

MEASURING THE EFFECTIVENESS OF THE CONUS
AIR AND MISSILE DEFENSE C2 SYSTEM

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

MASTER OF MILITARY ART AND SCIENCE
Joint Planning Studies

by
NEAL J. LAPE, MAJ, US ARMY
B.S., United States Military Academy, West Point, New York, 2001

Fort Leavenworth, Kansas
2012-01

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 08-06-2012		2. REPORT TYPE Master's Thesis		3. DATES COVERED (From - To) AUG 2011 – JUN 2012	
4. TITLE AND SUBTITLE Measuring the Effectiveness of the CONUS Air and Missile Defense C2 System				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Major Neal J. Lape				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Command and General Staff College ATTN: ATZL-SWD-GD Fort Leavenworth, KS 66027-2301				8. PERFORMING ORG REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release; Distribution is Unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The air and missile threat posed by hostile states and terrorist organizations to the continental United States is a reality. The United States has established organizations and developed capable AMD weapon systems to defeat these types of threats. However, an effective C2 system is essential in order to integrate these technologically advanced AMD weapon systems into an efficient fighting force. This thesis quantitatively measured the effectiveness of the CONUS AMD C2 system by analyzing the performance of five objective variables: people/authorities, facilities, communications equipment, unity of command/effort, and levels of control. This analysis successfully produced a numerical effectiveness result, but more importantly it identified five deficiencies in which the CONUS AMD C2 system effectiveness can be improved. The research concluded by shaping three overall recommendations to improve system effectiveness: delegate the doctrinal responsibilities to the RADC/SADC, lower the engagement authority, and establish a redundant common operating picture.					
15. SUBJECT TERMS C2, Effectiveness, C2, Air and Missile Defense					
16. SECURITY CLASSIFICATION OF: Unclassified			17. LIMITATION OF ABSTRACT (U)	18. NUMBER OF PAGES 91	19a. NAME OF RESPONSIBLE PERSON
a. REPORT (U)	b. ABSTRACT (U)	c. THIS PAGE (U)			19b. PHONE NUMBER (include area code)

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

Name of Candidate: Major Neal J. Lape

Thesis Title: Measuring the Effectiveness of the CONUS Air and Missile Defense C2 System

Approved by:

_____, Thesis Committee Chair
Jeffrey R. Oeser, M.S.

_____, Member
Dale C. Eikmeier, M.S.

_____, Member
O. Shawn Cupp, Ph.D.

Accepted this 8th day of June 2012 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, Ph.D.

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

ABSTRACT

MEASURING THE EFFECTIVENESS OF THE CONUS AIR AND MISSILE DEFENSE C2 SYSTEM, by MAJ Neal J. Lape, USA, 91 pages.

The air and missile threat posed by hostile states and terrorist organizations to the continental United States is a reality. Violent extremist organizations such as al-Qa'ida, as well as rogue nations, such as Iran and North Korea, are actively pursuing air and missile weapon systems to attack the United States. The United States has established organizations and developed capable AMD weapon systems to defeat these types of threats. However, an effective C2 system is essential in order to integrate these technologically advanced AMD weapon systems into an efficient fighting force. This thesis quantitatively measured the effectiveness of the CONUS AMD C2 system by analyzing the performance of five distinct and objective variables: people/authorities, facilities, communications equipment, unity of command/effort, and levels of control. This analysis successfully produced a numerical result for the system's effectiveness, but more importantly, it identified five deficiencies in which the CONUS AMD C2 system effectiveness can be improved. The research concluded by shaping three overall recommendations to improve system effectiveness: delegate the doctrinal AMD responsibilities to the RADC/SADC, lower the engagement authority or air and missile threats to the homeland, and establish a redundant common operating picture.

ACKNOWLEDGMENTS

This work is dedicated to my loving wife and editor, Angela, and my two sons, Connor and Caiden. Without their unwavering support and encouragement the completion of this thesis would not have been possible.

I am also deeply indebted to my thesis committee of Mr. Jeff Oeser, Mr. Dale Eikmeier, and Dr. O. Shawn Cupp. I sincerely thank you all for your constructive criticism, encouragement, and guidance while allowing me the latitude to scope my research onto a subject I thought necessary to conduct.

Finally, thanks to the countless friends and colleagues who took time from their busy schedules to review my work, listen to my methodology, and steer me in the right direction. Ted, Haile, Doug, Okie, Reggie, Sonny, Sam, Ryan, and everyone from Staff Group 17A, I cannot thank you enough for your support throughout this process.

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
Air and Missile Threats to the Homeland.....	1
Ends, Ways, and Means.....	5
Primary and Secondary Research Questions	8
Significance	9
Assumptions.....	10
Scope.....	11
Definition of Key Terms.....	12
Summary	14
CHAPTER 2 REVIEW OF LITERATURE	15
Introduction.....	15
C2 System Effectiveness: A General Analytical Model.....	15
Introduction.....	15
C2 Measures of Effectiveness Handbook	16
Towards a Theory of Measures of Effectiveness.....	18
The Art of Problem Solving.....	19
Summary	20
Air and Missile Defense C2 Doctrine.....	20
Countering Air and Missile Threats; Joint Publication 3-01	21
Integrated Air Defense Systems; FM 3-01.15	22
Summary	24
CONUS AMD C2 Structures and Entities.....	24
Organizational Websites	25
J-DIAMD Project Master Plan.....	26
CONUS AMD Exercise Reports	27

Summary	29
Literature Review Summary	30
CHAPTER 3 RESEARCH DESIGN	31
Data Collection	33
Data Analysis	35
Measuring Performance	35
Calculating System Effectiveness	38
Chapter Summary	38
CHAPTER 4 ANALYSIS	40
Introduction	40
CONUS AMD C2 Physical Entity Performance	40
CONUS AMD C2 System Performance: People	41
CONUS AMD C2 System Performance: Facilities	45
CONUS AMD C2 System Performance: C2 Communications Network Equipment	47
CONUS AMD C2 Structural Performance	50
C2 Structural Comparison	51
CONUS AMD C2 System Performance: Unity of Command/Effort	54
CONUS AMD C2 System Performance: Levels of Control	55
CONUS AMD C2 System Effectiveness	58
CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS	59
Thesis Question	59
Findings	59
Validation	63
Recommendations	65
Area for Further Study	68
Conclusion	69
GLOSSARY	71
APPENDIX A J-DIAMD Communications Network Plan	74
APPENDIX B J-DIAMD C2 Structures	75
BIBLIOGRAPHY	77
INITIAL DISTRIBUTION LIST	80

ACRONYMS

AADC	Area Air Defense Commander
AAMDC	Army Air and Missile Defense Command
AAW	Anti Aircraft Warfare
ADAFCO	Air Defense Artillery Fire Control Officer
AMD	Air and Missile Defense
BCC	Battle Control Center
BMD	Ballistic Missile Defense
C2	C2
CONUS	Contiguous United States or Continental United States.
CRC	Command and Reporting Center
DAADC	Deputy Area Air Defense Commander
DCA	Defensive Counter Air
GMD	Ground based Midcourse Defense
IADS	Integrated Air Defense System
J-DIAMD	Joint Deployable Integrated Air and Missile Defense
JADOC	Joint Air Defense Operations Center
JAOC	Joint Air Operations Center
JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JFMCC	Joint Forces Maritime Component Commander
NCR	National Capital Region
NORAD	North American Aerospace Defense Command
NORTHCOM	United States Northern Command

RADC	Regional Air Defense Commander
SADC	Sector Air Defense Commander
SMDC	Space and Missile Defense Command
SOCC	Sector Operations Control Center
STRATCOM	United States Strategic Command
THAAD	Terminal High Altitude Area Defense

ILLUSTRATIONS

	Page
Figure 1. CONUS AMD C2 Structure	52
Figure 2. Doctrinal AMD C2 Structure.....	52

TABLES

	Page
Table 1. Data Collection Matrix: Information Grouped by Relevance.....	33
Table 2. NORTHCOM AMD C2 System Effectiveness Variables and Attributes	37
Table 3. C2 Performance: People/Authorities	42
Table 4. C2 Performance: Facilities.....	46
Table 5. C2 Performance: Communication Network Equipment	48
Table 6. C2 Physical Entity Performances: Summary	50
Table 7. C2 Structural Performance: Unity of Command/Effort.....	54
Table 8. C2 Structural Performance: Levels of Control	56
Table 9. C2 Structural Performances: Summary	57
Table 10. CONUS AMD C2 System Effectiveness.....	58

CHAPTER 1

INTRODUCTION

Air and Missile Threats to the Homeland

Threats may mature more rapidly or more slowly than predicted, may appear in unexpected locations, or may involve novel technologies or concepts of operations. It is essential that the United States be well hedged and have a strong posture against unpredicted threat developments.

— *Ballistic Missile Defense Review*, 2010

The 2010 *National Security Strategy* warns that as the United States extends the ideology of democracy and the reality of globalized economic structure throughout the world, it “intensifies the dangers that we face—from international terrorism and the spread of deadly technologies.”¹ It is certainly within the national interests of states, such as North Korea and Iran, and the goal of some non-state terrorist organizations to curb western ideological influences on their populations. Air and missile attacks from hostile nations and non-state terrorist organizations represent a credible and relevant threat to the national security of the United States.

On 11 September 2001, the ability of a terrorist organization to attack the World Trade Center and the Pentagon and the inability of the government to defend against it sent shockwaves throughout the defense community and the nation as a whole. These attacks pale in comparison to the effects of an aircraft or ballistic missile system delivering a nuclear, chemical, biological, or high explosive weapon upon a populated area of the Continental United States (CONUS). This threat to the homeland only

¹Office of the President, *National Security Strategy* (Washington, DC: Government Printing Office, 2010), introduction.

increases if violent extremist organizations acquire conventional munitions and the ability to employ them on the United States.²

Unfortunately, nations such as North Korea and Iran also represent a credible air and missile threat to the security of the homeland. An attack from these nations by air breathing threats, such as armed unmanned aerial vehicles, cruise missiles, or conventional aircraft used in a terroristic suicide attack, represent an existing threat to the homeland. In addition to air breathing weapons, North Korea and Iran possess robust ballistic missile weapon programs that they are constantly modernizing.

Hostile nations see ballistic missiles as a means of deterrence against regional threats and the United States. As a result, the proliferation of ballistic missiles has steadily increased for decades. “Without a reliable defense against ballistic missile attacks, many nations have responded to enemy missile threat by acquiring ballistic missiles themselves.”³ Ballistic missiles are relatively cheap when compared to the cost of a modern offensive aircraft. The velocity at which a ballistic missile travels also makes it extremely difficult for a military power to effectively defend against it. Offensive combat aircraft are much more vulnerable to air defenses because of their comparatively slower operational speeds. Although the Arms Export Control Act denies “the transfer of missile equipment or technology” to “countries seeking to acquire ballistic missiles and related technologies that could be used to attack the United States,” it has not been

²Department of Defense, *Ballistic Missile Defense Review* (Washington, DC: Government Printing Office, 2010), 4.

³Daniel Barkley, “Ballistic Missile Proliferation: An Empirical Investigation,” *The Journal of Conflict Resolution* 52, no. 3 (June 2008): 455-473.

completely effective in preventing the proliferation of ballistic missiles and missile technology to North Korea and Iran.⁴

North Korea made its nuclear ambitions known to the world and continues to develop long-range, nuclear capable missiles such as the Taepo Dong 2. The Ballistic Missile Defense Review states that the United States “must assume that sooner or later North Korea will have a successful test of its [Taepo Dong 2] and, if there are no major changes in its national security strategy in the next decade, it will be able to mate a nuclear warhead to a proven delivery system.”⁵ Iran also continues to develop a nuclear capability and longer range ballistic missiles. One variant of the Shahab-3 is claimed to have an extended range around 2500km.⁶ The Sajjil family of ballistic missiles aims not only to eventually extend the range of Iran’s strike capability, but by utilizing a solid fuel propellant indicators and warnings of an impending missile launch would be cut drastically; limiting the time available to prepare a defense against such an attack.⁷

The most proliferated ballistic missile in the world is the Russian SCUD. The SCUD was designed by the Soviet Army in the 1950s and is capable of employing a nuclear, biological, chemical or high explosive warhead.⁸ These ballistic missiles have

⁴*The Arms Export Control Act*, 22 U.S.C. 2778, <http://uscode.house.gov/search/criteria.shtml> (accessed 5 April 2012).

⁵Department of Defense, *Ballistic Missile Defense Review*, 4.

⁶Council of Foreign Relations, *Iran’s Ballistic Missile Program*, 15 October 2009, <http://www.cfr.org/iran/irans-ballistic-missile-program/p20425> (accessed 5 April 2012).

⁷*Ibid.*

⁸Steven J. Zaloga, *Scud Ballistic Missile and Launch Systems 1955-2005* (Westminster: Osprey Direct, 2006), 17.

been proliferated to not only hostile nations such as Iran and North Korea, but to Afghanistan, Egypt, Iraq, Libya, Syria, Vietnam, and Yemen as well.⁹ Civil unrest and political turmoil in these nations logically give violent extremist organizations better opportunities to obtain and employ these conventional weapons against the United States.

Iran has developed a capability to employ short and medium range ballistic missiles on mobile sea launch platforms; the so called “SCUD in a tub” scenario. This capability has already been proven in Iranian test flights.¹⁰ A sea-launched ballistic missile fired from within 100km of the United States coastline can 53 percent of the United States population and 37 nuclear power sites.

The air and missile threat posed by hostile states and terrorist organizations to the CONUS is a reality. Al-Qa’ida and other terrorist organizations, as well as rogue nations, such as Iran and North Korea, are actively pursuing a nuclear capability and the means to employ them.¹¹ In addition, Iran has developed a technological means in which nuclear, chemical, biological, and high explosive capable short range ballistic missiles may be employed against the United States homeland.¹² Violent extremist organizations such as al-Qa’ida are actively pursuing air and missile weapon systems to attack the United

⁹Ibid., 33.

¹⁰Hashem Kalantari, “Iran Tests New Missile From Warship: Reports,” *Reuters*, 7 December 2008, <http://www.reuters.com/article/2008/12/07/us-iran-missile-idUSTRE4B60CO20081207> (accessed 7 September 2011).

¹¹Office of the President, *National Security Strategy*, 20-23.

¹²Kenneth R Timmerman, “New Iranian Missile May Outflank U.S. Defenses,” *Insight on the News* 15, no. 19 (24 May 1999): 28.

States.¹³ It is in the national interest of the United States to protect the homeland if a rogue nation or terrorist organization ever conducts such an attack on American soil.

Ends, Ways, and Means

“The security of the United States, its citizens, and US allies and partners” is an enduring national interest to the United States of America.¹⁴ The greatest responsibility of the United States government is to protect the American people. A goal of the 2010 National Security Strategy is to defeat and deter adaptive enemies through the development and maintenance of superior capabilities.

The geographic combatant command responsible for defending the homeland from enemy air and missile threats is the United States Northern Command (NORTHCOM).¹⁵ “USNORTHCOM consolidates under a single unified command existing missions that were previously executed by other DOD organizations. This provides unity of command, which is critical to mission accomplishment.”¹⁶ This responsibility includes the defense of the CONUS from air and missile attacks. The NORTHCOM commander is also responsible for the North American Aerospace Defense Command (NORAD). This organization “conducts aerospace warning, aerospace control

¹³Office of the President, *National Security Strategy*, 20.

¹⁴*Ibid.*, 17.

¹⁵US Northern Command, “About USNORTHCOM,” <http://www.northcom.mil/about/index.html> (accessed 17 September 2011).

¹⁶*Ibid.*

and maritime warning in the defense of North America.”¹⁷ NORAD is responsible defending airspace and preventing air attacks against North America.

The means in which NORTHCOM executes its mission of Air and Missile Defense (AMD) is divided into three parts; the intelligence, AMD, and Command and Control (C2). Intelligence provides indicators and warnings to alert the organization of a potential threat. AMD capabilities are the weapon systems available to the command. Lastly, NORTHCOM’s AMD mission execution is enabled through its C2 system. Air and missile threats are very difficult to predict, but there are indicators and warnings to these attacks that are continuously sought out by the intelligence community. While reliable human intelligence normally gives the best indication of such an attack, signal intelligence and ISR capabilities also provide such warnings. An example of an indicator might be liquid fuel tankers moving toward known launch sites or the interception of radio traffic detailing a potential launch event.

In the United States military, there are six operational ground/sea based active air and/or missile defense weapon systems. The Army has a majority of the weapon systems including Ground Based Midcourse Defense (GMD), Terminal High Altitude Area Defense (THAAD), the Patriot missile system, and the Avenger. The Navy utilizes one sea based AMD weapon system, the Aegis Combat System. The Marines employ the man-portable stinger missile, officially designated as Low Altitude Air Defense (LAAD).

An effective C2 system for these AMD weapon systems is critical to the successful execution of homeland defense. Mission success for active AMD is defined as

¹⁷North American Aerospace Defense Command, “About NORAD,” April 2011, <http://www.norad.mil/about/index.html> (accessed 26 September 2011).

the protection of assigned assets and friendly forces from air and missile attack.¹⁸ The C2 system integrates all the AMD weapon systems together creating a common operating picture for the theater, which enhances the situational awareness of all the weapon systems. More situational awareness contributes directly to earlier detection, faster and more accurate identification, and higher quality engagements of enemy air and missile threats. Without an effective C2 system, the worst case scenario is that the AMD systems fail to identify, engage, or destroy threatening air and missile targets. Any lack of air or missile defense to assigned assets or friendly forces leads directly to mission failure. In addition, the lack of an effective AMD C2 system can also contribute to mission failure due to the fratricide of friendly forces.

During Operation Iraqi Freedom, the Patriot system was responsible for two fratricides of coalition aircraft. One C2 system shortfall that led to these regrettable incidents is the following:

A second shortfall was the lack of significant situational awareness in our combined air defense system, which involved major systems such as Patriot, AWACS, and AEGIS. We tend to assume that data are routinely communicated from one system to the other, that targets are correlated, and target information is shared and assimilated by all. The Task Force believes that we are a long way from that vision. The communication links, the ability to correlate target tracks by disparate sensors, and the overall information architecture are simply not there. Thus, a Patriot battery on the battlefield can be very much alone. Its closest connection is its Patriot battalion headquarters unit, and in some cases in OIF even that connection was weak.¹⁹

¹⁸Joint Chiefs of Staff, Joint Publication (JP) 3-01, *Countering Air and Missile Threat* (Washington, DC: Government Printing Office, 2007), I-8.

¹⁹Defense Science Board Task Force, "Patriot Performance Report Summary" (Report, Washington, DC, January 2005), 2.

Without an effective C2 system, the risk of an AMD weapon system committing a fratricide greatly increases.²⁰ AMD engagement officers rarely get a visual confirmation that what they have been ordered to engage is in fact an enemy air threat. Identification and the decision to engage these threats take place at a higher echelon with more situational awareness or understanding. The engagement order is passed down to the soldier, sailor, or marine that executes the engagement order through the use of the AMD C2 system. As witnessed in Operation Iraqi Freedom, the effects of poor a C2 system in a threatening environment with very lethal and capable AMD systems can have fatal results on friendly forces in addition to the greater risk of failing to defend designated assets.

An effective C2 system for AMD is a critical factor to defeating air and missile threats to the homeland. While the lack of an effective C2 system ultimately leads to the failure of protecting defended assets, it can also contribute to unnecessary fratricide of friendly coalition aircraft. In the event an air or missile threat to the CONUS is identified through indicators, warnings, and other intelligence, NORTHCOM is the overall geographic combatant command responsible for the integration, command, and control of all assigned or attached AMD capabilities to defeat the threat.

Primary and Secondary Research Questions

The primary research question concerns the C2 of the homeland AMD mission. This question focuses specifically upon the effectiveness of the C2 system established within NORTHCOM, the supported geographic combatant command with the overall

²⁰In OIF I, more coalition fixed wing aircraft were lost to fratricide from friendly ground based air and missile defense systems than from enemy contact.

responsibility for homeland defense. The primary research question: Is the NORTHCOM C2 system for active AMD of the CONUS effective?

Measuring the effectiveness of a NORTHCOM's C2 system for AMD of the homeland is facilitated by several secondary research questions. How is the effectiveness of a C2 system measured? What are the specific measures for quantifying the effectiveness of an AMD C2 system, as established in joint doctrine and other operational research? What C2 physical entities are currently used and how are those assets structured to form the basis for NORTHCOM's C2 system?

Significance

This research is significant because it is tied directly to a national strategic objective of combating air and missile threats that are capable of employing nuclear, chemical, biological, and high explosive weapons within the CONUS. The severity of such an attack on a homeland population center, nuclear power plant, port facility, or strategic petroleum reserves deem the topic significant for study. Although capabilities exist within the United States to counter air and ballistic missile threats to the homeland, these capabilities are useless without an effective C2 system. The time to evaluate the C2 system is now—not when the enemy executes an attack. All the AMD capabilities in the world cannot defeat a threat if those capabilities are not integrated with an effective C2 system.

There is a significant amount of documented research on the topic of C2 system effectiveness. However, there is a lack of research detailing methods to measure the effectiveness of AMD C2 systems without conducting an exercise. Typically, scenario driven exercises are designed and executed to test and evaluate C2 processes. Lessons

learned from these exercises do make recommendations that improve these C2 processes, but many times they identify the lack of equipment, personnel, or facilities that are required for an effective C2 system. There is a lack of documented research that details methods in which to estimate C2 system effectiveness without conducting a robust scenario driven exercise. This research attempts to fill that void by modifying existing methods to measure C2 system effectiveness without specifically testing and evaluating the C2 system in an exercise.

Assumptions

This thesis makes two assumptions relating to enemy threat and US AMD force capabilities. One assumption is that the US intelligence community is aware of hostile nation and non state enemy intentions and can anticipate future hostile actions. Enemy intentions, indicators, and unambiguous warnings of an enemy air or missile attack on the homeland provide US AMD planners with an adversary template; a “model based on an adversary’s known or preferred methods of operations.”²¹ This adversary template leads joint planners to determine the best locations to employ AMD weapons systems to defend assigned assets and friendly forces.

A second assumption is that the US employs AMD forces where they are needed in the continental US prior to an enemy attack. The US does not have enough AMD weapon systems to protect the whole continental US at the same time. This fact leads to the creation of national defended asset list that prioritizes the areas that need to be

²¹Joint Chiefs of Staff, Joint Publication (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington, DC: Government Printing Office, 2010), 5.

defended based upon the likelihood of an enemy attack, the severity of such an attack, the criticality of the threatened area to national security, and the capacity of that area to recover from such an attack.

By assuming that the US employs a sufficient and capable AMD system in the right place to defend against an enemy air or missile threat, this thesis does not explore whether US AMD systems are capable of defeating such a threat. Rather, these two assumptions focus this thesis on the exploration of measuring the effectiveness of the AMD C2 system employed to defeat the enemy air and missile threat and protect a defended asset.

Scope

This thesis explores unclassified data of the active AMD C2 system in defense of the CONUS. Results from previous active air and missile homeland defense exercises are classified. The processes in which the C2 system interact with the environment are also classified and as a result, will not be explored.

A C2 system can be divided into three parts; C2 physical entities, C2 structure, and C2 processes. This thesis focuses on the physical entities and structure that form the basis of a C2 system, not the processes in which the C2 physical entities and structure interact with the environment. The processes involved in a C2 system are certainly important to the overall effectiveness of the system's performance, however the presence or lack of necessary physical entities required for an effective system are most important. Whether or not a control officer makes an engagement is important, but it is more important that the system has a control officer to execute the engagement. Otherwise, there will not be any successful engagements or protection of defended assets.

There is a wide breadth and depth of information regarding the measurement of C2 system effectiveness. However, there is a gap in information regarding the specific measurement of C2 system effectiveness for AMD without conducting a scenario driven exercise. It is important and possible to develop a method in which the effectiveness of a C2 system can be estimated without conducting an expensive and time consuming event driven scenario.

Ballistic missile and air defense sensors, as they are related to the AMD C2 system, will not be explored in this thesis. These sensors are used for early warning or cueing to active AMD systems. In order to concentrate on the effectiveness of the C2 system, it is assumed that these sensors will provide sufficient early warning and indication of incoming hostile threats.

Definition of Key Terms

Key terms defined as part of this thesis are described below. These definitions are the meanings in which these C2 terms are used throughout the thesis.

C2 (C2): “the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. C2 functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.”²² This thesis does not explore the effectiveness of NORTHCOM’s C2, but rather the C2 system that is used to execute C2.

²²Joint Chiefs of Staff, JP 1-02, 64.

C2 (C2) System: “viewed as having three components: physical entities, structure, and C2 process.”²³ The C2 system is everything needed to by a commander to exercise their authority over all their assigned forces. This includes all the *things* required at a basic level, how those *things* are properly arranged in space and time, and how they react with the environment.

C2 (C2) Physical Entities: “refer to hardware, software, people, and facilities.”²⁴ They are the required people with right authorities, sufficient facilities such as a Command and Reporting Center (CRC) or CAOC, radios, and computers. They form the base of the C2 system. Without them, there is nothing to conduct C2.

C2 (C2) Process: “reflects the functions carried out by the C2 system—sensing, assessing, generating, selecting alternatives, planning, and directing.”²⁵ This includes all the tasks, processes, and functions the physical entities need to perform on the environment or in reaction to the environment to accomplish the mission. For AMD units, this includes tactical standard operating procedures, area air defense plans, rules of engagement, or the execution of pre-planned responses.

C2 (C2) Structure: “refers to the relationship between physical entities, procedures, protocols, and concepts of operation and information patterns. It can reflect the effects of doctrine, the scenario, and time and space.”²⁶ It is manner in which the

²³John M. Green and Bonnie W. Johnson, “Towards a Theory of Measures of Effectiveness” (Master’s Thesis, Naval Postgraduate School, Monterey, CA, 2002), 5.

²⁴Ibid.

²⁵Ibid.

²⁶Ibid.

physical entities are arranged in space and time. For AMD, the structure is outlined in doctrine.

Summary

This thesis explores the effectiveness of the CONUS AMD C2 system. It aims to identify any perceived shortfalls or recommend improvements by analyzing the homeland's C2 physical entities, structure, and processes currently in place and without executing a scenario driven exercise. Rogue nations and non-state actors, such as al-Qa'ida, are pursuing the means to attack the CONUS with air and missile threats. The United States possesses the AMD weapon system capabilities to defend against such an attack, but all the AMD capabilities in the world will not be able to defend the homeland without an effective C2 system.

An effective C2 system for AMD weapon systems is required in order to protect the American people and other strategic national interests while minimizing the possibility of fratricide. The time to evaluate the effectiveness of the CONUS' C2 system is not when AMD forces are actively employed in the defense of the homeland after the discovery of an imminent threat.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

The review of literature for this thesis is divided into three sections. The first section explores resources pertaining to measuring the effectiveness of systems; focusing on C2 systems. By examining accepted models and methods, section one ultimately establishes a general analytical model to measure the effectiveness of a C2 system. The second section explores AMD joint doctrine in order to identify C2 system requirements. Applying these doctrinal C2 system requirements to the analytical model for C2 systems established in section one, leads to the creation of a refocused and AMD specific C2 system effectiveness model. The final section investigates primary sources that detail the C2 system being used in the execution of homeland AMD. Together these three sections (general C2 system effectiveness model, guidelines for AMD C2 systems, and current AMD C2 system for CONUS) provide an AMD specific analytical model that, in chapter four, measures the effectiveness of the current C2 system for the AMD of the CONUS.

C2 System Effectiveness: A General Analytical Model

Introduction

The first section of literature review draws upon three primary sources to identify a general model for measuring the effectiveness of a C2 system. First, the TRADOC Analysis Center's (TRAC) *C2 Measures of Effectiveness Handbook*, describes how an

analytical model to measure C2 system effectiveness can be developed.²⁷ Next, John Green, of the Naval Postgraduate School argues in *Towards a Theory of Measures of Effectiveness* that the C2 system model developed by TRAC can be simplified.²⁸ Green states that effectiveness of a C2 system can be measured merely by analyzing the system's physical organization and not how the system performed in a scenario driven exercise.²⁹ Finally, Russell Ackoff, a pioneer in the field of operational research and system effectiveness, reinforces Green's assertion, but from a different perspective centered upon probability and uncertainty. Exploring these three resources identifies a general analytical model to measure the effectiveness of a C2 system.

C2 Measures of Effectiveness Handbook

TRAC published the *C2 Measures of Effectiveness Handbook* "to assist analysts charged with the examination of C2 systems."³⁰ The handbook explains that it is not possible to have a set of universal measures of performance and effectiveness because each C2 system is inherently different. Instead, the handbook describes a method to establish measures of effectiveness and performance independently for each C2 system. The first step is to identify the elements of the C2 system.

The TRAC handbook explains that a C2 system is composed of six basic elements. The most basic of these elements are the physical objects that operate within

²⁷TRADOC Analysis Center, *C2 Measures of Effectiveness Handbook* (Washington, DC: Government Printing Office, 1993), abstract.

²⁸Ibid.

²⁹Green and Johnson, 2.

³⁰TRADOC Analysis Center, 13.

the system. TRAC calls these objects “physical entities” and they normally consist of people, facilities, and communications equipment. The manner in which these physical entities are arranged in space and time form the next element, the C2 structure. TRAC divides the actions performed by the physical entities into four additional elements called tasks, processes, functions, and mission. These four elements are separated based upon complexity and are interrelated. A task is a basic action performed by a physical entity. Many tasks form together to perform a process. Several processes join to perform a function and several functions unite to perform an overall mission. The aggregate of these measured levels of performance constitutes an overall measure of effectiveness for the C2 system.

TRAC requires that the performance of each C2 element be measured using an event driven scenario. A scenario is an artificial reality, based upon realistically plausible current or future events, used to stimulate a system under evaluation.³¹ This scenario may be developed to specifically test the C2 system as a whole or a specific part, but the measured effectiveness is always a result of how the C2 system performed in the evaluation. The measured effectiveness is then compared to a prescribed standard, normally “how a perfect C2 system would perform” in order to identify if the system’s effectiveness can be improved upon.³²

TRAC’s handbook is significantly relevant to this thesis because it provides a starting point to develop an analytical model to measure the effectiveness of an AMD C2

³¹Dana Mietzner and Guido Reger, “Advantages and Disadvantages of Scenario Approaches for Strategic Foresight,” *International Journal of Technology and Intelligence Planning* 1, no. 2 (March 2005): 220-239.

³²TRADOC Analysis Center, 17.

system. Rather than trying to define a universal set of C2 MOEs, TRAC describes an accepted and practical method to develop and evaluate meaningful MOEs that are specific to that C2 system. This general analytical model partially answers secondary research question number one: How is the effectiveness of a C2 system measured? It only partially answers this question because TRAC recommends this measurement be evaluated using a scenario driven exercise, which is outside the scope of this thesis. John Green, of the Naval Postgraduate School, describes a way around this dilemma in *Towards a Theory of Measures of Effectiveness*.

Towards a Theory of Measures of Effectiveness

John Green, of the Naval Postgraduate School, argues in *Towards a Theory of Measures of Effectiveness* that the effectiveness of a C2 system can be measured without developing and executing a scenario driven exercise. Green asserts that it is still possible to evaluate a system with it isolated from the environment.³³ A valid measurement of C2 system effectiveness can be determined by analyzing the performance of the C2 system's organization and composition.³⁴

Green's *Towards a Theory of Measures of Effectiveness* is relevant to this thesis because it describes that C2 system effectiveness can be measured without having to conduct a scenario. The performance of only the C2 system's physical entities and structure can be measured and assessed in the aggregate to form a valid measurement of overall C2 system effectiveness. Green's work answers one of this thesis' secondary

³³Green and Johnson, 5.

³⁴*Ibid.*

research questions by determining an analytical model that measures the MOE for a C2 system without conducting a scenario. Russell Ackoff, a pioneer of operational research and system effectiveness, confirms Green's assertion with his research's exploration of the relationship between system effectiveness and probability.

The Art of Problem Solving

Russell Ackoff describes in *The Art of Problem Solving* that the MOE for any system is merely a probability.³⁵ It is a probability of how that system might perform sometime in the future, under similar circumstances. Ackoff asserts that a MOE is always measured in terms of probability because the system being measured interacts directly with the environment.³⁶ The environment can be defined as anything outside the complete control of the system being analyzed and may include the actions of an enemy, the weather, or other uncontrolled variables that can directly impact the performance or effectiveness of the system. Due to the fact that these variables are uncontrollable, it is more important to measure the performance of the variables that can be controlled. These controlled variables include the physical entities and structure of the system under evaluation.

The Art of Problem Solving, by Russell Ackoff, is relevant to this work because he reinforces Green's argument that a system's effectiveness can be determined without conducting a scenario. Ackoff states that the measurement of a system's effectiveness is always a probability. Whether the system's effectiveness was measured in a scenario or

³⁵Russell L. Ackoff, *The Art of Problem Solving* (New York: John Wiley and Sons, Inc., 1978), 124.

³⁶Green and Johnson, 9.

by some other method, it is always a probability that the system will perform at the same level of effectiveness in the real world. Ackoff's pioneering efforts in the development of operational research and system effectiveness support the analytical model for measuring C2 system effectiveness developed within this section of literature review.

Summary

The three primary sources described in this section of literature review identify a general model for measuring C2 system effectiveness. The *C2 Measures of Effectiveness Handbook*, written by TRAC, described a model to measure C2 system effectiveness through the use of an event driven scenario. John Green's, *Towards a Theory of Measures of Effectiveness*, argues that a C2 system's effectiveness can also be determined by measuring the performance of the system's physical entities and structure; not necessarily how the system performed in a scenario. Finally, the work of Russell Ackoff, who established the field of operational research and system effectiveness, described the relationship between measures of effectiveness and probability, supporting the analytical model described by Green. Now that a general analytical model has been identified that can measure the effectiveness of a C2 system, the next section of literature review explores AMD joint doctrine in order to identify the C2 physical entities and structure required for an effective AMD C2 system.

Air and Missile Defense C2 Doctrine

JP 3-01 and Army FM 3-01.15 are the doctrinal references utilized within this section of the literature review to explore the physical entities and structures required by an effective AMD C2 system. These two primary sources outline the C2 physical entities

required by doctrine for an effective AMD C2 system. They include the roles, responsibilities, and relationships between commanders and controllers, recommended facilities, and guidelines for C2 communication networks. JP 3-01 and FM 3-01.15 also outline the recommended C2 structure for an effective AMD C2 system including levels of control and unity of command. The goal of this section of literature review is to explore current joint doctrine to identify required AMD C2 physical entities and structure. The performance of these two elements is measured in Chapter four in order to determine an overall measure of effectiveness for the AMD C2 system currently used in the defense of the CONUS.

Countering Air and Missile Threats; Joint Publication 3-01

JP 3-01 was prepared under the direction of the Chairman of the Joint Chiefs of Staff in order to provide “military guidance for the exercise of authority by combatant commanders and other joint force commanders” specifically to “counter theater air and missile threat across the range of military operations.”³⁷ This joint publication generally describes the overall concept of joint counterair operations. This concept includes the use of US aircraft and other AMD weapon systems to defend against enemy air and missile attack. JP 3-01 also describes the roles, responsibilities, and relationships between commanders and controllers in theater AMD operations. Overall, JP 3-01 provides specific roles and responsibilities for AMD commander and controllers, general descriptions of AMD facilities and communications equipment, and overarching doctrinal

³⁷Joint Chiefs of Staff, JP 3-01, i.

concepts for the establishment of processes and procedures used in countering air and missile threats.

JP 3-01 is relevant to this thesis because it describes in detail the roles and responsibilities for commanders and controllers involved in the execution of AMD. The facilities that these commanders and controllers operate in, as well as the communications network equipment they use, is also described within this joint manual. As described in the previous section, these individuals, facilities, and communication equipment are doctrinally required physical entities; the performance of which can be measured to assist in the determination of an overall AMD C2 system measure of effectiveness. JP 3-01 partially answers secondary research question number two: What are the specific measures for quantifying the effectiveness of an AMD C2 system, as established in joint doctrine. However, *Countering Air and Missile Threats* fails to describe in any detail the structure needed by an effective C2 system. FM 3-01.15, fills the analytical gap left by JP 3-01 and describes the AMD C2 structure in detail.

Integrated Air Defense Systems; FM 3-01.15

Although FM 3-01.15 is an Army field manual, it is also accepted joint doctrine for the Marine Corps, Navy, and Air Force. The purpose of the manual is to “provide guidance for command, control, and communications specific planning, coordination, and interoperability for an Integrated Air Defense System (IADS).”³⁸ Where JP 3-01 provided general guidance for countering air and missile threats, FM 3-01.15 provides

³⁸Headquarters, Department of the Army (HQDA), Field Manual (FM) 3-01.15, *Integrated Air and Missile Defense System* (Washington, DC: Government Printing Office, 2009), i.

much greater level of detail on AMD operations. In addition to describing the same physical entities covered in JP 3-01, it outlines the doctrinal C2 structure required for AMD operations. Using the doctrinal C2 structure provided by FM 3-01.15, two evaluation criteria can be fashioned to evaluate its performance. The concept of “levels of control” is one possible criterion used to evaluate a C2 structure. Levels of control represent the number of echelons between the individual authorized to order the engagement of an air or missile threat and the individual in the weapon system who actually makes the engagement. Doctrinally, levels of control within an AMD C2 structure can number anywhere between one and three.³⁹ FM 3-01.15 also describes the importance of unity of command and effort to an effective C2 structure. A single responsible combatant commander should command all AMD forces involved in the defense of a theater of operations.⁴⁰ In addition to guidance for a C2 structure, FM 3-01.15 outlines C2 communications equipment requirements. These communication requirements assist in determining the overall effectiveness of the AMD C2 system. Overall, the Integrated Air Defense System manual outlines a number of doctrinal requirements for an effective AMD C2 system.

FM 3-01.15 is relevant to this thesis because it describes, in detail, specific elements that can be used to measure the performance of a C2 structure. It describes and visually depicts the prescribed doctrinal standard for an AMD C2 structure. This doctrinal C2 structure is the benchmark that will be compared to the actual C2 structure used in the AMD of the CONUS. This comparison can be performed by analyzing the C2

³⁹Ibid., 33.

⁴⁰Ibid., 4.

structure's levels of control and for unity of command/effort. FM 3-01.15 is relevant to this thesis because it identifies structural requirements needed for an effective C2 system.

Summary

This section of literature review identified doctrinal C2 physical entities and structural requirements needed for an effective C2 system. JP 3-01 and FM 3-01.15 are two primary joint doctrinal resources utilized for the planning and employment of AMD forces. While this section of literature review established what an effective C2 system should be composed of, the next section of literature review outlines the sources that contain the data needed to analyze the performance of the CONUS based AMD C2 physical entities and structure.

CONUS AMD C2 Structures and Entities

The final section of literature review focuses on resources that describe the current C2 system employed in the AMD of the CONUS. The first section of literature review determined an analytical model to measure the effectiveness of a C2 system by analyzing the performance of the system's physical entities and structure. The second section of literature review identified the specific AMD physical entities and structure required for an effective C2 system. This section reviews three types of primary sources used to identify the AMD C2 entities and structure currently employed in the defense of the homeland. The thesis organizes this section into three parts based upon the type of documents that contain information about the homeland AMD C2 system. The three parts are CONUS-based service and functional component command organizational websites,

the Joint-Deployable Integrated Air and Missile Defense (J-DIAMD) project master plan, and CONUS AMD exercise reports.

Organizational Websites

Unclassified organizational websites provide a wide array of data about the organizations involved in the AMD of the CONUS. This data includes organizational mission statements and responsibilities, operationally controlled weapon systems and units, and the location of AMD C2 facilities. Of all the websites for the numerous organizations that play a role in the AMD of the CONUS, the NORTHCOM website was the most informative. Since NORTHCOM is the “combatant command established in 2002 to provide C2 of Department of Defense (DOD) homeland defense,” its website describes in detail its relationship with the numerous organizations that play a role in the execution AMD operations.⁴¹ Since NORTHCOM is the supported combatant command responsible for defense from air threats and the “warning of attacks against North America whether by aircraft, missiles or space vehicles,” their organizational website was an important starting point for this thesis’ research.⁴² The NORTHCOM website does not offer the detailed data needed to conduct this thesis’ analysis, but it does list its subordinate organizations websites that do.

These unclassified organizational websites are critically relevant this thesis because they identify the current C2 physical entities and structure in place for the AMD

⁴¹US Northern Command, “About USNORTHCOM,” <http://www.northcom.mil/about/index.html> (accessed 17 September 2011).

⁴²First Air Force, “First Air Force Mission,” <http://www.1af.acc.af.mil/main/welcome.asp> (accessed 12 January 2012).

defense of the homeland. This thesis used the performance of the people and authorities listed in these websites to measure the effectiveness of the CONUS AMD C2 system. The websites also describe the relationship between the AMD engagement authorities. These relationships formed the basis for an analysis of the CONUS AMD C2 structure's performance. Although these organizational websites contributed a significant amount of data to this thesis' analysis, they did not contain all the data required. The J-DIAMD project master plan described in the following section filled these research voids.

J-DIAMD Project Master Plan

The *J-DIAMD Project Master Plan* is an unclassified concept for integrating all assigned AMD assets under the command of NORTHCOM.⁴³ J-DIAMD concept was chartered in response to congressional concerns about the nation's vulnerability to cruise and short range ballistic missiles.⁴⁴ It is the near term response from NORAD/NORTHCOM to mitigate this threat by integrating AMD operations in the homeland.⁴⁵ Instead reorganizing the CONUS AMD C2 structure or modernizing equipment currently owned by AMD forces and C2 facilities, J-DIAMD focuses on developing and executing new C2 processes and tactics.⁴⁶ The J-DIAMD master plan also describes in detail the C2 communications network used by NORAD/NORTHCOM, depicted in Appendix A. In

⁴³Mark Emmer, et al., *Joint Deployable Integrated Air and Missile Defense (J-DIAMD) Joint Test (JT) Project Master Plan* (Washington, DC: Government Printing Office, 2011), ES-2.

⁴⁴House Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 2011* (Washington, DC: Government Printing Office, 2010), 196.

⁴⁵Emmer, ES-1.

⁴⁶*Ibid.*, ES-2.

addition to identifying the IAMD communications network, the J-DIAMD concept portrays the operational facilities, AMD organizational responsibilities, and an illustration of the J-DIAMD C2 structure (see Appendix B). In summary, the J-DIAMD master plan outlines the overall concept for defending the United States homeland from air and missile attacks.

The J-DIAMD master plan is particularly relevant to this thesis. This single document outlines the status of CONUS AMD C2 physical entities and structure, and an estimation of the concept's progress in the years to come. This thesis used the timely and pertinent data from the J-DIAMD concept to measure the performance, and subsequent effectiveness, of the C2 physical entities and structure for the AMD of the CONUS in chapter 4.

CONUS AMD Exercise Reports

The research of this thesis resulted in the discovery of two unclassified exercise reports that provide insight as to the effectiveness of the current CONUS AMD C2 system. These two reports are from exercise scenarios that were developed and executed specifically to evaluate the performance and effectiveness of the J-DIAMD concept. This thesis did not use these exercise reports to measure the effectiveness of the current CONUS AMD C2 system. Instead, this thesis used the two reports to validate any issues and recommendations that resulted from data analysis. The first document is a trip report for an exercise scenario named Ardent Sentry, which occurred from May 10-12, 2011 at Tyndall AFB. The second document is an executive summary of Vigilant Shield, executed from November 1-12, 2011 at Key West Naval Air Station.

The Ardent Sentry exercise scenario, executed in May 2011, evaluated the J-DIAMD concept. This exercise used a mix of live air and ballistic missile simulations to threaten a defended asset within the US. The report indicates four major issues identified during the execution of the exercise. First, the non-doctrinal C2 structure caused confusion with aircraft engagements.⁴⁷ Second, there was a general misunderstanding concerning the roles and responsibilities of the brigade and Army Air and Missile Defense Command (AAMDC) Air Defense Artillery Fire Control Officer (ADAFCO).⁴⁸ In addition, there was confusion on who held the engagement authority for specific threats.⁴⁹ The last issue identified in the Ardent Sentry report details issues with a common operating picture and other communication related issues.⁵⁰ Overall, the report stated that AMD forces planned and executed Ardent Sentry well, but the second exercise also reports similar operational deficiencies for the J-DIAMD concept.

The second exercise report is an executive summary for a US patriot brigade's participation in Vigilant Shield. Vigilant Shield was an exercise conducted in November 2011 as part of a J-DIAMD field training exercise.⁵¹ The document mentioned integration problems between the patriot brigade engagement managers and the

⁴⁷32d AAMDC, "Ardent Sentry; Proof of Concept IAMDC NORTHCOM" (Trip Report, Fort Bliss, May 2011), 1.

⁴⁸Ibid., 2.

⁴⁹Ibid., 1.

⁵⁰Ibid., 2.

⁵¹Mary McHale, "601st AOC Helps Support Key West Exercise," 10 November 2011, <http://www.1af.acc.af.mil/news/story.asp?id=123279546> (accessed 3 March 2012).

NORTHCOM C2 system.⁵² This report indicated that the NORTHCOM C2 system is different from other geographic combatant commands; different enough that trained and certified crews had problems integrating and executing operations because of non-doctrinal C2 processes and procedures.⁵³

Again, these two CONUS AMD exercise reports were not used to directly measure the performance or effectiveness of the CONUS AMD C2 system. However, they are relevant to the thesis because they indicate potential issues within the CONUS AMD C2 system as observed in the recent past. Chapter 5 draws parallels between the themes identified in these two reports and recommendations for improvement determined in this thesis' quantitative data analysis.

Summary

The primary sources detailed throughout this section of literature review explored organizational websites, the J-DIAMD project master plan, and CONUS AMD exercise reports to identify the specific C2 physical entities and structure currently used in the AMD of the CONUS. Chapter 4 measures the performance of these entities and their C2 structure. An aggregate of these measures of performance will indicate an overall measure of effectiveness for the CONUS AMD C2 system.

⁵²Wong Kim, "Vigilant Shield 12" (Executive Summary, Fort Sill, OK, November 2011), 3.

⁵³Ibid.

Literature Review Summary

The purpose of this literature review was to summarize and briefly evaluate the literature relevant to measuring the effectiveness of the CONUS AMD C2 system.

Overall, this chapter was successful in identifying an AMD specific analytical model to measure CONUS AMD C2 system effectiveness. In addition, it explored primary sources that supplied this analytical model with data in order to measure the performance and effectiveness of the CONUS AMD C2 system. The next chapter describes this quantitative data analysis.

CHAPTER 3

RESEARCH DESIGN

This chapter describes the research methodology used in this thesis to answer the primary research question; what is the effectiveness of the NORTHCOM C2 system for active AMD of the CONUS? The research methodology used in this thesis is a documentation review with a quantitative analysis of this data.⁵⁴ This method follows Creswell's "quantitative approach" by using an accepted model to measure the effectiveness of a C2 system.⁵⁵ The same quantitative model ultimately leads this thesis to recommendations aimed at improving the overall effectiveness of the C2 system. The information required for this methodology already exists and no surveys or additional data collection is necessary. One disadvantage for this method is that measuring how effective a system might perform within an uncontrolled environment is always a measure of probability.⁵⁶ As a result, the analytical model used in this thesis is only a probability of how the C2 system will *likely* act if faced with an air or missile threat. Another disadvantage to this method is that the research is constrained to unclassified data only, leading to some inconclusive analytical results.

This thesis provides research for a national strategic interest, the security of the United States and its citizens.⁵⁷ Combating air and missile threats that are capable of

⁵⁴John W. Creswell, *Research Design; Qualitative, Quantitative, and Mixed Methods Approaches* (Thousand Oaks, CA: Sage Publications, Inc., 2009), xxiv.

⁵⁵*Ibid.*, 245.

⁵⁶Green and Johnson, 9.

⁵⁷Office of the President, *National Security Strategy*, 7.

employing chemical, biological, high explosive, and nuclear weapons is certainly significant to ensuring this national interest. Hostile nations and terrorist organizations are actively developing and procuring air and missile technological capabilities to attack the CONUS. Fortunately, the United States has a geographic combatant command responsible for the defense of the homeland. Given enough indicators and warnings for such an attack, this geographic combatant command can use the US military's AMD weapon systems to defend against it. Thus, an effective AMD C2 system is critical to defending the US's primary national interest because the C2 system integrates the multi-service AMD weapon systems together under the control of NORTHCOM.

This thesis is unique because it measures the effectiveness of the CONUS AMD C2 system without conducting an event driven scenario. TRAC recommends the development and execution of a scenario, usually a simulation, in order to measure how effective the evaluated C2 system was in a controlled environment.⁵⁸ This method for measuring effectiveness is outside the scope of this thesis because it does not have the means to conduct such a scenario. Instead, this thesis used an analytical model that measures effectiveness based only on the composition and structure of the C2 system. The scope for this thesis is now narrower and the following sections detail the collection of research data and how the analysis of that data determined the effectiveness of the CONUS AMD C2 system.

⁵⁸TRADOC Analysis Center, 17.

Data Collection

The information needed for this quantitative analysis already exists in documentation so it was not necessary to conduct interviews or surveys. There are gaps in the data needed to calculate all the variables that relate to the effectiveness of the CONUS AMD C2 system. These gaps in data are due largely to the classification of the data and not a lack of it. They do not affect the validity of the thesis' results or recommendations.

This thesis divides the data necessary for answering the primary research question into five groups; operational research literature, US Joint AMD doctrine, CONUS defense organizational websites, CONUS AMD plans/concepts, and CONUS AMD exercise reports. Each of these five groups aims to answer one of this thesis' secondary research questions. Table 1 represents these groups of information and which secondary research question they contain data to answer.⁵⁹

Table 1. Data Collection Matrix: Information Grouped by Relevance

<i>Information Group</i>	<i>Secondary Research Questions</i>		
	<i>Question 1</i>	<i>Question 2</i>	<i>Question 3</i>
Operational Research Literature	Yes		
US Joint AMD Doctrine		Yes	
CONUS Defense Organization Websites			Yes
CONUS AMD Plans/Concepts			Yes
CONUS AMD Exercise Reports			Yes

Source: Created by the author.

⁵⁹John W. Creswell, *Qualitative Inquiry and Research Design* (Thousand Oaks, CA: John Wiley and Sons, Inc., 2007), 342.

This thesis explored the operational research literature group to discover a model for measuring the effectiveness of a C2 system. The analytical model used by this thesis was created by Green and argues that measuring effectiveness is based primarily upon two variables; the composition of a C2 system and its structure.⁶⁰ The aggregate of the C2 system's physical entity and structural performance is a valid measure of effectiveness for the C2 system as a whole.⁶¹

The next group of literature was used to determine the C2 physical entity and structural requirements for an AMD C2 system, as required by current US joint doctrine. The physical entities required by an AMD C2 system are the specific people, facilities, and communication network equipment needed to make the system effective. Doctrine also requires that these physical entities be organized according to a specific structure. This structure can be analyzed using the concepts of unity of command/effort and levels of control. In summary, the second group of literature determined that the effectiveness of an AMD C2 system can be determined by analyzing five C2 system variables; people, facilities, communications equipment, unity of command/effort, and levels of control.⁶²

This thesis used the next two literature groups, CONUS defense organizational websites and CONUS AMD plans/concepts, in the analysis of the CONUS AMD C2 system effectiveness. They identify the five variables, described previously, used specifically in the AMD C2 system of the homeland. This thesis used the performance of

⁶⁰Green and Johnson, 5.

⁶¹Ibid.

⁶²HQDA, FM 3-01.15.

these five variables in the aggregate to determine an overall effectiveness for the CONUS AMD C2 system.

Finally, this thesis used the last literature group to draw parallels between its data analysis results and themes from CONUS AMD exercise reports. It did not use these exercise reports to assist in quantitatively analyzing the effectiveness of the C2 system. Instead, this thesis used these themes to validate data analysis results and to assist in developing recommendations to improve the CONUS AMD C2 system.

Data Analysis

This section of the research design chapter describes the method in which the thesis analyzed the research data to determine the effectiveness of the CONUS AMD C2 system. This thesis follows Creswell's quantitative research approach by measuring the CONUS AMD C2 system's effectiveness in two steps.⁶³ Using Green's analytical model for measuring the effectiveness of a C2 system, the first step taken by this thesis was to measure the performance of the five variables identified in joint doctrine for an effective AMD C2 system. The second and final step is to determine the aggregate of these performance measures, in order to determine the overall effectiveness of the C2 system.

Measuring Performance

The first step used in this methodology was to analyze the performance of the five AMD C2 system variables. Three of these variables are the people, facilities, and communication network equipment. Again, Green identifies these three factors as the

⁶³Creswell, *Research Design; Qualitative, Quantitative, and Mixed Methods Approaches*, 21.

physical entities that form the C2 system at the most basic level. Additionally, he defines the arrangement of these physical entities in space and time as the C2 structure. The two remaining variables, unity of command/effort and levels of control, assisted in the analysis of this structure. Table 2 depicts these five variables. The left column of this “L-shaped matrix diagram” displays the C2 physical entities and the right column displays the C2 structure.⁶⁴

Listed below each variable are the attributes that were observed to measure performance. These attributes were identified using joint doctrine and represent the actual people, facilities, communication equipment, and C2 structural requirements needed for an effective C2 system. In order to determine the effectiveness of the C2 system, this thesis measured the performance of these variables.

Measuring the performance of these variables is very objective. According to Green, it is not a measure of how these variables perform with the environment, but simply whether they are present or absent from the C2 system. If a specific attribute is present in the CONUS AMD C2 system, a value of “1” was given. If absent, the value assigned to the variable was a “0”. If the attribute’s presence or absence cannot be determined using the research data, a value of “INS” was assigned, indicating insufficient data. Insufficient data was not used in calculating the overall effectiveness of the C2 system.

⁶⁴American Society for Quality, “Matrix Diagram,” <http://asq.org/learn-about-quality/new-management-planning-tools/overview/matrix-diagram.html#L> (accessed 24 April 2012).

Table 2. NORTHCOM AMD C2 System Effectiveness Variables and Attributes

C2 Physical Entities			C2 Structure		
		NORTHCOM			NORTHCOM
People/Authorities			Unity of Command/Effort		
ATTRIBUTES	JFC		Levels of Control		
	JFACC		ATTRIBUTES	Aegis AAW	
	JFMCC			Aegis BMD	
	AADC			THAAD Battery	
	DAADC			Patriot Battery	
	AAMDC			DCA Fighter	
	RADC/SADC			Avenger Battery	
	AAMDC ADAFCO			NCR-IADS SHORAD	
	BDE ADAFCO				
Facilities					
ATTRIBUTES	JAOC				
	CRC/BCC				
	JADOC				
C2 Comms Network Equip					
ATTRIBUTES	COP				
	Secure voice/data				
	Redundant				
	Real time voice/data				
	Integrated w/in AMD				

Source: Created by the author.

While the measures of performance for all these C2 system variables simply indicate the observation of a presence or lack of the required physical entity or structural attribute, the level of control analysis is slightly more extensive. Doctrinally, the number of echelons between the engagement authority and the individual conducting the engagement is between one and three. Like the other four variables, if the seven observations for the levels of control analysis result between one and three, they were assigned a “1”. If their result is outside of this range, a “0” was recorded in the table. Now that this thesis has described the method for measuring the performance of the five

variables, the next section outlines the method for using this data to calculate the C2 system's effectiveness.

Calculating System Effectiveness

The second step in used by this thesis calculates the effectiveness of the C2 system, using the performance measures calculated in the previous step. Overall, Green and TRAC do not specify which of the five variables used in this thesis are the most important for calculating effectiveness. As a result, none of the variables are weighted more heavily than another. The method used to calculate an un-weighted C2 system effectiveness measured the average performance of each variable. As stated previously, this analysis did not use insufficient results from any system performance attribute in the effectiveness calculation.

TRAC and Green's method for calculating effectiveness recommends that these measures of effectiveness are then compared to a prescribed standard. This thesis used doctrine as its standard, and the model equates this perfect effectiveness to a result of "1". Any calculated result of CONUS AMD C2 system effectiveness less than "1" indicates that improvements can be made to the system.

Chapter Summary

This research methodology presents an impartial analysis of the CONUS AMD C2 system's effectiveness. This thesis first required a thorough review of scholarly and doctrinal literature on measuring C2 effectiveness in order to identify an analytical model. This thesis then used this model to measure the effectiveness of the CONUS AMD C2 system. Additionally, this model should assist in providing recommendations to

improve the overall effectiveness of the system. The conclusions found as a result of this thesis are unbiased, based upon the objective and quantifiable analysis of the five variables researched. Hopefully, these conclusions can be used to create a more adaptive, capable, and effective AMD C2 system used in the defense of the homeland.

CHAPTER 4

ANALYSIS

Introduction

Is the NORTHCOM C2 system for the active AMD of the CONUS effective?

This chapter explores that question using a sequential quantitative analysis. First, this analysis used open source data to measure the performance of the people, facilities, and communication network equipment used in the AMD C2 system currently defending the CONUS. Next, this study measured the structure's performance by analyzing qualities such as unity of command/effort and levels of control. Finally, this thesis used the performance of these five variables to measure the overall effectiveness of the CONUS AMD C2 system.

CONUS AMD C2 Physical Entity Performance

This section of analysis aims to measure the performance of the CONUS AMD C2 system's physical entities. The physical entities of a C2 system are collectively the people, facilities, and communication equipment at the most basic level. This section first analyzes CONUS AMD C2 physical entities by measuring the performance of the individuals who are doctrinally required to operate within an effective AMD C2 system. Next, it analyzes the C2 facilities that operate in the AMD of the homeland. Finally, the performance of the communications equipment currently used in the CONUS AMD C2 system is measured.

As described in chapter 2, the measures of performance for this section are objective. They do not measure how the people, facilities or communications equipment

interact with the environment. Instead, they simply measure the presence or absence of the doctrinally required people, facilities, and communications equipment in the homeland's AMD C2 system. If the attribute is present in the CONUS AMD C2 system, the thesis rated their performance as "1". If absent, this analysis recorded the variables' performance as "0". If the attribute's performance was not determined because of a lack of unclassified or conflicting data, this thesis assigned an "INS" for insufficient data.

More significant than the numerically determined measure of performance for each variable is its relation to the doctrinal standard of "1". Any variable that is determined to have an overall measure of performance less than "1" means that an improvement can be made to the C2 system. Since the performance of each variable is directly related to the effectiveness of the system, this thesis determines a numerical measure of performance only to identify areas within the system that can be improved upon to increase overall effectiveness.

CONUS AMD C2 System Performance: People

Overall, the performance of the people involved in the CONUS AMD C2 system was determined to be ".75". The blue highlight outlines this result in table 3. The table also represents the detailed outcome of the analysis. The performance of six attributes were determined to be consistent with doctrinal recommendations, two attributes were absent from the C2 system, and the data needed to determine one attribute's performance was insufficient.

Table 3. C2 Performance: People/Authorities

		NORTHCOM
<u>People/Authorities</u>		0.75
ATTRIBUTES	JFC	1
	JFACC	1
	JFMCC	1
	AADC	INS
	DAADC	1
	AAMDC	1
	RADC/SADC	0
	AAMDC ADAFCO	1
	BDE ADAFCO	0

Source: Created by the author.

The performance of people/authorities such as the Joint Forces Commander (JFC), Joint Forces Air Component Commander (JFACC), Joint Forces Maritime Component Commander (JFMCC), Deputy Area Air Defense Commander (DAADC), AAMDC, and AAMDC ADAFCO are consistent with doctrinal requirements. Organizational websites and the J-DIAMD plan provided evidence for these results. NORTHCOM's official website defines its organization as being responsible for the defense of the CONUS, representative of the JFC.⁶⁵ 1st Air Force states on its organizational website that is assigned as NORTHCOM's air component command, responsible for the defense of the CONUS.⁶⁶ US Fleet Forces Command reports on its official website that it is NORTHCOM's maritime component command responsible for

⁶⁵US Northern Command, "About USNORTHCOM," <http://www.northcom.mil/about/index.html> (accessed 17 September 2011).

⁶⁶First Air Force, "First Air Force Mission," <http://www.1af.acc.af.mil/main/welcome.asp> (accessed 12 January 2012).

the C2 of maritime homeland defense efforts.⁶⁷ The J-DIAMD plan reports that the 263d AAMDC is the Army air defense organization responsible for the defense of the homeland and also serves as the DAADC for the Air Force Northern Command.⁶⁸ The J-DIAMD plan also describes the role and responsibilities of the AAMDC ADAFCO within the CONUS AMD C2 system.⁶⁹ While these six people/authorities are undoubtedly present within the CONUS AMD C2 system, the two doctrinally required engagement managers described in the following paragraphs are not.

The first engagement manager missing from the CONUS AMD C2 system is the brigade ADAFCO. The J-DIAMD plan only describes the requirement for an ADAFCO at the AAMDC level within the CONUS AMD C2 system.⁷⁰ The brigade ADAFCO's responsibilities are different from that of an AAMDC ADAFCO. Brigade ADAFCOs function specifically as Army air defense experts, integrate with the Regional Air Defense Commander (RADC) / Sector Air Defense Commander (SADC), and issue engagement orders to Army AMD lower tier weapon systems.⁷¹ The lack of a brigade ADAFCO in the CONUS AMD C2 system signifies a major departure from doctrinal requirements and negatively influences the effectiveness of the CONUS AMD C2 system.

⁶⁷US Northern Command, "About USNORTHCOM," <http://www.northcom.mil/about/index.html> (accessed 17 September 2011).

⁶⁸Emmer, 3-5.

⁶⁹Ibid., 1-6.

⁷⁰Ibid.

⁷¹HQDA, FM 3-01.15, 9.

Analysis also indicated that the authorities of the RADC/SADC within the CONUS AMD C2 system are not doctrinally consistent. The J-DIAMD plan provided evidence for this result. The RADC/SADCs present within the CONUS AMD C2 system do not tactically control all the air defense weapon systems within their area of responsibility.⁷² These responsibilities are in direct contravention to those outlined in JP 3-01, where RADC/SADCs are delegated responsibilities and decision-making authorities for all Defense Counter Air (DCA) operations within their assigned region or sector.⁷³ This non-doctrinal use of RADC/SADCs decreases the effectiveness of the C2 system.

Data available to this thesis' analysis was insufficient in determining if NORTHCOM's Area Air Defense Commander (AADC) responsibilities are doctrinally aligned. This result was due to conflicting information from the J-DIAMD plan and US Strategic Command (STRATCOM) official websites. The J-DIAMD concept describes NORTHCOM's AADC as responsible for overall DCA operations.⁷⁴ However, this analysis found no resource that described the relationship between the AADC and the GMD units defending CONUS from ICBM attacks. The Space and Missile Defense Command (SMDC) website, on the other hand, describes the 100th Missile Defense Brigade and the 49th Missile Defense Battalion as operational elements within SMDC's

⁷²Emmer, 1-6.

⁷³Joint Chiefs of Staff, JP 3-01, II-12.

⁷⁴Emmer, 1-5.

“operational chain of command.”⁷⁵ SMDC appears to control these national guard GMD units and not NORTHCOM’s AADC. This conflicting information requires further analysis in order to determine a definitive result. Due to the insufficient results of this thesis’ analysis, the performance of the AADC was not used in determining the effectiveness of the CONUS AMD C2 system.

To measure the overall performance of the C2 people/authorities, this thesis simply averaged the performance of the eight attributes listed in table 1. The result of this analysis indicated the performance to equal “.75”. This result was used later in this thesis’ analysis to calculate the overall effectiveness of the CONUS AMD C2 system. It also indicates that improvements can be made to increase the performance of the C2 people/authorities and the effectiveness of the CONUS AMD C2 system.

CONUS AMD C2 System Performance: Facilities

The performance of the CONUS AMD C2 system was determined to be “.67”. The blue highlight outlines this result in table 4. The table also details the outcome of the C2 facility performance analysis. While, the performance of two attributes were determined to be consistent with doctrinal recommendations, one attribute was not doctrinally aligned.

⁷⁵SMDC/ARSTRAT, “SMDC/ARSTRAT Operations,” <http://www.smdc.army.mil/2008/SpaceBMD.asp> (accessed 18 November 2011).

Table 4. C2 Performance: Facilities

		NORTHCOM
<u>Facilities</u>		0.67
ATTRIBUTES	JAOC	1
	CRC/BCC	1
	JADOC	0

Source: Created by the author.

The Joint Air Operations Center (JAOC) and CRC/BCC are present within the CONUS AMD C2 system and are consistent with doctrinal requirements. The J-DIAMD plan and NORTHCOM organizational websites contain evidence that support these results. NORAD/NORTHCOM's website describes the JAOC is the highest echelon facility used in the AMD of CONUS, directly responsible for two air defense sectors.⁷⁶ The 1st Air Force and NORAD websites describes the C2 facilities for these air defense sectors as Sector Operations Control Centers (SOCCs).⁷⁷ Although "SOCC" is a non-doctrinal term, the J-DIAMD plan describes these facilities as functionally identical to a doctrinal Battle Control Center (BCC) C2 facility.⁷⁸ While the use of C2 facilities such as the JAOC and SOCC are certainly consistent with doctrine, the employment of the remaining C2 facility identified in table 2 indicated a major shift from doctrine.

⁷⁶US Northern Command, "About USNORTHCOM," <http://www.northcom.mil/about/index.html> (accessed 17 September 2011).

⁷⁷North American Aerospace Defense Command, "About NORAD," April 2011, <http://www.norad.mil/about/index.html> (accessed 26 September 2011).

⁷⁸Emmer, I-2.

The use of a Joint Air Defense Operations Center (JADOC) in the homeland's AMD C2 system is clearly non-doctrinal. FM 3-01.15 describes the JADOC as being responsible for the engagement control of ground based air defense weapon systems only in the defense of the national capital.⁷⁹ The use of a JADOC is not described or required anywhere in other joint doctrine. However, the J-DIAMD concept is heavily reliant upon the use of JADOCs explicitly for C2 of all Army AMD weapon systems.⁸⁰ This non-doctrinal use of a C2 facility directly decreases the overall effectiveness of the CONUS AMD C2 system.

In order to determine the aggregate performance of the C2 facilities, this analysis averaged their measured performance. The result revealed a measured performance rating equal to “.67”. This indicates that improvements to the performance of the C2 facilities are possible, which are discussed in chapter 5.

The performance analysis for C2 facilities is only the second variable of the three C2 physical entities explored in this section. Next, the performance of the C2 communication network equipment is measured.

CONUS AMD C2 System Performance: C2 Communications Network Equipment

The third variable analyzed within this thesis was the communications network equipment that operates within the CONUS AMD C2 system. The performance of the CONUS AMD C2 communications network equipment was determined to be “.80”. This result is highlighted blue in table 5. This table also depicts a detailed outcome for the

⁷⁹HQDA, FM 3-01.15, 86.

⁸⁰Emmer, 1-6.

communications equipment analysis. The performance of four attributes meets the doctrinal standard, while one additional attribute falls short.

Table 5. C2 Performance: Communication Network Equipment

		NORTHCOM
C2 Comms Network Equip		0.80
ATTRIBUTES	COP	1
	Secure voice/data	1
	Redundant	0
	Real time voice/data	1
	Integrated w/in AMD	1

Source: Created by the author.

The communication equipment currently used in the CONUS AMD C2 system possesses secure voice/data, real time voice/data, and is integrated within all AMD elements. The J-DIAMD plan was the source of data for this analysis. It identifies the Global C2 System (GCCS) as the COP, which displays the air and missile domain picture within the CONUS AMD C2 system.⁸¹ GCCS is also a near real time and secure C2 computer system.⁸² It is web-enabled, meaning engagement managers only need access to a secure internet host to receive access to the CONUS AMD C2 system COP.⁸³ The J-DIAMD plan also describes in detail the concept for integrating all AMD elements, using

⁸¹Emmer, 1-7.

⁸²Defense Information Systems Agency, “DISA C2 - GCCS-J,” <http://www.disa.mil/Services/Command-and-Control/GCCS-J> (accessed 29 April 2012).

⁸³Ibid.

a combination of Link 16 and C2BMC data feeds.⁸⁴ Secure voice communications are successfully accomplished using secure transmission equipment telephones, the defense red-switch network, and local operational communication networks.⁸⁵ In summary, this section's analysis observed the four attributes listed above as being consistent with doctrinal recommendations. However, one deficiency was identified; the redundancy of the COP.

Analysis revealed that completely redundant communications are not present within the CONUS AMD C2 system, a characteristic divergent from doctrinal requirements. Although GCCS provides a COP for all AMD elements, its backup is the C2, battle management, and communications (C2BMC) system.⁸⁶ C2BMC displays missile threats to the AMD C2 facilities, but not any other air tracks.⁸⁷ As a result, if GCCS becomes non-operational, the use of the C2BMC as a backup is not consistent with doctrinal requirements for redundant communications.

Averaging the performance measures for the C2 communication network equipment attributes produced an overall measure of performance for this C2 system variable. The result indicated a performance equal to ".80", indicating some room for improvement. This performance measure also signifies that improvements to the performance of the C2 communication network equipment can be made to increase the overall effectiveness of the CONUS AMD C2 system.

⁸⁴Emmer, 1-7.

⁸⁵Ibid., 1-8.

⁸⁶Ibid., 1-7.

⁸⁷Ibid.

This measure is the last of the three C2 physical entity performance variables. Table 6 summarizes the assessment of all three measures of performance. The next section analyzes the C2 structure by measuring the performance of the remaining two C2 system variables; unity of command/effort and levels of control.

Table 6. C2 Physical Entity Performances: Summary

<u>C2 System Variables</u>		NORTHCOM
	<u>People/Authorities</u>	0.75
	<u>Facilities</u>	0.67
	<u>C2 Comms Network Equip</u>	0.80

Source: Created by the author.

CONUS AMD C2 Structural Performance

This section of analysis aims to measure the performance of the CONUS AMD C2 system's structure. The two variables of the C2 system's structure measured in this section of analysis are unity of command/effort and levels of control. In order to measure these variables, this analysis first assembles the structure for the CONUS AMD C2 system, using unclassified and open source documents. This C2 structure represents how and where the physical entities are arranged within the CONUS AMD C2 system. After the CONUS AMD C2 structure is compared to the doctrinal example, it is analyzed by measuring its performance in terms of unity of command/effort and levels of control.

The measures of performance for this section are also objective. They do not measure how the C2 structure interacts with the environment. Instead, they simply

measure if the CONUS AMD C2 structure's consistency with the doctrinal concepts of unity of command/effort and levels of control. If the C2 structure exhibits unity of command or effort, this study rated its performance a "1". If not, the performance of the structure was indicated by a "0". The specific measure of performance for the concept levels of control is slightly different from unity of command/effort.

Level of control analysis measures the number of echelons between the individual authorized to order an engagement and the person making the actual engagement. Doctrinally, this number is required to be between one and three.⁸⁸ If the number of levels of control between the engagement authority and the individual conducting the engagement is between one and three, the C2 structure is consistent with doctrine and its performance was awarded with a "1". If the number of echelons is not between one and three, its structure is non-doctrinal and rated with a "0".

C2 Structural Comparison

In order to measure the performance of the CONUS AMD C2 structure, it was first necessary to reconstruct it. The C2 structure displayed in Figure 2 was derived by analyzing official NORTHCOM and STRATCOM missions, requirements, and responsibilities. Figure 3 represents the doctrinal AMD C2 structure.⁸⁹ Before measuring the performance of the C2 structure, a general comparison of the two structures was performed.

⁸⁸HQDA, FM 3-01.15, 33.

⁸⁹Ibid.

CONUS AMD C2 Structure

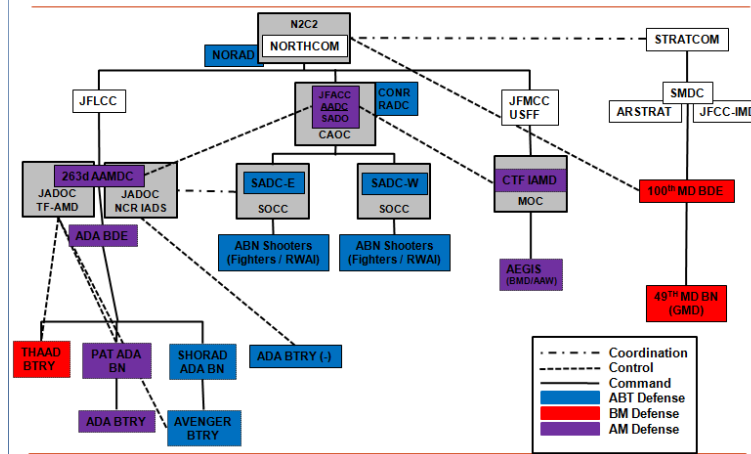


Figure 1. CONUS AMD C2 Structure

Source: Created by the author

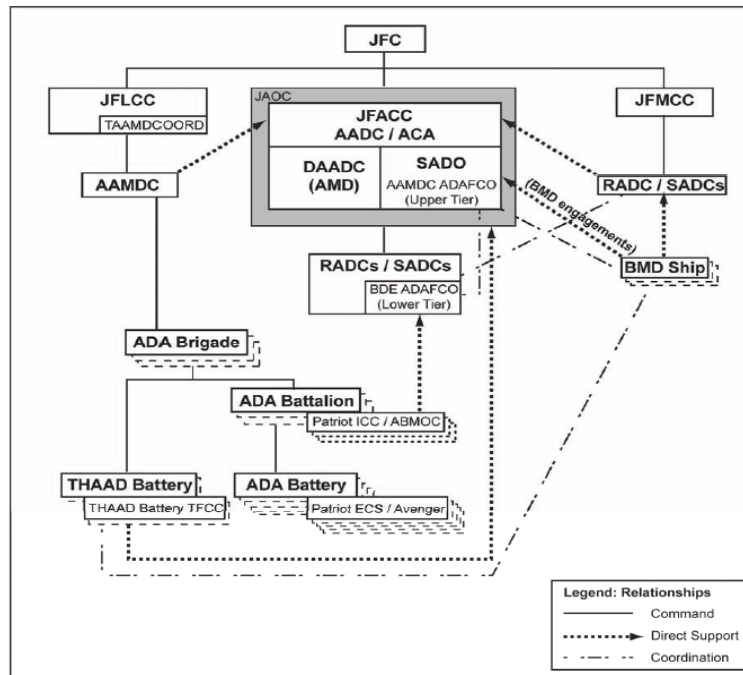


Figure 2. Doctrinal AMD C2 Structure

Source: Headquarters, Department of the Army (HQDA), Field Manual (FM) 3-01.15, *Integrated Air and Missile Defense System* (Washington, DC: Government Printing Office, May 2009), 33.

After comparing these two structures, two general observations emerge. The first and most obvious theme is that these two C2 structures appear significantly different. This is because the NORTHCOM AMD C2 structure is overlapped by the NORAD C2 structure. NORTHCOM's more recently assigned mission of missile defense, seems to be formed around the preexisting NORAD C2 structure. These overlapped responsibilities created redundant areas of operation, which is inconsistent with the economy of force principle of war. It is obvious that this C2 structure is not organized with the most "judicious employment and distribution of forces" possible.⁹⁰ The C2 structure for homeland AMD is also much more complex than the doctrinal C2 structure. Integrating AMD weapon systems into an effective fighting force is already a difficult task to accomplish.

It appears that construction of the CONUS AMD C2 structure was an attempt to simplify this integration by compartmentalizing the control of the AMD weapon systems by their branch of service. This second and somewhat less obvious observation is evident after comparing the two C2 structures. In the doctrinal structure, it is apparent that although the command of the AMD weapon systems is divided by service, they all directly support the AADC.⁹¹ The CONUS AMD C2 structure has compartmentalized the engagement chain by service ownership and weapon system. Although the AADC at the JAOC does integrate the Army, Navy, and Air Force AMD systems, this the lowest level of physical integration in the C2 structure. Conversely, the CONUS AMD C2 structure has actually taken steps back from the direction of other COCOMs and become less joint

⁹⁰Joint Chiefs of Staff, JP 1-02, 111.

⁹¹HQDA, FM 3-01.15, 33.

as a result. After identifying these two general observations, the performance of the CONUS AMD C2 structure was then measured, starting with the structure's unity of command/effort.

CONUS AMD C2 System Performance:
Unity of Command/Effort

The first C2 structural variable analyzed within the CONUS AMD C2 system was unity of command/effort. The performance of the structure in terms of unity of command/effort resulted in a measurement of "1.00", as highlighted in blue in table 7. Although this analysis indicates a perfect alignment with doctrinal requirements, one concern is discussed below.

Table 7. C2 Structural Performance: Unity of Command/Effort

	NORTHCOM
<u>Unity of Command/Effort</u>	1

Source: Created by the author.

This potential issue is the unknown relationship between the CONUS AMD C2 system and the GMD weapon system, which may be controlled by STRATCOM, the JFC, or the AADC. If GMD is operationally and tactically controlled by STRATCOM, unity of command is not present in the AMD of the CONUS. However, this relationship is still unknown and requires further investigation and analysis. This analysis did reveal that STRATCOM coordinates with NORTHCOM on ballistic missile related events.

Therefore, at a minimum, unity of effort is present between GMD and the CONUS AMD C2 system. As discussed in chapter 2, unity of command is doctrinally preferred in a C2 structure, but when this principle is not possible, unity of effort is required. This leads to the conclusion that the CONUS AMD C2 structure is consistent with doctrinal requirements because it exhibits unity of effort.

This section only partially analyzes the performance of the C2 structure as a whole. The following section continues the performance measurement of the C2 structure by analyzing its levels of control.

CONUS AMD C2 System Performance: Levels of Control

The second and final C2 structural variable analyzed within the CONUS AMD C2 system were levels of control. Overall, the level of control analysis for the CONUS AMD C2 system was rated with a score of “0”. The blue highlight depicts this result in table 8. Analysis determined that the performance of all seven attributes failed to meet doctrinal requirements, indicating a significant decrease to overall C2 system effectiveness. The far right column indicates the actual number of echelons between the engagement authority and the weapon system making the engagement. The left column indicates the performance of each attribute.

In order to calculate the levels of control for each weapon system, the engagement authority for the CONUS AMD C2 system first needed to be identified. The J-DIAMD project master plan defines that the engagement authority in the AMD of the homeland is typically retained at high levels, with either the Secretary of Defense or the President.⁹²

⁹²Emmer, ES-2.

This thesis' level of control analysis considered the Secretary of Defense as the CONUS AMD engagement authority. With the shooter identified in the left column of table 8 and the engagement authority identified as the Secretary of Defense, the number of echelons between the engagement authority and the shooter was simply counted.

Table 8. C2 Structural Performance: Levels of Control

		NORTHCOM	
<u>Levels of Control</u>		0	
ATTRIBUTES	Aegis AAW	0	4
	Aegis BMD	0	4
	THAAD Battery	0	4
	Patriot Battery	0	5
	DCA Fighter	0	4
	Avenger Battery	0	4
	NCR-IADS SHORAD	0	4

Source: Created by the author.

The level of control analysis indicated too many echelons between the engagement authority and the weapon system making the engagements. The number of echelons between proposed Aegis Anti Aircraft Warfare (AAW), Aegis Ballistic Missile Defense (BMD), THAAD Battery, Patriot battery, DCA fighter, Avenger battery, and National Capital Region (NCR) IADS SHORAD weapon systems were all above the maximum doctrinally required three echelons. Two fundamental issues within the CONUS AMD C2 system cause these non-doctrinal results.

First, the engagement authority for the defense of the homeland is held at a high and non-doctrinal level. This authority is normally delegated to the AADC who may even further delegate it to the tactical level (RADC/SADC).⁹³ Holding the engagement authority at the Secretary of Defense or Presidential level adds one or two additional echelons to the engagement chain.

Second, the use of a non-doctrinal C2 node in the CONUS AMD C2 system, the JADOC, also adds an additional echelon to the engagement chain, specifically for Army AMD weapon systems. The retention of the engagement authority for air and missile threats at higher levels and the use of non-doctrinal JADOC increases the levels of control within the CONUS AMD C2 system and decreases the C2 structure's performance.

This level of control analysis is the last of the two C2 structural performance variables. Table 9 summarizes these measures of performance. The next step in this thesis' analysis uses the performance results from these two variables to assist in the determination of the overall effectiveness of the CONUS AMD C2 system.

Table 9. C2 Structural Performances: Summary

<u>C2 System Variables</u>	NORTHCOM
<u>Unity of Command/Effort</u>	1.00
<u>Levels of Control</u>	0.00

Source: Created by the author.

⁹³HQDA, FM 3-01.15, 19.

CONUS AMD C2 System Effectiveness

Overall, this thesis determined the effectiveness of the CONUS AMD C2 system to equal “.64”, which serves as the basis for answering the primary research question. The yellow highlight indicates this result in table 10. This result was determined by averaging the performance of the five C2 system effectiveness variables: C2 people/authorities, facilities, communications network equipment, unity of command/effort, and levels of control.

Table 10. CONUS AMD C2 System Effectiveness

<u>C2 System Variables</u>	NORTHCOM
<u>People/Authorities</u>	0.75
<u>Facilities</u>	0.67
<u>C2 Comms Network Equip</u>	0.80
<u>Unity of Command/Effort</u>	1.00
<u>Levels of Control</u>	0.00
<u>Overall System Effectiveness</u>	0.64

Source: Created by the author.

This measure of C2 system effectiveness is only meaningful when compared to the doctrinal standard of “1.00”. This comparison signifies that the model is indicating that improvements can be made to increase the system’s overall effectiveness. The next and final chapter of this thesis first explores some parallels between the results of this analysis and those from CONUS AMD exercise reports before exploring recommendations to improve the overall effectiveness of the system.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Thesis Question

The objective of this thesis was to determine the effectiveness of the NORTHCOM C2 system for the active AMD of the CONUS. Answering three subordinate questions first established a model to measure the effectiveness of an AMD C2 system. Using this model, they then aimed to measure the effectiveness of the AMD C2 system by analyzing the performance of five CONUS AMD C2 system variables: people/authorities, facilities, communications equipment, unity of command/effort, and levels of control. Finally, this thesis calculated the CONUS AMD C2 system's effectiveness by averaging the performance of these five C2 system variables.

Findings

Based on the evidence presented, the overall effectiveness of the CONUS AMD C2 system can be improved. Green's model produced a system effectiveness rating of "0.64." When compared to the doctrinal standard of "1.00", it is clear that improvements can be made within the system. More important than the numerically calculated measure of effectiveness is the model's identification of five C2 system attributes that negatively affected the current system's effectiveness. Collectively, these attributes concern the absence of a redundant COP, the roles and responsibilities of the brigade ADAFCO, RADC/SADC, and JADOC, and the high number of levels of control within the CONUS AMD C2 system. In order to make recommendations for improvement, this chapter first explores the attributes that decreased overall system effectiveness.

The first attribute that negatively influenced overall system effectiveness was the lack of redundant communications. JP 3-01 establishes the requirement for redundant C2 communications equipment within an AMD C2 system. The publication states that all DCA weapon systems must have redundant common operating displays.⁹⁴ The CONUS AMD C2 system uses GCCS as its primary COP; however, the backup system is C2BMC. The C2BMC system is only capable of displaying missile threats, eliminating a redundant common display for hostile aircraft, cruise missiles, or unmanned aerial vehicles. This lack of a redundant AMD COP is one attribute that decreased the overall effectiveness of the CONUS AMD C2 system.

The absence of a brigade ADAFCO in the CONUS AMD C2 system was another attribute that decreased overall system effectiveness. FM 3-01.15 requires that the brigade ADAFCO is the only link between lower tier Army AMD weapon systems and the RADC/SADC.⁹⁵ In addition to the responsibility of the brigade ADAFCO, FM 3-01.15 also requires that they collocate with a RADC/SADC.⁹⁶ Neither of these requirements are met in the CONUS AMD C2 system as the J-DIAMD plan does not discuss the utilization of brigade ADFACOs in CONUS AMD operations. This practice is unheard of in the rest of the AMD community. NORTHCOM allows such a drastic shift from these C2 AMD requirements because of the non-doctrinal roles and responsibilities assigned to their RADC/SADCs.

⁹⁴Joint Chiefs of Staff, JP 3-01, V-2.

⁹⁵HQDA, FM 3-01.15, 32.

⁹⁶Ibid.

The RADC/SADC is a third system attribute that contributes negatively to the overall effectiveness of the C2 system. RADC/SADCs operating in the CONUS AMD C2 system do not utilize brigade ADAFCOs because they do not have the full complement of required responsibilities, as outlined in FM 3-01.15. FM 3-01.15 states that the JFC may choose to divide a large and complex JOA into smaller and more manageable pieces.⁹⁷ Doctrinally, these smaller portions of the JOA are controlled by air defense commanders; responsible for all DCA assets within their assigned region or section.⁹⁸ However, in the defense of the homeland, the JFC and JFACC have not delegated control of Army AMD weapon systems to the RADC/SADCs.⁹⁹ This lack of delegated responsibility undermines their duty description as air defense commanders and puts an unnecessary strain upon JFACC's span of control. The roles and responsibilities of RADC/SADCs in the defense of the homeland are non-doctrinal and serve to decrease the overall effectiveness of the CONUS AMD C2 system.

The fourth attribute that decreases the overall effectiveness of the CONUS AMD C2 system is the non-doctrinal use of a JADOC as a C2 facility. Joint doctrine does not require the use of a JADOC in joint AMD operations. However, the J-DIAMD plan uses the JADOC heavily as a C2 facility.¹⁰⁰ The J-DIAMD plan identifies the JADOC as the C2 facility for control of Army AMD weapon systems.¹⁰¹ This responsibility pulls the

⁹⁷Ibid., 48.

⁹⁸Ibid.

⁹⁹Emmer, 1-6.

¹⁰⁰Ibid.

¹⁰¹Ibid.

control of Army AMD weapon systems away from the RADC/SADC and complicates the CONUS AMD C2 structure. The engagement capabilities of multiple weapon systems may overlap without a single air defense commander with the situational awareness necessary to de-conflict those fires. The use of a JADOC diverges from doctrinal guidelines and decreases the effectiveness of the overall CONUS AMD C2 system.

The last attribute that decreases the effectiveness of the homeland's AMD C2 system are its levels of control. According to FM 3-01.15, the number of echelons between the engagement authority and the weapon system making the engagement should range between one and three.¹⁰² This thesis' analysis indicates that the levels of control within the CONUS AMD C2 system all exceed this range. This deficiency is attributable to the assignment of the engagement authority at a non-doctrinal level.¹⁰³ The J-DIAMD plan defines the engagement authority for CONUS AMD to be the Secretary of Defense or the President.¹⁰⁴ FM 3-01.15 dictates that at a minimum the JFACC be delegated engagement authority for air threats within the JOA.¹⁰⁵ The manual also recommends the delegation of the engagement authority down to the RADC/SADC at the tactical level of operations during hostilities.¹⁰⁶ Keeping the engagement authority at the strategic national level expands the engagement control chain and as a result, decreases the effectiveness of the CONUS AMD C2 system.

¹⁰²HQDA, FM 3-01.15, 33.

¹⁰³Emmer, ES-2.

¹⁰⁴Ibid.

¹⁰⁵HQDA, FM 3-01.15, 10.

¹⁰⁶Ibid.

Validation

One drawback identified by this thesis with measuring the effectiveness of an AMD C2 system is that the result is always a probability. It is only a possibility that the C2 system will perform as effectively against an uncontrolled and unpredictable enemy as it did in its evaluation. This shortcoming is true whether the effectiveness of the system was measured using a model, as this thesis did, or by conducting an event driven scenario, as recommended by TRAC.

In an attempt to validate the findings of this thesis' analysis, this section describes some parallels between the five identified deficiencies and the results of several recent CONUS AMD exercises. Ardent Sentry 11 and Vigilant Shield 12 were executed in 2011 and both used event driven scenarios to measure the performance of CONUS AMD. A major theme evident in the exercise reports indicated that DCA operations were inconsistent with doctrinal standards. This divergence caused confusion with engagement operations. Analysis of these exercise reports indicate the identification of the engagement authority, the roles and responsibilities of the brigade ADAFCO and JADOC, and the COP were three areas that contributed directly to this confusion. These three factors parallel the result of this thesis' analysis.

One factor identified from the Ardent Sentry exercise report that parallels the result of this thesis' analysis is the identification of the engagement authority. The Ardent Sentry report indicated that there was confusion from "most operators" as to who held the engagement authority.¹⁰⁷ The confusion caused by the use of a non-doctrinal engagement authority from the Ardent Sentry exercise is a similar result to that identified within this

¹⁰⁷32d AAMDC, 1.

thesis. Both Green's model, used in this thesis' analysis, and the exercise scenario indicated that the effectiveness of the C2 system decreased as the result of a non-doctrinal engagement authority.

Another factor that decreased effectiveness identified in both exercises and this thesis was centered on the non-doctrinal roles and responsibilities of the brigade ADAFCO and JADOC. The Vigilant Shield report indicated that the brigade ADAFCO did conduct operations during the exercise, but from inside the JADOC.¹⁰⁸ A brigade ADAFCO must be collocated with the RADC/SADC in order to effectively deconflict lower tier fires. This exercise observation is comparable to this thesis' analytical results relating the roles and responsibilities of the brigade ADAFCO and JADOC to system effectiveness.

The last factor similar to both Ardent Sentry and this thesis' analysis is the relationship between the use of C2BMC as a COP and system effectiveness. The Ardent Sentry report indicated that the COP for the exercise was C2BMC.¹⁰⁹ The report states the exercise introduced C2BMC to increase the situational awareness of the engagement managers, but also identified that it was incapable of displaying all types of threats.¹¹⁰ This thesis' analysis indicated that NORTHCOM has made improvements to its COP by officially utilizing GCCS. However, in both cases, the effectiveness of the C2 system decreased because of utilizing C2BMC within the CONUS AMD C2 system, either as a primary or redundant COP.

¹⁰⁸Kim, 2.

¹⁰⁹32d AAMDC, 2.

¹¹⁰Ibid.

In summary, parallels connect the lessons learned from NORTHCOM's execution of Ardent Sentry and Vigilant Shield in 2011 and the results of this thesis' analysis. The use of a non-doctrinal C2 system, including the roles and responsibilities of the engagement authority, brigade ADAFCO and JADOC, and the use of the C2BMC as a COP all resulted in a decreased level of performance and overall system effectiveness.

Overall, the 2011 Ardent Sentry and Vigilant Shield exercise reports indicated mission success. However, the measured effectiveness of the CONUS AMD C2 system from either these exercises or this thesis do not mean that the system will perform as successfully when faced with an actual air or missile threat. This section aimed to validate this thesis' results by drawing parallels with the lessons learned from relevant and recent CONUS AMD exercises. The next section attempts to increase the effectiveness of the C2 system by making recommendations to improve the performance of the five identified deficiencies.

Recommendations

Based on analysis using Green's model for C2 system effectiveness, there are three recommendations key to improving the effectiveness of the CONUS AMD C2 system. This thesis' primary recommendation is to establish doctrinal roles and responsibilities for the NORTHCOM RADC/SADC within the homeland's AMD C2 system. The establishment of these responsibilities leads directly to positive changes regarding the roles and responsibilities of the brigade ADAFCO and the JADOC. Lowering the CONUS AMD engagement authority is the second recommendation. Doctrinally aligning the engagement authority will decrease the high number of levels of

control and increase overall system effectiveness. Finally, this thesis recommends the establishment of a redundant COP.

This thesis' first recommendation is to delegate doctrinal roles and responsibilities to the NORTHCOM RADC/SADCs. This means that all AMD units and weapon systems within a region or sector should fall under the tactical control of the RADC/SADC. BMD and air defense missions then become primarily the responsibility of the RADC/SADC. This recommendation integrates the C2 structure at the tactical level and reduces the redundancy of AMD operations. This recommendation is the most significant recommendation to the overall CONUS AMD C2 system effectiveness because it also forces positive changes regarding the use of the brigade ADAFCO and JADOC.

Delegating AMD tactical control to the RADC/SADC reinforces the requirement to establish brigade ADAFCOs at the CRC. In the current CONUS AMD C2 system, brigade ADAFCOs are not necessary because the RADC/SADCs do not have the authority to control Army AMD fires. After following doctrinal requirements and assigning this authority to the RADC/SADC, it is now imperative that the brigade ADAFCO serves as a representative of the RADC/SADC and the controlling authority for Army AMD fires. The establishment of a brigade ADAFCO in the CRC, as an agent of the RADC/SADC, increases the C2 system's overall effectiveness by allowing the brigade ADAFCO to deconflict lower tier fires.

Assigning the RADC/SADC doctrinal authorities also eliminates the role of the JADOC in the CONUS AMD C2 system. The removal of this non-doctrinal C2 facility also increases the overall effectiveness of the system. The current CONUS AMD C2 system utilizes the JADOC to control the fires of Army AMD weapon systems.

Doctrinally, this responsibility rests with the RADC/SADC that manage operations from a CRC. This C2 facility is perfectly capable of managing all AMD operations within their area of responsibility. The operation of a JADOC within an area already utilizing a CRC is overly redundant and reduces the effectiveness of the CONUS AMD C2 system. Delegating the RADC/SADC their doctrinal authorities increases the effectiveness of the CONUS AMD C2 system because it also removes the need for a JADOC to control Army AMD fires.

The second recommendation is to lower the authority for engagements of air and missile threats to the homeland. The J-DIAMD master plan specifies that the Secretary of Defense of the President regularly retains the authority to engage targets within the homeland. Maintaining this authority at such a high level increases the echelons between the decision maker and the individual conducting the engagement and the overall time required to order the engagement. Time is of the essence when conducting the engagement of air and missile threats and often times, AMD weapon systems have less than a minute to engage a threat. In a threatening environment, the authority to engage air and missile threats must be delegated to the lowest possible level. This concept of decentralizing execution is a central tenet of joint air operations, and necessary to achieve “effective control and foster initiative, responsiveness, and flexibility.”¹¹¹ Giving the AADC or RADC/SADC the authority to engage air and missile threats to their areas of responsibility increases the performance of the homeland’s C2 structure and the effectiveness of the CONUS AMD C2 system.

¹¹¹Joint Chiefs of Staff, Joint Publication (JP) 3-30, *C2 for Joint Air Operations* (Washington, DC: Government Printing Office, 2010), I-3.

This study's last recommendation is to establish a redundant COP for NORTHCOM AMD operations. Redundant communications are doctrinally required within a C2 system. NORTHCOM recognizes the need to improve their COP and they have made significant improvements since the Ardent Sentry exercise in May 2011. However, the current reliance on C2BMC as a backup to their primary COP does not meet doctrinal requirement because it fails to display ABTs. Implementing a backup COP that displays and disseminates both ABT and TBM threats will increase the effectiveness of the CONUS AMD C2 system.

In summary, this thesis makes three overall recommendations to increase the effectiveness of the homeland's AMD C2 system. Giving NORTHCOM's RADC/SADC their doctrinally defined responsibility to control all DCA assets within their assigned area, lowering the overall ABT and TBM engagement authority, and developing a redundant COP will improve the effectiveness of the CONUS AMD C2 system. Implementing these three recommendations corrects the five deficiencies identified in the analysis of this thesis and brings the system effectiveness calculated by Green's model up to a "1.00".

Area for Further Study

The C2 relationship between NORTHCOM and the GMD weapon system was one area studied that produced an inconclusive result. This relationship requires further study because it influences the effectiveness of the CONUS AMD C2 system. This study's results were inconclusive in respect to the roles and responsibilities of the AADC because its research discovered conflicting evidence regarding the operational control of the GMD weapon system. Using unclassified and open source data, it was unclear

whether GMD falls under the operational control of NORTHCOM's AADC or STRATCOM. The GMD program is a critical component of the homeland's BMD system and its C2 relationship with NORTHCOM must be studied further to analyze its impact on the CONUS AMD C2 system's effectiveness.

Conclusion

The defense of the American people and the CONUS from air and missile attacks is a vital national interest. The tragic events on 11 September 2001 demonstrated that air and missile threats to the homeland by terrorist organizations and hostile states are a reality. Fortunately, the United States has the right organizations and capable AMD weapon systems to defeat these types of threats. An effective C2 system integrates these technologically advanced AMD weapon systems into an efficient fighting force and is a critical factor in defending the homeland from these air and missile threats.

The goal of this thesis was to determine the effectiveness of the current CONUS AMD C2 system. To this end, it analyzed the performance of five AMD C2 system variables and determined a quantitative rating for the effectiveness of the homeland's AMD C2 system. More important than this numerical result was the identification of five C2 system attributes whose performance can be improved upon in order to increase the system's overall effectiveness. These five deficiencies can be corrected with the implementation of three recommendations.

These three recommendations are to delegate the doctrinal AMD roles and responsibilities to the RADC/SADC, lower the overall authority for engaging air and missile threats, and establish a redundant COP. Implementing these three

recommendations increases the effectiveness of the overall system by improving the performance of the deficient C2 system attributes identified in this thesis.

These recommendations improve the effectiveness of the C2 system in two ways. First, they give the C2 system the doctrinally required people/authorities, facilities, and communications equipment necessary for an effective system. Second, these recommendations restructure the C2 system into one that is doctrinally consistent.

This new CONUS AMD C2 system is more effective because it reduces redundant roles and responsibilities and decentralizes the execution of the homeland's AMD. Just as important, this new C2 system allows for the implementation of doctrinal AMD C2 tactics, techniques, and procedures and eliminates the need stated to create new processes that are unique to defending the homeland, as stated in the J-DIAMD plan.¹¹²

As we look to the future, the only known constant is that the enemy will continue to evolve their capabilities and the means to employ them. The model used in this thesis to calculate system effectiveness changes alongside the evolution of doctrine. It is essential that while the capabilities of the enemy are constantly analyzed, so too must the capabilities and effectiveness of the homeland to defend itself against these types of threats.

¹¹²Emmer, ES-3.

GLOSSARY

Air and Missile Defense (AMD)—active ground, sea, or air based DCA intended to destroy, defeat, or neutralize the effectiveness of hostile air and missile threats on defended assets.

Air and Space Operations Center (AOC)—the senior C2 facility of the Air Force component commander that provides C2 of Air Force and air and space operations and coordinates with other components and Services. The AOC also typically referred to as a JAOC or CAOC (Joint or Coalition).¹¹³

Air Defense Artillery Fire Control Officer (ADAFCO)—the individual responsible for controlling Army Air and Missile Defense (AMD) for designated assets/areas on the defended asset list (DAL) within an assigned region/sector and for coordinating and monitoring the tracking and engagement activities of individual Army AMD fire units. The ADAFCO is collocated with an AADC, RADC, or SADC that is controlling Army AMD weapon systems.¹¹⁴

Area Air Defense Commander (AADC)—the component commander with the preponderance of DCA assets and the command, control and communications capability to execute integrated air and missile defense operations. This commander is normally also assigned as the Joint Force Air Component Commander (JFACC).¹¹⁵

Area Air Defense Plan (AADP)—the defensive plan that integrates all active air defense design, passive defense measures, and the C2 system to provide a comprehensive approach to defending against the threat. It specifically integrates theater and/or Joint Operating Area (JOA) wide DCA priorities, authorities, procedures, tasks, and actions approved by the JFC.¹¹⁶

Ballistic Missile Defense System (BMDS)—a complex system of networked ground and sea-based radars, interceptors, and C2 elements being developed, tested, and deployed by the United States to counter ballistic missiles of all ranges.

Command and Control (C2)—“the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. C2 functions are performed through an arrangement of personnel,

¹¹³Joint Chiefs of Staff, JP 1-02, 7.

¹¹⁴Joint Chiefs of Staff, JP 3-01, II-12.

¹¹⁵Joint Chiefs of Staff, JP 1-02, 23.

¹¹⁶Joint Chiefs of Staff, JP 3-01, XVII.

equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.”¹¹⁷

Command and Control Measures of Effectiveness (C2MOE)—“a measure of how a C2 system affects the other entities within an operational environment (e.g., reaction time, susceptibility to deception). C2MOE are measured relative to some perceived standard, which is often implicit (e.g., how a perfect C2 system would perform). C2MOE are scenario-dependent.”¹¹⁸

Command and Control Measures of Performance (C2MOP)—“related to the inherent parameters (physical, structural, task/activity, and process) but represents a measurement of an attribute of system behavior (e.g., throughput, error rate, process resource requirements (time, space, quantities of physical entities)). C2MOP are internal to the system being analyzed and are scenario-independent. These may be derived from measures of effectiveness”¹¹⁹

Command and Control Process—“reflects the functions carried out by the C2 system—sensing, assessing, generating, selecting alternatives, planning, and directing.”¹²⁰ C2 processes interact with the environment and their performance is normally measured by conducting an event driven scenario or simulation.

Command and Control System—“viewed as having three components: physical entities, structure, and C2 process. Physical entities refer to hardware, software, people, and facilities. Structure refers to the relationship between physical entities, procedures, protocols, and concepts of operation and information patterns. It can reflect the effects of doctrine, the scenario, and time and space.”¹²¹

Integrated Air Defense System (IADS)—integrated air defense capabilities from different components with a robust C2 structure. This system is sometimes differentiated from AMD because it does not necessarily involve the defense of assets from missile threats.

Intercontinental Ballistic Missile (ICBM)—ballistic missile with a range greater than 5500km.

¹¹⁷Joint Chiefs of Staff, JP 1-02, 64.

¹¹⁸Ibid.

¹¹⁹TRADOC Analysis Center, 17.

¹²⁰Ibid.

¹²¹Green and Johnson, 5.

Intermediate Range Ballistic Missile (IRBM)—ballistic missile with a range greater than 3000 km, but less than 5500km.

Joint Forces Air Component Commander (JFACC)—“the commander within a unified command, subordinate unified command, or joint task force responsible to the establishing commander for recommending the proper employment of assigned, attached, and/or made available for tasking air forces; planning and coordinating air operations, or accomplishing such operational missions as may be assigned.”¹²² This commander is usually also assigned the responsibilities of the Area Air Defense Commander (AADC).

Medium Range Ballistic Missile (MRBM)—ballistic missile with a ranges greater than 1000km, but less than 3000km.

Regional Air Defense Commander (RADC)—commander subordinate to the area air defense commander (AADC) and responsible for DCA in an assigned region.¹²³

SCUD—“the most common form of tactical ballistic missile (TBM), designed by the Soviet Army in the early 1950s. The Scud is the most proliferated and modified TBM in the world and is capable employing of nuclear, biological, chemical or high explosive warheads.”¹²⁴

Sector Air Defense Commander (SADC)—commander subordinate to an area/regional air defense commander and responsible for DCA in an assigned sector.¹²⁵

Short Range Ballistic Missile (SRBM)—ballistic missile with a range less than 1000km.

Weapon of Mass Destruction (WMD)—“chemical, biological, radiological, or nuclear weapon capable of a high order of destruction or causing mass casualties and excludes the means of transporting or propelling the weapon where such means is a separable and divisible part from the weapon.”¹²⁶

¹²²Joint Chiefs of Staff, JP 1-02, 185.

¹²³Ibid., 289.

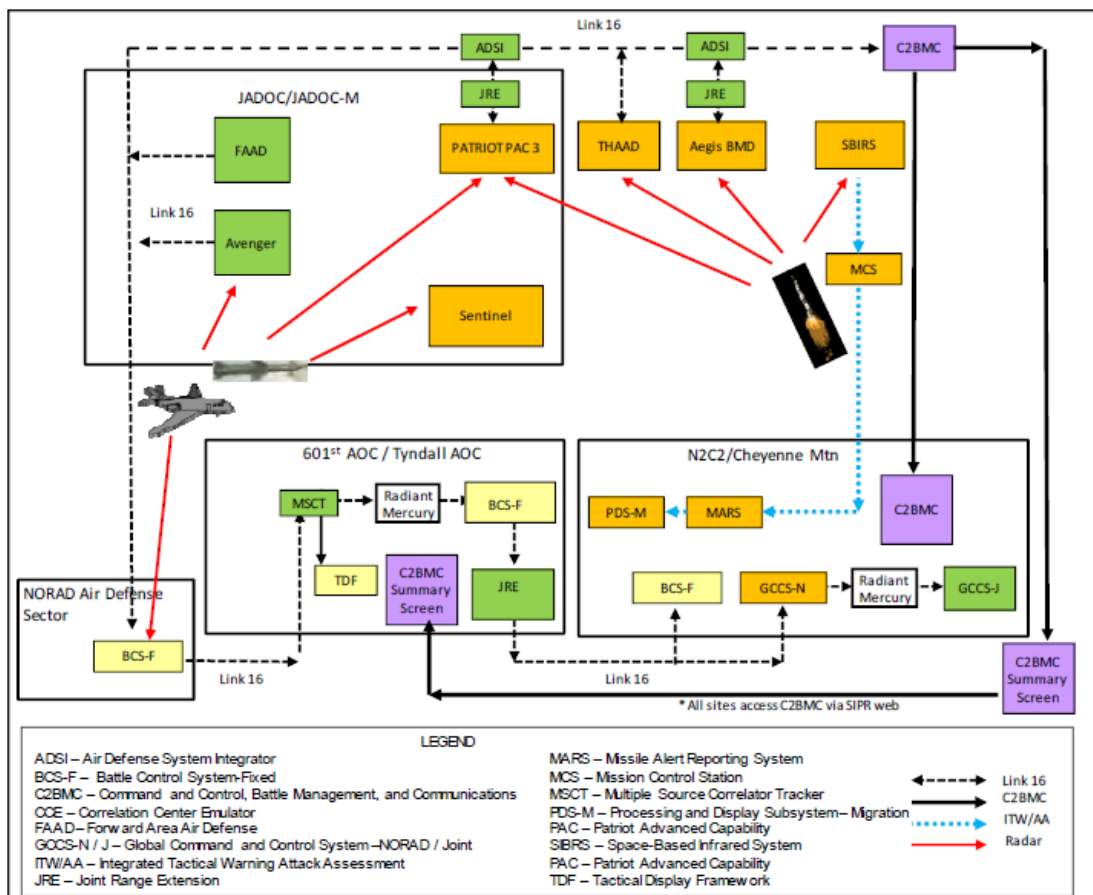
¹²⁴Zaloga, 17.

¹²⁵Ibid., 304.

¹²⁶Joint Chiefs of Staff, JP 1-02, 369.

APPENDIX A

J-DIAMD Communications Network Plan

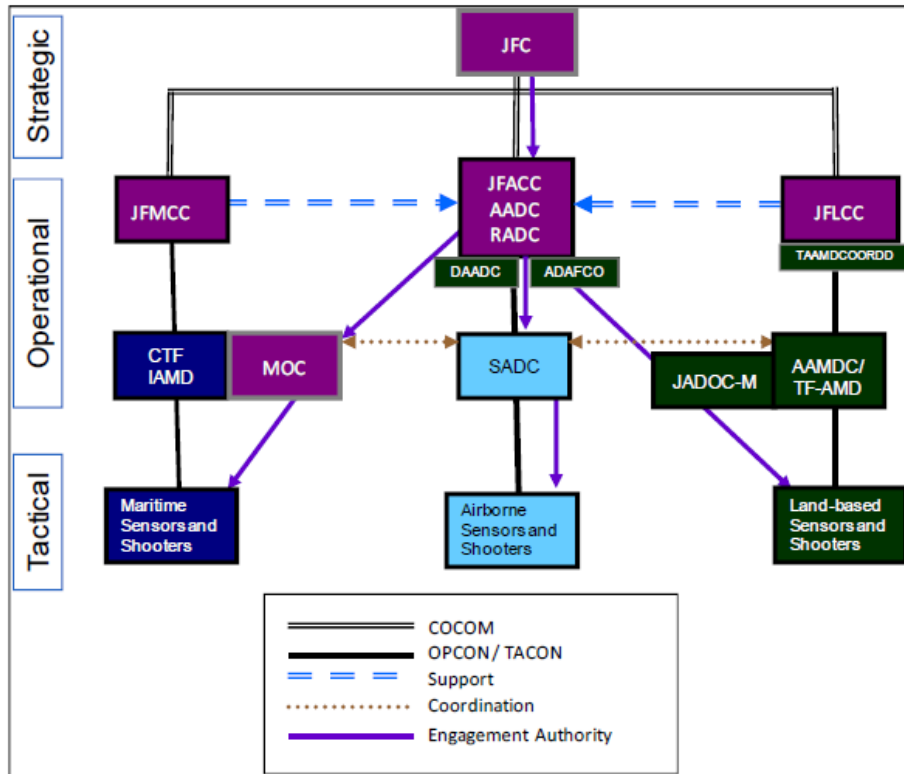


Communications Network Plan for J-DIAMD

Source: Mark Emmer, Robert Schwartz, James Benton, David Blessinger, Leonard Edwards, Michael Knudsen, Milton Foster, Paul Fletcher, Kevin Murphy, Rick Sindel, and Ty Wolfer, *Joint Deployable Integrated Air and Missile Defense (J-DIAMD) Joint Test (JT) Project Master Plan* (Washington, DC: Government Printing Office, 2011), 1-7.

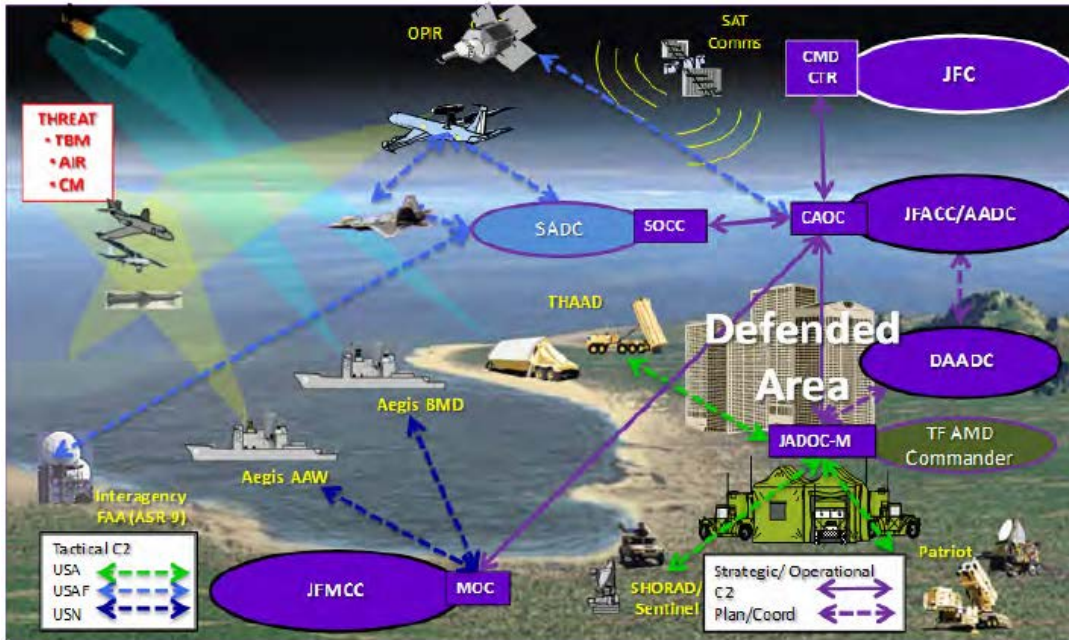
APPENDIX B

J-DIAMD C2 Structures



J-DIAMD C2 Structure

Source: Mark Emmer, Robert Schwartz, James Benton, David Blessinger, Leonard Edwards, Michael Knudsen, Milton Foster, Paul Fletcher, Kevin Murphy, Rick Sindel, and Ty Wolfer, *Joint Deployable Integrated Air and Missile Defense (J-DIAMD) Joint Test (JT) Project Master Plan* (Washington, DC: Government Printing Office, 2011), 1-6.



J-DIAMD C2 Structure—An Operational Scenario

Source: Mark Emmer, Robert Schwartz, James Benton, David Blessinger, Leonard Edwards, Michael Knudsen, Milton Foster, Paul Fletcher, Kevin Murphy, Rick Sindel, and Ty Wolfer, *Joint Deployable Integrated Air and Missile Defense (J-DIAMD) Joint Test (JT) Project Master Plan* (Washington, DC: Government Printing Office, 2011), 1-4.

BIBLIOGRAPHY

Books

- Ackoff, Russell L. *The Art of Problem Solving*. New York: John Wiley and Sons, Inc., 1978.
- Creswell, John. W. *Qualitative Inquiry and Research Design*. Thousand Oaks, CA: Sage Publications, Inc., 2007.
- . *Research Design; Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, CA: SAGE Publications, Inc., 2009.
- Zaloga, Steven J. *Scud Ballistic Missile and Launch Systems 1955-2005*. Westminster, UK: Osprey Direct, 2006.

Government Documents

- 32d Army Air and Missile Defense Command. “Ardent Sentry; Proof of Concept IAMDC NORTHCOM.” Trip Report, Fort Bliss, TX, May 2011.
- Department of Defense. *Ballistic Missile Defense Review*. Washington, DC: Government Printing Office, February 2010.
- Defense Science Board Task Force. “Patriot Performance Report Summary.” Report, Washington, DC, January 2005).
- Green, John M., and Bonnie Johnson. “Towards a Theory of Measures of Effectiveness.” Master’s thesis, Naval Postgraduate School, Monterey, CA, 2002.
- Emmer, Mark, Robert Schwartz, James Benton, David Blessinger, Leonard Edwards, Michael Knudsen, Milton Foster, Paul Fletcher, Kevin Murphy, Rick Sindel, and Ty Wolfer. *Joint Deployable Integrated Air and Missile Defense (J-DIAMD) Joint Test (JT) Project Master Plan*. Washington, DC: Government Printing Office, 2011.
- Headquarters, Department of the Army (HQDA). Field Manual (FM) 3-01.15, *Integrated Air and Missile Defense System*. Washington, DC: Government Printing Office, May 2009.
- House Committee on Armed Services. *National Defense Authorization Act for Fiscal Year 2011*. Washington, DC: Government Printing Office, 2010.

Joint Chiefs of Staff. Joint Publication (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*. Washington, DC: Government Printing Office, 2010.

———. Joint Publication (JP) 3-01, *Countering Air and Missile Threat*. Washington, DC: Government Printing Office, 2007.

———. Joint Publication (JP) 3-30, *C2 for Joint Air Operations*. Washington, DC: Government Printing Office, 2010.

Kim, Wong. “Vigilant Shield 12.” Executive Summary, Fort Sill, OK, November 2011.

Office of the President. *National Security Strategy*. Washington, DC: Government Printing Office, May 2010.

TRADOC Analysis Center. *C2 Measures of Effectiveness Handbook*. Fort Leavenworth, KS: Government Printing Office, October 1993.

Periodicals

Barkley, Daniel. “Ballistic Missile Proliferation: An Empirical Investigation.” *The Journal of Conflict Resolution* 52, no. 3 (22 February 2008): 455-473.

Mietzner, Dana, and Guido Reger. “Advantages and Disadvantages of Scenario Approaches for Strategic Foresight.” *International Journal of Technology and Intelligence Planning* 1, no. 2 (2005): 220-239.

Timmerman, Kenneth R. “New Iranian Missile May Outflank U.S. Defenses.” *Insight on the News* 15, no. 19 (24 May 1999): 15-19.

Internet Sources

American Society for Quality. “Matrix Diagram-ASQ.” <http://asq.org/learn-about-quality/new-management-planning-tools/overview/matrix-diagram.html#L> (accessed 24 April 2012).

Council of Foreign Relations. *Iran's Ballistic Missile Program*. <http://www.cfr.org/iran/irans-ballistic-missile-program/p20425> (accessed 5 April 2012).

Defense Information Systems Agency. “DISA C2 - GCCS-J.” <http://www.disa.mil/Services/Command-and-Control/GCCS-J> (accessed 29 April 2012).

First Air Force. “First Air Force Mission.” <http://www.1af.acc.af.mil/main/welcome.asp> (accessed 12 January 2012).

Kalantari, Hashem. "Iran Tests New Missile From Warship: Reports." *Reuters*.
[http://www.reuters.com/article/2008/12/07/us-iran-missile-
idUSTRE4B60CO20081207](http://www.reuters.com/article/2008/12/07/us-iran-missile-idUSTRE4B60CO20081207) (accessed 7 September 2011).

McHale, Mary. *601st AOC Helps Support Key West Exercise*. [http://www.1af.acc.af.mil/
news/story.asp?id=123279546](http://www.1af.acc.af.mil/news/story.asp?id=123279546) (accessed 3 March 2012).

North American Aerospace Defense Command. "About NORAD." [http://www.norad.
mil/about/index.html](http://www.norad.mil/about/index.html) (accessed 26 September 2011).

SMDC/ARSTRAT. "SMDC/ARSTRAT Operations." [http://www.smdc.army.mil/
2008/SpaceBMD.asp](http://www.smdc.army.mil/2008/SpaceBMD.asp) (accessed 18 November 2011).

The Arms Export Control Act. 22 U.S.C. 2778. [http://uscode.house.gov/search/
criteria.shtml](http://uscode.house.gov/search/criteria.shtml) (accessed 5 April 2012).

US Northern Command. "About USNORTHCOM." [http://www.northcom.mil/
about/index.html](http://www.northcom.mil/about/index.html) (accessed 17 September 2011).

INITIAL DISTRIBUTION LIST

Combined Arms Research Library
U.S. Army Command and General Staff College
250 Gibbon Ave.
Fort Leavenworth, KS 66027-2314

Defense Technical Information Center/OCA
825 John J. Kingman Rd., Suite 944
Fort Belvoir, VA 22060-6218

Mr. Jeffrey Oeser
DJMO
USACGSC
100 Stimson Ave.
Fort Leavenworth, KS 66027-2301

Mr. Dale Eikmeier
DJMO
USACGSC
100 Stimson Ave.
Fort Leavenworth, KS 66027-2301

Dr. O. Shawn Cupp
DLRO
USACGSC
100 Stimson Ave.
Fort Leavenworth, KS 66027-2301