations.

[50] Command and General Staff College, F100.

Table 4. FFNA Capability Gap Metrics				
Mission Area	**Capability Required**	**Description**	**Metrics**	**Minimum Value**
Unified Land Operations	Secure multiple entry points into an area of operations and the lines of communications that connect those points.	The Force may have to seize secure multiple entry points from a determined enemy to set conditions for sustained land operations, or demand highly decentralized operations.	Expeditionary in nature, ease of set up and training, ability to rapidly deploy and become fully operational, operational resilience.	8 Hour Set up time, On the move connectivity on lower and upper tactical internet (TI), 95 percent operational rate.
	Function against a near peer competitor	The Force requires the capability to communicate in a contested cyber domain environment	Jamming resistant, address cyber security, electronic warfare	Addresses Jamming, Cyber defense and electronic warfare
	Communicate in a space degraded environment	System must use multiple methods for communications	Air to ground waveforms, multiple transport methods	Additional transport methods that are not reliant on Fiber optics or Satellite dependent.

Source: Created by author.

Warfighter Information Network-Tactical

As described in chapter 3, WIN-T was the Signal Corps' primary tactical program of record since 2007; the current version of the system (WIN-T increment 2) has been assessed against ULO mission requirement criteria above and has been found to possess a myriad of ULO specific capability gaps. Based on both Signal Corps internal assessments and congressionally mandated investigations, WIN-T was deemed to possess a lack of real-time feedback, no ability to address jamming, cyber, electronic warfare, power and spectrum consumption, joint and interagency interoperability problems, and has air-to-ground communications shortfalls. Additionally, starting in 2016 the office of the Director, Operational Test and Evaluations Annual report deemed “WIN-T Inc 2 was not adequate to support the assessment of operational suitability due to problems with reliability, availability and maintainability data collection, documentation of fieldservice representative maintenance activities, and data instrumentation.”[51]

The impact of these capability gaps severely restricts the conduct of ULO operations across all accessed metrics (table 4). The US Army Signal Corps has deemed to recapitalize this program of record due to its failure to meet its primary mission set. The system has been designated to serve as a gap filler for an unnamed adapt and buy strategy.

Commercial off the Shelf

Commercial off the Shelf consists primarily of home station IT Hardware and Software solutions that are available in the commercial marketplace purchased under government contract. COTS foundational document is the Federal Acquisition Streamlining Act of 1994 § 2377: Preference for acquisition of commercial items. The intent of the act was to lower procurement barriers and take advantage of the latest

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[51] Office of the Director, Operational Test and Evaluation (DOT&E), *DOT&E FY 2016 Annual Report* (Washington, DC: Government Printing Office, 2016), 186.

technologies using commercially available solutions. The purchasing method COTS uses is the CHESS database.

Computer Hardware, Enterprise Software and Solutions allows authorized US Army units to procure IT hardware, software, and information management services through multiple contracting vendors. CHESS' mission set is "enabling information dominance by rapidly delivering innovative and cost-effective IT solutions connecting the global Army."[52] The CHESS database uses a reverse auction format that allows military units to present their desired purchases to registered vendors and then has multiple vendors bid to support the purchase. The reverse auction format is employed in an attempt to use the power of US industry in the US Government's favor. The reverse auction system allows the government to leverage its spending power and to drive the individual end item price down, "from its deployment in January 2016 through September 2016, the CHESS reverse auction capability processed 153 auctions resulting in cost avoidance estimated at more than $2.5 million dollars."[53]

The CHESS contracting system has three distinct realms of focus, desktop, and mobile computing, IT enterprise solutions (information management) and software solutions. Each of these focuses are divided into branches that process a total of 25 percent of the Army's IT budget–$2.15 billion annually.[54]

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[52] Stacy Watson, "CHESS Has Another Move" *Army AL&T Magazine* (January-March 2017): 62-64.

[53] Ibid.

[54] Ibid.

Traditionally COTS and CHESS have not been used to provide an entire tactical communications assemblage, but to augment capability, provide a subsystem or in the example of counterinsurgency operations in Afghanistan and Iraq provide the FOB IT infrastructure. The FOB infrastructure was not purchased as a complete system but was pieced together ad hoc through individual CHESS contracted purchases. Tactical assemblages require an overarching technical architecture and hardening for field use which is typically not found on the commercial shelf, the majority of IT equipment purchased for field use requires modifications of some quantity.

Commercial off the Shelf meets the urgent operational need and speed of acquisition for new equipment, but must be balanced against the risks of poor integration with existing systems, security and operational risk, and insufficient support for enduring capabilities.[55] Additional risks include the "functionality of the product, operational perspective of a set of stakeholders. The problem is that COTS utilization, quality and reliability, maintenance costs, and more important trends to be of an ill-defined characteristic, product volatility, and vendor viability"[56]

In its current configuration, COTS present capability gaps are deemed unable to achieve mission command objectives in a ULO operating environment. There are eight recommended Tactics, Techniques, and Procedures to mitigate COTS vulnerabilities. First, ensure that mission critical systems are not single sourced from vendors. Second,

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[55] Shara Williams et al, *Rapid Acquisition of Army Command and Control Systems* (Santa Monica, CA: RAND Corporation, 2014).

[56] Ronald J. Kohl, "Determining the Suitability of COTS for Mission Critical Applications" (Paper Presented at the Information Systems Technology Panel (IST) Symposium, Brussels, Belgium, April 3-5, 2000).

determine the capabilities of COTS products, and integrability with subsystems. Third, the military unit must understand the operational lifespans of the system. Fourth, ensure that any operational concepts for COTS products are shared by the venders and the command. Fifth, ensure assumptions are validated regarding the needs of the end system. Sixth, understand the interoperability of COTS products with mission critical requirements and its required neighbor relationships. Seventh, establish positive relationships with the products vendors to promote good business dealings. Finally, a unit must understand alternative COTS products.[57]

Considering all mitigating factors of the afore mentioned Tactics, Techniques, and Procedures, combined with careful system management still does not qualify COTS for a standalone program to suit ULO objectives, but leads the way towards a hybrid solution, which will be presented in the R2 contained below.

Hardware Regulatory Compliance

Hardware Regulatory Compliance (HRC) is an emerging technique where an industry provides standard specifications, architectural framework, and design guidelines to enable the integration and interoperability of new equipment. HRC is a technical regulatory architecture that deals mainly in Layer's 1 through 4 of the Open System Interconnection Model, focusing on the interoperability between the physical characteristics with in the IT infrastructure.

The benefits of regulatory compliance allows a potential vender to focus on developing a new capability verses defining and integrating new network architecture

[57] Kohl.

into a preexisting technical environment. HRC "implementation provides an open architecture that will allow platforms to accept future technologies without the need for significant re-design."[58] This regulatory process combined with modularity architecture allows easy upgradability, decreases the R&D costs, and increases the speed of development.

This regulatory compliance standard has been successfully implemented in tactical vehicle operations; the program is named Vehicle Integration for C4ISR/EW Interoperability. The Vehicle Integration for C4ISR/EW Interoperability "program involves several vetronics companies and Army program executive offices and seeks to define standard interconnects for the networked armored combat vehicles of the future."[59] "VICTORY uses 'adopt-adapt-author' methodology in the effort to move towards establishing a set of common open standards for use within the vehicle and mission system communities."[60]

The main deficiency with this program is that it is unable to achieve relevant effects in its present condition. There is currently not an overarching organization requiring an HRC within the US Army Signal Corps; furthermore, there are no HRC

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[58] Victory Standards, Home Page, accessed February 27, 2018, https://www.victory-standards.org/.

[59] John Keller, "Emerging Vetronics Standards Aim to Spell VICTORY for Tomorrow's Combat Vehicles" *Military and Aerospace Electronic's* 24, no. 5 (May 2013), accessed February 20, 2018, http://www.militaryaerospace.com/articles/print/volume-24/issue-5/special-report/emerging-vetronics-standards-aim-to-spell-victory-for-tomorrow-s.html.

[60] Victory Standards.

standards pertaining to tactical communication assemblages. HRC shows potential to be a powerful tool for the US Army Signal Corps but has yet to be utilized.

R2 Informed Position

Researched position (R2) is the result of R1 evaluated utilizing the research model outlined in chapter 3. After conducting the literature review (conducted in chapter 2), US Army Signal Corps situational template and conducting a Functional Needs Analysis of WIN-T, COTS, and HRC against the ULO mission set (discussed earlier in this chapter) modifications to the original initial personnel recommendation (R1) is required.

The initial intent of this research (R1) was to justify a replacement of all tactical communications assets currently provided by WIN-T with COTS-based solutions. As covered in the COTS FNA, COTS was deemed unsuitable for ULO operations based primarily on interoperability, security, and a lack of an overarching management solution.

Researched position (R2) recommends five modifications to US Army Signal Corps procurement processes:

1. Change adapt and buy procurement strategy to "adopt-adapt-author."
2. Adopt an open, modular-based hardware architecture, adapt the process to Signal Corps Standards, author Hardware Regulatory Compliance standards. Publish the standard to US Industry to produce capability modules; Joint Communications Capability Components (JC3).
3. Take the lead in creating an open architecture, modular based Joint Communications platform (JCT-T).
4. Create an additional branch of CHESS to facilitate new modular contractual processes.

5. A quality control organization should be formed to monitor HRC acquiescence.

The first modification to R1 consists of the US Army Signal Corps' which needs to change its adapt and buy strategy to an adopt-adapt-author methodology. These standards establish a set of common open architectures for use within a tactical communications assemblage. The assemblage architectures will be independent of specific hardware, software, or firmware solutions. Fast fail methodology should be incorporated into every aspect of this process. The adopted standard should be the recognized industry standard, the adaptation process should incorporate a fare sampling of industry representatives and Joint military subject matter experts. Interactions of compliance standards need to be published quickly following the Fail fast business methodology.

Second, the Signal Corps should facilitate the creation of an open hardware architecture by creating a set of HRC standards. The standards' utilizing embedded modularity would give vendors a common hardware architecture to utilize. The term used for developed modules will be Joint Communication Capability Components. JC3 modular design supports the Army Signal Corps initiative to fail fast in the fact that each JC3 is simply a singular function to the whole of the Joint Communications Tactical-Terminal (JCT-T) system.

Third, the Signal Corps should take the lead in developing a Joint, multi-functional, tactical communications assemblage per the newly formed open architecture standards. The term used for this proposed adaptive hardware terminal is the Joint Communications Terminal-Tactical (JCT-T). The JCT-T would be an air droppable, modular based open architecture, supporting multiple inputs and transport methods. The

JCT-T is essentially a mobile powered motherboard, in other words a JC3 modular docking station. To survive in the ULO mission set and operate under a cyberspace and space contested environment the JCT-T would require multiple types of dish inputs to accommodate a diverse selection of transport methodology. The HRC would encapsulate a common dish attachment criterion, the HRC compliant dishes would be procured exactly as JC3 modules.

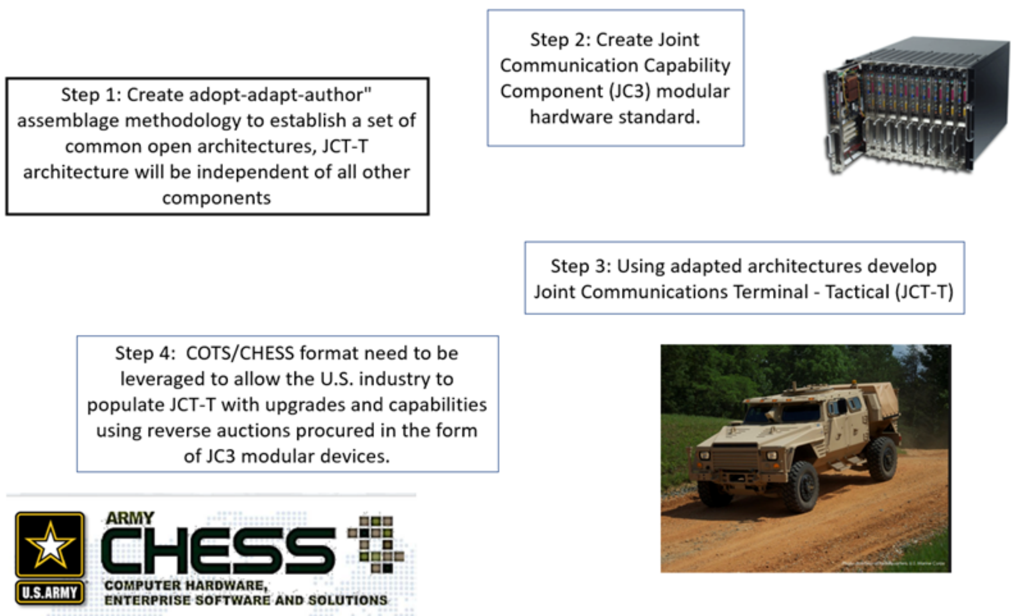

Figure 3. Recommended Solutions

Source: Created by author.

Fourth, the JC3 modules would utilize COTS contracting solutions for procurement. An additional branch of CHESS would need to be stood up to fully focus on the additional contracts required for the JC3.

Finally, an overarching organization would be required to monitor and test vendors HRC compliant solutions and implement quality control measures. The resulting changes would create a highly scalable (upgradeable) multi-functional solution that can meet the vast scope of ULO for the US Army Signal Corps and the entire US Military and facilitate a unified joint communications environment.

R3 Stakeholder Perspectives

In this section, the stakeholder's individual perspective values are evaluated against the three case studies (WIN-T, COTS, HRC) and the hybrid solution suggested in the informed position (R2). The four solutions will be compared to the R3 criteria as described in chapter 3. The stakeholder COA selection criteria has a maximum point value associated. Each case study can be given up to that point value per criteria. For example: Communications Reliability has been given a 9 point maximum value and each case study can receive a point value of 1 to 9 based on how well they address the stakeholders concerns. The case studies scored points per concern will be represented at the end of each table in parenthesis (). The case study with highest point total will be selected as the recommended COA.

Table 5. Battalion Commanders Prospective

Area of Concern	**WIN-T**	**COTS**	**HRC**	**R2 Solution**
Communications Reliability (10 points Max)	Not adequate to support the assessment of operational suitability due to	Commercial grade, pieced mailed technological solutions (9)	Creates the standard for architectural reliability (10)	Dynamic self-healing, modular network built with COTS equipment to HRC standards (10)

Communications Integration/Availability (9 points Max)	problems with reliability[61] (3) Deemed inadequate in DOT&E 2015-2017 annual reports (3)	COTS products fail at integration of all secondary and tertiary systems (5)	Creates standards of integration and availability but provides no actual communications assets (4)	Uses COTS based products combined with HRC standards of integration (9)
Area of Concern	**WIN-T**	**COTS**	**HRC**	**R2 Solution**
Bandwidth Availability/Latency (8 points Max)	Provides Satellite based availability for upper tactical internet (TI) communications (5)	Provides a wide range of communication options (8)	Provides standards for availability but provides no actual communication assets (4)	Uses COTS based options with HRC regulated standards (8)
Network Interoperability (7 points Max)	Fails at air to ground communications (5)	COTS are produced by individual venders with no interoperability considerations (0)	Generates Interoperability standards for all network interactions (7)	Uses HRC interoperability standards to provide COTS venders a common architecture (7)
Training Requirements/ FSR Support (6 points Max)	Complex architecture requiring FSR support (2)	Individually purchased items require overhead to support a network (3)	Hardware standards that do not account for individual software training req (3)	Each solution will be unique to the unit's requirements, potential training issues (3)
Serviceability (5 points Max)	Currently experiencing fielding and parts replacement issues (2)	Military time of use standards exceed that of its civilian counterparts, resulting in obsolescence issues (2)	Provides standards for hardware architecture provides no guidance on serviceability (0)	Uses modular technology standards for ease of capability replacement, individual modules have COTS limitations (3)
Tailored Communications Standards (4 Points Max)		Highly tailorable, individual	Provides standards for	JCT-T base module would be air droppable but

[61] J. Michael Gilmore, *Director, Operational Test and Evaluation FY 2016 Annual Report* (Washington, DC: Government Printing Office, 2016).

	WIN-T INC2 provides only a heavy solution, a light variant has been proposed but not implemented (2)	technical solutions (4)	adaptive solutions (3)	larger models could be adapted JCT-S with the S representing a strategic model (4)
Totals	**22**	**32**	**31**	**45**

Source: Created by author.

Battalion Commanders Remaining Concerns

A majority of the battalion commander's concerns have been met with the recommended COA, the R2 hybrid solution. One outstanding concern remains, training requirements and Field Service Representative (FSR) support. The R2's solution calls for a module based technical architecture. The solution's highly adaptive architecture and standard hardware infrastructure eases the procurement and development problems, but this advantage compounds troop training issues. No two JCT-T's would have identical exterior or interior workings and individual user interfaces create a technical proficiency challenge. The training requirements and individual technical specializations on such a system would be difficult to manage; a training solution would need to be addressed prior to the systems deployment. The way forward will be discussed in chapter 5.

Table 6. Army Chief Information Officer Prospective				
Area of Concern	**WIN-T**	**COTS**	**HRC**	**R2 Solution**
Innovation (10 points max)	Has been unable to adapt new technologies as promised (3)	Elegant, flexible solutions but no overarching program of record (8)	Creates common technical architecture so vendors can focus on capability (9)	Uses COTS solutions with overarching program of record and HRC capability focus (10)
Requirements (9 points max)	Currently does not capture warfighter requirements (2)	Individually can meet warfighter requirements but lacks integration measures. (5)	Does not meet address warfighter requirements. (1)	Modular designed for upgradability but requirements process not defined in R2 (1)
Acquisition Process (8 points max)	Slow process, unable to meet technical growth curve. (2)	Fast, elegant process that meets warfighter emerging needs as they request them (8)	Adds initial overhead to acquisition process and additional organization required to quality control compliance (5)	Initial Program of record for JCT-T but uses COTS based procurement methods for HRC compliant capability Modules(6)
Integration (7 points max)	A program of record that does not meet the G-6's overarching requirement to integrate across the network (2)	An individual solution that does not meet the G-6's overarching requirement to integrate across the network (2)	A technical standard that creates a common hardware integration platform (7)	Uses HRC standards to integrate network operability (7)

Network governance (6 points Max)	A program of record that does not cover Network governance (0)	Individual technical solution that does not cover Network governance (0)	A hardware standard that does not cover network governance concerns (0)	A modular technical platform that does not cover network governance concerns (0)
Totals	**9**	**23**	**22**	**24**

Source: Created by author

Army Chief Information Officer Remaining Concerns

Two outstanding concerns remain on the G-6's selected COA, the R2 hybrid solution. The requirements process, and network governance solutions were not covered in the R2 solution; both areas would need to be addressed prior to system deployment. The G-6 should take the lead in addressing network governance and ensure that signal personnel are involved in the cross functional team acquisitional process. This issue will be covered in chapter 5: Conclusions

Conclusion

This chapter evaluated the three-case study's (WIN-T, COTS, HRC) against the signal specific ULO mission requirements. Each case study's capability gaps were identified and denoted. The R2 was articulated and a hybrid technical solution was suggested. The R2 Solution highpoints include adopting an open, modular-based hardware architecture, adapting the process to military technical standards, authoring additional HRC standards, creating a capability housing module (a motherboard akin assemblage call JCT-T), utilizing the US technical industry to provide the individual capabilities though a standardized technical architecture (capability modules called JC3) and, procuring JC3 through the COTS based methodology.

The R2 solution and case studies were then cross-referenced against the stakeholder concerns. Based on those findings a COA was selected (R2 Solution) and any outstanding concerns identified. The three outstanding concerns identified were:

1. Training requirements and FSR support;
2. Requirements process management;
3. Network governance.

CHAPTER 5

CONCLUSIONS

Chapter 4 completed the modified CBA and selected a COA based on Stakeholder prospective in the R3. This chapter will take the chosen COA and identify the actions required to initiate it. The actions required will be covered via Lines of Effort; LOE's will be the mechanism that will link the multiple recommendations to a specific end state.[62] The LOE approach will be covered in a section titled, The Way Forward. Furthermore, the unresolved issues identified in chapter 4 will be addressed in a section titled, Beyond the Scope. Personnel learning reflections from the author will also be covered in this chapter, in a section titled, Lessons Learned.

The Way Forward

The JCT-T solution includes adopting an open, modular-based hardware architecture, adapting the process to military technical standards, authoring additional HRC standards (LOE 1 and 2), creating a capability housing module (LOE 4), utilizing the US technical industry to provide the individual capabilities though a standardized technical architecture (JC3) and, procuring JC3 through the COTS based methodology (LOE 5 and 6).

[62] LOE is a line that links multiple tasks using logic of purpose rather than geographical reference to focus effort towards establishing operational and strategic conditions.

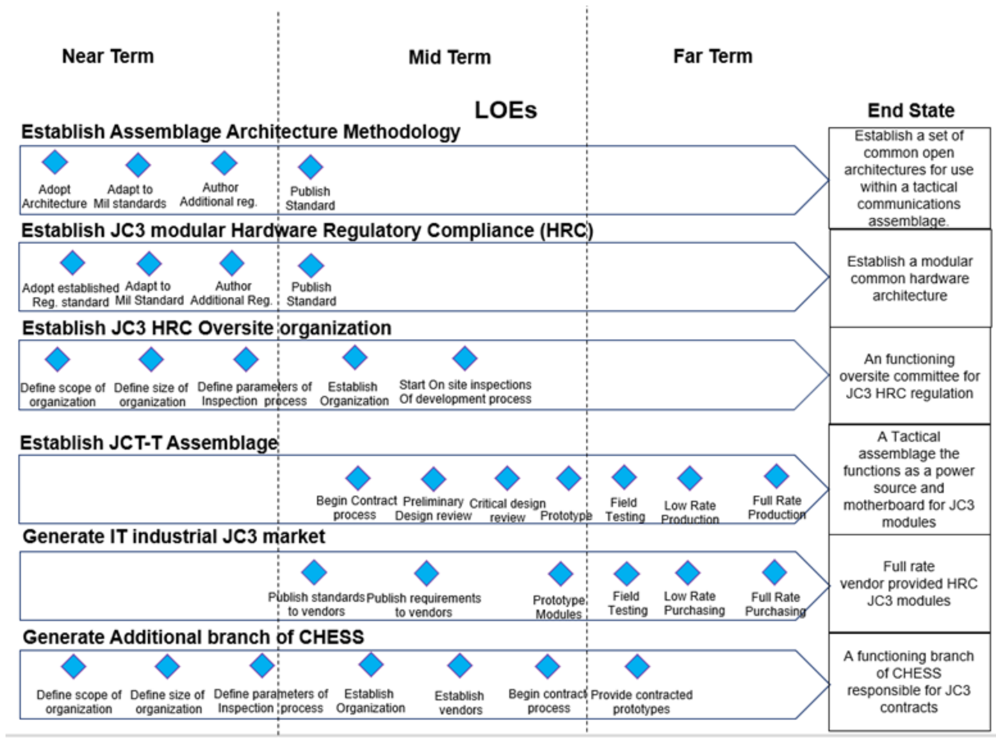

Figure 4. Lines of Effort

Source: Created by author. Note: LOE 1 and 2 conducted in tandem as they are two separate but interlocking regulatory standards.

The way forward is depicted graphically via figure 4 above. There are three primary concerns regarding LOE coordination:

1. Compliance standard interoperability;

2. JCT-T acquisition process and timeline;

3. JCT-T and JC3 tandem production timelines.

Compliance Standard Interoperability. A technically complete assemblage architecture and HRC is critical for system interoperability and should be vetted prior to beginning JCT-T and JC3 construction. Without this foundational architecture working to standard, the modular concept will fail. The system should incorporate "Fast Fail" business practices to ensure that the project is published incrementally and pivoting towards successful implementation.

JCT-T Acquisition Process and Timeline. Figure 4 represents the JCT-T going through a standard military acquisitions process while the adjoining JC3 modules processing through the COTS accelerated purchasing process. The JCT-T is an Army program of record that could be entrenched in an excessively long acquisition process.

> If the Army solely relied on the Department of Defense's normal acquisition processes, including the Joint Capabilities Integration and Development System (JCIDS) to establish formal requirements, the Planning, Programming, Budgeting, and Execution System (PPBES), and the DoD Instruction 5000.02, it would have been reasonable to expect the acquisitions to take fifteen years or more. [63]

Elongated process would greatly diminish the JCT-T operational impact and leave the JC3 modules without a platform to populate. The recommended method of procurement would be through a rapid acquisition process, similar to the Joint Node Network (see figure 5 below).

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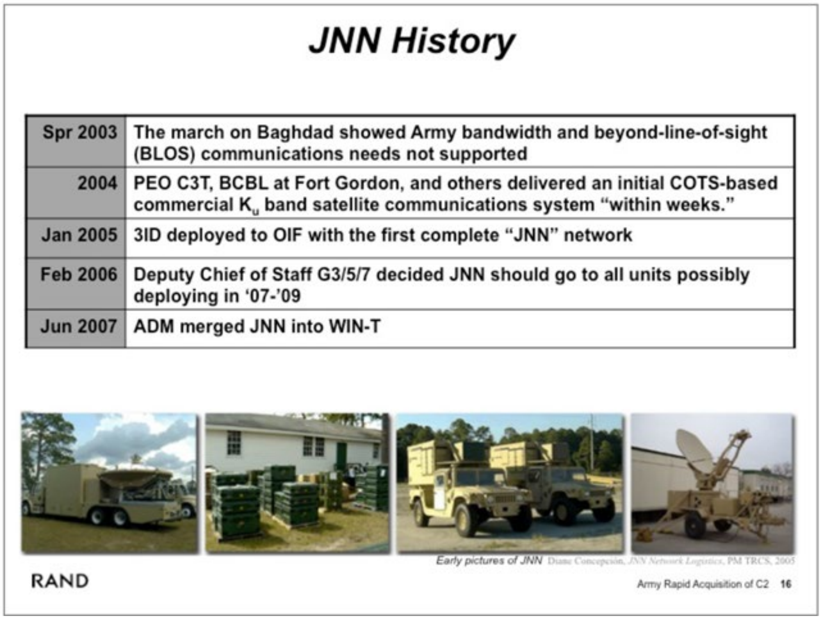
[63] Business Executives for National Security, "Getting to Best: Reforming the Defense Acquisition Enterprise," July 2009, accessed February 28, 2018, https://www.bens.org/document.doc?id=44.



Spr 2003	The march on Baghdad showed Army bandwidth and beyond-line-of-sight (BLOS) communications needs not supported
2004	PEO C3T, BCBL at Fort Gordon, and others delivered an initial COTS-based commercial K_u band satellite communications system "within weeks."
Jan 2005	3ID deployed to OIF with the first complete "JNN" network
Feb 2006	Deputy Chief of Staff G3/5/7 decided JNN should go to all units possibly deploying in '07-'09
Jun 2007	ADM merged JNN into WIN-T

Figure 5. Joint Node Network Acquisitioned History

Source: Shara Williams, Jeffrey A. Drezner, Megan McKernan, Douglas Shontz, and Jerry M. Sollinger, *Rapid Acquisition of Army Command and Control Systems* (Santa Monica, CA: RAND Corporation, 2014), 29.

JCT-T and JC3 Tandem Production Timelines. The challenge would be to establish the JCT-T assemblage and produce working JC3 prototype modules in tandem timelines, as both products are interdependent but produced via different manufacturers and procurement processes.

Beyond the Scope

Several issues were identified during this research are beyond the scope of the paper. These issues require further research to address actions taken to move forward with the project:

1. Training requirements and FSR support;
2. Software standardization;

3. Requirements process management;

4. Network governance;

5. Acquisitional personnel career field management process (Honest Broker);

6. Joint acquisitional solution analysis.

Training Requirements and FSR Support. The way forward depicts a module based technical architecture. This type of infrastructure does not currently exist within the US Army Signal Corps and further research is required to manage the tactical Non-Commissioned Officer's Military Occupational Specialties to support this type of assemblage.

Software Standardization. With the focus of this research being on material and organizational solutions within the DOTMLPF-P spectrum, software solutions were not covered in this paper. During the scope of the research the JTA was referenced. "The JTA mandates IT standards and guidelines for DoD system development and facilitate interoperability in joint and coalitions force operations."[64]Adhering to the JTA standard is recommended based on cursory research but further focused study is recommended for a comprehensive solution prior to system deployment.

Requirements Process Management. The author's original thought process was to allow individual units to purchase JC3 modules and built communication infrastructure based on a unit's unique requirements, thereby delegating the responsibility down to the unit. After further study, the author has deemed that additional research is required on this subject, and an overarching organizational body should supervise this process. What

[64] Department of Defense, *Joint Technical Architecture Version 6.0* (Washington, DC: Government Printing Office, October 2003).

that body would consist of, and how it would function, would be a topic for a separate study.

Network Governance. This topic was not covered in this study because its primary focus is on the hardware infrastructure aspect of the tactical assemblage: network governance is a software, Troop Training Protocol Tactics, Techniques, and Procedures, and Standard Operating Procedure issue. Network governance remains a primary focus of the Chief G6 and a separate issue that needs to be covered prior to deployment of the system.

Personnel Career Field Management Cultivation at the Acquisitional Management Level. Personnel cultivation was not covered in the scope of this study but should be further researched. A technical subject matter expert needs to be cultivated within the Signal Corps ranks so that they can act as an honest broker for dealings with IT industry representatives. Contract negotiations involve large sums of money and the threat of corruption is always present, a check and balance system with an honest broker involved should be researched.

Joint Acquisitional Solution Analysis Process. The explanation of this process was not included into the scope of this thesis. During this research the MITRE Corporations acquisitions in the digital age process was discovered but not thoroughly vetted. If the US Army Signal Corps used the recommended joint R2 solution, further research would be needed to utilize acquisitions in the digital age as a viable acquisition solution.

Lessons Learned

There have been several personal learning observations during the creation of this thesis. For the sake of brevity, the author will focus on the top three main themes which are; Organization, Writing ability and Research.

In terms of Organization and the production of this thesis occurred in concurrence with the Command and General Staff College provided Intermediate Level Education, its tempo was often interrupted for weeks at a time. Revisiting a project, a week to a month apart can lead to knowledge attrition and force the author to relearn sections of information. Being well organized and note keeping is key for continuity of operations. Further, organizational lessons learned would include receiving Dr. Long briefing as soon as possible. Dr. Long's thesis methodology put the entire project in scope and framed the process expertly.

Regarding writing ability, at the beginning of this thesis, the author's writing ability was not up to master level thesis production. The author received mentorship from his thesis chair and the Learning Resource Center. The author highly recommends utilizing the Learning Resource Center, located within the Ike Skelton Combined Arms Research Library.

In terms of the research that was being conducted on this thesis is of a highly technical nature, finding master level research criteria was a challenging experience. Initially the author submitted a research request via the Combined Arms Research Library. It is not recommended to use the Combined Arms Research Library offered research services, the services results consisted of only three Google Scholar searches (unusable) after a six-week delay. Furthermore, the Combined Arms Research Library databases provide hundreds of false positives with little technical information. The best results occurred when the author independently consulted technical manuals, utilized Joint military documentation and, referenced RAND Corporation reports as sources of technical expertise.

Conclusion

Chapter 5 provides the LOE way forward with three primary cohesion related concerns, which were, compliance standard interoperability, JCT-T acquisition process and JCT-T and JC3 tandem production timelines. This chapter also covered issues that were identified, but beyond the scope of the research. Finally, the author covered his personnel learning reflections that were portrayed in three broad areas of learning, organization, writing ability, and research related reflections.

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