DEVELOPING A SERIOUS GAME TO EXPLORE JOINT ALL-DOMAIN COMMAND AND CONTROL

THESIS

Nathaniel W. Flack, Captain, USAF

AFIT-ENG-MS-20-M-019

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT-ENG-MS-20-M-019

DEVELOPING A SERIOUS GAME TO EXPLORE JOINT ALL-DOMAIN COMMAND AND CONTROL

THESIS

Presented to the Faculty

Department of Electrical and Computer Engineering

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Cyber Operations

Nathaniel W. Flack, B.S.C.E.

Captain, USAF

March 26, 2020

AFIT-ENG-MS-20-M-019

DEVELOPING A SERIOUS GAME TO EXPLORE JOINT ALL-DOMAIN COMMAND AND CONTROL

THESIS

Nathaniel W. Flack, B.S.C.E.
Captain, USAF

Committee Membership:

Mark G. Reith, Ph.D
Chair

Gilbert L. Peterson, Ph.D
Member

Lieutenant Colonel Alan C. Lin, Ph.D
Member

AFIT-ENG-MS-20-M-019

Abstract

Changes in the geopolitical landscape and increasing technological complexity have prompted the U.S. Military to coin Multi-Domain Operations (MDO) and Joint All-Domain Command and Control as terms to describe an over-arching strategy that frames the complexity of warfare across both traditional and emerging warfighting domains. Teaching new and advanced concepts associated with these terms requires both innovation as well as distinct education and training tools in order to realize the cultural change advocated by senior military leaders. Battlespace Next (BSN), a Collectable Card Game, was developed to teach concepts integral to MDO and initiate discussion on military strategy. BSN, is designed to provide an engaging learning tool that educates advanced capabilities such as cyber, information operations, and electronic warfare in a multi-domain conflict, seeking to reveal the synergy between military capabilities and challenge learners to innovate by creating their own strategies for victory. This thesis describes an extensible framework for modeling and reasoning about MDO concepts using specific game elements, and presents empirical feedback from 103 military play testers evaluating the game. Survey and play test results provide evidence that the game teaches current MDO concepts and delivers an engaging, hands-on learning experience. Specifically, this thesis suggests it improved military readiness in seven areas related to MDO in at least 68% of participants. Furthermore, 90% reported being focused during the session, 76% wrote they enjoyed playing the game, and over half expressed they would play the game again in their free time. Military instructors reported game integration would require at most 1/20 of the time it would take to create their own interactive tool. The results inform current efforts enhancing military learning while driving appropriate transformations to prepare individuals to navigate in a complex and contested environment.

Dedicated to Christ, my Savior,

who loved me and gave himself for me (Galatians 2:20).

Soli Deo Gloria

Acknowledgements

Only one life twill soon be past, only what's done for Christ will last.

- C.T. Studd

I am grateful to my friend and unofficial advisor, Lt Col (ret.) Mark Reith, who spent many hours guiding me and this research. Thank you to my official advisor, Dr. Gilbert Peterson, for accepting another student in stride. Thank you to Lt Col Alan Lin for creating the MDC2 Trading Card Game and providing continuous suggestions for improvement to BSN and my research. I have learned much from you all.

Thank you to Lt Col John Staudt, Dr. Jeffrey Reilly, Lt Col George Noel, Dr. Barry Mullins, Dr. Timothy Lacey, and LTC Eric Slover for offering their valuable course hours to support this research. Thank you to Brayden Hollis and Lieutenants Chris Voltz, Landon Tomcho, Brad French, Jake Orner, Albert Taglieri, and Kyle Morse for play testing the game and providing needed enhancements.

Thank you to the ENG 20M class who endured countless WhatsApp messages and provided camaraderie on our journey through AFIT. Thank you to the AFIT Ultimate Club (it's now a thing). Thank you especially to Tim True and Andrew Watson for their accountability and encouragement.

I am deeply grateful to my parents for teaching to be faithful in the little things. I am thankful for and blessed by the joy and enthusiasm of my four boys. Most profoundly, I am grateful to my godly wife. Thank you for your steadfast love, care, and support through the hills and valleys. I love you.

Nathaniel Wesley Flack

Contents

Page

Page

Page

Page

List of Figures

List of Tables

DEVELOPING A SERIOUS GAME TO EXPLORE JOINT ALL-DOMAIN COMMAND AND CONTROL

I. Introduction

1.1 Background

In 2018, the National Defense Strategy (NDS) reported, "Inter-state strategic competition, not terrorism, is now the primary concern in United States (U.S.) national security." Near-peer adversaries, identified in the NDS as China and Russia, are defined as nation states whose military and economic powers closely match U.S. capabilities. This shift away from counter-insurgency and return to "great power competition"[1] is a significant shift move away from how the military characterized its primary purpose since September 11^{th}, 2001. Future conflicts with near-peer adversaries are predicted to be characterized by a complex and contested battlespace forged by the intersection of Air, Space, Cyber, Land, and Maritime domains as well as Information Operations (IO) and Electronic Warfare (EW) capabilities [2]. According to military leaders, achieving successful military results in this new environment requires new operating concepts that leverage complexity to create a decisive advantage over the enemy. In response to this challenge, these leaders have coined the terms Multi-Domain Operations (MDO) and Joint All-Domain Command and Control (JADC2) to describe the needed transformation unifying effort across the Department of Defense (DoD). One significant problem now facing the military services, and the Air Force (AF) in particular, is improving education and training to

[1] See [1] for a current discussion of great power competition.

produce a workforce able to adapt and respond in an environment characterized by the intersection of traditional and emerging warfighting domains.

1.2 Problem Statement

In response to the shifting geopolitical landscape, senior AF leaders have requested that MDO and JADC2 concepts be quickly integrated into current courses with a specific emphasis on hands-on learning [3]. This call is an initial step toward transforming the AF culture, moving away from a domain-centric model to one that is thoroughly multi-domain. To realize MDO across the force, military leaders need contributions from a broad community who deeply understand the problem and are empowered to help shape the solution. Emerging MDO education and training solutions fall primarily into two categories. First, targeted wargames provide hands-on learning to small groups of personnel who are further defining MDO and shaping its future use. Second, a small number of informational briefings and videos have provided a broader, but still limited, audience with a basic description of core MDO concepts. The first solution comes at a high cost in money and time, thus limiting its broader application for MDO learning. The second may be able to reach a broad audience, but only provides an initial understanding of the problem and basic idea of MDO. While both of these contribute to the overall solution, additional tools are needed that provide hands-on learning and allow exploration of this ill-defined concept for a broad population of AF personnel. This difficulty of this issue is intensified by the lack of MDO definition and established lesson objectives to compare to emerging solutions. Therefore, effective learning tools will provide experiential and engaging learning, be accessible to educators for efficient course integration, and teach relevant MDO concepts. Serious games (SGs) provide a body of research, based in experiential learning, to help fill this gap by providing hands-on and engaging learning tools. One such solution, The

Multi-Domain Command and Control Trading Card Game (MDC2 TCG), is an SG modeling portions of MDO with a specific emphasis on cyber operations integration. However, extensive empirical studies addressing the use of SGs in military education and training are not available. The problem statement this thesis seeks to answer is as follows: what is the response to, and effect of, the integration of an SG, designed to model and teach MDO, into military education and training?

1.3 Hypothesis

This research hypothesizes that a majority of military members will respond positively to the use of an SG in the classroom, report learning central MDO concepts through play, and grow in readiness in areas linked to near-peer conflicts. This hypothesis is based on previous SG research provided in Chapter II and the initial response to the MDC2 TCG by students and senior leaders.

1.4 Research Objectives

This work attempts to create a hands-on learning tool engineered to initiate relevant discussion and exploration of current MDO concepts in the military classroom. It begins with the evaluation of MDC2 TCG and then, through game development and exposure to the operational community, seeks to tailor the game to capture the essence of the current MDO discussion while providing a relevant tool that can be quickly integrated into current courses. Furthermore, this effort provides an extensible MDO Game Framework that may be useful in both current and future force development discussions. To evaluate this approach the following research questions (RQ) were developed:

RQ1. What is the response to an SG in military education and training courses?

RQ2. To what extent does the game model and teach current MDO concepts?

RQ3. What effect does the game have on players?

RQ4. How time-efficient is the integration of the game into current education and training courses?

RQ5. To what extent does the game facilitate MDO innovation?

RQ1 highlights the current lack of empirical data measuring the response to SGs in the U.S. Military. This response must be known to accurately evaluate the impact of this game type and the presence of any negative bias towards educational games. RQ2 builds on the previous general question by asking how well the game reflects the current MDO and JADC2 discussion. RQ3 seeks to describe the effects that MDC2 TCG and Battlespace Next (BSN) have on players to inform their future use. RQ4 evaluates course integration to know if the tool can be efficiently integrated into current curricula. Finally, RQ5 was formulated to evaluate the game as a tool for MDO innovation. Innovation, specifically the creative coupling of capabilities to create overwhelming effects, is a core attribute of our MDO perception.

1.5 Approach

To examine the research questions, a series of human subjects research experiments were performed in formal military courses testing game effectiveness and efficiency. The intent behind the classroom experiments were to collect play testing data from a variety of military members with a range of career expertise and depth. Additionally, play testing and game exposure to the operational community collected feedback from experts and military leaders shaping MDO discussions. The results provide detailed answers to RQ1-RQ4 and offer insight on RQ5.

1.6 Assumptions and Limitations

The following assumptions are identified in relation to MDO learning and the evaluation of SGs:

- Self-reported learning is sufficient to characterize the learning obtained by the student during game play.
- Responses received form a representative sample of the total number of participants from each of the experiments.

Specific limitations of the research are explained throughout Chapters III and IV.

1.7 Contributions

This thesis adds to the fields of MDO and SGs through four primary contributions:

- An MDO Game Framework. The framework proposed provides a novel method to model MDO using specific game elements for the purposes of education and strategy development while maintaining challenge for all levels of players.
- The Measurement of Military Members' Response to SGs. The research portrays the general attitude of military personnel, both uniformed and DoD civilians, toward the use of SGs in education and training courses.
- An Accessible, Engaging Learning Tool. The product of the research and the associated resources, which include a facilitator's guide, game instructions, and tutorial video are publicly available and ready for integration into current learning environments in military and civilian contexts.
- SG Evaluation Methodology and Data Collection Tools. The data collection tools and procedures demonstrate how a specific SG can be evaluated using both qualitative and quantitative data.

1.8 Document Overview

This thesis document is arranged in five chapters. Chapter 2 discusses the nature of MDO and provides a brief overview of SGs, wargaming, and other relevant research. Chapter 3 describes the MDO Game Framework used in the experiment and details the human subject research procedures. Chapter 4 presents the results from the experiments, analysis of the quantitative and qualitative data, and a discussion of study implications. Finally, chapter 5 summarizes the research, discusses its significance, and presents suggestions for future research.

II. Background and Literature Review

2.1 Overview

The purpose of this chapter is to provide a review of the relevant literature covering Multi-Domain Operations (MDO), Joint All-Domain Command and Control (JADC2), Experiential Learning Theory (ELT), current education and training solutions, wargaming, serious games (SGs), and Collectable Card Games (CCG).

2.2 Multi-Domain Operations

The United States (U.S.) Military, through Joint Doctrine, defines five domains as central to operations: Land, Maritime, Air, Space, and Cyber [4]. Others, such as the Electromagnetic Spectrum (EMS) [5] and human[1] domains, are considered key to winning future conflicts [6]. EMS is considered by some as the domain encompassing cyber and Electronic Warfare (EW) capabilities [7]. The military services are considering how to handle the complexity of future warfare which will likely encompass all domains [8]. This is evident in the shifting focus from counter-insurgency to near-peer adversaries. Near-peer adversaries are defined as those nation states that closely match U.S. Military capabilities and economic power, specifically Russia and China. The 2018 National Defense Strategy explains, "Inter-state strategic competition, not terrorism, is now the primary concern in U.S. national security" [9].

This shift back to a focus on near-peer adversaries will likely require fine-grain interoperability and detailed coordination across domains and services. These ideas were formerly championed by organizations such as U.S. Joint Forces Command (JFCOM), a Unified Combatant Command operational from 1999-2011 [10]. JFCOM was designed to manage joint training, integration of forces from all military services,

[1]The human domain is also referred to as the cognitive or social domain.

and transformation of military capabilities. It conducted large scale joint exercises for the purpose of experimentation and interoperability [11]. It was stood down in 2011, largely as a cost savings effort, after ten years of military effort dedicated to counter-terrorism. The counter-terrorism fight was against an inferior force both in military strength and economic power, and victory did not require extensive interoperability or highly-detailed coordination. However, force size and technological superiority may not deliver the advantages relied upon for past success [9]. Prior to 2001, the joint force considered Information Operations (IO), EW, and control of the EMS to achieve objectives [12], however, cyber warfare was a vague concept compared to the robust idea of cyber operations discussed today. Additionally, the global rise of cellular technology and increasing saturation of the EMS contribute to a more complex environment than faced prior to 2001 [2]. These complexities, paired with the reemergence of near-peer threats, means future success will potentially require a level of technological interoperability and fine-tuned coordination across domains and military branches making historical ideas of joint operations potentially insufficient. The military's emphasis on combined exercises and interoperability, which hearkens back to the emphasis on joint operations in the days of JFCOM, highlight the lack of attention it received during the last era in military operations.

2.2.1 Terminology

In response, the U.S. Military developed the terms such as Multi-Domain Battle (MDB), Multi-Domain Command and Control (MDC2), MDO, and JADC2. The U.S. Army first used MDB while the Air Force (AF) focused on MDC2 [13]. In 2018, the Army united with the AF to support MDO and MDC2 as the primary terms to characterize the problem and unify efforts to build potential solutions [14]. Then in late 2019, the Chairman of the Joint Chiefs of Staff aligned efforts under

the term JADC2 [15]. This thesis will use MDO to encapsulate the nature of the problem. MDO captures the broad concept of warfare across many or all domains while JADC2 characterizes the operating concept designed to unify effort and help manage the complexity of the emerging battlespace [15]. The U.S. Military developed these terms in order to better understand and leverage complexity to maintain the asymmetric advantage it enjoys today [16] [7].

2.2.2 Current Research

Individuals across the AF are seeking to understand and trace the origins of MDO in order to reap its benefits. Reilly traces the origins of MDO to the 12^{th} century B.C. when ancient Egypt achieved victory by leveraging both land and maritime capabilities simultaneously [6]. Alberts examines the concept from a historical perspective to identify what is new and what is merely a continuation of past efforts or methods. He writes that MDO will include facets that are outside the experience of most operators leading to a greater need for synchronization [17]. Contemplating MDO, Barber writes, "The nature of war remains the same, but the rapid pace of technology is creating a world so interconnected that the character of war is undergoing fundamental changes" [18]. Bruza and Reith identify the need to avoid stove-piping that is inherent in joint operations and leverage capability transparency to enable "integrated awareness of the operational environment" [19]. Campbell provides a board definition of MDO as "visualizing and executing operations with simultaneity and depth to dislocate the adversary and outpace his ability to respond" [20]. Chief of Staff of the Air Force (CSAF), General David Goldfein, projects that JADC2 is the key to winning current and future conflicts. He contends, "Having the ability to credibly attack enemies independently by land, sea, air, space or cyberspace – or all at once – creates untenable dilemmas [for our enemies]" [21].

Further emphasizing the need for multi-domain understanding, Generals Holmes and Perkins write, "Victory in future combat will be determined by how successfully commanders can understand, visualize, and describe the battlefield to their subordinate commands, thus allowing for more rapid decision making to exploit the initiative and create positions of relative advantage" [8]. Perkins, who heads the Army's Training and Doctrine Command (TRADOC), has led the way in defining the multi-domain environment. Figure 1 depicts TRADOC's view of the modern battlespace and the complexities that exist within [5]. The representation of threats created by a near-peer adversary reveals elements of the future battlespace. These include the integration of space and cyber capabilities across other domains, disruption and denial of communications and navigation, long-range fires, the weaponizing of information, the presence of Integrated Air Defense Systems (IADS), and the vulnerability of military and civilian personnel, including those geographically separated from primary areas of conflict.

However, this attention on MDO has not fully explored its essential characteristics and how it will impact military operations.

2.2.3 Definition of Key Concepts

Precise definition of the essential elements of MDO is needed. In 2019, Goldfein defined MDO using an operational vignette [22]. The scenario he presented sought to provide a tangible example to solidify the concept in the minds of personnel both inside and outside the AF. The vignette described a fictitious scenario where a opposing force invades a U.S. ally using multiple domains. After establishing the context and environment, Goldfein described a potential military response and showed the possible effects of the all-domain conflict. He then provides his definition of MDO as "using dominance in one domain or many, blending a few capabilities or many, to

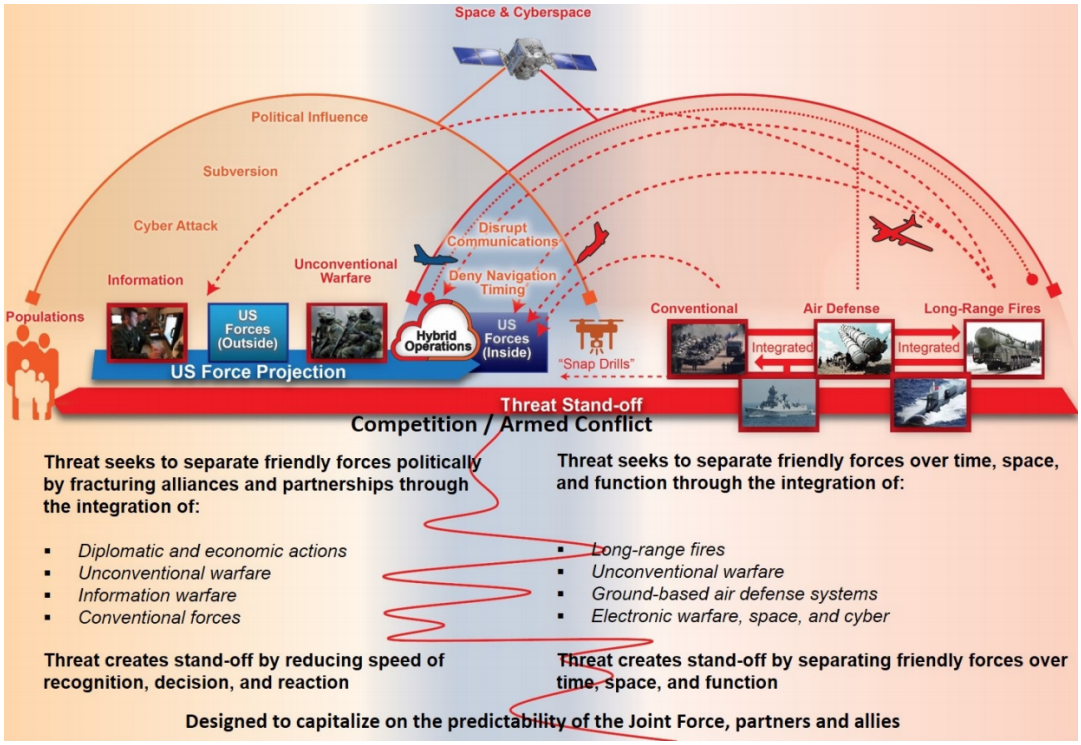


Figure 1: China and Russia in armed conflict and competition. The red line on the lower half of the figure represents the movement back and forth between competition and armed conflict.

create multiple dilemmas for our adversaries."

The author's analysis of the vignette reveals three broad takeaways:

- The goal of MDO is to overwhelm the enemy to accomplish the operational objective at hand and restrict enemy actions.
- It is essential for military personnel to understand joint systems and how to integrate them to produce effects in the battle space.
- Effective MDO requires a fully integrated and aware force made possible by a resilient mesh network fused with Artificial Intelligence (AI).

From this description and the definitions above, three primary MDO concepts emerge: (1) capability awareness, (2) combining capabilities to create effects, and (3) strategies to leverage the first two concepts to overwhelm the enemy. Although the

idea of MDO is still largely under development, this thesis formulates that these three aspects are not sufficient to adequately teach MDO.

2.2.4 Education and Training

This shift in thinking toward MDO must be accompanied and facilitiated by changes in education and training. Goldfein highlights the importance of integrating this concept into every exercise, wargame, and home station operation [23]. He argues, "Developing the systems, training, and methods by which to practice this new brand of warfare will require extraordinary focus from our military" [21]. Challenges to effective MDO education are numerous. Most notably, it is inherently broad, fluid, complex, and must integrate disparate communities [24]. These challenges are exacerbated by the lack of innovation and consensus of how MDO concepts will operate in future conflicts. Significant education and training are often required before operators exhibit depth of knowledge and skill in just one domain, but now strategists and operators will require proficiency in multiple, complex domains to both plan and execute operations that integrate breadth and depth at the intense speed required for victory.

According to the MDC2 Implementation Plan (I-Plan), signed by the top AF leadership in June 2018, Air Education and Training Command (AETC) is tasked to provide "Airmen with a broad understanding of multi-domain operations and AF Command and Control (C2) concepts and capabilities." This mandate also includes a requirement to "maximize opportunities to gain hands-on experience with multi-domain operations to enhance ability to plan, execute and staff multi-domain capabilities" [3]. However, current approaches are limited to specialized programs for as small number of students, informational briefings providing shallow definitions of MDO, and targeted wargames.

Air Command and Staff College (ACSC) implemented the Multi-Domain Operational Strategist (MDOS) concentration to develop 20-50 mid-career officers (O-4s) who understand MDO and are equipped to respond [18]. This annual program is approximately ten months long and covers all warfighting domains in detail focusing on the projected operational environment in 2030 [25].[2] Additionally, Weapons School Integration (WSINT) provides top AF Weapons School students an opportunity to participate in a three week capstone experience dedicated to multi-domain warfare integration [26]. While the depth of these programs is sufficient, they are only available to a small number of officers each year.

Reaching a larger population of mid-level AF captains (O-3s), Squadron Officer's School (SOS) implemented a 2-hour MDO lesson that combines instructional videos, such as portions of [23], a group brainstorming project, and classroom discussion on historical examples [27].[3] This training will eventually cover a broad population of AF officers, however its length does not allow for in-depth exploration of the subject.

To address a wider scope of personnel, AETC is developing the AF Continuum of Learning (CoL) initiative. The CoL consists of "five, interlinking innovations all designed to forge more creative, intellectually agile, resilient, and competent Airmen for our Air Force" [28]. This initiative provides more distance learning and less face-to-face education so as to achieve the desired scalability. However, distance learning will increase difficulty to provide hands-on learning that is central to the MDC2 I-Plan's mandate. Additionally, because students and trainees will no longer be in the physical classroom, learning resources and tools must be more engaging to compete for Airmen's attention. To date, the CoL is still under development and no learning tools have been proposed to deliver hands-on MDO learning.

[2]Information received from author via personal correspondence. Used by permission.

[3]Curriculum document received through personal correspondence with SOS personnel. Used by permission.

A more developed digital learning platform, called the Cyber Education Hub (CEH) is under development at Air Force Institute of Technology (AFIT). It is designed to engage and motivate students by providing a range of content that might appeal to a broad audience, to include digital serious games [29].

2.2.5 Wargaming

The only hands-on solution currently leveraged in AF MDO education is wargaming. Wargames have impacted training, education, and research in both military and, more recently, non-military contexts [30]. Many levels of wargames are used in the military today encompassing small, table top exercises to National exercises. Wargaming is used by the military services to build understanding of a specific scenario or problem set. The U.S. Army War College defines a wargame as "a tool for exploring and informing human decision-making [31]." The exercise of wargaming guides future decisions, thus increasing the opportunity to make the right decision when it matters. The U.S. Army War College's Strategic Wargaming Series Handbook states, "Results from a wargame can provide insights and options on the employment and appropriate application of the instruments of national power [31]."

A specific example of a war game in the field of MDO is the annual Doolittle Wargaming series chartered by Goldfein. The annual event is central to the exploration of multi-domain warfighting concepts to enhance JADC2 [32]. Its purpose is to "explore multi-domain warfighting concepts to improve command and control of air, space, and cyberspace forces in support of dynamic and operationally agile operations [33]." Other wargames, including National and Combatant Command exercises involving multiple global and regional commands, are slowly integrating MDO scenarios [5] [34]. These wargames are essential to shape future military strategies but time, money, and expertise prohibit their use on a larger scale for MDO education.

One Army wargame expert said that major wargames can cost $100,000 to $1 million, require months of planning, and hundreds of man-hours.

2.3 Experiential Learning

2.3.1 Experiential Learning Theory

The CSAF's push for hands-on learning to help the force better understand MDO is supported by Kolb's Experiential Learning Theory (ELT) [35]. ELT provides a foundation for how learning occurs as a result of an experience. He writes, "Truth is not manifest in experience; it must be inferred by a process of learning that questions preconceptions of direct experience, tempers the vividness and emotion of the experience with critical reflection, and extracts the correct lessons from the consequences of action" [35]. Therefore, experience is a central aspect of learning but must be accompanied by reflection.

2.3.2 Dale's Cone of Experience

Hands-on learning is critical to deeply ingrain the ideas of MDO in to the student. Dale theorizes that learners retain more information from what they do compared to what is heard, read, or observed [36]. Dale created pictorial view of this theory called the Cone of Experience shown on the left side of Figure 2 [37]. Experiences closer to the bottom of the cone are more concrete and the items at the top represent more abstract activities, such as those primarily using words to convey ideas. Activities closer to the bottom of the cone will, theoretically, deliver a more memorable learning experience than those at the top.

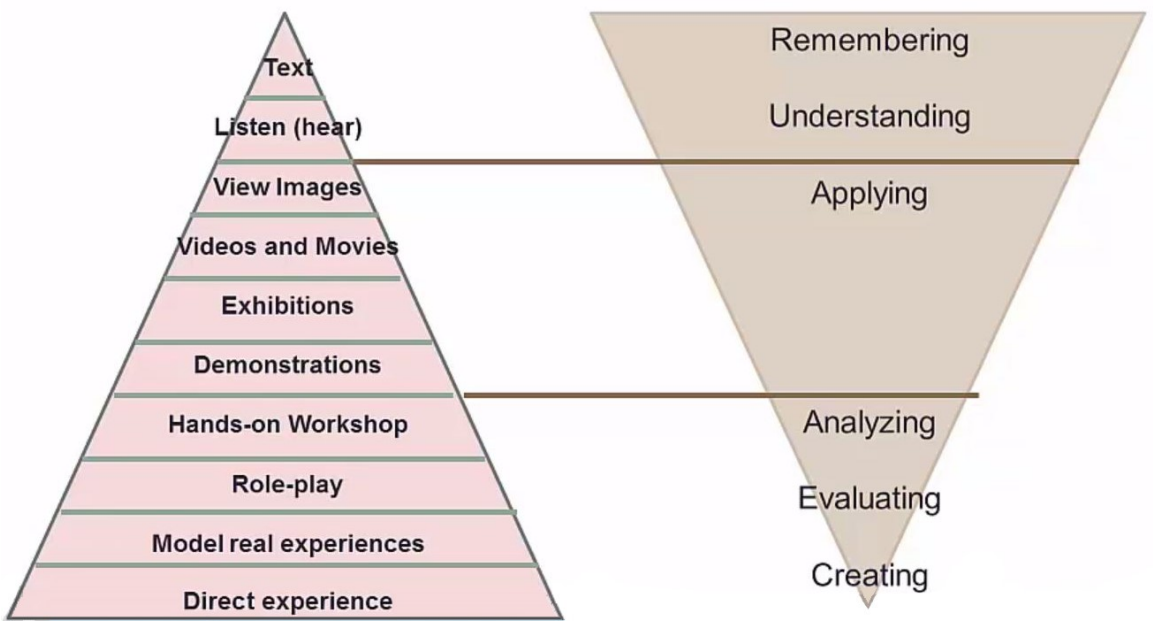


Figure 2: Alignment of Dale's Cone of Experience and Bloom's Taxonomy of Learning.

This applies to the field of SGs because they are designed to provide experiences that map to a hands-on workshop, role-play activity, or model real experiences making them more memorable than word-based activities such as lectures and briefings.

2.3.3 Bloom's Taxonomy of Learning

To facilitate the integration of an SG into current courses, Bloom's Taxonomy of Learning is leveraged to communicate to curriculum developers what learning objectives (LOs) might be addressed through the game and tailor the experience based on students' experience levels [38].

Pairing Bloom's Taxonomy [38] with Dale's Cone of Experience reinforces ELT and identifies the levels of learning targeted by SGs. SGs provide experiences where players are allowed to control components of the game, thereby influencing the events and outcomes. This is different from a lecture where students are typically passive observers. Figure 2 implies that role-play and hands-on activities lead to higher levels

of learning (Analyzing, Evaluating, and Creating). Aligning the two structures shows the approximate mapping. The pyramid representing Bloom's Taxonomy is inverted, highlighting that experiences relate to higher levels of learning. The chart uses an updated version of Bloom's Taxonomy with slightly different terminology [39].

SGs do not provide the direct experiences as described by Dale and Kolb, but instead use various levels of abstraction to allow for play in artificial environments, such as classrooms. However, they do create pseudo-experiences that require, in the case of table-top games, hands-on manipulation of assets. These pseudo-experiences are further enhanced by allowing the player to control events to a certain degree. This control leads to, what Perla and McGrady call, the interplay between expectation and experience [40]. SGs provide an environment where expectations are formed, tested, and re-formed through play. Specifically, the game tested in this thesis seeks to create a rich learning experience by modeling military conflict, providing assets (cards) for hands-on manipulation, and place the player in the seat of an operational commander and strategist (role-play).

While the specialized programs and wargames described above will provide rich experiences for exploring and developing the idea of MDO, implementation of MDO necessitates that a large majority of the force understand and have the opportunity to explore it. A deeper understanding, facilitated by SGs, will help to align efforts and enable exploration leading to the effective application of MDO.

2.4 Serious Games

SGs are described as games designed for purposes beyond entertainment [41] [42] [43]. Susi, Johannesson, and Backlund [44] define SGs as "the application of gaming technology, process, and design to the solution of problems faced by businesses and other organizations. SGs promote the transfer and cross fertilization of game develop-

ment knowledge and techniques in traditionally non-game markets such as training, product design, sales, marketing, etc."

2.4.1 History

Abt [45] published *Serious Games* in 1970 describing an idea of pairing the experimentation of play with problems that require careful thought. Current literature surveys [46] [47] [48] provide empirical evidence for the effects of SGs, which are largely positive. Specifically, serious games are connected to improved knowledge acquisition and content understanding. Additionally, they are shown to be effective training tools and produce behavioral change in players [49]. Rhodes et al. [50] is an example of a recent study showing the methodology and results of a rigorous empirical study to prove the efficacy of SGs as compared to traditional forms of instruction. The experiment examined the difference between procedural knowledge versus declarative knowledge. Procedural knowledge addresses how to do something (hands-on knowledge) while declarative knowledge focuses on what something is (tested knowledge). The study demonstrates that SGs have advantages over video-based learning when teaching procedural knowledge but the two methods performed equally well for declarative knowledge.

SGs move beyond the teaching of facts and rote memorization to encompass other aspects of education such as teaching, training, and informing [46]. They function as effective education tools because they reduce large-scale competitive processes to expose the essential elements with a unique "drama" not present in other teaching techniques [40]. One way this drama is created is through competition, which is shown to increase student performance [51] and engagement [52]. One SG designer stated, "I believe [games] have the capacity to be one of the most effective ways to discuss a serious topic as they cast the player in the role of active participant [53]."

Research also identifies some negative aspects of SGs. Studies suggest that video games can be accompanied by negative affects such as anxiety and frustration [54]. Other negative aspects include increased aggressiveness after playing violent video games [55]. However, some in the SG research community see this as a matter of debate [44]. In this study, aggression was rewarded within the game in order to appropriately model near-peer adversaries. However, the game is a card game (vice a video game) and the cards do not contain violent images. Some participants reported experiencing anxiety and frustration during game play, but this response was interpreted as part of the competitive nature of the game. No follow-up was conducted with participants who expressed these emotions and further research is needed to determine any long-term affects. Another negative aspect of SGs is the development time and and the increased chance of negative student response compared to more traditional methods of instruction. A failing game can "appear almost childish in its oversimplification and abstractions" [40]. Research efforts have not created methods to build fail-proof games, so this reaction is always a possibility without extensive testing. Furthermore, some adults may view any game used for the purpose of learning as a childish or unimportant activity [56].

2.4.2 Military Applications

Many SGs have been used in the military for education and training. Research at the Naval Postgraduate School[4] has produced several digital SGs covering a broad range of topics including counter-terrorism and cyber operations. *CyberCEIGE*, is a single player game presenting the learner with a range of cybersecurity scenarios teaching network configuration, protection, and management [57]. In-game evaluation data is available for CyberCEIGE and small studies have compared it with video instruction, however, the authors admit that no formal empirical studies exist validat-

[4]https://my.nps.edu/web/ecco/game-center

ing the game's effectiveness. Another game, *CyberStrike*, was designed to teach basic cyber operations terminology to non-cyber Army personnel in a classroom setting [58]. Long and Mulch redesigned *CyberStrike* to balance game play and reinforce the explicit learning objectives in *CyberWar 2025*. This game was evaluated using formal play tests and group debriefings, however, the surveys used only collected game improvement data and did not measure player learning [58].

Squadron Officers School uses a digital SG called *Air Doctrine Wargame (ADWAR)* designed to foster teamwork and application of air power in warfare. Students learn the game as part of a six week course and execute a capstone game evaluating how their ten to fourteen person team competes against a scripted adversary. The game integrates space, cyber, land, and maritime capabilities into the scenarios, but is primarily focused on controlling air assets. This game has many strengths, including establishing an environment where students can experiment with different C2 structures. Berube reports ongoing improvements to *ADWAR* based on direct student feedback, but the authors are unaware of any published evaluation studies [59]. A game built on the same game engine and with the same purposes, called *Air Force Expeditionary Exercise (AFEX)*, is used in AF accessions programs such as AF Reserve Officer Training Corps (ROTC) and Officer Training School (OTS) [60].

Other notable games include a list of computer network security table-top games compiled by Shostack [61]. One of these games is *Cyber Threat Defender (CTD)*,[5] which provided some inspiration in the creation of The Multi-Domain Command and Control Trading Card Game (MDC2 TCG). *CTD* is a multi-player Collectable Card Game (CCG) where players earn points by building and defending a computer network against threats. The game is currently used at the 338$^{\text{th}}$ Training Squadron at Keesler Air Force Base (AFB). In 2018, two wargames were used in [62] to analyze

[5]https://cias.utsa.edu/ctd.php

cyber operations in conflict. Finally, *Cyber Space Odyssey*, is utilized as part of the Advanced Cyber Education (ACE) program at AFIT to teach computer networking to ROTC cadets [63].

2.4.3 Description

Hunicke, LeBlanc, and Zubek [64] describe SGs as a combination of their Mechanics, Dynamics, and Aesthetics. They refer to this as the MDA game design and research framework. A game Mechanic is a game feature (action, behavior, or control mechanism) that a player can interact with toward a specified goal. Dynamics refer to the "run-time behavior" of the mechanics [64]. They emerge from the Mechanics and include the part of the Mechanics a player can see. Finally, Aesthetics describe the desired response while a player interacts with the game system.

Järvinen [65], in his comprehensive game categorization, describes games systems as a collection of components, environment, ruleset, information, theme, interface, players, and contexts. He also uses mechanics as a central feature of a game. Games typically possess core mechanics, sub-mechanics, modifier mechanics, and various levels of goals. Both of these constructs help describe and categorize the games used in this research.

2.4.4 Evaluation

Many varied methods have been used to evaluate SGs and the literature is somewhat fragmented on the subject [66]. In 2012, Bedwell et al. asserted, "The use of SGs is progressing without explicit knowledge as to why games are effective teaching tools" [67]. Since then, the growth in the number and rigor of empirical studies examining SGs added more legitimacy to the field. These studies focused on proving the positive impacts of SGs, many in a classroom setting. Connolly et al. [46] analyzed

129 papers describing the empirical evidence of the impacts and outcomes of computer games and SGs. Most often, positive impacts of SGs were linked to knowledge acquisition, content understanding, affective outcomes, and motivational outcomes. Boyle et al. [47] updated this study in 2016 concluding that further research has confirmed early findings and provide a range of affective, behavioral, perceptual, cognitive, and physiological outcomes.

Assessment methods typically focus on four areas: (1) the player, (2) the SG, (3) interactions between items one and two and (4) the context where the interactions take place [68]. This thesis collected data in each of these areas, but focused primarily on 1-3.

While many methods exist, pre-survey and post-survey methodology is commonly used to examine the effects of the game on the players when compared to other forms of instruction. Many of these studies use a custom or standardized knowledge assessment to quantitatively measure learning [43] [50] [69]. Others measure self-reported learning collected from players [70] [71] [72]. Knowledge assessments are superior to self-reported learning when choosing the best curriculum to convey LOs, however, this requires a proven evaluation method which is not always available.

An objective pre-test and post-test method would have increased the value of this research and was preferred to self-reported learning for the reasons listed above. However, due to the novelty of the game's subject matter, a standardized assessment was not available. Efforts to create such an assessment were limited by (1) a lack of consensus of the knowledge that is valued in the military in the area of MDO, (2) bias in the proposed test toward the game content, and (3) difficulty of creating a standardized test that effectively measures student learning at the higher levels of Bloom's Taxonomy of Learning which are targeted by the game. This challenge is present for professional instructors leading programs such as the 13O Initial Skills

Training (IST) and MDOS concentration at ACSC. They desire to address higher levels of learning but are having a difficult time crafting meaningful, broadly applicable assessments. This challenge points to the primary difficultly of MDO education. MDO describes an outcome and high-level strategy, without including specific steps to achieve it. Therefore, students require critical thinking skills congruent with high levels of learning in order to effectively advance the topic, which are inherently hard to evaluate using existing methods.

In-game data collection was also desired, but the number of concurrent games (up to 20) made individual game observation impossible without significantly increasing the cost of the study. Additionally, the design and implementation of a digital version of the game, which could have integrated in-game data collection, was beyond the resources and timeline of this research effort.

Therefore, this research was restricted to the use of self-reported learning attainment from participants. SGs, however, may actually increase student understanding without the student's recognition leading to players under-reporting their learning. One empirical study measuring the effect of active teaching methods found while students who received a lecture using active methods scored better on tests, they self-reported lower levels of learning than students who passively observed a lecture [73]. An SG is similar to active teaching in that it forces students to grapple with the content on their own, while potentially veiling the effort as a pleasant experience. If a similar effect occurs in this study, students may actually achieve a higher level of MDO understanding than they report because of the effort required to play the game versus sit through an organized lecture or video.

2.4.4.1 Data Collection Tools

Data collection tools were used to collect player feedback and measure learning as part of our Human Subjects Research. Several standard assessment tools exist, such as the Game Experience Questionnaire [74] and the Game Engagement Questionnaire [75]. These were used in part to shape the custom surveys used in this research, while other questions were added to measure other effects of the game as well as isolate unique aspects of the target audience (military members), environment (military classrooms), and subject matter (MDO). The surveys included questions linked to common SG factors identified by [66] including enjoyment, motivation, playability, usability, realism, relevance to personal interests, and learning effectiveness.

In addition to the Human Subjects Research (HSR) experiments, informal play tests were performed to explore game development decisions and improve game resources. Initially, feedback was collected by the author using a pen and paper, as shown in Appendix I, but this soon shifted to formal play testing forms published by Fail Faster.[6] Both play testing and experiments were used in order to quickly improve the game and resources for use in formal courses. While formal courses exclusively employed play tests to evaluate the learning aspects of the game, informal groups of students explored with different game mechanics and dynamics using both play tests and experimentation.

2.4.5 Debriefing

Returning to the application of ELT in SGs, Kolb's theory holds that experiences must be paired with reflection and interpretation if students are to grasp appropriate learning outcomes. This reveals the importance of debriefing, an aspect of SG utilization that is frequently overlooked [67] [43]. The goal of debriefing is to process the

[6] https://failfaster.ca

game experience and outcomes to solidify the desired learning. Crookall argues that a significant amount of SG learning takes place during the debriefing [43]. Therefore, game debriefing played an important role in the methodology and was integrated into each of the experiments.

2.4.6 Collectable Card Games

Many game genres are used for SG and wargame applications [65] [71]. The game in focus in this thesis is a Collectible Card Games (CCG), which are also referred to as Trading Card Games (TCG) or deck-building games. CCGs are inherently extensible and have shown to develop communities of loyal players, even after 25 years in some cases [76]. Commercial examples of CCGs include *Hearthstone*,[7] *Magic the Gathering (MtG)*,[8] and the *Pokémon Trading Card Game (TCG)*.[9] *CTD* is an example of a SG in the CCG genre. As mentioned above, it is a multi-player game to learn cyber terminology and network defense. CySEC [77] is another SG in this vein. Both are designed for introductory cyber learning, particularly for middle school and high school students. *Hearthstone* is the topic of recent academic research applying AI to create capable autonomous agents [78] [79].

According to Järvinen's taxonomy, the core mechanic of CCGs is "arranging and choosing," which refers to the organization of the cards and the order they are played. The primary modifier mechanic, "attacking and defending," changes the state of the game as players use cards to hinder their opponent. Järvinen identifies "sequential reasoning" and "induction" as the key abilities required to excel at CCGs. Sequential reasoning is needed to order cards and capabilities to create effects. Players who know the ability of each card and play it at the appropriate time will excel. Induction is defined as the process of deducing rules or other common characteristics underlying a

[7]https://playhearthstone.com/en-us
[8]https://magic.wizards.com/en/mtgo
[9]https://www.pokemon.com/us/pokemontcg

given set of stimulus materials. Both sequential reasoning and induction have obvious strong applicability to warfare. In CCGs, players must identify winning combinations both at the beginning of the game (during strategy development) and then during game play as they draw random cards from their supply. In summary, CCGs requires players to use sequential reasoning and induction to arrange and choose cards to outplay their opponent and eventually eliminate them from the game through attack and defense actions.

2.5 Multi-Domain Command and Control Trading Card Game (MDC2 TCG)

In 2018 an AFIT professor, Alan Lin created MDC2 TCG, a CCG exposing players to military capabilities from multiple domains and the integration of cyber capabilities into a warfare context [80]. The game borrows from several CCGs mentioned in Section 2.4.6, but implements a unique card design and introduces several new game mechanics.

2.5.1 Learning Objectives

MDC2 TCG was designed using specific LOs. Table 1 lists the primary Aesthetics from the MDA framework linking them to the LOs and level of Bloom's Taxonomy of Learning [38]. The table is adapted from the game introduction created by Lin and Reith [80] and personal correspondence with the creator. Bloom's Taxonomy levels are included to associate familiar educational terms to the game objectives in order to describe the level of learning intended and how the game might integrate to complement or replace current activities.

Table 1: MDC2 TCG learning objectives

Aesthetic	**Learning Objective (LO)**	**Bloom's Taxonomy of Learning Level**
Discovery	Recognize that cyber is not "magic dust" but requires a kill chain and advanced planning	Comprehension (Level 2)
Expression	Evaluate trade-offs between cyber and kinetic operations in the context of a scenario	Evaluation (Level 6)
Challenge	Formulate different strategies	Analysis/Synthesis (Levels 4 & 5)

2.5.2 Game Overview

MDC2 TCG is a 2-player CCG featuring military capabilities from Air, Cyber, Ground, and Space domains. The CCG genre enabled the integration of a large number of capabilities from many warfighting domains while explaining how they relate to one another. Each player chooses from 59 cards to build a deck of 40 cards to wield against an opponent, seeking to reduce the other's health points (HP) from 20 to zero. Kinetic capabilities, such as ground units and bombers, can strike the opposing player, removing a specific amount of HP. The mechanics allow players to group air and ground capabilities into force packages to create desired effects and counter enemy offensive and defensive actions. Detailed instructions are provided in Appendix D.

The current edition of the game places heavy investment in cards from the cyber, air, and land domains, but the game is extensible to support other warfighting domains.

The game emphasizes the integration of cyber capabilities into warfare. Capabilities follow a simplified version of the cyber kill chain first proposed by Lockheed Martin [81] including reconnaissance, gaining access, and exploitation. By using a cyber kill chain and actual capabilities such as Insider Threat, Ransomware, Worms,

Firewalls, Access Control Lists, Knowledge Management, etc. players learn about real-world cyber capabilities and the relevant dependencies. Three examples of cyber capabilities are included in Figure 3. The game offers non-cyber professionals a hands-on tool to learn a simplified cyber kill chain and how various cyber capabilities may factor into a larger kinetic conflict.

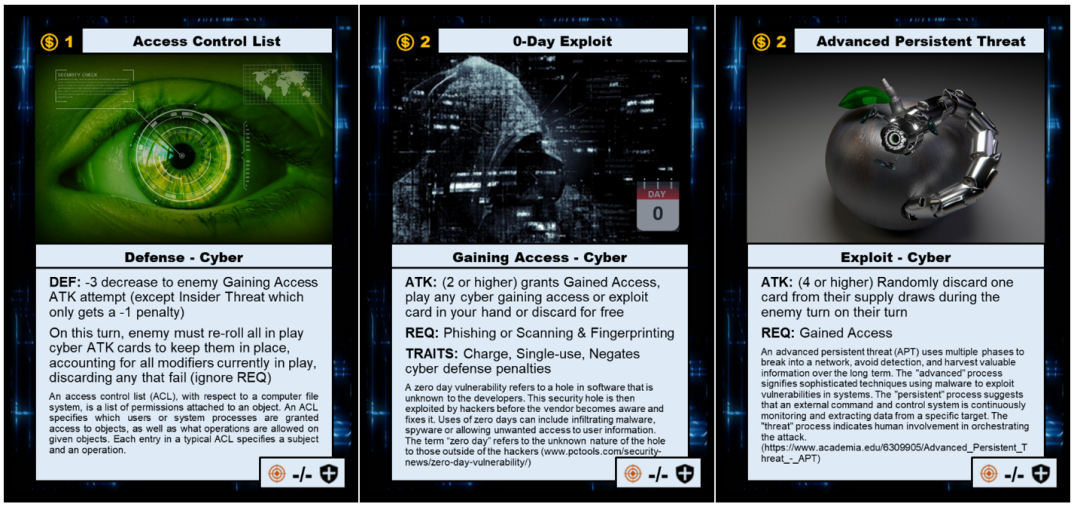


Figure 3: Examples of Cyber domain capabilities in MDC2 TCG

During game play, on a turn-by-turn basis, each player purchases and deploys cards they secured during the strategy development phase to conduct military operations in the battlespace. Deployed cards are used to make operational and tactical decisions including attack and defense actions against the opposing player. In addition to selecting the right capability, the player must weigh the cost of a card against its potential impact. The various combinations of cards across functions and domains forces the player to continually solve a resource optimization problem, where she must efficiently select capabilities from different domains to deliver the maximum damage to the opponent while defending her interests. The various combinations of cards across functions (offense, defense, and support) and domains (Cyber, Land, and Air) creates a complex web of choices creating various effects.

2.5.3 Mechanics, Dynamics and Aesthetics (MDA)

The game can be described using the MDA model described in Section 2.4.3. The primary Mechanics are purchasing and deploying cards, attacking and defending, combining cards info force packages, revealing and hiding cards, and information-seeking through Intelligence, Surveillance and Reconnaissance (ISR) assets.

The Dynamics are strategy, surprise, force imbalance, supply or logistics failure, uncertainty (fog of war), momentum, and initiative to name a few. For example, the game allows players to reveal cards in response to enemy attacks. This grants players the freedom to conceal defensive assets until they are needed, thereby creating the Dynamics of surprise and uncertainty. The attacker may surprise the defender by attacking from an unexpected domain while, at the same time, the defender can create uncertainty in the mind of the attacker by deploying unrevealed (hidden) capabilities.

The game uses the Aesthetics of Competition, Expression, and Challenge to elicit interest and engage the players. Competition is fostered by having two players with equal resources play one-on-one games simulating near-peer warfare. The game seeks to increase engagement and create learning through emotional investment in defeating the opponent. Next, Expression describes the self-discovery aspects of the game. Players are invited to create a strategy, test it, and then refine it as they play more games. This prompts the player to seek out strategies they think will work within the game and then reflect on why their strategies were successful or not. Furthermore, Discovery is achieved by modeling realistic military capabilities on the cards. As the player grows in familiarization with real military capabilities and their essential function or purpose, they improve their strategic thinking and are likely to discover new combinations and unique effects. Finally, Challenge is created in the interaction between the players as attack and defense actions are executed. These elements are maintained through various game iterations to include Battlespace Next (BSN).

2.5.4 Advantages

MDC2 TCG has several advantages over other SGs and MDO education programs mentioned in this chapter. First, it allows players to directly control capabilities from several domains providing hands-on evaluation and decision making. ADWAR, used in SOS, is specifically designed for teams of 10-14 players, but the game controls and scenario are too complex for a single player or small team, especially those who are new to air operations. Also, the Air domain is primary and dominates the scenario by design. The game is distinct from the Doolittle Wargames, the MDOS concentration at ACSC, and WSINT because it is designed to reach a broad population of the AF. The aforementioned courses and events provide hands-on MDO learning, but only reach a small population each year. In contrast, because MDC2 TCG is not tied to a specific program there is very little barrier to entry. The only barrier is the time it takes to learn the game for the first time, which is approximately 60-90 minutes based on data collected through this research. MDC2 TCG is designed to be lightweight and portable. It only requires two players and no computer or third-party facilitation to play and it can be stored in a small box. Additionally, it is designed to be played across a range of environments such as a large classroom setting, a small unit training session, or even between friends at lunch. Finally, the time required for one game (between 30 and 60 minutes) allows for quick iteration. This repetition creates an environment that lowers the consequence if failure as well as and enables rapid strategy refinement.

2.6 Summary

This chapter presented a brief summary of MDO as well as efforts to understand and integrate the concept into AF education and training. Building on the foundation provided by ELT, it provides evidence to support the use of a SG to provide hands-on

and engaging learning. One solution, MDC2 TCG, provides a workable solution but is largely untested.

The next chapter explains the methodology to redesign MDC2 TCG to create a new game, called BSN, based on feedback from interactions with players, subject matter experts (SME), the operational community, and MDO leaders. Additionally, it explains the methodology used to test how the game integrates and performs in military education and training environments.

III. Methodology

3.1 Introduction

The research methodology is divided into two major sections. First, the methodology used to produce Battlespace Next (BSN) and the associated MDO Game Framework is described. This section describes the major changes made to The Multi-Domain Command and Control Trading Card Game (MDC2 TCG) and the strengths and weaknesses of the new engineered learning tool. Second, this chapter describes the serious game (SG) assessment methodology, including the key aspects of the Human Subjects Research (HSR) experiments used for data collection.

3.2 Game Development

Previous research identify SGs as viable tools to help address the desire for engaging, hands-on Multi-Domain Operations (MDO) learning. Chapter II identified MDC2 TCG as a potential solution to increase hands-on MDO learning at a low cost. To test this game, an initial HSR study and other game feedback sessions were conducted. The comments received from these activities revealed that game changes were needed to better model MDO by including more domains and capabilities, as well as reducing the learning curve by simplifying the game and providing instructional tools such as tutorial videos. In order to provide structure that would guide game development decisions, an extensible MDO Game Framework was crafted by examining the dimension of potential play. This framework also serves to communicate the value proposition of using SGs in a military education and training environment to address MDO and related concepts.

3.2.1 MDO Game Framework

Analysis of MDC2 TCG and its operation both inside and outside of formal classroom environments led to the creation of an MDO Game Framework designed to model and teach current MDO understanding as well as provide the flexibility to adapt as the DoD's comprehension of this term congeals. The framework explains how the same game elements, specifically the cards, supplies, mechanics, and rules, can be utilized in several ways to both teach and explore MDO relationships in a classroom or unit training environment. The framework has three levels:

(1) Intro Game. A version of MDC2 TCG or BSN with simplified instructions designed to teach the basics of the game using approximately 20 cards with no dependency chains. This level was not implemented in this research due to time constraints in both the academic timeline and individual experiment schedules. However, it could be developed by those familiar with the current applications for use by instructors introducing the game for the first time.

(2) Target Game. This level describes versions of the game in the moderate to difficult category, designed to go beyond an introduction, but can be learned and played in under four hours. BSN is designed to serve as the primary, and most general, version on this level. This level also includes other games that introduce specific rules, capabilities, or scenarios to emphasize a particular learning objective (LO). For example, nuclear capabilities could be introduced to explore how players react during and following a nuclear event. Even though these cards may need to be excluded from Level 3 applications due to rule complexity. A game version at this level of the framework, BSN, was designed first to display the concept and provide a flexible tool for experimentation in a variety of military learning environments. BSN belongs in Level 2 because it is only meant to be played with a 54 card deck.

(3) Meta Game. This level would introduce many more cards, including capabili-

ties from near-peer adversaries, to deeply explore emerging technologies and military strategy. At this level, each player must build a deck containing a specified number cards from a large number of available options. This element creates another "game" within the game in which players must weigh the advantages and disadvantages of many cards in order to effectively match their deck composition and game strategy. This activity highlights the larger problem the military faces in making future investment decisions. A digital platform is necessary to efficiently create and operate a game instance at this level. Applications at this level will require an integrator to gather new capabilities from knowledgeable card creators and distribute them to the community. This central authority would also need to define and regulate game rules to maintain balance. MDC2 TCG fits in this level because it includes a deck-building component, although the ruleset needs to be revisited to integrate lessons learned from experimentation with BSN during this research effort. The MDO Game Framework has several advantages. First, it generally uses the same cards across all levels, unless excluded to meet specific LOs. This encourages the addition of new cards from a variety of sources with one integrator for consistency and game balance. Cards should be designed by individuals with game knowledge and capability knowledge on the cards they are creating. Cards should then be forwarded to the integrator for review by the game community. Reviewers should make a suggestion based on the card's content if it should be included in the Meta Game or integrated into a Target Game. Second, the framework allows for various levels of engagement with the game from beginners to experienced players, providing sufficient challenge for all. As the community of experienced players increases, tournaments and card creation challenges can be implemented to maintain a high level of challenge. This establishes a path to long-term intervention which is linked to behavioral change [49]. Third, it provides introductory games that reduce barriers to start playing the game.

Finally, it maintains game rules and mechanics across all levels, so that players who have experience in a lower level of the game can quickly adapt to higher levels.

3.2.2 Game Overview

BSN draws heavily from MDC2 TCG sharing card layout, similar mechanics, and requirements structure. Significant changes were also made, which are detailed in Section 3.2.6. Järvinen, in his comprehensive game categorization, describes a game as a collection of components, environment, ruleset, information, theme, interface, players, and contexts. Table 2 describes these game elements for MDC2 TCG and BSN.

Table 2: MDC2 TCG and BSN game elements

Game System Element	**Characteristics of MDC2 TCG & BSN**
Components	[Both] Physical cards, dice, and damage chips [BSN] resource chips
Environment	Various; Designed for formal (classroom), informal (breakroom/home) settings
Ruleset	Custom rules created by game designers to represent/model military strategies and MDO warfare concepts
Information	Card attributes and functions; Cards also contain real-world information in the card descriptions
Theme	MDO warfare
Interface	Moving physical cards in the playing area (table)
Players	[MDC2 TCG] 2 players [BSN] 2-4 players organized in teams or playing as individuals
Context	Primarily academic course or training setting with flexibility for informal contexts

3.2.3 Learning Objectives

LOs were used during development as detailed in Table 3. Each is identified with a specific level of Bloom's Taxonomy of Learning to help instructors identify how they

game might meet their particular lesson goals and tailor to student experience levels. The primary game elements that map to the LOs are also included.

Table 3: Definition of game LOs with associated Bloom's Taxonomy level

#	**Learning Objective**	**Level of Bloom's Taxonomy of Learning**	**Game Element Mapping**
1	Recognize that both cyber and kinetic capabilities require a kill chain and advanced planning	Knowledge (Level 1)	Strategy Development & Attack/Defense
2	Match cyber defense capabilities to corresponding threats	Comprehension (Level 2)	Reviewing Cards & Attack/Defense
3	Recognize the two levels on the Spectrum of Conflict (competition and conflict) and practice using appropriate assets within each	Comprehension (Level 2)	Competition and Conflict Phases (first 3-7 rounds)
4	Develop and execute an MDO strategy in a complex and contested environment	Synthesis (Level 5)	Strategy Development & Tactical Decisions
5	Select and combine capabilities to anticipate, adapt, and respond to surprise and uncertainty in near-peer warfare	Evaluation (Level 6)	Deploying Capabilities & Attack/Defense

LOs 1 and 4 were adapted from MDC2 TCG LOs described in Section 2.5.1. LO 2 was written to highlight the value of the cyber capabilities reflected in the game. The cyber cards chosen for BSN focused primarily on gaining access, exploitation, defense, and mitigation. From this it was expected that players practice matching attacking cards (gaining access and exploitation) to defensive cards (defense and mitigation). To this end, the cards specifically state what cards should be matched together. LO 3 was drawn from literature on the spectrum of conflict, such as [82], and the Army's characterization of MDO conflict in Figure 1. LO 5 was adapted from the unpublished objectives of the Multi-Domain Operational Strategist (MDOS) program written by Dr. Jeffrey Reilly. One of the explicit goals of the MDOS program is to produce graduates who are able to "anticipate, adapt, and respond to surprise and uncertainty in complex environments" [25]. This objective also communicates one of

the higher-level objectives of the game that was implicit until specifically added after reviewing the MDOS documentation.

3.2.4 Modeling MDO Concepts

As described in Section 2.4.6, Järvinen summarizes the CCG genre as one that requires players to use sequential reasoning and induction to arrange and choose cards to outplay their opponent, and eventually eliminate them from the game through offensive and defensive actions. Therefore, to partially answer RQ2, this game genre is well-suited to model MDO concepts and relationships. In addition, the following attributes of BSN enhance its applicability as an MDO model. First, the cards provide a tangible method of distilling actual military capabilities and weapon systems into maneuverable assets within the game. Students can control and combine assets in numerous ways revealing how capabilities from multiple domains create synergistic effects while challenging them to develop new and innovative combinations. The player selects 6 cards from the 48 available for strategy development leading to over 12 million possible combinations in the starting hand alone. Second, the primary goal of each country in near-peer warfare is to out-maneuver (outplay) the other country in order to eliminate their ability to wage warfare.[1] Therefore, the game creates a similar win condition to MDO scenarios, such as the one proposed by Goldfein in his operational vignette [22]. Finally, military strategists require sequential reasoning to develop effective strategies and execute operations. As a player orients to the operational environment created by the game and combats an opponent, he or she is exercising the skills and competencies required for military operations planning. The inherent aspects of the game genre and these unique aspects of BSN combine to make

[1]The explicit goal of the game (outplay and eliminate opponent) may push players to over-value kinetic conflict in real-world situations. However, the game is meant as a tool to model military combat, not to promote its use in every situation. All countries and parties should seek to use other means of power and only resort to armed conflict when all other options have been exhausted.

the game useful for modeling MDO warfare and developing competencies in military personnel.

3.2.5 Development Decisions

The research methodology included game development activities modifying and expanding MDC2 TCG to create a revised game, named Battlespace Next: MDO, or BSN. The game was treated in internal and external discussions as an engineered learning tool. The end product required improvement both in its content and usability, which required input from both game and MDO experts. To this end, potential game modifications were collected through formal classroom experiments, informal play testing, and presentations to the operational community and military leaders. The classroom experiments are covered in depth in Section 3.3. Informal play testing was conducted to validate specific elements of the game, including new mechanics, rule changes, and resources to learn the game. Initially, the author recorded potential changes on a notepad, but eventually a form designed for game play testing was used from Fail Faster[2] as shown in Appendix I. The game was presented in a variety of briefs, conferences, and informal events. One purpose of these engagements was to identify potential populations for experimentation, but they also served as another avenue to capture informal feedback from a broad audience. For example, the game was presented at several AF level events detailed in Appendix A. One of these events, strongly suggested adding Electronic Warfare (EW) and Information Operations (IO) capabilities in order to align the cards to current Department of Defense (DoD) priorities.

Play testing revealed the difficulty of balancing realism with simplicity across groups of diverse experience levels. Careful development and testing were employed to create an effective game that conveys and supports the LOs. The LOs were central

[2]https://failfaster.ca/

in design decisions and suggestions were only implemented after considering if they supported or detracted from the effectiveness of the game, as determined by its ability to convey the LOs.

3.2.6 Difference Between Game Versions

BSN leverages the card format and basic game design from MDC2 TCG but was engineered for greater effectiveness based on play testing, subject matter expert (SME) interaction,[3] and experiment feedback. A robust description of the game rules, card formats, and experiment procedures can be found in Appendices B and D. Additionally, the final verions of the cards from BSN, Version 3, are included in Appendix C. The major changes include:

- Removal of the deck-building phase to reduce start-up time and limit the amount of cards required. This change lowers the cost to produce the game (approximately $7 per student) and is designed to reduce the amount of time required for the students to learn the game and start playing their first round. This change reduced the initial decision space for players as they learned game mechanics assisting integration into busy course schedules. However, it also limited the strategy development aspects of the game because players are not allowed to choose the capabilities they want to include in their inital deck.

- Addition of new cards, based on senior leader input, representing capabilities across all warfighting domains, including human. BSN includes more Space cards, Maritime assets, and IO and EW capabilities. IO capabilities represent capabilities leveraging information to manipulate the human domain. BSN uses 25 cards from the original game and adds 29 new cards designed by the author.

[3]Lieutenant Colonel Alan Lin and Dr. Mark Reith provided expertise on cyber and IO capabilities, Dr. Robert Mills contributed to the Electronic Warfare aspects, and Colonel Timothy Albrecht, Major Robert Bettinger, and Major Joshuah Hess provided input on the space capabilities.

- Addition of an explicit resource mechanic to limit confusion and more closely simulate real-world resource management. MDC2 TCG included a mechanic where cards were discarded to deploy other cards. For example, if a card had a cost of two, the player would have to discard two cards from their hand to purchase the first card. Feedback from SMEs led to the the introduction of resource chips to track a players resources. This shows that, while resources are limited, capabilities are not sacrificed to pay for others, but instead may not receive necessary funding. In BSN, players receive a set amount of resources each turn that they use to deploy cards from their hand. Resource chips may carry over to the next turn if they are not used.

- Addition of the Multi-Domain Operations Center (MDOC) to represent current terminology in AF future operating concepts [32]. This change included a deliberate shift in the game's objective, as players now try to destroy their opponent's MDOC instead of the player themselves. This was easier for players to grasp leading to fewer questions. This card and other game elements are shown in Figure 4. A Cyber Operations Center and Combined Space Operations Center were also added to portray the current division in US military operations planning across operations center usually dedicated to one domain. This change allows players to consider the implications of both combined and distributed operations planning and execution. The addition of a cyber operations center also highlights the potential impact of kinetic operations on cyber operations. In part, this change was influenced by the Israeli strike on the alleged origin of an on-going Hamas cyber attack [83]. This change highlights the extensible nature of the game genre and provides an example of how the game development effort responded to real-world events.

- Removal of explicit force packaging. MDC2 TCG contained a form of force

Figure 4: Examples BSN game resources and cards

packaging allowing players to combine cards for attack and defense to model strategies such as fighter escort and close air support in the air and synergy of Brigade Combat Teams (BCT) on the ground. However, this was reported as one confusing part of the game and generated many questions during play testing, ultimately leading to its removal. Instead of combining forces together when deployed or pairing capabilities together when attacking, the player now attacks with one card at a time. This has several advantages: (1) it is simpler to determine which cards should be included in each battle so players reach resolution more quickly, (2) players can also more accurately predict what will happen during an attack (unless the defensive player reveals a hidden defensive capability), and (3) it makes force packaging implicit instead of removing it completely. The force package is now defined as the capabilities that a player uses in one turn. Instead of attacking with a bomber and sending a fighter with it to intercept defensive counter-air assets, the attacker must take out the defensive fighter(s) first and then use their bomber on the second action during the same turn. This single-card-attack concept allows players to string capabilities together from multiple domains to create battlefield effects while increasing playability. Explicit force packaging can be easily re-added to BSN if

required by LOs, by including sections from previous game instructions provided in Appendix D.

- Removal of the BCT mechanic. The resource savings obtained by deploying BCT cards together was removed to simplify game play and instructions.

- Addition of the Spectrum of Conflict mechanic to represent the difference between conflict and competition[4] in near-peer warfare. This change directly supported LO 3 and helped regulate the beginning of the game. It also added value to the more unpredictable cyber capabilities and minimized the "first strike" advantage possessed by the player who went first in MDC2 TCG.

3.2.7 Game Evolution

Table 4 details research activities and identifies the significant changes from one version of the game to the next. Play tests A-D focused on the game design and accuracy of the game instructions and tutorials. The classroom experiments, detailed in Appendices L and M, focused on the effect of the game on the participants. Suggestions for classroom integration and game improvements were pursued during both, however the data collection tools used in HSR experiments focused on what the participants learned while informal play tests was more narrowly focused on the game's playability, not the player's learning experience. Game instructions for all game versions are included in Appendix D.

3.2.8 Comparison to Other Military Serious Games

In contrast to the other SGs mentioned in this paper, BSN was designed using LOs shaped by current MDO concepts. *CyberStrike*, *CyberSeige*, *CyberWar 2025*,

[4]Additional information located here: https://www.jcs.mil/Portals/36/Documents/Doctrine/concepts/joint-concept-integrated-campaign.pdf

Table 4: Evolution of game changes and feedback mechanisms

Event [Key]	**Game Version**	**Version Notes**
Pilot Study A [CSCE 525]	MDC2 TCG v1	Original version of the game
Pilot Study B [RMCS]	MDC2 TCG v1	Updated instructions to answer questions based on personal correspondence with game creator
Play Test A - 88th Communications Group	MDC2 TCG v1	Tested removing force packaging and allowing any deployed card to intercept enemy attacks
Experiment 1 [13O]	MDC2 TCG v2	Removed persistent force packaging
Experiment 2 [ACE]	MDC2 TCG v3	Removed strategic investment by establishing set starter deck; Added Spectrum of Conflict mechanic
Play Test B - AFIT Students	BSN v1	Tested "C2 Action Points;" persistent capabilities; strict order of battle; and ad-hoc force packaging. All cards could be used on the turn they were deployed. Used resource and damage chips
Experiment 3 [ACSC]	Treatment A: MDC2 TCG v1 Treatment B: BSN v1	Utilized MDC2 TCG v1 as a comparison against re-designed game (BSN v1). BSN v1 included C2 Action Points, persistent capabilities, and allowed attack to include multiple cards in an attack wave
Play Test C - AFIT Students & Staff	BSN v1	Tested removal of C2 Action Points, increase of resources for player who goes second, and changing all zero cost cards (made them all 1); added levels 1-3 of playing area
Experiment 4 [SENG 593]	BSN v2	Removed C2 Action Points and persistent capabilities; reintroduced a deployment phase to delay the time between capability deployment and availability
Play Test D - AFIT Students	BSN v2	Tested new cost structure, single-card-attacks, and edited cyber-attack thresholds
Experiment 5 [CSCE 525]	BSN v3	Removed ad-hoc force packaging; implemented single-card-attacks; refactored card costing in order to remove zero cost cards and balance the cost of stealth; lowered missile defense thresholds to make cruise missile attacks more effective
Experiment 6 [ROTC]	BSN v3	Maintained both game cards and instructions from previous experiment
Experiment 7 [ACC]	BSN v3	No changes
Play Test E - Cyberspace Technical Center of Excellence (CyT-CoE) Event	BSN v3	Played the game with personnel planning to digitize BSN in the future
Experiment 8 [AFRL]	BSN v3	Added to FAQs based on questions from facilitator

and *Cyber Threat Defender (CTD)* are focused on one or two domains, but do not allow players to interact with capabilities from all warfighting domains and show how they interact. This game allows players to directly control capabilities from all domains providing hands-on evaluation and decision making. Similarly, *Air Doctrine Wargame (ADWAR)* and *Air Force Expeditionary Exercise (AFEX)*, contain rich detail for conducting air operations, but do not reveal the integration of non-kinetic effects into more traditional (kinetic) warfare. This restricts their ability to effectively model an MDO conflict. Additionally, the level of detail and student investment required to learn and play these two games limit their use both inside and outside of an established course. One AF Reserve Officer Training Corps (ROTC) detachment commander commented that, "The *AFEX* program AFROTC provides has some amazing features, but success is more dependent on understanding the nuisances of a 78 page manual than employing tactics [84]." In contrast, BSN provides detailed game instructions and examples in a 12 page document.

3.2.9 Comparison to Popular Strategy Games

BSN is also superior to other popular strategy games to model and teach MDO. *Battleship* is largely a guessing game with little detail about the maritime assets involved. *Risk*, like BSN, includes a dice rolling mechanic to determine battle outcomes, however, there is only one unit type, most strategy decisions are tied to geographic considerations, and game duration can be significant (1-8 hours). Also, dice rolls are used to determine every battle, which means success is dependent on rolling high numbers instead of sound strategy decisions. BSN abstracts geography and uses cards to diversify unit types across domains. Die rolls are used to determine some, but not all battle outcomes to better reflect reality. *Axis and Allies*, is also limited by its game duration (2-10 hours) and reliance on geographic considerations. Additionally,

it is tied to historical weapons and circumstances relevant to World War II (WWII), which do not include space and cyber domains or other modern military capabilities. Similar to BSN, *Chess* has multiple unit types with different abilities, shorter game duration, and a single game objective. However, the game is played in two dimensions where all units can remove enemy assets from the game. MDO games require units that are protected from capabilities in some other domains. For instance, cyber capabilities cannot be directly affected by kinetic capabilities unless the source of the cyber effect or the physical data connection are targeted directly.

3.2.10 Comparison to Commercial Collectable Card Games (CCG)

One significant departure of BSN and MDC2 TCG from Collectable Card Games (CCG) described by Järvinen (the Pokémon Trading Card Game (TCG) and Magic the Gathering) is that they do not include activities related to collecting or trading cards [65]. The commercial game design companies print hundreds or even thousands of cards which players must consider in building the deck they will use. In this study all players have access to the same cards. This was required in order to execute a fair and standardized experiment and place the focus on the player's strategy, not the strength of the cards or resources available to them. Additionally, the limitation of the deck-building phase in subsequent versions of MDC2 TCG and its removal in BSN was designed to reduce the time it took players to learn the game, develop a strategy, and start playing. However, this departure is not significant enough to change the game characteristics identified by Järvinen in Section 3.2.4. Applications developed for the Meta Game (level 3) of the MDO Game Framework will take advantage of this unique aspect of CCGs.

3.2.11 Advantages and Disadvantages

BSN has several advantages for military training. First, it only requires two players, making it accessible for small groups or pairs both inside and outside formal education environments. Second, BSN can be acquired cheaply and quickly, creating accessibility to educators and individuals.[5] Third, the game is flexible, meaning it can be used to teach a wide range of lesson objectives, including non-MDO concepts. Fourth, the game reaches unique populations in the military. This was a strength of the game identified by Brigadier General Chad Raduege, a senior cyber leader in the AF. In response to the game he said, "This game is a brilliant idea. In our Air Force, we need various tools and methods to educate personnel who have a variety of experience and interests [85]." Finally, the game is designed to be easily integrated into formal and informal settings aided by resources such as the Facilitator's Guide provided in Appendix B and the tutorial video.[6] These are designed to equip educators to understand the game and lead effective debriefings. The example debriefing questions address various levels of Bloom's Taxonomy of Learning [38] to integrate into a wide range of courses and operational communities across all domains.

However, the game also has disadvantages that, although reduced through development and the available resources, need to be considered before widespread acceptance.

First, BSN abstracts many capabilities and relationships to create a playable game. These abstractions can lead players to draw faulty conclusions about reality. This weakness of the game, and other games, simulations, and models, can be mitigated through careful debriefing and other forms of instruction introduced either before and after game play.

[5]The game is available through a commercial game distributor for less than $7 per student: https://www.printplaygames.com/product/battlespace-next.

[6]https://www.youtube.com/watch?v=GIEq3LNekXw

Second, the game's complexity requires players to commit a significant amount of time to learn it. This disadvantage can be reduced through guided play with a knowledgeable player or exposure to effective teaching tools. Initial capabilities exist but are still not sufficient to effectively teach the game to a broad audience. Additional game demos, tutorials, and strategy guides are needed. If BSN elicits interest within the military in similar ways to popular commercial games, then this community will organically generate many of these products. Initial efforts to establish this community have produced a site displaying the current game versions and provide a space for community feedback and discussion.[7] According to [76], CCGs are shown to build a strong community of followers, which motivates play.

Finally, this research reveals that games in general, and this game in particular, do not interest everyone. Using a game for education may disinterest those who do not enjoy games or think they are childish. One specific comment from Pilot Study B revealed that one person learned only one thing from the game: "Don't play it." Although this concern will be a reality with many educational and commercial games, the complexity of BSN may increase this negative aspect, leading to a negative experience for a limited number of students. A game's design and quality of instructional material may help to mitigate this concern, but the vast number of games in the commercial space reveals that even those who enjoy games do not enjoy every game. As professional CCG developer, Mark Rosewater, has commented, "When you aim to please everyone, you often please no one." BSN was designed for specific purposes and a broad audience, but this may become a disadvantage as a few players will be dissuaded from further engagement by game the details of this specific game or the use of a game in general.

[7] https://boardgamegeek.com/boardgame/292874

3.2.12 Conclusion

A significant part of this research effort is dedicated to developing a game to model MDO and provide a valuable education and training tool for use in current military curricula. The next section presents the methodology used to evaluate the game using contemporary SG methodology.

3.3 Human Subjects Research Experiments

The second major effort of this research is evaluating the effects and integration efficiency of SGs in military education and training environments. Specifically, the experimentation attempts to answer the five research questions (RQ) presented in Chapter I:

RQ1. What is the response to an SG in military education and training courses?

RQ2. To what extent does the game model and teach current MDO concepts?

RQ3. What effect does the game have on players?

RQ4. How time-efficient is the integration of the game into current education and training courses?

RQ5. To what extent does the game facilitate MDO innovation?

RQ2 was partially answered in Section 3.2.4, however, results from the HSR experiments provide additional evidence.

3.3.1 Pilot Study

Early in the research process a Pilot Study was undertaken to gather initial feedback on the operation of MDC2 TCG in two formal environments. The Pilot Study and the Primary Study described below were both approved by the Institutional Review Board (IRB) at Air Force Institute of Technology (AFIT). Approval details are

provided in Appendix K. Pilot Study A, was held within a Master's course at AFIT taught by the Computer Science and Engineering Department title "Cyber Warfare and Security," or CSCE 525. The class, taught by a committee member, consisted of 13 students including the author.[8] The second experiment was held during a one-time seminar presented at the Rocky Mountain Cyberspace Symposium (RMCS) in Colorado Springs, CO. The author submitted a proposal to use the game during one of several training seminars offered the day before the main conference. Therefore, participants in this experiment knew that they would be playing a game when they signed up for the seminar. However, other topics were covered during the four hour seminar. Additional details, observations, and research notes are included in Appendix L.

The two experiments captured data about the participants' views on SGs (referred to as educational games in data collection), their experience during the session, and their game improvement recommendations. The procedures followed those used in the Primary Study which are outlined in the following sections. One significant difference was the use of paper surveys instead of the electronic surveys used in the Primary Study.[9] The applicable versions of the surveys are provided in Appendix E.

This study measured the response to the original 2018 version of MDC2 TCG, although minor updates were made to the game instructions inherited from the game creator. The significant takeaway from the Pilot Study was the need for improvements to the game including adding additional capabilities, improving instructions, creating resources to teach the game mechanics, and designing a formal approach to debriefing the in-class sessions. Specifically, the addition of Space and Maritime domain cards

[8]The author took part in the experiment as a student, but did not completed a survey

[9]Paper surveys were completed by 69% of Pilot Study participants (N=58), compared to only 54.8% of Primary Study participants (N=188). However, electronic surveys led to more robust open-ended responses. Those who answered on paper only used a few words or a sentence, but those who completed an electronic survey usually provided multiple sentences of input.

was mentioned several times by participants. It was also apparent that implementing the game in a classroom requires a significant time commitment. For example, Pilot Study B, provided a two hour session to give a brief description of MDO, explain the game rules, and then play a demo game. However, this time block was not sufficient for this purpose as no players completed their games and numerous questions were asked during the session about basic setup and game mechanics. Overall, the two experiments that became the Pilot Study helped to refine the experiment procedures used in the Primary Study. Additional details and findings from the Pilot Study are provided in [86].

3.3.2 Primary Study

Input from the Pilot Study helped to shape the experiment procedures and the development of BSN, which was the focus on the Primary Study. To further evaluate the research questions, investigators initiated eight additional HSR experiments. The research methodology followed best practices identified by [87] and [88], although some departures were necessary based on environment constraints. The study was conducted over a period of 7 months reaching a total of 188 participants in formal education settings. 103 (54.8%) participants completed both pre-survey and post-survey.

Each experiment followed this basic protocol:

(1) Deliver outline of experiment procedures and send pre-survey.

(2) Distribute game resources and provide instructions for in-class session.

(3) Conduct in-class session where all students play the game for at least one hour and participate in a group debriefing.

(4) Send post-survey to all participants.

These steps are consistent with other SG studies [70] [50] [89] and [69], although

most controlled the time spent learning and playing the game, which was an uncontrolled variable in this study.

3.3.3 Game Evaluation

The study evaluated BSN by collecting instructor and student self-reported learning and game response.[10] Instructors received a 13 question post-survey containing Likert Scale and open response questions on their perception of the game's operation in their classroom. All participants received a 51 question pre-survey and 38 question post-survey to measure the effect of the game on MDO learning and military readiness. Surveys collected participants' game experience, what they learned, and recommended improvements. The surveys included questions linked to the common factors identified by [66] and [52] including enjoyment, motivation, playability, usability, realism, relevance to personal interests, and learning effectiveness. Electronic data collection tools were provided outside of both the game and in-class session, which is referred to as external assessment.

This study used external assessment, instead of game scoring or internal assessment, as it fits the physical nature of the game and provides the richest data for analysis [66]. Game scoring was initially implemented alongside external assessment, however, it only collected 6 data points for each game, was significantly impacted by the opponent's (not the player's) skill, and many games ended without a clear winner. Therefore, the scorecards did not contribute to measuring the player's learning. Copies of the scorecards are provided in Appendix H. Finally, the number of concurrent games (up to 20) meant human or digital observation was not feasible.

[10]Responses were collected through Limesurvey: https://www.limesurvey.org

3.3.4 Population

MDO education is required for a broad audience so a wide range of experiment populations were sought. This choice drove variability in the data, but also allowed comparison across a wide range of ages, military experience, and enjoyment of games. Experiments were limited to education and training environments in which curriculum owners were willing to use training hours to complete the experiment. The courses contained objectives matching the explicit game LOs or the instructors were interested to use a version of the game in future courses. Conducting experiments in established courses provided opportunities to test game integration, conduct experiments under an IRB exemption condition, and increase the population size over other proposed recruitment methods.

The research targeted the 13O Initial Skills Training (IST) to provide feedback from personnel with Command and Control (C2) experience chosen to advance the implementation of Multi-Domain Command and Control (MDC2) in the AF. 13O IST is designed to train members of the new AF career field focused on MDC2 in operational centers. Although the course was focused on initial training, all students were chosen to be the first members of the career field because they possessed significant C2 experience. This experienced cadre of officers provided early data on the game's realism and applicability to MDO. Next, the Advanced Cyber Education (ACE) course provided a large group of students in the 18-24 age group, a common target audience for SGs, without MDO experience. Also, ACE is focused on cyber education, aligning with multiple game LOs. The third experiment at Air Command and Staff College (ACSC) provided a large population where the two major versions of the game could be tested by personnel familiar with MDO concepts. In this study, BSN was introduced and compared to the original version of MDC2 TCG to validate

the development process. Experiments four[11] and five[12] tested the game's integration into master's-level courses with a majority of students in the junior officer category, which was recommended by senior leaders as a prime audience. Sixth, the Army ROTC experiment tested the improved game version with younger players as well as examined the integration of the game in an officer accessions program, identified as an appropriate target environment for long-term use. Next, the game was tested at Air Combat Command (ACC) Headquarters in the Cyberspace and Information Dominance Directorate (ACC/A6). This experiment was designed to validate the game as an operationally relevant tool by those on the leading edge of non-kinetic warfare integration. Finally, the game was tested in a unit training session at the Information Directorate for Air Force Research Laboratory (AFRL) located at Rome Labs, NY. This experiment was not led by the author, but by a point of contact (POC) at AFRL who heard about the game and wanted to use it to introduce personnel to MDO. This POC conducted a small familiarization session with a few colleagues who helped him execute a larger study for 25 other participants, all associated with AFRL. The POC had access to the Facilitator's Guide and shared emails and two phone conversations with the author to review experiment procedures and answer specific game questions.

Figure 5 shows participants playing MDC2 TCG during the ACE Experiment.

The populations provided a sufficient number of participants with a broad range of ages and military experience. However, these populations were grouped into different environments, which limited direct comparison because of other uncontrolled variables, such as the time players had to interact with the game, duration of in-class sessions, and saturation of academic schedules. Additional populations were pursued, such as Squadron Officer's School (SOS) and Officer Training School (OTS)

[11]CSCE 525 is a Master's level course titled "Cyber Warfare and Security" offered by the Computer Science and Computer Engineering (CSCE) Department at AFIT.

[12]SENG 593 is a Master's level course titled "Agile Software Systems Engineering" offered by the Systems Engineering and Management (ENV) Department at AFIT.

Figure 5: Experiment participants playing MDC2 TCG (Photo taken by author and included with permission from participants)

that would have provided more consistency, but sufficient training hours were not available to facilitate the experiment.

3.3.5 Data Collection

Data was collected through pre-surveys and post-surveys, both distributed electronically through email. Initially, participant names were used to align both surveys and paper scorecards. However, later experiments assigned a random token to participants to align responses. No participant names or other identifying information were included in any data release. Surveys were collected in Limesurvey [13] and responses were encrypted with a password known only to the author. The pre-survey collected demographic data, game habits, and military experience. It also included questions about the use and response to general educational games (serious games).

The post-survey queried individuals on their response to the game and growth in

[13] https://www.limesurvey.org/

readiness. Several post-survey questions measuring game response were modeled after published game questionnaires [75] [74], while other questions measuring improvement in military readiness were modeled after content by the Gaming Research Integration for Learning Laboratory (GRILL),[14] who frequently experiment with games for military training.

The data collection tools were significantly altered between the Pilot and Primary Studies, and a few small changes were introduced between Primary Study experiments. Some questions were deleted while others were adjusted to effectively capture players' game experience and adjust to game changes. The pre-survey was adjusted to include academic major, which was necessary once college students were included in the ACE experiment. The two versions of the pre-survey are provided in Appendix F. The post-survey, on the other hand, had several questions added and removed to balance data acquisition and survey fatigue. Three major versions of the post-survey were used, which are included in Appendix G. The author intends to make the sanitized data set available to inform future game development and SG evaluation inside and outside the military.

3.3.6 Environment

Experiments were limited to education and training environments of the courses selected, as detailed in Section 3.3.4. These courses established the unique environment of each experiment. Four of the experiments (1, 3, 4, and 5 from Table 5) were held in a traditional classroom during the courses' scheduled meeting time. In these experiments, instructors required all enrolled students to participate. Student attendance was mandatory as it was during a scheduled class period, but survey completion was optional. Figure 6 shows the classroom environment where several games are being played at once during the CSCE 525 experiment.

[14] https://gamingresearchintegrationforlearninglab.com

Table 5: Summary of primary study experiments

Experiment	**Location**	**Total Participants**	**Completed Surveys**	**Experiment Duration**
1 (Jul 19)	13O (MDC2 Career Field) Initial Skills Training, Hurlburt Field, FL.	27	15 (55%)	2 Hours & 15 Minutes
2 (Jul 19)	Advanced Cyber Training (ACE), ROTC cadet summer training program	36	9 (25%)	3 Hours (split over 4 days)
3 (Aug 19)	Air Command and Staff College (ACSC), Multi-Domain Operations Strategist (MDOS) Program	45	21 (47%)	2 Hours & 30 Minutes (split over 3 days)
4 (Oct 19)	Air Force Institute of Technology, Agile Software Engineering Masters Course (SENG 593)	23	20 (86.9%)	1 Hour & 30 Minutes (split over 2 days)
5 (Nov 19)	Air Force Institute of Technology, Cyber Warfare and Security Master's Course (CSCE 525)	16	10 (62.5%)	2 Hours & 30 Minutes (split over 2 days)
6 (Nov 19)	Army ROTC, Wright State University	13	8 (62%)	2 Hours & 15 Minutes
7 (Nov 19)	Information Warfare MDO Challenge, Langley AFB, VA	3	2 (66.7%)	2 Hours
8 (Jan 20)	Air Force Research Laboratory, Rome Labs, NY	25	18 (72.0%)	2 Hours
Total		**188**	**103 (54.8%)**	

The other four experiments (2, 6, 7, and 8) required special circumstances. The instructor for the Army ROTC experiment elected to establish a separate time for students to voluntarily participate in the experiment. The primary purpose was to increase participation from all those enrolled in the ROTC program. The ACE schedule limited the experiment to volunteers who committed time to participate over four consecutive lunch periods. The Langley AFB experiment was held at the Langley Club for convenience and availability to base personnel. This setup was similar to other specialized training seminars hosted on the base. The room was setup with round tables for game play. This setting felt more relaxed than a traditional classroom and popcorn was provided to all attendees. The AFRL experiment was held in a unit training room. Participants signed up for one of two sessions held on the same day to maximize participation. In all four of these studies participants knew that they would be playing a game during the seminar. Therefore, participation in the experiment and survey completion were both optional.

Figure 6: Classroom setup during the CSCE 525 experiment (photo taken by author and used with permission from participants)

3.3.7 Participant Instructions and Schedule

Participants were given access to the pre-survey electronically through their email and then provided the game resources (instructions, cards, and tutorial video). All participants, except those in the 13O IST experiment, received physical cards and paper instructions at least two days prior to the in-class session. Participants were instructed to review the resources, develop an initial game strategy, and arrive at the in-class session ready to play. This out-of-class preparation was needed because course instructors would only allow 1-2.5 hours of class time for the experiment instead of the 4 hours requested. Instead of dedicating more in-class time, the instructors chose to assign the game preparation activities as homework. This setup was not ideal for

data collection, however, it was necessary to integrate the experiment into current courses with established priorities and training schedules. The post-survey queried participants about the amount of time spent reviewing the game resources outside of class, however experiments that controlled the exact time allowed for learning and playing the game would likely produce more stronger evidence. The ACE study was unique in this aspect because the first 45-minute period was spent viewing the tutorial video and answering questions.

Overall, post-surveys showed that it was common for participants to ignore the game preparation tasks.

One third of all participants did not review the materials before the in-class session. In order to complete the experiment, students were still expected to play the game during the in-class session instead of taking time to review the basic game rules. This forced unprepared students to learn the game while playing. It is assumed that this distracted all students from the primary LOs as the unprepared students were much more focused on the game rules and mechanics than strategy development and real-world implications.

Participants had between 2-6 days to review all resources before the in-class session. The in-class session lasted 1-2.5 hours and allowed participants to play at least one game against a similarly skilled opponent and participate in a group debriefing led by the author or course instructor. The first game served as a demo to build familiarity. In subsequent games, players are matched to an opponent of similar skill to maintain a high challenge level, which is connected to engagement and learning in SG experiments [52]. To maintain challenge without frustrating players who did not perform well, participants who won the first game would be paired with another winner and vice versa with the losing players or teams.[15] Figure 7 shows four participants

[15]In experiments 4, 5, and 8 most players formed their strategy and played the game in pairs to increase teamwork and cooperation during game sessions.

playing BSN during the CSCE 525 experiment.

Figure 7: Participants playing BSN (photo taken by author and used with permission from participants)

3.3.8 Conditions

The study tested the two games described in Chapter II and Section 3.2. Both served as specific implementations of a Base Game (Level 2) of the proposed MDO Game Framework. Changes made to the game and associated materials across experiments and play tests is discussed in Section 3.2.7.

The 13O IST and ACE experiments used MDC2 TCG, although slight changes were made to the tutorial video and game instructions between experiments. In the 13O IST experiment players did not use persistent force packaging, although

escorts could still be used. During the the ACE experiment the game was further simplified by reducing the starting deck to 40 cards thereby removing the strategic investment phase. Additionally, a "quick start" version of the instructions was used that simplified the game rules and mechanics.

The ACSC study provided a unique environment due to the number of participants and available classroom space. The class of 45 students was already split into four groups that were evenly distributed by operational experience, gender, and branch of military service. This allowed for a comparison study that was not reproducible in other courses. MDC2 TCG was tested in 2 seminars with a total of 22 students and BSN was used in 2 seminars with a total of 23 students. The original 2018 version of MDC2 TCG was used; specifically, players completed the strategic investment phase and were able to use persistent force packaging. The remaining experiments used BSN, although further changes were made after experiment 3 as detailed in Table 4. Experiment 4 used the second version of the BSN cards, but corrections had to be posted on a projector during the experiment. These issues were resolved when new cards were printed for experiments 5-8. The instructions and tutorial video were also consistent over these experiments as no significant errors were identified. The condition changes, though necessary to create the most relevant end product, introduced variability in the experiments and may have caused uncertainty in the data and limited statistical significance.

3.3.9 Research Limitations

The research must be interpreted in light of several limitations. First, variations in environment, experiment duration, game instructions, game resources, and data collection tools may have negatively impacted the reliability of the data set. For example, most participants were asked to complete the strategy development phase on

their own time to shorten the time consumed by the experiment. However, this created variability in the time each participant dedicated to learning the game. Although the post-survey tried to measure these factors, the variation limited comparison across experiments because the differences in participant answers could not be solely based on the treatment, except in the ACSC experiment. Overall, this led to a greater emphasis on the qualitative aspects of the data. Second, a control group for all experiments was not available in order to draw direct comparisons to other methods of instruction. While MDO awareness education is increasing, no standardized training exists that addresses similar LOs, especially related to strategy development and capability awareness. Analysis of quantitative data was tempered by the lack of a control group limiting broader conclusions. Third, the author was highly involved with all the studies and one of the committee members instructed both CSCE 525 (Pilot Study A) and SENG 593 (Primary Study, experiment 6),[16] which may have biased participants to inflate game effectiveness, although we find this unlikely because this instructor did not track respondents or responses. Finally, the limited response to both surveys (only 103 of 188 participants) may not constitute a representative sample of the courses tested.

More consistent environments with a larger population and multiple, simultaneous classes were requested, such as SOS and OTS. While both schoolhouses were interested in supporting the experiments, their course schedules could not support the shortened research timeline. Future studies that control the amount of time between initial game exposure and the in-class session, standardize the time to review game resources, and use a control group will likely produce more precise and statistically significant results. Additionally, paper surveys administered immediately after intervention would likely produce a higher response rate.

[16]No committee members completed an instructor survey.

3.4 Methodology Summary

This chapter details the methods to develop an SG to model and teach MDO concepts and the HSR experiments used to gather empirical data to evaluate the game and answer the proposed research questions. The next chapter analyzes the results from the eight Primary Study experiments described above.

IV. Results and Analysis

4.1 Overview

This chapter describes the results from the Human Subjects Research (HSR) experiments described in Chapter III. The results are discussed in sections that seek to answer each of the research questions (RQ) and other items relevant to Multi-Domain Operations (MDO) education and the use of serious games (SGs) in the military. Although several factors limited the statistical significance of the data, the quantitative and qualitative data provides evidence to answer RQ1-4 and provides insights on RQ5. Results are discussed to provide insight into the response to SGs, in general, and Battlespace Next (BSN), in particular, from military personnel.

Overall, ten HSR experiments were conducted, two for the Pilot Study and eight for the Primary Study. In total, 246 participants played a version of the game in a controlled environment, 188 in the Primary Study. Within this study, 141 individuals completed a pre-survey and 121 completed a post-survey. However, only 103 participants completed both surveys. Section 4.2, reveals the demographics of this population. The following sections focus primarily on these 103 participants, but some questions that do not require a before and after comparison take all survey responses into account. Additionally, three of the five instructors who observed experiments provided a response to the instructor questionnaire following the in-class session. Informal written feedback via email was received from the other two instructors. All other instructors were not eligible to complete questionnaires because they did not directly observe the experiment or were members of the thesis committee.

Survey question nomenclature is based on the order of appearance to participants. "PreQxx" is used for pre-game question #xx, where xx represents a numerical value. A similar nomenclature is used for post-game questions substituting "post" for "pre"

(PostQxx). The quantitative data was analyzed for statistical significance based on participant age, military experience, weekly game usage, and game version played. However, no two groups answered in a way to find statistical significance in measured game response. Additionally, the lack of a control group, changes in environment, and variability in the time allowed to examine game materials across experiments limited comparative analysis.

4.2 Participant Demographics

As designed, the research collected data from a variety of military personnel. Figure 8 depicts the number of participants, surveys completed, average age, and military experience of each experiment. The error bars show ±1 Standard Deviation (SD) for age and military experience for individual experiments and the entire study. 86% of participants were AF personnel (89), the remaining participants were split among other U.S. Military branches, specifically the Army (11), Marine Corps (2), and Coast Guard (1). Of the 89 AF personnel, 17 were DoD Civilians. 83 participants were male, 19 were female, and 1 preferred not to respond. The composition of this population was dependent on those who signed up for these courses and no student had a priori knowledge that they would be playing the game except for those in experiments 6-8.

The pre-surveys revealed that many participants did not have previous experience with educational games. 34% reported they had played one in the past, but only 24% had played one in the last 6 months. When asked to describe their experience with educational games, many referenced games played during childhood or during Professional Military Education (PME). Participants played an average of 3.8 hours of digital games per week (SD 5.4) and 1.78 hours of physical games per week (SD 2.06). Based on the wording of the question this may include physical sports as well

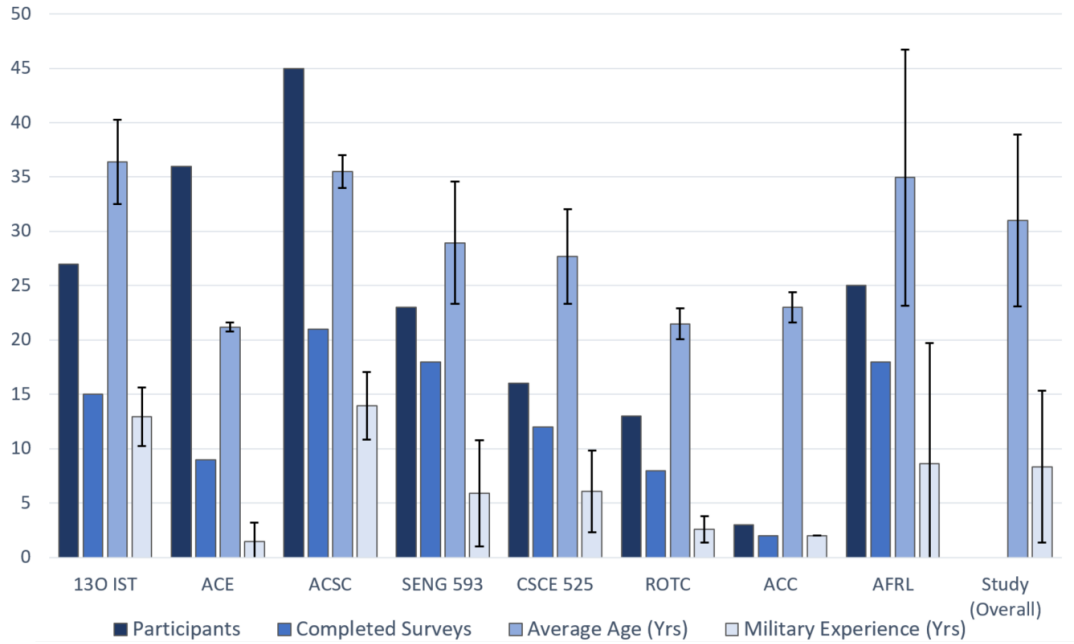


Figure 8: Participant demographic data by experiment (N=103)

as table-top or other physical games. Only 19 had played physical Collectable Card Game (CCG) similar to BSN in the past 6 months and 6 additional participants had played only a digital CCG. Two of those who had played CCGs in the past said that they strongly dislike them, while 17 enjoyed playing them. Of the 78 participants that had not recently played a CCG, 34 reported they would enjoy learning to play one, while another 33 were undecided. However, 11 participants said they would not enjoy learning how to play this genre of game. This reveals a preconceived bias against this game genre from some participants, however, this did not significantly impact the results as 6 said that they agreed or strongly agreed that they enjoyed playing BSN in the post-survey.

4.3 RQ1: Serious Game Response in Military Education and Training

The response to the use of games in military education and training was largely positive. Analysis of the 141 completed pre-surveys, show only 4 (2.8%) participants

reported that they do not enjoy learning through games and 7 (5%) did not want to see more games used in military education and training. However, 19% and 30% respectively were undecided. Figure 9 shows the results the following statements from the pre-survey using a 5-point Likert Scale:

[PreQ48] Formal military education and training needs to be more engaging.

[PreQ49] I enjoy strategy games.

[PreQ50] I enjoy learning through games.

[PreQ51] I want to see more games used in the military for education and training.

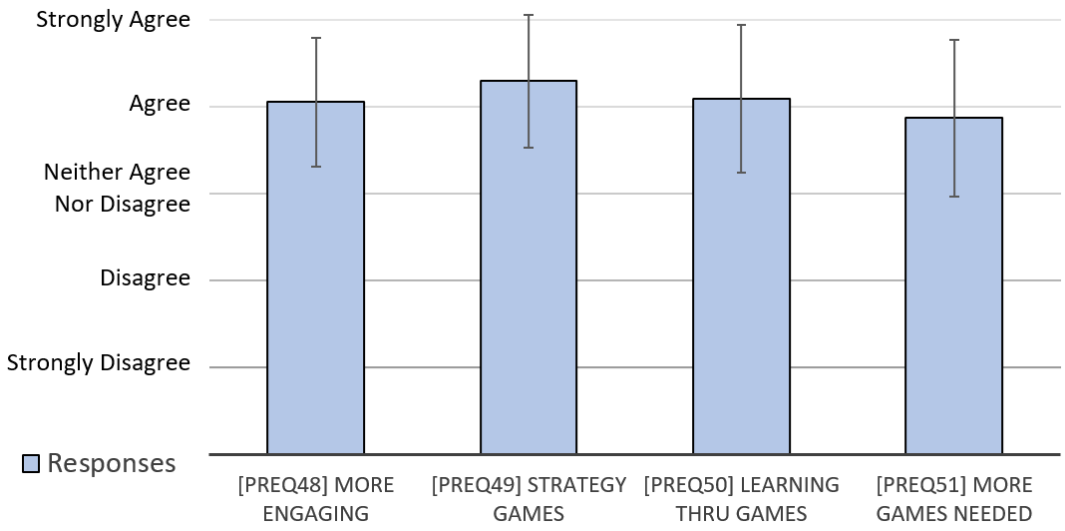


Figure 9: Participant Response to the Use of SGs in military education and training (N=141). Error bars show ±1 SD.

Participants' enjoyment of games and their desire for more games in formal learning help characterize an individual's response to the use of a game. Figure 10 shows this relationship by comparing responses to PreQ50 and PreQ51. While strong correlation was expected between these two questions, the results suggest additional factors at work. Although an individual may enjoy educational games, they may not always desire to use them in formal learning settings. A group of participants (N=25) enjoy learning through games but were neutral or disagree on their increased

use in military education (values highlighted in red). A few (N=6) who were neutral on the enjoyment of games still thought they should be used more often in military education (values highlighted in blue). These results may be partially explained by the broad terminology ("game") as the specific game implemented in a course may significantly impact the response.

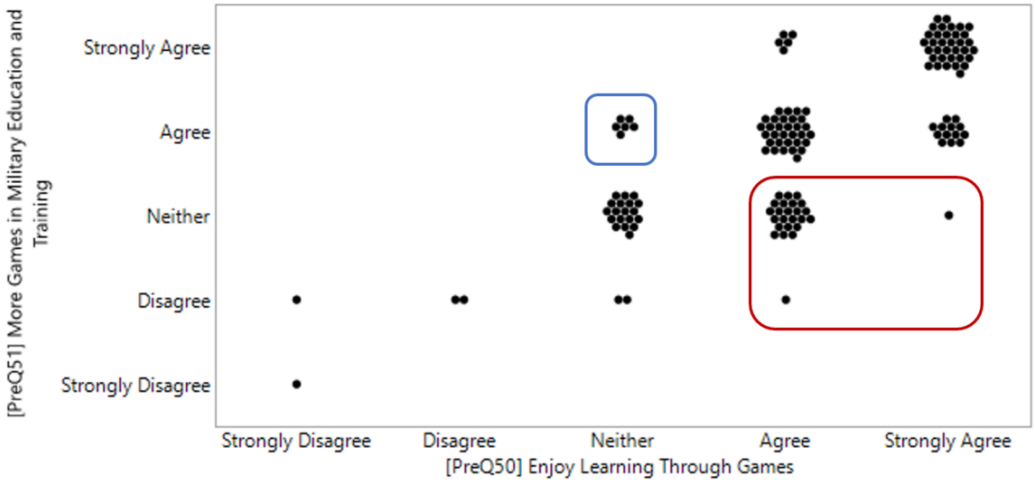


Figure 10: Comparison of responses to PreQ50 and PreQ51 (N=141). The red box shows participants who like games but not in formal education. The blue box shows participants who are unsure about games but think they should still be used in formal education

After experiencing the treatment, participants were asked to compare it to a hypothetical lecture on MDO. Of all those that completed a post-survey, 70% of those questioned said they would have rather played the game. Some participants (17%) would have rather attended a lecture and 13% were undecided. This reveals a strong preference for the games played in this study over a more traditional lecture. However, conclusions with broader application are not viable due to the lack of a control group who experienced a lecture or similar treatment.

4.3.1 Unpredictability of Serious Games

These results show that military educators and curriculum owners will receive a mixed response when implementing a game, but a majority will find it valuable. However, this reality may be common across all learning methods and tools due to the varied desires and interests of students. Games, however, seem to have a unique unpredictability inherent to their design. A person may be enjoy learning through games in general but have less enthusiasm for a specific SG. Comparison of results from both surveys reveal the unpredictability of the game used in this study. Figure 11 is a scatter plot comparing individual game enjoyment responses for generic games before the experiment and their enjoyment of the specific SG used as the treatment. Results show how well MDC2 TCG and BSN met player expectations. Points between the red and blue lines (N=46) represent participants whose expectations were met. The points below the red lines show respondents who thought the game did not meet expectations (N=31). Finally, the game exceeded expectations for 26 individuals, some as much as two points on a 5-point Likert Scale.

Similarly, Figure 12 compares participant thoughts on the increased use of any game in the military education and training as well as the future use of this game in particular. The game did not meet expectations for 21 (20%) individuals but exceeded expectations for 34 individuals (33%). 48 participants answered consistently for both questions, which are the points between the two lines.

This result could also be explained by the broad meaning of the word "game." If participants had another type of game in mind when answering the pre-survey this could explain their response after using a CCG in the experiment. Given the wide variety of game genres it is expected that individuals will find particular games and game genres more engaging and enjoyable than others, adding to their unpredictability in the classroom.

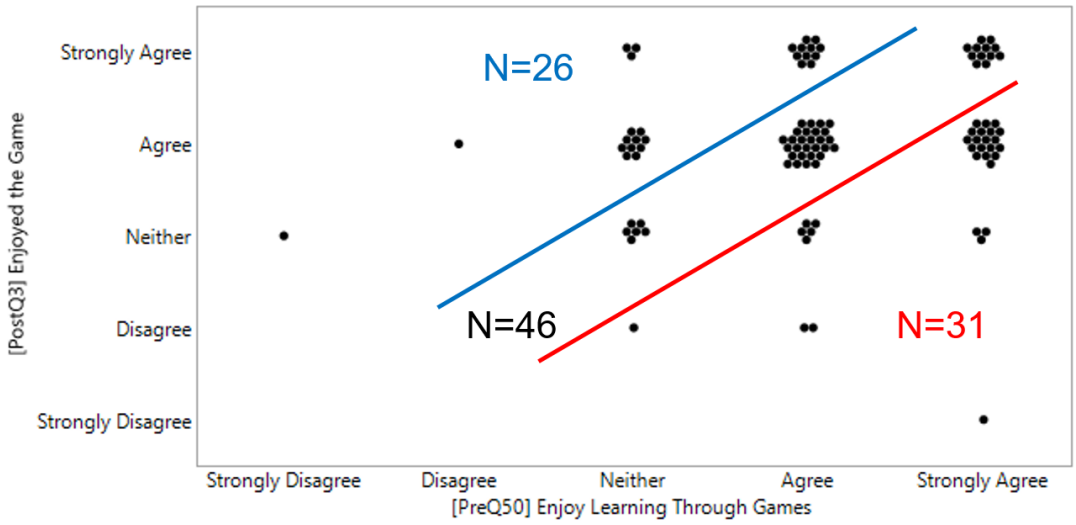


Figure 11: Comparison of responses to PreQ50 and PostQ3 (N=103). Highlights the difference between a participant's expectation of game enjoyment compared to their reaction to a specific game. The blue number is a count of the items above the blue line representing participants who enjoyed treatment more than they expected. The red number under the red line identifies the number of participants who's expectations were not met.

4.3.2 Valuable Alternative to Traditional Educational Activities

The qualitative data, specifically responses to the open-ended questions revealed that military personnel valued the game as an alternate learning method. One Air Command and Staff College (ACSC) participant shared, "I enjoyed that it was another learning venue besides lectures and reading. It allowed for learning by trial and error and implementation of concepts." In response to the question "What did you enjoy about the game?," six participants, including the one above, reported that they enjoyed that it provided an alternate method of learning in a classroom setting. Figure 13 shows this area was the fifth most cited response to PostQ32. The figure identifies the number of comments associated with each area as interpreted and coded by the author. Each comment was individually considered and summarized leading to the categories shown. If a comment addressed more than one area, it was split leading to 120 unique comments.

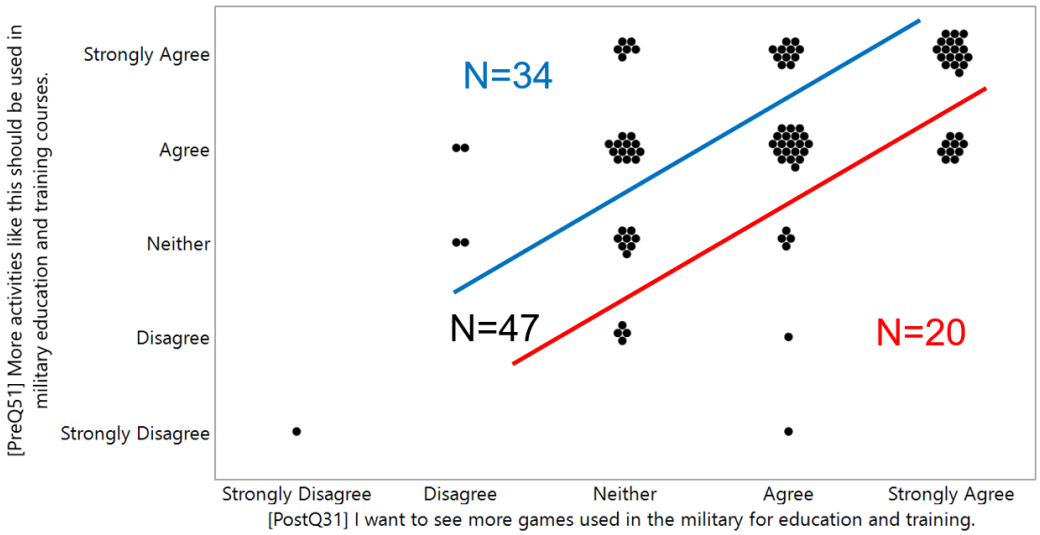


Figure 12: Comparison of Responses to PreQ51 and PostQ31 (N=101). Highlights the difference between a participant's desire for more games in military education and their response to a specific game. The number above the blue line identifies the number of participants who rated the game as exceeding expectations and the number below red line identifies participants who's expectations were not met.

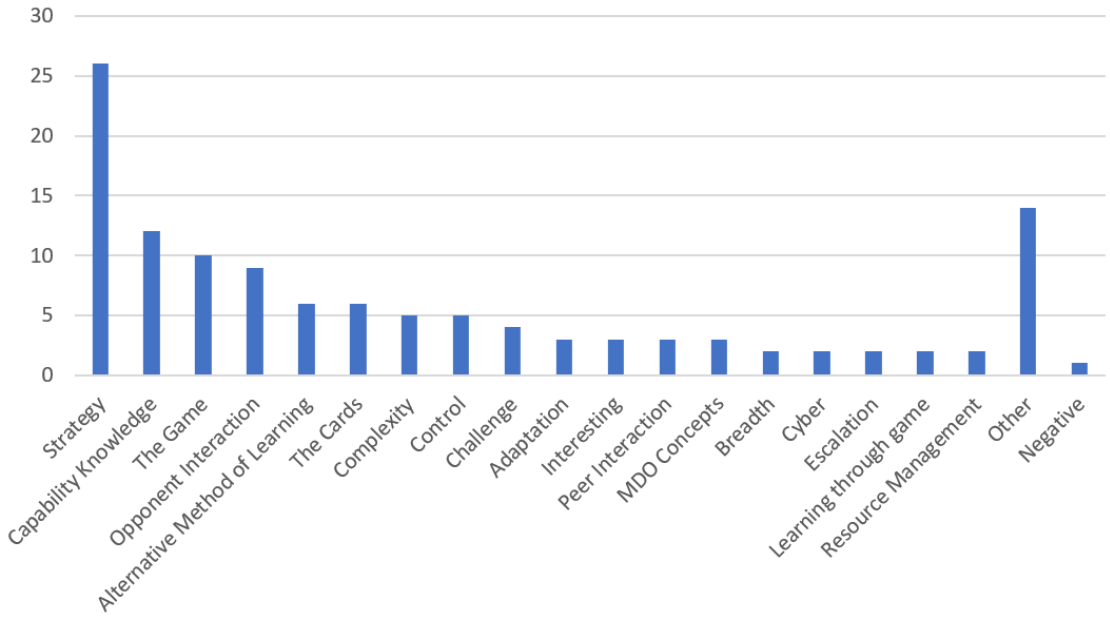


Figure 13: Histogram of open-ended responses to [PostQ32] "What did you Enjoy?" (N=120). The bar marked as "Other" includes items that were only mentioned by one participant. The negative response revealed that one player didn't enjoy anything about the game.

4.4 RQ2: Teaching Current MDO Concepts

Section 3.2.4 explains why the MDO Game Framework is appropriate to model MDO. In addition, both qualitative and quantitative data revealed the game was well-suited to teach MDO concepts and increase MDO readiness. Specifically, students reported an increased knowledge of capabilities, improved understanding of cyber, and the synergistic effects created by combining capabilities from multiple domains.

4.4.1 Mapping to Current MDO Discussion and Learning Objectives

Qualitative analysis of all post-surveys[1] (N=149) identifies 98 who responded to the question [PostQ22] "What did you learn from this game?" These were analyzed and coded based on the main idea in the response. If a response touched on multiple themes, it was broken into two or more categories. This led to 130 unique comments, of which 110 were interpreted as positive (35 for MDC2 TCG and 75 for BSN). Figure 14 shows the outcomes by percentage of comments by game version. Twelve negative responses were received, nine for MDC2 TCG and three for BSN. Half of the negative comments addressing the first version of the game were addressed by game changes in BSN. The remaining comments revealed three participants thought the game was inappropriate to teach MDO, two said capabilities weren't realistic, and one reported they didn't learn anything.[2] Six other participants reported they needed more time to play the game to identify learning outcomes.

Participants explicitly mentioned an increase in Cyber domain knowledge. This is believed to be connected to elevated focus on integrating cyber operations. Participants said the game increased their knowledge of military capabilities (capability awareness) and how they can work together in the battlespace to achieve effects (syn-

[1]This includes the Pilot Study and those who did not complete the pre-survey.

[2]This participant played MDC2 TCG in the ACSC experiment. They reported spending 2 hours reviewing game resources before the in-class session and said they were focused during the session. The comment seemed to suggest that they already knew everything the game was seeking to teach.

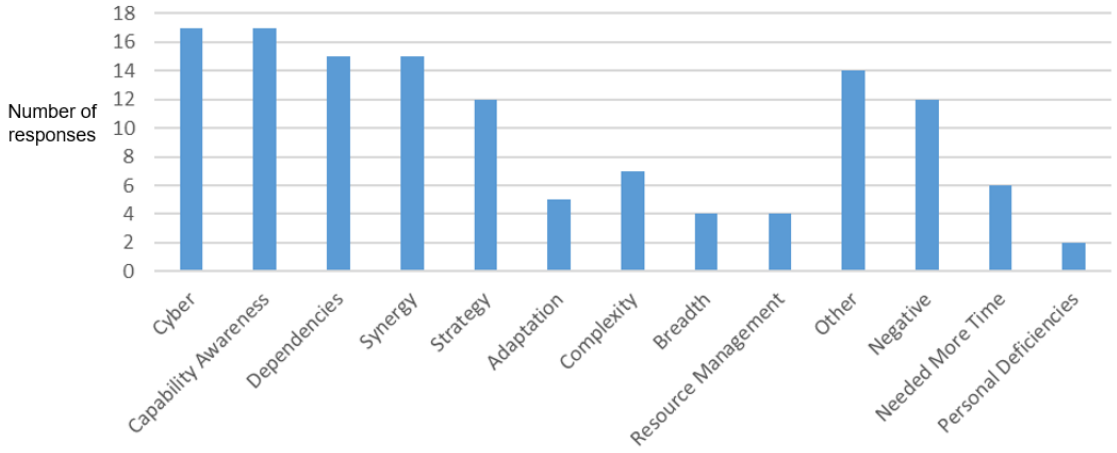


Figure 14: Histogram of open-ended responses to [PostQ22] "What did you learn from this game?" Bars show total number of comments received as interpreted by the author.

ergy). The number of responses related to strategy reveal that the changes made to BSN increased the number of participants who reported learning about MDO strategy. Learning about military dependencies was also mentioned in the top five categories, which is most likely due to the requirement mechanic inherent to the game. Requirements are listed on the cards identifying the support and logistics prerequisites required to employ that specific card. The development changes highlighted this aspect leading to a higher percentage of participants listing it as a learning outcome.

4.4.1.1 Learning Objective Mapping

Mapping these responses to the game's learning objectives (LOs) defined in Section 3.2.3 reveals parallels to learning areas identified by participants. The LOs are provided here for reference:

1. Recognize that both cyber and kinetic capabilities require a kill chain and advanced planning
2. Match cyber defense capabilities to corresponding threats.
3. Recognize the two levels on the Spectrum of Conflict (competition and conflict)

and practice using appropriate assets within each.

4. Develop and execute an MDO strategy in a complex and contested environment.

5. Select and combine capabilities to anticipate, adapt, and respond to surprise and uncertainty in near-peer warfare.

Cyber was tied with capability awareness for most often mentioned by students as a learning outcome. Cyber is directly identified in LOs 1 and 2, although more specific questions about matching offensive and defensive capabilities or advanced planning were not included in the survey or specifically identified in participant answers. Learning related to the Spectrum of Conflict (LO 3) was not specifically mentioned by any participants. LO 4 relates directly to Strategy, which was mentioned by 12 participants. Finally, capability awareness and synergy, identified by 17 and 15 students respectively are related to selecting and combining capabilities as identified by LO 5. The final topic mentioned in the top five is dependencies which is related to LOs 1, 4, and 5 as players must be aware of, and leverage, dependency chains to plan and execute actions within the game.

4.4.1.2 Current MDO Concept Mapping

These responses also reveal that by playing BSN, participants learned core MDO concepts identified by Goldfein. His priorities, as detailed in Section 2.2.3, are: (1) capability awareness, (2) combining of capabilities to create effects, and (3) strategies to use one and two in order to overwhelm the enemy. Capability awareness, the concept most often listed relates directly to (1). (2) related directly to synergy, which is the third highest element identified in Figure 14. Finally, strategy is fifth on the list and, as noted above, was mentioned much more frequently by those who played BSN.

Goldfein explicitly states that the goal of MDO is to overwhelm the enemy. This

goal is consistent with the overall objective of CCGs to outplay the opponent to eliminate them from the game. Specifically, in BSN, the game objective is to destroy the enemy's Multi-Domain Operations Center (MDOC) or force them to burn through their supply pile twice. Both of these events will immediately end the game. The player can choose to do this in many ways including overwhelming the enemy with superior force, creating windows of superiority to enable effective strikes, or outlasting the enemy causing them to run out of resources. This was aspect was confirmed by one 13O Initial Skills Training (IST) participant who reported, "I enjoyed the strategy. By picking the right starting cards and utilizing them properly, you can definitely overwhelm your opponent. The games seemed to be a measure of strategy and placement, rather than luck."

Open-ended responses aligned to Goldfeins characterization of MDO. One Air Force Research Laboratory (AFRL) participant wrote, "I thought [the game] was very sophisticated and...I enjoyed that it required you to bring together complex technical information from multiple domains and then act/strategize using that information, but in presence of many of unknowns." This comment is an example of a participant who recognized the complexity and depth of combining information from multiple domains into a comprehensive warfare strategy, which aligns to current MDO concepts.

4.4.2 Identification of Additional MDO Concepts

Results from the game identify other concepts that describe aspects needed to understand MDO. The additional elements are dependencies, complexity, adaptation, and breadth. These elements should be considered when defining and teaching MDO. Adaptation, for example, needs to be a central concept in future MDO definitions and discussions because it is closely linked to the anticipation of enemy actions and

ability to execute a mission through uncertainty. Future MDO conflicts will require operators and strategist who can quickly orient to their environment and create the needed effects with available resources. In a contested environment, where capability availability will be severely limited, the most adaptable warfighters will likely have the best chance of success.

4.4.3 Course Instructor Response

Instructor responses affirm the game is well-suited to teach MDO. These experts were asked "What did your students learn while playing the game?" One noted capability awareness, dependencies, and strategy. Specifically, they wrote, "Students [learned] about asset capabilities and dependencies within multi-dimensional operations. Students were exploring strategic and operational planning and execution using the assets." Another commented that the game taught breadth: "They learned to look beyond their focused learning and to understand there are many different aspects to our chosen profession. National defense is wide spectrum of different operations that provide offensive and defensive effects. It helped them begin to understand that not every problem has a kinetic answer." A third commented on the cyber and non-kinetic elements and dependencies, writing, "[The game] provided an understanding of how IO and Cyber would fit into conventional warfare. Helped them understand dependencies and limitations in warfare." The educators observing the experiments and the student participants identified some of the same learning outcomes that point to the effectiveness of the game to teach MDO concepts.

4.5 RQ3: The Effect of the Game on Players

The core of the data collection centered on the effect of the two major game versions on players. The lack of a control group, comparison activity, and variance

between game versions must be considered when applying these results to other games and contexts. However, qualitative data provides evidence of (1) a positive effect creating a fun and engaging classroom experience, (2) impact on players at an emotional level, and (3) an increase in military readiness in areas relevant to MDO.

4.5.1 90% of Participants were Focused During Experiment

A large majority of players reported the game had a positive effect and created a fun and engaging classroom experience. Participants responded to these statements on a 5-point Likert Scale:

[PostQ3] I enjoyed the game.

[PostQ4] I was focused during the game.

[PostQ26] This game helps players see the importance of MDO.

[PostQ8] The game helped me better understand MDO.

[PostQ9] The game offered valuable education and training.

[PostQ29] I would recommend this game to others.

[PostQ28] I would play this game again in my free time.

The comparison of the major game versions in Figure 15 shows a similar result in both enjoyment and focus, with focus scoring the highest of any of the game response factors. 90% of students responded "Agree" or "Strongly Agree" with PostQ4. This was interpreted as a positive result because increased player engagement is strongly linked to learning in other SG studies [47]. Of the remaining ten participants, eight responded "Neither Agree Nor Disagree" to the same statement. Six of these were from the 13O and ACSC experiments who may have been distracted by other academic priorities. Therefore, we theorize that, while the game elicits high engagement, environments linking game performance to course grades or other performance measures will increase engagement. Although, this may also increase frustration and decrease

overall enjoyment for losing players as the stakes will be higher.

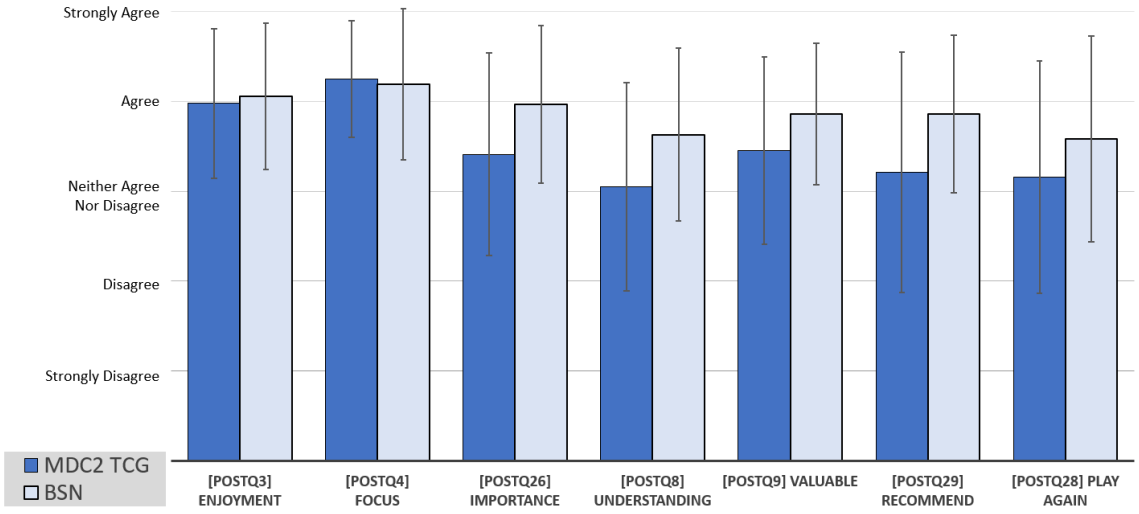


Figure 15: Game version comparison (N=103). Error bars show ±1 SD.

Response to PostQ28 reveals many participants do not want to play the game again outside of a formal learning environment, however, the question was worded in a way that set a high standard. Participants were asked if "they would enjoy playing the game again in their free time?" By agreeing or strongly agreeing with this statement would require participants to value the game over other games and competing priorities. In total, 55% of participants reported they would enjoy playing the game again in their free time outside of a formal learning environment. Of the 64 participants who played the final version of BSN (version 3), 44 (68%) agreed or strongly agreed with the same statement. This result was interpreted positively and the author believes this percentage would be higher if participants were asked about their desire to play the game again during course hours when it would replace other academic activities.

4.5.2 Game Version Comparison

To further reveal differences between game versions, the results from the ACSC study are shown in Figure 16. This study was unique in that all other variables, besides game version, were consistent.

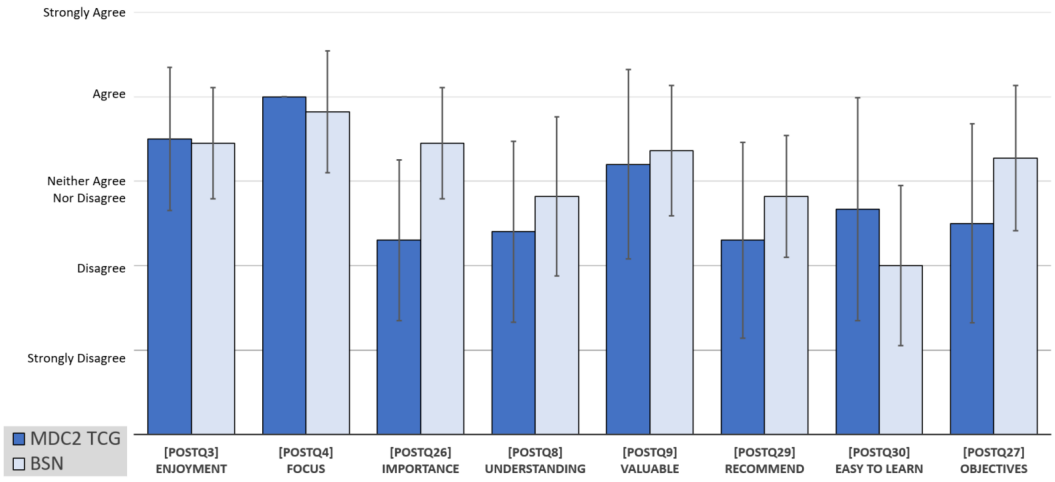


Figure 16: Direct game version comparison from ACSC experiment (N=21)

The comparison shows the post-survey responses for MDC2 TCG (N=10) and BSN (N=11). The largest difference in the responses comes in the questions related directly to MDO. These results are significant because they come from experienced military officers focused on MDO education, giving more weight to their responses than participants of other experiments with less MDO expertise (ACE and ROTC participants).

Figure 16 show that MDC2 TCG scored higher than BSN for being easy to learn. This is curious because elevated focus was placed on making BSN simpler than its predecessor. This result may be explained by the introduction of extra game pieces and the Spectrum of Conflict mechanic. The C2 Action Points were also a part of this version, which required manual tracking. This result from the ACSC experiment were taken into consideration and led to changes to further simplify BSN, following

experiments 3 and 4, as described in Section 3.2.5.

Figures 15 and 16 show BSN performed consistently higher in four categories summarizing game quality and delivery of LOs (Questions 26, 8, 9, and 29). This result was not statistically significant and other uncontrolled variables must also be considered. However, it reveals that engineering efforts helped to make the game seem more valuable to students. Specifically, players using BSN were more likely to report that it helped them realize the importance of MDO and improved their understanding.

Overall, the game's complexity was frequently identified as a negative aspect. Given the complexity of this game genre, it is predicted that new players will most likely find the game hard to learn and somewhat frustrating at first. However, this does not necessarily point to a deficiency in the game. This question was posed to course instructors in the post-experiment questionnaire to collect their opinions as education and training subject matter experts (SME). All the instructors who provided feedback disagreed that the game was too complicated for the subject matter, validating that the game's complexity was appropriate. This complexity is likely to be present in most CCG. For example, the basic rulebook for the *Magic the Gathering* TCG is 36 pages.[3] In contrast, the final instructions for BSN, including examples and frequently asked questions, is only 12 pages. However, the comprehensive rules for *Magic the Gathering* require 225 pages to explain.[4]

4.5.3 Impact of Age and Military Experience

Four questions were combined to create a metric using one number to summarize an individual's response to the game. The metric is an equally weighted average of responses to the following questions:

[3]https://media.wizards.com/images/magic/resources/rules/EN_MTGM14_PrintedRulebook_LR.pdf

[4]https://media.wizards.com/2019/downloads/MagicCompRules%2020190125.pdf

[PostQ3] I enjoyed the game.

[PostQ8] The game helped me better understand MDO.

[PostQ26] This game helps players see the importance of MDO.

[PostQ28] I would play this game again in my free time.

The questions were measured on a 5-point Likert Scale, so the metric ranges from 1 to 5. Plotting this metric against age and military experience revealed that the older the player and the more military experience, the less likely to respond positively to the game. Figure 17 plots the game response metric in relation to the player's age and Figure 18 does the same with total years of military experience. The red trend lines reveal the negative correlation with age and military experience, with low p-values. The game response numbers are elevated for the few participants over the age of 45 (N=5) and those with at least 25 years of military experience (N=3). Three of the five overlap. This result breaks the general trend described above. However, this seems to be a result of "cheer leading" from experienced members who want to see tools like this succeed and who may have inflated the game's performance in their responses.

Qualitative data, specifically open-ended responses and experiment observations, help to explain this result. These reveal that those with greater military experience, especially in operations or a deployed environment, were more critical of the game's realism. Their comments referred both to the game cards as well as the attack and defense mechanics. For instance, some players in the 13O experiment (representing relatively more military experience) reported having to suspend their knowledge of reality to follow the battle outcomes as dictated by the cards. When coupled with the qualitative data above, this result implies increased experience was a barrier to enjoying and learning from the game. Increased insight could be gleaned from differentiating military experience from operational experience in the data collection

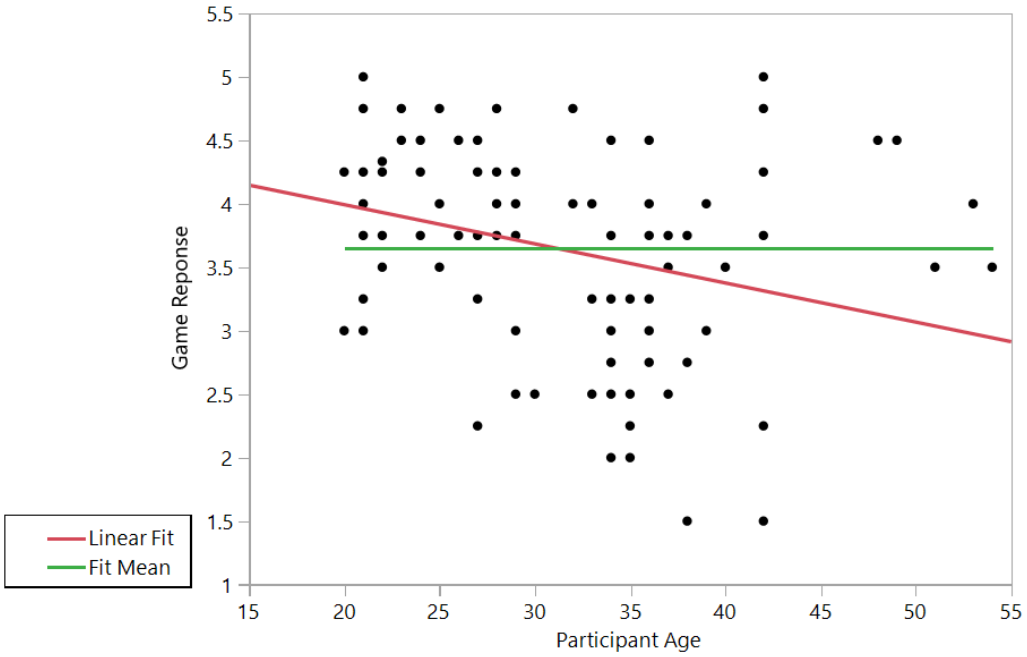


Figure 17: Game response metric by participant age (N=103). $R^2 = 0.18$ and $P < 0.0001$.

tools. One way to accomplish this is to have participants identify the amount of time they spent in a deployed environment or directly supporting a named operation. This is important to capture the operational experience of those in non-traditional domains who may have supported combat operations or work in an operations center without deploying overseas.

This result may reveal weaknesses in the game to portray current military operations and accurately reflect battlefield realities. Further game development could improve this aspect of the game, thus making it more relevant to more experienced personnel. However, those efforts will quickly hit a ceiling where no more realism can be produced by the abstract model presented in this SG, without introducing significant changes compromising the current advantages of the tool.

This result also confirms that those with less experience, such as military members in initial training or commissioning programs, are a better target audience. In the

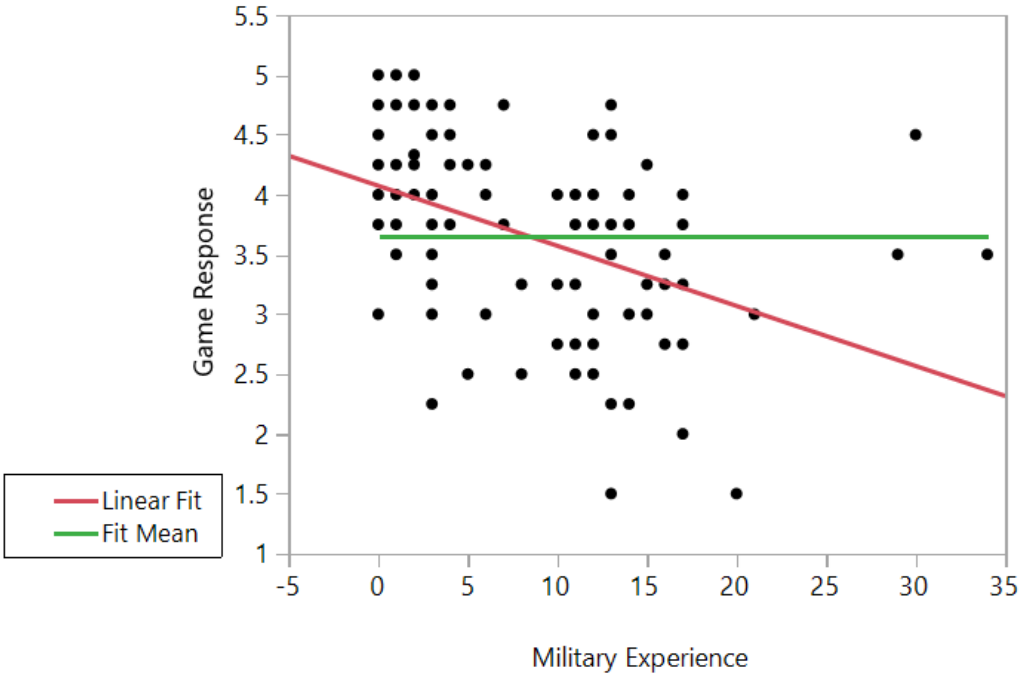


Figure 18: Game response metric by participant's military Experience (N=103). $R^2 = 0.09$ and $P < 0.0018$.

worst case, the data reveals the game may misrepresent reality even in the non-abstracted aspects. This could lead to a negative classroom experience as players draw the wrong conclusions about military operations by playing the game. Detailed feedback from operators on specific inaccuracies may mitigate this concern. Also, careful debriefing will allow knowledgeable instructors to channel student responses toward accurate learning.

4.5.4 Emotional Responses

The game elicited strong emotional responses from a majority of players, which was evident through direct observations. Many participants cheered, pumped their fists, or banged on the table during the in-class sessions in response to game events. Abdul Jabbar and Felicia [90] show that both emotions and cognition are central in learning and engagement in game interaction. 58 of the 103 participants were asked,

"What emotions did you feel while playing the game?" Many participants listed more than one emotion leading to 88 separate responses shown in Figure 19.

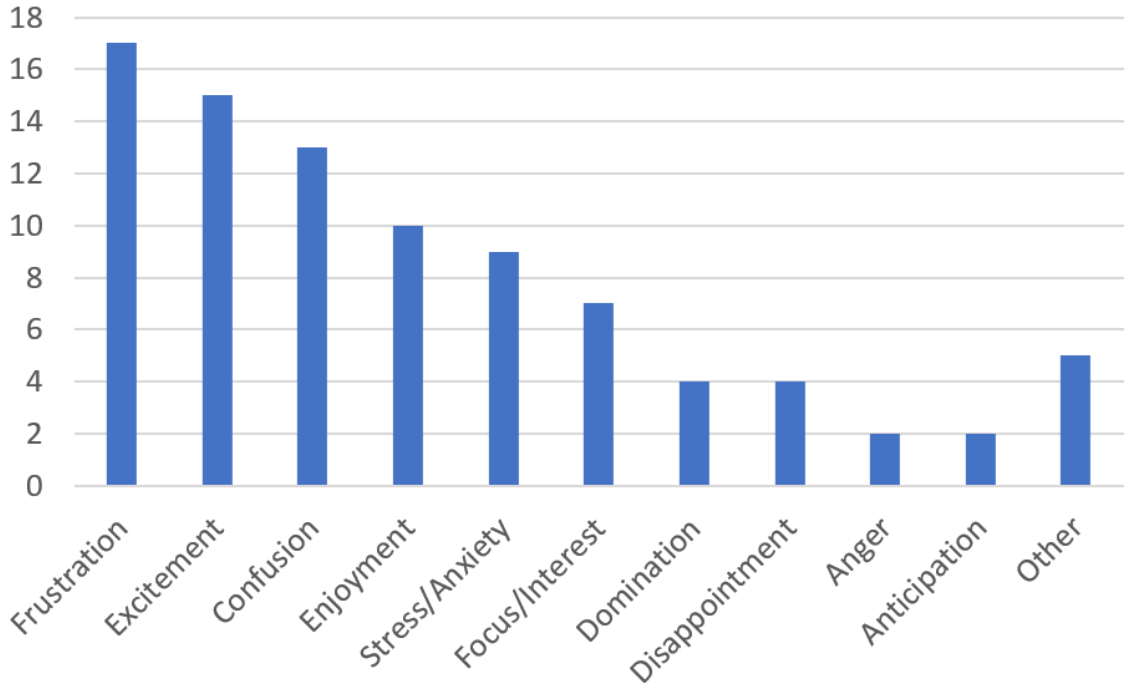


Figure 19: Reported emotions while playing BSN (N=88). Participants open-ended responses have been categorized by main idea.

Frustration (17), excitement (15), confusion (13), and enjoyment (10) were the highest reported emotions and it was common for participants to list both frustration and confusion (5 times). One participant responded, "Frustration, joy (when winning)" which describes the trend that positive game outcomes (winning) led to positive emotions (enjoyment and excitement) while losing led to more negative emotions (anger and disappointment). Although frustration seems like a negative emotion, this was considered a positive result since frustration can be a catalyst for learning. Realizing a knowledge or experience gap is the first step to conscience learning. One participant said he or she felt "frustrated (but that was a good thing!)." The positive side of frustration is that players are learning what does not work, challenging their preconceptions about MDO. Defeat can be a good teacher. Confusion, on the other

hand, was not positive as it points to a lack of understanding of the game. This was not strongly correlated to time spent reviewing game materials, but is likely due to the game's complexity.

4.5.5 Increase in Military Readiness

The quantitative data shows the game performed well in the classroom increasing military readiness in areas linked to MDO concepts. In the pre-survey, participants were asked to rate their current degree of readiness in seven areas using the 5-point scale shown on the left side of Figure 20. These areas are drawn directly from the game's LOs and objectives of the Multi-Domain Operational Strategist (MDOS) course:

[PreQ26] Identification of military capabilities and their general role/function.

[PreQ27] Military strategy development.

[PreQ28] Linking cyber threats to corresponding defensive capabilities.

[PreQ29] Applying Multi-Domain thinking in your military context.

[PreQ30] Anticipating enemy actions.

[PreQ31] Adapting to operational environment and enemy strategy.

[PreQ32] Continuing to execute a mission through uncertainty.

In the post-survey, participants were asked how much the game improved their readiness based on the 4-point scale at the top of the matrix in Figure 20. Responses were gathered and summarized in custom matrices, that are color-coded to highlight the desirability of each of each cell to educators and curriculum owners.

The colors describe the areas of the matrix that correspond to neutral, positive, and excellent results. The matrix and the three result categories are unique to this study and created to reveal the game's strengths and weaknesses. Providing a 5-point scale on the degree of improvement would enhance the matrix in future experiments.

Linking Cyber Threats to Defensive Capabilities (N=103)					
		Degree of Improvement			
		Not at All Improved	A Little Improved	Much Improved	Very Much Improved
Prior Level of Readiness	Not at all Ready	5	8	8	0
	Slightly Ready	5	28	14	4
	Moderately Ready	4	14	5	0
	Very Ready	3	1	2	1
	Extremely Ready	0	1	0	0
Totals		**Neutral (orange): 25 | Positive (green): 70 | Excellent (blue): 8**			

Figure 20: Matrix depicting prior levels of readiness and growth in matching cyber threats to defenses due to game play.

Negative responses were not possible as it was assumed that participants could not regress in their military readiness. The orange area marks the responses that are not desired because they show no growth in learning or only a little improvement for those with no prior experience. The green area marks a positive result showing those participants who were much improved and began the experiment at or below a moderate level of readiness. It also includes those who showed a little improvement but reported some prior readiness. The excellent results are marked in blue highlighting those with significant prior training who still improved or those with any prior level of readiness who reported significant improvement.

The results from all seven area are graphed in Figure 21. The graph shows the games' ability to improve military readiness in 68% to 82% of participants. The neutral results may be explained by the nature of self-reported learning. As Section 2.4.4 explains, active teaching methods similar to SGs proved more effective than passive lectures, but received lower ratings from students on self-reported learning [73]. If this same effect occurs with the game, students may actually achieve a higher level of learning than reported because of the effort required to play the game versus

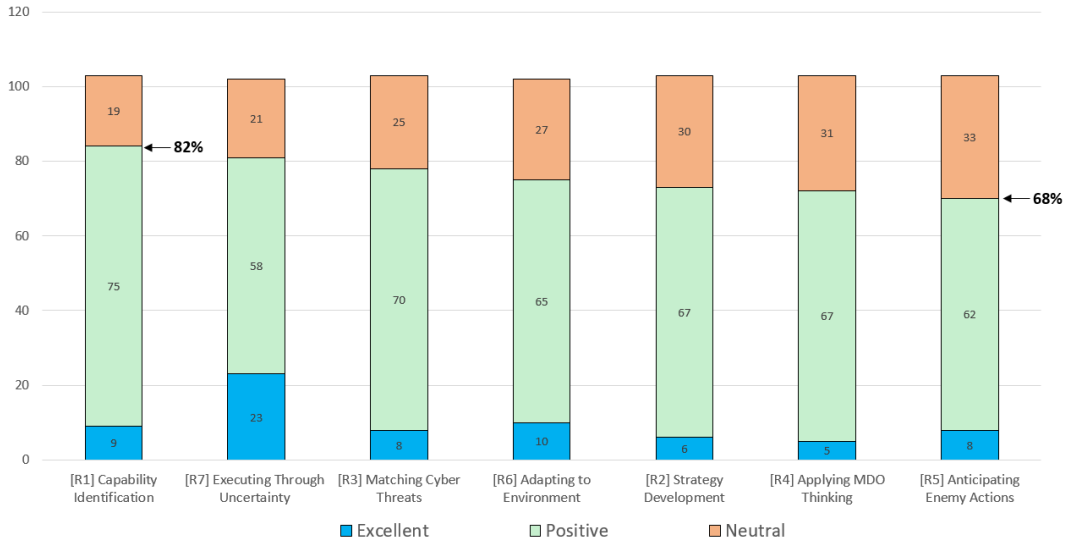


Figure 21: Game effect on individual military readiness in seven areas linked to MDO LOs. Readiness items (R1-R7) are ordered by the sum of positive and excellent responses (largest to smallest). N=103 for all but R7 and R6, which were left blank by one participant

sit through an organized lecture. The neutral results may also be explained by a lack of definition of what is valuable MDO knowledge. As discussed, the concept of MDO is still nebulous and ill-defined, meaning that the players themselves probably cannot accurately identify what is beneficial MDO learning. Furthermore, the results may be explained by too little time to play. Of 103 participants queried, 66 (60%) reported that they wanted to keep playing at the end of the in-class session. If students do not understand the game, it is expected they would find it difficult to grow in higher levels of learning. Finally, poor game design and implementation may have hampered learning. Specifically, game complexity was often identified as a barrier to learning and playing the game. This emphasizes the need to develop instances of the Intro Game at Level 1 of the MDO Game Framework to use with first time players.

4.6 RQ4: Time-Efficiency of Course Integration

Instructors may desire to use tools like SGs to increase their courses' engagement, however the cost to create a product or modify an existing one may be prohibitive. Items in the instructor questionnaire addressed this concern. Three of the five course instructors who oversaw experiments provided comments on the game and its integration into their course. All three reported at least two hours of game interaction. All agreed that the game supported their LOs, fit well into their course, and they would recommend the game to other instructors. The instructors also completed open responses on integration time. Without researcher facilitation, the effort required for game integration ranged from 8 to 20 hours. In contrast, the time to create their own similar tool would require "several months to two years." Conservatively, we can assume that 20 working hours covers three full days and there are approximately 21 working days, on average, in each month. If "several" is assumed to be three and instructors can only dedicate two hours each day on this project then they would spend 122 hours building a similar game. This means that integrating this tool into a curriculum requires 6% to 16% of the time it would take to create a similar tool on their own. This reveals the value of education and training tools that are mature and readily available to instructors to enhance the course engagement.

4.7 RQ5: Facilitation of MDO Innovation

Due to the difficulty of measuring the game's ability to produce innovation and the ambiguity of defining quality MDO innovation, no specific post-survey questions refer to this subject. However, open responses point to several outcomes linked to innovation.

First, strategy was mentioned as a learning outcome 12 times (Figure 14) and 26 participants reported that they enjoyed the strategy aspects of the game (Figure 13).

Additionally, Figure 22 reveals that 15 respondents reported that strategy development was the game element that contributed most to their learning, and 16 said this element was the most fun (N=57).[5] These questions were added to the post-survey between experiments 4 and 5 so they were not answered by all participants . Strategy is linked to innovation in that players must develop better solutions to improve game outcomes and make the most beneficial choices within the game environment. There is no predestined path to victory and players' success and failure are determined by numerous factors. The innovation aspects are further enhanced by the game's ability to lower the consequences of failure making strategy changes easy and (potentially) rewarding.

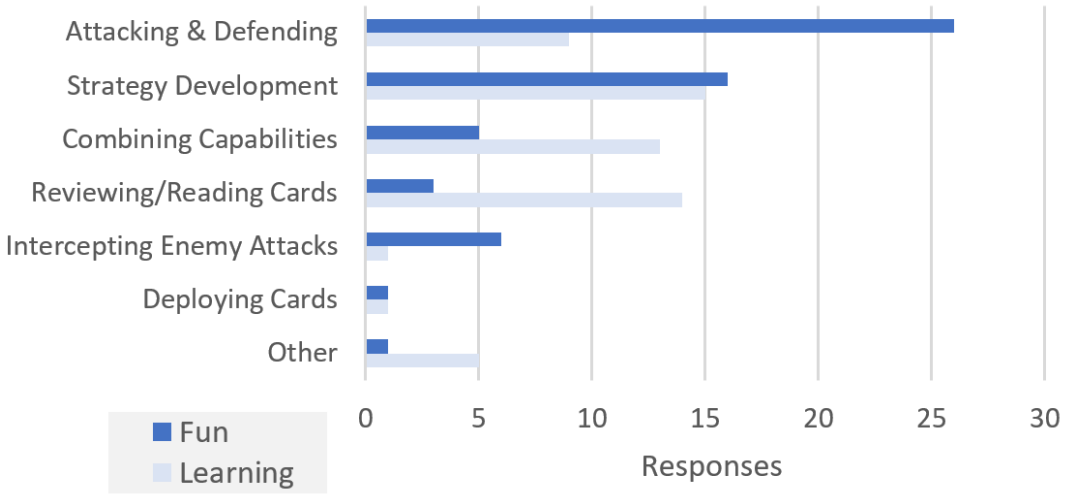


Figure 22: Participants' response to [PostQ34] "What game element was most fun for you?" and [PostQ23] "What game element contributed most to your learning?" (N=57).

Second, participants identified nine major areas in response to the question, "What did you learn from playing the game?" as shown in Figure 14. This points to the value of the game as a tool for innovation because it is does not limit players to a defined set of learning outcomes. By putting the student in the driver's seat

[5]These two questions were separated in the post-survey to avoid mindless repetition of the same answer.

and providing a dynamic setting for experimentation, BSN creates an environment ripe for innovation. In addition, the repetitive nature of the game may help shape future MDO strategies by allowing strategy developers to quickly test new and unique strategies. This will be further improved by adding more capabilities and increasing the realism of attack and defense actions. These development efforts and the collection of data needed to analyze the merits of player strategies would be best served by a digital version of the game.

4.8 Debriefing Essential to Focused Learning

Debriefing, identified as a best practice for SGs implementation [43], was leveraged in each of the experiments to guide students toward the correct learning outcomes. Debriefing questions guided players from their game experiences toward lessons applicable outside of the game environment. If players' experiences could be linked to specific LOs, then that was preferred. Debriefing was essential to effective implementation of the game into military courses by helping to guide participants away from two pitfalls: misconceptions of cyber capabilities and hyper-focus on one's functional area.

First, debriefing students on mistaken ideas about the effects of cyber capabilities and the reality of MDO. Many players, even those with higher military experience, wanted cyber capabilities to trump kinetic capabilities during conflict. This highlights misconceptions about non-kinetic capabilities. While advances in cyber warfare capabilities may produce more potent effects in future conflicts, current capabilities cannot thwart enemy kinetic attacks. In the MDO Game Framework, cyber capabilities were limited to hinder and confuse enemy actions without inflicting physical damage to enemy assets. These comments reveal that some students may think too much about what is fun and entertaining instead of what is currently possible.

Second, debriefing challenged participants who were too focused on their own functional area. During game debriefings, some participants were narrowly focused on how the game applied to their career field. This led to comments in post-surveys reporting that the game is not relevant to a player's current position as well as comments in debriefing that personnel in a support role do not need to be concerned with operational realities. To counteract this tendency, more cross-function emphasis is needed at all levels to encourage an *MDO-mindset* that considers how other domains interact with one's own functional community.

4.9 Need for Appropriate Educational Materials

Experimentation reveals that the concept of MDO requires further refinement in the wider military community aided by appropriate educational materials. These materials must allow for exploration and innovation while teaching domain fundamentals. Several comments pointed to a preconceived misunderstanding of MDO as the integration of every domain in every military effect. One participant in the ACSC experiment wrote that he or she learned, "Improper relationships for multi-domain interaction. This game didn't show the integrated nature (requirement) for successful MDO." However, to be successful in multi-domain warfare does not require the use of all domains, but the consideration of all domains in decision making. This reflects Goldfein's description of MDO as the blending of capabilities from *one domain or many*. If forces in one domain can effectively accomplish the mission, then a more complicated (integrated) approach may not be necessary. BSN can help to correct these preconceived misunderstandings while promoting creative interaction.

4.10 Results Summary

This section details the results of all HSR experiments conducted by this research effort. Responses reveal 78% enjoy learning through games and 64.5% want to see more educational games in military education and training. However, response to BSN were unpredictable as 53% of participants changed their answer, 33% were more positive and 20% were more negative about the game. Participants' open-ended responses singled-out the three major MDO concepts within the top five elements learned while playing the game. Along with these, dependencies, complexity, adaptation, and breadth were each identified by multiple respondents as areas of learning.

Furthermore, the game captured the focus of 90% of participants, elicited various emotions, and increased military readiness in at least 68% of participants in seven areas linked to game LOs and military competencies. Course instructors affirmed the game's complexity as appropriate for the subject matter and reported that integrating the game would require, at most, 16% of the time it would take to create their own tool. Results confirmed the need to use debriefing during SG implementation to correct misunderstandings. They also revealed the need for MDO resources to enable MDO exploration, teach domain fundamentals, and elevate participants' mindset to consider impacts beyond their functional area.

These results show that targeted development successfully enhanced an SG creating a tool ready for integration that conveys MDO concepts, engages students, and enhances military readiness. The final chapter describes the implications and significance of this research and recommends areas of future research.

V. Conclusions

5.1 Overview

This chapter summarizes the results found through experimentation and other activities conducted during this research effort. Section 5.2 reiterates the conclusions of the Human Subjects Research (HSR) experiments identified in Chapter IV. Section 5.3 identifies the significance of the research and implications for future Multi-Domain Operations (MDO) learning and the use of serious games (SGs) in military education and training. Finally, Section 5.4 identifies potential areas for future research.

5.2 Research Conclusions

This research successfully analyzes the application of SGs through four contributions: first, creating a framework to model MDO using specific game elements and guide the development of relevant education and training tools; second, collecting the response to SGs from a wide range of military members; third, developing an accessible learning tool to integrate into current military education and training curricula to convey relevant MDO and Joint All-Domain Command and Control (JADC2) concepts; and fourth, applying and evaluating current SG research to address a specific military problem.

As hypothesized, a majority of military members responded positively to the use of SGs in formal course, players reported learning the three most relevant MDO concepts, and at least 68% of participants reported an increased military readiness through game play.

Out of 141 pre-survey respondents, 78% reported they enjoy learning through games and 64.5% desired more games in military education and training. However, learning enjoyment for a specific game was unpredictable as 25% of participants raised

their rating and 30% lowered their rating from their pre-survey response. Similarly, after playing, 33% of participants increased their rating from the pre-survey, wanting more games like Battlespace Next (BSN) in military education and training. Overall, the game met or exceeded expectations in 80% of respondents. Finally, 70% of respondents said they would have rather played the game then attend a hypothetical lecture covering the same topic.

The game genre models MDO relationships and concepts compared to other game genres providing a dynamic environment for exploration and learning. Through open-ended responses, both instructors and students reported the game's learning outcomes map to all three of the major MDO concepts outlined by the Chief of Staff of the Air Force (CSAF).

Results reveal the game created an enjoyable and engaging learning experience. 77.6% reported enjoying the game and 90% said they were focused during the session. Of the 64 participants who used the final version of the game, 68% valued the game enough to want to play it again in their free time outside of a formal academic environment. The game also elicited high emotions further highlighting its ability to capture student engagement.

Course instructors identified the efficiency of integrating an existing game, with associated documentation and resources, into established courses. They reported that integrating this game without the author's assistance would take, at most, 1/20th of the time required to create their own, similar tool.

Feedback and classroom performance identify the potential of this game to serve as an innovation tool in the area of MDO and military strategy. Players reported learning from and enjoying the strategy aspects of the game created by the dynamic, competitive, and iterative environment. Specifically, the game's ability to allow for players to combine capabilities from multiple domains, receive immediate feedback on

their decisions, and rapidly refine their strategy make BSN a ready tool for continued MDO innovation research.

Results confirmed the need to implement robust debriefing when using SGs to guide student learning and correct misunderstandings and lead players to consider implications of near-peer adversaries beyond their own functional area. Additionally, qualitative data revealed that MDO resources are needed that provide exploration while teaching domain fundamentals, especially in non-traditional domains, such as Cyber.

5.3 Research Significance and Synthesis

MDO is a new, and to date ill-defined, concept created to take advantage of the growing complexity that defines the modern battlespace. This work attempts to explore this complexity through education and discussion of capability integration across warfighting domains using innovative education and training tools. It is an important step to better understand MDO, SGs, and their integration into current curricula. Although a small minority of military members will not prefer games or find them engaging, overall, they hold great potential to improve student engagement and learning. The proposed MDO Game Framework, and BSN specifically, is poised to fill a current gap in MDO education between lectures and costly wargames providing hands-on learning and further define MDO. The empirical results confirm the game is both engaging and beneficial for MDO learning and can be integrated at a relatively low cost. This study has implications for current and future MDO education and training, JADC2 implementation, and SGs design and implementation.

5.3.1 MDO Education and Training

Four implications emerged for MDO education and training:

1. SGs should complement the use of wargames to both explore and educate. Wargames are needed to closely simulate operations and inform current operators and strategic planning. These resource-intensive activities should be directed toward those who will soon be expected to understand and operate in an MDO environment, such as the 13O Initial Skills Training (IST). However, personnel in education programs or who have limited military experience can benefit from SGs like BSN. The higher level of abstraction may save educators money, equipment, and time. This makes SGs a good fit for programs such as officer accession programs and initial and intermediate Professional Military Education (PME). This should encourage leaders and educators to consider similar SGs because those in the 18-30 age group who responded more positively to games constitutes the largest demographic of active duty military members.[1]

2. More cross-function emphasis is needed at all levels to encourage an *MDO-mindset* that considers how other domains interact with one's functional community. Personnel who are narrowly focused on their own career field will inhibit the proposed shift to JADC2. Instead, all military members must develop an MDO-mindset to create the lethal force needed to win future conflicts. This emphasis will support MDO learning as personnel will be encouraged to think about how their functional community relates to others, thereby increasing knowledge of other domains.

3. Educators should discuss dependencies, adaptation, complexity, and breadth along with current core MDO concepts. When applying this game as a model of MDO relationships in the classroom, players reported these concepts as central learning outcomes. Moving forward, these needs to be listed as central

[1]According to the DoD's 2018 Demographics Report, 61.1% of the total DoD force is 30 years old or younger and 40.7% are younger than 25.

concepts in MDO definitions and discussions. First, knowledge of multi-domain capabilities is important, but operators must also know the dependencies of these capabilities in order to effectively plan and support operations. If dependencies are not discussed in MDO education and training, future JADC2 advantages may be temporary, lacking the support needed to endure. Furthermore knowledge of the enemy's dependencies will enable planners and operators to see weaknesses the enemy may not. Second, adaptation is a needed skill for planners and operators in the midst of a conflict with a near-peer adversary. Adaptation is linked to the anticipation of enemy actions and ability to execute a mission through uncertainty. Future conflicts will require personnel who can quickly orient to their environment and create the needed effects with available resources. In a environment contested by a near-peer adversary, where capability availability will be severely limited, the most adaptable warfighters will likely have the best change of success. Finally, complexity and depth should be included to help characterize both the challenge of MDO and solutions to harness it to create operational advantage.

4. The concept of MDO requires further refinement aided by appropriate educational materials. The current ambiguity regarding MDO's integration into current operations prohibits the creation of effective and broadly applicable education and training materials. Because of this reality, the most useful learning tools will allow for exploration and innovation while teaching domain fundamentals. Materials must pay particular attention to the integration of non-kinetic capabilities such those in the Cyber domain as well as Information Operations (IO) and Electronic Warfare (EW) assets as they remain the least familiar to military personnel.

5.3.2 Utilization of BSN and other Serious Games

Military curriculum developers should consider the use of SGs as a supplement to current materials to elicit player engagement and convey lesson objectives at upper levels of Bloom's Taxonomy of Learning. However, they should be considered carefully as the specific application may not create the intended effects. Implementation and development decisions should be guided by relevant learning objectives (LOs) and play testing is essential to validate a game's effectiveness. While bad decisions might be made in the development process, intentional debriefing can help mitigate negative effects and correct misconceptions. Additionally, educators must be realistic about which and how many LOs to implement in a serous game. Continued focus on the LOs was necessary so that BSN was not overburdened by divergent requirements.

Application of the MDO Game Framework will provide tools to educate and train a broad population as well as identify individuals with a propensity for MDO and JADC2. Its future use in current courses that do not include MDO objectives may evoke informed discussion. Where MDO is already discussed, the game may supplement current curriculum to allow student exploration of this complex concept leading to a deeper understanding and usable innovations. As revealed, the game will generate experiences and inform rich discussion on these ill-defined concepts creating opportunities for learning and growth. Engaging a broad population in this way creates the opportunity to start and refine a conversation essential to transforming the way individuals think about military operations. As the Air Superiority Flight Plan 2030 states, "The AF projected force structure is not capable of fighting and winning against the future threats the U.S. faces without a shift in focus to multi-domain capabilities and capacity" [91]. This transformation will not be driven by traditional methods of education and training but requires a new mindset and new tools. BSN may be one piece to a larger effort helping to drive this mindset shift across the force

and shape the way it responds in an increasingly complex and contested environment.

5.4 Future Work

Many avenues exist to apply this research and the MDO Game Framework to further refine and implement MDO and JADC2 concepts as well as guide education integration. The most relevant areas are:

1. The game can be further evaluated in an established military course where multiple classrooms can be dedicated to a controlled experiment. This study could validate the usefulness of a SG as a supplement to, or replacement of, other forms of instruction such as briefings and classroom discussion. The ideal target audience for these experiments should be military members in commissioning programs, initial training, or intermediate education.

2. Further HSR experiments could directly compare a version of BSN to *Air Doctrine Wargame (ADWAR)* or *Air Force Expeditionary Exercise (AFEX)* to determine its value among currently accepted solutions for air operations. This study would further clarify the general response to the use of games in the military and inform decisions related to the most effective and efficient learning tools for future use.

3. As MDO and JADC2 are further defined, a standardized and independent evaluation tool is needed to validate MDO knowledge and abilities. This assessment should target higher levels of learning beyond domain knowledge, such as adaptation, strategy development, anticipation of enemy actions.

4. Digitize BSN to increase accessibility, reduce the learning curve, and create a research platform capable of internal and external assessment. The platform would enforce game rules and track game states allowing players to focus on

the capabilities and strategy. This tool should be created to explore next generation JADC2 constructs and how new weapons and emerging technologies could impact the battle space. This would also increase data collection opportunities diversifying populations and lowering the time and monetary costs of individual experiments. Finally, data collection would capture player strategies and trends that are difficult to capture in a physical game to identify MDO talent.

5. Create applications and rule sets for the Meta Game (Level 3) of the framework. This effort should include guidance on creating new cards and mechanics within the current game applications. A digital game is best suited for this purpose as it allows for inexpensive card additions and distribution, including opposing force capabilities. Cards can be created by anyone with knowledge of the game and specific military capabilities. This approach will require a game integrator, or governing body, to balance and standardize cards and regulate Meta Game rules.

6. Leverage Artificial Intelligence (AI) research to validate game balance and create opponents to simulate near-peer adversaries. Digitization is also a useful stepping stone to future AI research. This line of effort should focus on probabilistic model checking to validate game balance and building smart opponents that can "think" like near-peer adversaries. One possible AI method is the Monte Carlo search tree implemented for *Hearthstone* in [78].

Appendix A. Additional Presentations and Publications

The following list outlines engagements where this research was presented. These engagements provided opportunities to collect feedback from a wide range of personnel across Air Force (AF) and Joint organizations:

- 3-7 February 2019: Rocky Mountain Cyberspace Symposium, Colorado Springs, CO. The author and a team of researchers[1] presented a 4-hour training seminar on cyber education innovation and conducted a Pilot Study for this research. The game was also featured at a booth informing attendees of Air Force Institute of Technology (AFIT) research and ongoing projects led by the AF Cyberspace Technical Center of Excellence (CyTCoE).

- 7 February 2019: BSN discussed during an informal discussion with Air Combat Command (ACC) Commander, General James Holmes (ACC/CC).

- 19 March 2019: 88th Communications Group (88 CG) Play Test. Six players familiar with Collectable Card Games (CCG) learned to play the game and made suggestions for future changes. This included a presentation of the game to 88 CG/CC, Colonel Lori Winn.

- 29 March 2019: BSN Brief provided to Air Education and Training Command (AETC) Deputy Director of Operations and Communications (AETC A3/6), Colonel Jeffery Sorrell.

- 11-12 April 2019: BSN Brief provided to the AF MDO Working Group hosted by the School of Strategic Studies at AFIT (AFIT/EX).

- June - August 2019: Gaming Research Integration for Learning Laboratory (GRILL) Summer Project. This short project leveraged the efforts of three

[1]Major Richard Dill, PhD, and Lieutenants Chris Dukarm and Jake Orner served as co-presenters and helped execute the experiment.

high school students to create a deck-builder application to augment the digital game development at AFIT. The project was part of the GRILL's summer intern program. The author filled the role of customer to make the experience more realistic for the students.

- 3-4 July 2019: Presentation at the European Conference for Cyber Warfare and Security (ECCWS) in Portugal. The paper presented was published in the conference proceedings.

- 16 July 2019: BSN Demo to AF CyTCoE Board of Directors. This included an overview of the game and the progress made to create a digital version of the game.

- 17 July 2019: Presentation to the Distinguished Review Board for the Center for Cyberspace Research (CCR). The audience included Brigadier General Chad Raduege (ACC/A6) and 26 other leaders in cyber education and training.

- 26-28 August 2019: AF Information Technology & Cyberpower (AFITC) Conference, Montgomery, AL. Presented research during a 1-hour breakout session attended by approximately 30 conference attendees. This presentation was recorded and published to the Air University (AU) YouTube channel for public viewing.[2] The game was also featured at a booth informing attendees of AFIT research and ongoing projects led by the AF CyTCoE.

- 28 August 2019: BSN Brief provided to curriculum owners at Squadron Officer's School (SOS) and Officers Training School (OTS) at Maxwell AFB, AL.

- 31 October 2019: BSN featured to attendees of the AFROTC Detachment Commanders Conference at Maxwell AFB, AL. John Florio physically traveled

[2]https://www.youtube.com/watch?v=2ejJpE-n_m0

to the conference to make game resourcs and handouts accessible to AFROTC detachments around the country.

- 8 November 2019: BSN Brief provided to Air Force Warfighting Integration Capability. This included an in-person brief to Doug Fullingim (HAF/A5), Director of the Adaptive Wargaming Division and distribution of game documentation to Philip Bolger (AFWIC) and Mitch Reed (HAF/A5) who are adaptive wargame designers.

- 15 November 2019: BSN Brief provided to MDO wargamming experts at Army Training and Doctrine Command (TRADOC) at Fort Eustis, VA.

- 15 November 2019: BSN Brief provided to a group of joint Field Grade Officers at the Air, Land, Sea Application (ALSA) Center at Langley AFB, VA.

- 15 November 2019: BSN Demo for Brigadier General Chad Raduege (ACC/A6) and other Information Warfare (IW) leaders at Langley AFB, VA.

- 19 November 2019: Paper accepted for publication in the International Conference for Cyber Warfare and Security (ICCWS) proceedings. The paper will be presented by co-author Lieutenant Chris Voltz on 12-13 March 2020 in Norfolk, VA.

- 22 November 2019: BSN Brief provided to AF Chief Transformation Officer, Ms. Lauren Knausenberger and AF Chief Experience Officer, Mr. Colt Whittall.

- 23 November 2019: BSN Demo to Air University Commander, Lieutenant General James Hecker.

- BSN is currently in use at ACC/A6, AF Research Lab Information Directorate, the 267$^{\text{th}}$ Intelligence Squadron at Otis Air National Guard Base, MA, and the Space Security and Defense Program.

Appendix B. Facilitator's Guide

To assist instructors and educators in their use of the game produced by this research effort, an Instructor's Guide was created. The guide includes explanation of game elements, methods to integrate the game into their course, and instructions for leading an effective debriefing. The guide also includes numerous sample debriefing questions and a list of relevant MDO resources. The following pages show the final version of the facilitators guide that is available at https://www.afit.edu/ccr.

Battlespace Next: Multi-Domain Operations Instructor's Guide – Version 1.0

Created by the Cyberspace Technical Center of Excellence (CyTCoE) and the Center for Cyberspace Research (CCR) at Air Force Institute of Technology (AFIT) at Wright-Patterson AFB, OH

Disclaimer: The views expressed in this guide are those of the authors and do not necessarily reflect the official policy or position of the Air Force, the Department of Defense, or the U.S. Government.

I. INTRODUCTION

This guide helps leaders, instructors, and facilitators effectively utilize *Battlespace Next: Multi-Domain Operations* (MDO), a card game designed to spark discussion concerning the implementation of MDO and Multi-Domain Command and Control (MDC2). This guide will not explain how to play the game, but is meant to be paired with the game instructions (see Appendix A for a summary of game instruction). The game is engineered to provide an engaging and hands-on experience for players as they consider the realities of modern peer-to-peer warfare. Please modify order of steps, discussion questions, or game instructions to best fit your context.

A comprehensive game tutorial can be accessed here:
https://www.youtube.com/watch?v=GIEq3LNekXw

A trailer promoting the game can be found here:
https://www.youtube.com/watch?v=2niX5l_MSBY

The game is available for the cost of supplies here:
https://www.printplaygames.com/product/battlespace-next/

II. GAME OVERVIEW

1. Description: 2-4 player card-based game featuring military capabilities from Air, Space, Cyber, Ground, Maritime, and Cognitive/Human domains
2. Intended Audience: Ages 16 and up. Engineered for current military personnel (Active Duty, Guard, Reserve, civilian, and contractor), potential recruits, or those interested in military strategy
3. Resources needed: 1 set of cards (54 cards) for each player or team, game instructions, instructional video(s), this instructor's guide, damage and resource chips, and 1 die for each game
4. Time; 1-1.5 hours to play the first game, 30-45 minutes for each subsequent game. If using the game in the classroom context, plan for students to interact with the game for 3-4 hours. This

provides sufficient time for the students to review game resources and instructions, play multiple games, and participate in a guided discussion (debrief) led by the instructor.

The game serves as a dynamic platform for teaching players about the considerations involved in choosing assets to deploy (strategic level of warfare) and leverage for attack and defense (operational level of warfare). It examines the impacts of one domain on another domain, including how a cyber and non-kinetic attacks and defenses can influence more conventional warfare (forces creating kinetic effects in and through Air, Sea, and Land Domains). It allows a player to create an individual strategy by starting the game with a set of cards that have been chosen from the full deck. In this way, the player must consider the benefits, weaknesses, and trade-offs of the assets by continually performing cost-benefit analysis, and adapting to the strategy of the opposing player. The player's choices focus on the effects assets can create on the battlefield, especially as they are combined with other assets. This game provides a powerful engagement strategy to begin a deeper examination of MDO concepts for a wide range of populations.

III. LEARNING OBJECTIVES

The games learning objectives are classified using the Game Aesthetic from the Mechanics, Dynamics, and Aesthetics game development framework by Hunicke, LeBlanc, and Zubek (2004) and the appropriate level of Bloom's taxonomy (1956).

Game Aesthetic	Lesson Objective	Bloom's Taxonomy Level	Game Phase/Element
Discovery	Recognize that both cyber and kinetic capabilities require a kill chain and advanced planning	Knowledge (Level 1)	Strategy Development & Attack/Defense
Discovery	Identify the two major phases of the "Spectrum of Conflict" (conflict and competition)	Comprehension (Level 2)	Competition and Conflict phases (first 3-7 rounds)
Expression	Match cyber defense capabilities to corresponding threats	Comprehension (Level 2)	Examining Cards & Attack/Defense
Challenge	Develop and execute an MDO strategy in a complex and contested environment	Synthesis (Level 5)	Strategy Development
Challenge	Select and combine military capabilities to anticipate, adapt, and respond to surprise and uncertainty in the context of peer-to-peer warfare	Evaluation (Level 6)	Deploying Capabilities & Attack/Defense
N/A	Appreciate the complexity and effectiveness of executing Multi-Domain warfare and initiate multi-domain thinking across all operational contexts.	Valuing [Affective Goal]	All phases and elements

IV. MDO BACKGROUND

MDO is the broad term referring to the consideration of all six warfighting domains in any and every conflict. It has been discussed heavily at the highest levels of leadership in the Army and Air Force and increasingly across the Department of Defense. Summarizing the thoughts of General David Goldfein, Air Force Chief of Staff, MDO seeks to create warfighting synergy by integrating capabilities and effects from all domains (air, space, cyber, land, maritime, and human/cognitive) to create multiple and various

dilemmas against an enemy cannot sufficiently respond. Many resources exist for understanding, introducing, and teaching about MDO and MDC2. Refer to Appendix C for a list of recommended resources.

V. EQUIPMENT DESCRIPTION

A. Game Cards: 54 cards are included in each deck. 53 of those cards are divided into the 6 warfighting domains (see figure 1) and 1 card regulating the current level of conflict. Some cards include Electronic Warfare (EW) capabilities that are not marked with their own domain, but with the domain of the asset creating the EW effect. The player starts the game with 4 of these cards, 1 is shared by both players, and the rest are used to create the users hand (6 cards) and supply pile (42 cards).

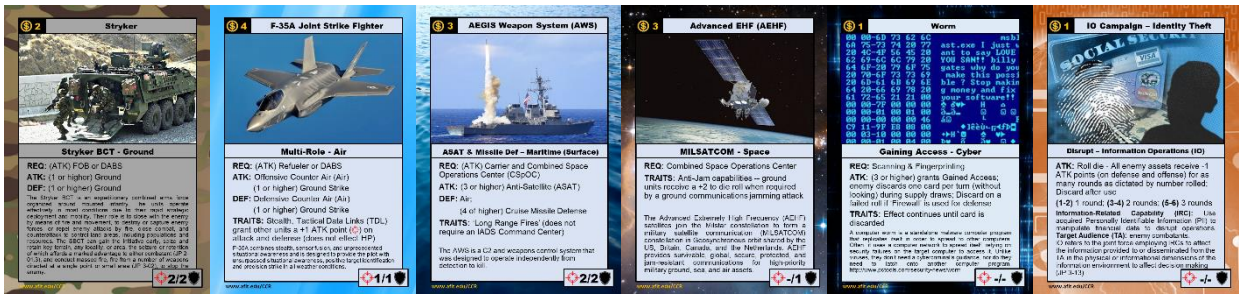


Figure 1. Example Game Cards

B. Spectrum of Conflict Card: The final card in the deck is not tied to a domain but controls the elevation of the conflict level at the beginning of the game. This aspect of the game is very simplistic, but provides a way to introduce players to the difference between competition and conflict with a near-peer adversary. The competition phase allows users to setup kinetic defenses or try to cripple adversary using Information Operations (IO) and cyber capabilities. The spectrum of conflict makes the cyber capabilities in the game more valuable while reducing the value of "first [kinetic] strike." This mechanic can be removed, but the player who goes first may have a distinct advantage because they can attack before the opponent has a chance to setup robust defenses.

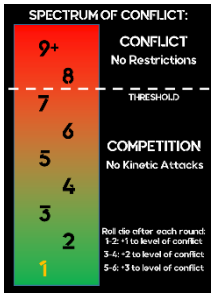


Figure 2. Spectrum of Conflict Card

C. Resource and Damage Chips: The small chips included help the players track how many resources (gold chips) they are spending and what units have received damage during play (red/black chips). The damage chips can also be used to mark cards that have an ongoing effect. For example, if a player gains access to the opponent's network, they should add a damage chip to the card to show both players that this card has an on-going impact. IO cards can be marked in a similar way depending on the player's roll.

Figure 3. Damage Chips

Figure 4. Resource Chips

Figure 5. 6-Sided Die

D. Six-Sided Die: One is needed for each game (can be shared between opponents)

E. Turn Timer: Each player needs a turn timer. A smartphone app or 60 second sand timer can be used. Facilitators can increase the time allowed for each turn as necessary. Players should be encouraged to make decisions quickly as this is required during a real world-conflict. Because real-time strategy (RTS) games are typically more complex, the turn timer is used to speed up player decisions during this turn-

based game. This goes back to the OODA (Observe, Orient, Decide, and Act) Loop, created by John Boyd in the 1950s. The player who can make good decisions faster and is more familiar with the game environment will have an advantage, which mirrors a real-world conflict.

VI. ADAPTING THE GAME FOR YOUR CONTEXT

The game is highly adaptive to your context and instructors or facilitators are encouraged to make changes to the game instructions to more effectively address your lesson objectives and limitations. The cards themselves can be altered and reprinted if pre-coordination occurs with AFIT personnel. Current game rules and cards should not limit the creation of new capabilities and creation of new forms of gameplay.

VII. DEBRIEF INSTRUCTIONS AND SUGGESTED QUESTIONS

Debriefing is an essential part of using a game for an education or training purpose. Forethought is needed to craft discussion questions to guide students from the game experience to real-world application. The instructor should seek to push the group's discussion toward realizing the lesson objectives without dominating the discussion. Specific focus should be used to identify the emotions felt by the players through the experience and introduce relevant examples from past and present military operations. The following questions are provided as examples and instructors are encouraged to create additional questions to drive home their specific learning objectives. In-depth discussion of game debriefing can be found in David Crookall's article listed in Appendix C.

Questions specific to learning objectives [Bloom's Taxonomy level identified within the brackets]

1. **Recognize that both cyber and kinetic capabilities require a kill chain and advanced planning**
    a. [Remember] What are the steps of the simplified cyber kill-chain (Scanning & Reconnaissance, Gaining Access, and Exploit)?
    b. [Understand] Did you execute any specific cyber attacks that did not use this progression (Man-in-the-Middle & Distributed Denial of Service)? Why did these attacks break the mold?
    c. [Evaluate] Do a majority of warfare planners and operators understand the effort and time required to create an effect from or through the cyber domain?
2. **Identify the two major phases of the "Spectrum of Conflict." Figure 6 shows the cycle as explained by Kelly McCoy in this article from Modern War Institute.**

3.

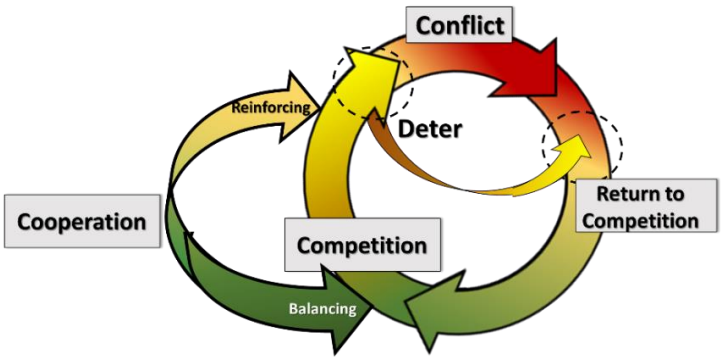


Figure 6. Spectrum of Conflict Explanation

a. [Knowledge] What were the two phases in the Spectrum of Conflict?
b. [Comprehension] What is the difference between the two phases? Which capabilities could be used in each? What allows cyber and IO to be used in this way?
c. [Application] Will the next major conflict move beyond the competition phase of the Spectrum of Conflict?
d. [Evaluation] Should the US and its allies focus on developing and using military capabilities during the competition phase of conflict with our near-peer competitors?
e. [Evaluation] Why should we consider the use of non-kinetic actions when responding to threats from other nations? Will this increase or decrease the level of conflict? How would it differ from a kinetic response (shooting a missile or dropping a bomb)?

4. **Match cyber defense capabilities to corresponding threats**
    a. [Knowledge] What were the key cyber defense and mitigation cards in the game? What cyber exploits or attacks did these capabilities help to protect against?
    b. [Application] Where are these cyber capabilities used within the military? How does your branch of service group defensive and offensive cyber capabilities?
    c. [Evaluation] Does the typical warfighter understand cyber defensive and offensive capabilities that might affect them?
5. **Develop and execute an MDO strategy in a complex and contested environment**
    a. [Analysis] What strategies did you employ during your game(s)?
    b. [Synthesis] How did you come to use this strategy? Did you consider other strategies?
    c. [Synthesis] What factors did you need to account for while executing your strategy?
    d. [Evaluation] How can capabilities from different warfighting domains be used in concert to create more potent effects? For example, how would an information operation or cyber attack create an advantage prior to a kinetic strike?
6. **Select and combine military capabilities to anticipate, adapt, and respond to surprise and uncertainty in the context of peer-to-peer warfare**
    a. [Comprehension] Did you accurately predict your enemy's actions/tendencies?
    b. [Evaluation] What effects did you create while using capabilities? Did these effects make your opponent change their strategy?
    c. [Application] Does the US currently have peer adversaries? Are we prepared to fight peer-adversaries? Is there a way that our adversaries could leverage our technically-superior capabilities against us?
7. **Appreciate the complexity and effectiveness of executing Multi-Domain warfare and initiate multi-domain thinking across all operational contexts.**
    a. [Comprehension] Is this game complex? Was it <u>too</u> complex? If so, is this because the game itself was too complex or the idea of MDO a complex reality that is hard to model?
    b. [Application] How does this game represent the current real-world military?
    c. [Application] How/where does this game depart from reality?
    d. [Evaluation] What does the military need today to encourage and facilitate multi-domain thinking? What technology is necessary to enable MDO in the US military?

Use these additional example questions to highlight various aspects of MDO:

1. **What emotions were you feeling while playing the game?**
    a. Games engage the emotions, which is one of the reason they are so successful. Try to capitalize on players' emotions and translate their experiences into real-world learning.
2. **What strategies worked for you during the game?**
3. **What strategies didn't work?**

4. **How can cyber capabilities be integrated into current military operations?**
    a. Does the use of cyber capabilities increase our surface for kinetic attacks?
    b. Can cyber capabilities win against an enemy leveraging kinetic weapons?
    c. The Israeli air strike against the launch point of a Hamas cyber attack may be a good example (https://www.theverge.com/2019/5/5/18530412/israel-defense-force-hamas-cyber-attack-air-strike)
5. **In the game, your assets had perfect communication unless specifically interrupted by enemy actions. Is this realistic?**
    a. If one radar in our arsenal detects a stealth asset, will our ground, maritime, and air assets see it too?
    b. What innovations and improvements are needed to ensure machine to machine communication? How can we connect all of our sensors to our shooters? How do we efficiently share information?
    c. One example is the F-22 and F-35. We assume they can efficiently share information, but recent news debunks this view. https://www.military.com/daily-news/2019/11/08/first-air-force-will-send-secure-data-between-f-22-and-f-35.html
    d. General Goldfein's comments from AFA Conference from September 2019 may be relevant to this question (https://www.youtube.com/watch?v=f43Z0-jk-LQ&feature=youtu.be). If you have time, this could be a helpful resource to watch in its entirety during your MDO instruction.
6. **How might the addition of nuclear capabilities change the nature of the game? How does this apply to real-world conflict?**
    a. Tactical nuclear weapons may be used in future conflicts. How does this change the nature of warfare? How should military leaders respond when faced with an enemy who used a tactical nuclear weapon?
7. **Were you able to build effective force packages?**
    a. Force packaging in the game is the sequence of cards a player uses on a single turn. This may be unclear to students unless it is specifically identified.
    b. Have students share what combinations of cards worked well and what purpose they were trying to accomplish (effect) at the time. What effect were they trying to create?
8. **How does this game relate to your career field or current position?**
    a. How does your current role fit into the military's role in peer-to-peer warfare?
    b. Several previous debriefs conversations revealed that after playing, students did not see the game as relevant to their career field or current position. This view seems to come from military personnel and others who are hyper-focused on their field and have difficulty relating their role or function to the bigger picture of competition and conflict.
9. **Given the current power competition with peer adversaries, are you (player) seeing the big picture of competition and (potential) conflict in all domains?**
    a. This is a key take-away for those that do not currently possess an "attack and defense" mindset in cyber, space, and cognitive (or other) domains.
10. **Are you (player) preparing now to lead a multi-domain force in the future?**
    a. What knowledge gaps do you need to fill in order to effectively leverage and command multi-domain capabilities?
    b. What skills will a future Component Command (COCOM) Commander need to effectively execute a multi-domain strategy?

VIII. EXPLAINATION OF GAME CONCEPTS

1. *Cyber Kill-Chain* – The cyber capabilities are separated into five categories: (1) scanning and reconnaissance, (2) gaining access, (3) exploits, (4) mitigations, and (5) defense. Offensive Cyber Operations (OCO) capabilities follow a simplified version of the Cyber Kill Chain first created by Lockheed Martin. A majority of cyber attacks require the players to first perform scanning and reconnaissance actions. Second, players must gain access to the enemy's network. Third, players can use certain exploits and cyber ISR capabilities. Some of the gaining access capabilities have a negative impact on the enemy, but the more potent effects come after gained access is obtained. Most of the cyber mitigations and defenses are aimed at preventing the adversary from gaining access. In real-world cyber conflict, it is (relatively) more difficult to hunt down an adversary within a network then to build and deploy secure systems to the battlefield. The three step cyber kill-chain is a key point to drive home during debrief. If you have more specific cyber/Electro-Magnetic Spectrum (EMS) domain objectives, it may be helpful to identity where the game simplifies or abstracts a key concept and then fill in the gap to match your learning objectives. As players become more experienced in using cyber capabilities, they will see that both cyber and kinetic capabilities require pre-planning and logistical support.
2. *Multi-Domain Operations Center (MDOC)* – This card and game concept was drawn from observations of the Doolittle Serious 18 war game. The event featured three teams of experienced operators assigned to develop the most appropriate C2 architecture for fighting future wars given various constraints. Each team independently included the idea of an MDOC into their architecture. This idea led to the creation of the MDOC card and made destroying it the central objective of the game. Although in real-world conflict the military objective may be different, destroying the MDOC represents removing the enemy's ability to plan and execute operations. A full discussion can be found in Saltzman and Rothstein's LeMay Paper found in Appendix 3. Additionally, Doolittle Series 19, held in October 2019, focused on developing the role of the MDOC in future warfare.

3. Levels of Playing Area

   a. Level 1 – Cards in Deployment. These cards are only in deployment during the player's current turn and then assigned to the appropriate level (2 or 3) at the end of the turn. This game mechanic forces the player to wait to attack with the cards that they just bought from their hand. This simulates the wait time needed to bring a cyber capability online, fly a plane from its home country to the area of conflict, or coordinate the relocation of a space asset. The game has been simplified so that all cards are in the deployment phase for the same amount of time, however more complex versions (especially an electronic version) of the game could specify wait times for various capabilities to more closely resemble reality. For example, travel time for ships is greater than planes which is greater than cyber capabilities. This change would make time another dimension for the player to consider while making game decisions. Such changes bring more realism to the game and reduce abstraction but at the same time may add complexity.
   b. Level 2 – Cards without Defensive Capabilities. Cards that don't have any defense are placed in level 2. These capabilities are those that need to be defended against opponent attacks. If an opponent attacks this level, the player may intercept the attack with cards in level 3. This simulates a geographic separation that allows the attacking card to be intercepted.
   c. Level 3 – Cards with Defensive Capabilities. Cards with DEF options are placed in level 3 and are the primary attack and defense assets. In many cases these assets can be used to intercept enemy attacks.

IV. FREQUENTLY ASKED QUESTIONS

A. **Can I add my own cards/capabilities to the game?** Yes, instructors are encouraged to make changes to the game to best fit their context. However, care should be taken to consider the effect that new capabilities will have on the game (balancing). A specific scenario could be the best way to introduce new learning objectives. Playtesting and evaluation will be needed when introducing new game mechanics, cards, or capabilities.

B. **Can I print new cards to use in my classroom?** Yes, the AFIT POCs listed in this guide can help with the card creation and ordering process. If you would like to brand the cards with your organization's logo, please work with AFIT CyTCoE for approval.

C. **Why do some of the capabilities depart from actual military weapon systems?** In order to reduce the complexity of the game and make it playable by students in a classroom setting, abstractions had to be made. These abstractions may lead to negative results, meaning that players will learn the wrong lessons and take-away inaccurate perceptions of military operations and MDO. Facilitators should use the debrief session to de-emphasize lessons learned that mislead students. One example of this is the F-22. Although the actual weapon system has ground strike capability (depending on the available munitions) the game card was simplified to focus on the key capability the F-22 provides to current operations (offensive and defensive counter-air and air superiority). This simplification of capabilities also requires players to decide between more powerful assets dedicated to a single function versus weaker multi-role assets. Sources and links are provided on many of the cards to assist players in personal research of real-world military systems and their application.

V. CONCLUSION

Thank you for considering Battlespace Next: MDO for your education and training purposes. Editable versions of the game cards and instructions are available upon request. If you have any questions about the game or feedback in how to improve the game or this guide, please contact Capt Nathan Flack (Nathaniel.flack@afit.edu) or the AF Cyberspace Technical Center of Excellence at AFIT (cytcoeworkflow@afit.edu).

VI. ACKNOWLEDGEMENTS

Creator: Captain Nathan Flack, Student, AFIT
Principle Investigator: Dr. Mark Reith, Assistant Professor of Cyber Systems, AFIT
Based on the *Multi-Domain Command and Control Trading Card Game* created by Lt Col Alan Lin, Assistant Professor of Computer Science, AFIT

Current as of: 5 Dec 2019

Approved for public release by 88 ABW/PA (2019-5823) on 2 December 2019

APPENDIX A:
Summary of Game Instructions

1. Place the following cards in the middle (only 1 of each per game):
    a. GPS II
    b. Spectrum of Conflict
2. Place these cards in your playing area face-up (level 2)
    a. Multi-Domain Operations Center (MDOC) – Ground Domain
    b. Combined Space Operations Center (CSpOC) – Space Domain
    c. Cyber Operations Center – Cyber Domain
    d. IADS Command Center – Ground Domain
3. Roll to see who goes first – highest roll wins (2nd player receives 1 additional resource chip on first turn)
4. Turn overview:
    a. Reset turn timer
    b. Gain 4 resources
    c. Draw additional cards until you have 6 in your hand
    d. Deploy cards – pay the cost and place on the table nearest to you (level 1) in a revealed or unrevealed state. These cards will be become active at the end of your turn. Any card can be played in the "unrevealed" state, but it will not have any effect until revealed
    e. Attack opponent's cards with previously deployed cards
        i. Note: No ATK actions are allowed in the first round. No kinetic ATK actions are allowed before the conflict level crosses the threshold
    f. Move any deployed cards from level 1 to levels 2 or 3 (depending on DEF options)
    g. You MAY discard some or all remaining cards in your hand
5. Each player starts with 4 resources and 6 selected cards in their hand, therefore no additional resources will be collected and no additional cards will be drawn on the first turn
6. After each round (both players take 1 turn each) roll to increase Conflict Level. Once the Conflict Level reaches 8 or higher, you can stop rolling
7. Order of Battle:
    a. **Attacker** chooses 1 card to attack and chooses a revealed enemy card as the target
    b. **Defender Intercepts -** IF the target does not have applicable DEF options, the defender may intercept with one other card (she can reveal cards for interception). All applicable cyber defenses MUST be revealed
    c. **Resolution** - The players determine the outcome of the battle. IF the attacker is not destroyed, it will continue to the original target. In this case its Attack Points (target icon) is applied to both the interceptor and the original target (if the ATK options apply)
8. Attack/Defense:
    a. To attack, your card's ATK options must match the target card's type. To defend or intercept, the DEF options must match the attacking card's type
    b. Attack Points (target) go against Health Points (shield) for both ATK & DEF
    c. Attacker can only attack revealed cards
    d. Both cards will take damage unless "Long Range Fires" or another element is present (stealth, domain mismatch, disabled card, etc.)
9. Long-Range Fires: means a card can attack or defend and the opposing card cannot do damage back. Cruise Missiles can still be defended against if an asset possess "Cruise Missile Defense" but cannot damage the launcher
10. Die Rolls: All modifiers are added or subtracted to the roll (not the threshold)
11. Once player depletes their supply, they must shuffle the discard pile which becomes their new supply pile. Reduce resources gathered per turn by 2. If player depletes their supply pile twice, they automatically lose the game. For example, the first time a player cycles through their supply, they will only receive 2 resources at the beginning of each turn instead of 4

APPENDIX B:
Experiment Procedures

If you are conducting an experiment using Battlespace Next (BSN) use this appendix to help you use the game effectively in your classroom and collect data to further improve BSN and shape future learning tools. Please coordinate each in-class playtest with Capt Nathan Flack (nathaniel.flack@afit.edu). Thank you!

SESSION 1 – PRE-SURVEY, EXPLAINATION, & DEMO GAME

After an introduction of MDO, show the game to your classroom or audience. For best results, introduce the game at least one day before playing to ensure that players have time to examine cards and choose their starting hand.

1. Coordinate with Capt Flack to send a Pre-Survey link to all players. This is an individual link that each participant will receive in their email. The Pre-Survey take approximately 5 minutes to complete.
2. Distribute a game box and game instructions to each player or team of two.
    a. The game box will contain a deck of 54 cards, 25 black chips, and 8 gold chips, (approximately)
    b. You may provide game instructions electronically, but only if they are easily accessible during preparation and game play.
    c. Players may download turn timer apps on their smartphones (this is optional)
3. Show the video tutorial(s) provided.
4. Briefly explain the details (day, timeframe, opponent, etc.) of how you will the game in the future (more information on this in the "Play the Game" section of this document).
    a. Providing incentives or prizes to top ranking players will increase motivation and engagement, however, you cannot link game performance to course grade/rating.
5. Have players or teams choose opponents and play a demo game. This allows players to learn some of the mechanics of the game. The goal should be to play through several rounds to see how the Spectrum of Conflict, turn progression, and attack/defense actions are performed.
    a. During play, show a slide (provided) that identifies each of the turn phases, the card pile layout, and any card corrections (provided by Capt Flack)
6. Instruct players to select the 6 cards for their starting hand. This will require the player to do in-depth strategy development. If desired, strategy development can be done with a partner or teammate to increase engagement and innovation.
    a. This is a key element to the learning objectives of the game, as players must look through all available cards to find dependencies and connections as well as build an overall warfighting strategy.
    b. The beginning hand represents the capabilities that are ready to immediately deploy to the battlespace (the cost still must be paid).

SESSION 2 – EXHIBITION GAMES & DEBRIEFING (2 HOURS)

Players should now grasp how to play the game and have developed an initial strategy with a corresponding starting hand. Now play more "official" games in which scores will be tallied. Instructors may also want to post the highest performing teams/players on a scoreboard visible to the class. As multiple games are played, the best teams should be matched to one another to keep the exercise challenging or all. This session concludes with a 30-minute debriefing session to emphasize the learning objectives and allow time for players to learn from others' experiences.

1. Review strategies with partner or teammate from session 1 (5-10 mins)
2. Match teams with opponent (individual or team)
3. Play first exhibition game (50 mins)
    a. Record game results from each game (scorecard provided)
    b. Post scores to a scoreboard if available (1 point for each damage point inflicted against enemy MDOC and each health point remaining on their MDOC). Point range: 0-24
4. Allow players to adjust their game deck and their strategy (10 mins)
5. Match new opponents using the leaderboard
    a. 1 vs 2
    b. 3 vs 4
    c. 5 vs 6
    d. Etc.
6. Play second game (30-40 mins)
7. Record game results and update leaderboard
8. If you have time you can play additional games. As much as possible players should be matched with those about their skill level. Players should be playing someone new each match.
9. Conduct Debriefing
10. Administer Post-Survey (email with link will be delivered to students during Session 2 with coordination with Capt Flack). Post-survey takes approximately 12 minutes to complete.
11. Conclude the session
    a. Encourage students to continue to experiment with the game by play more rounds or developing cards of their own to submit to AFIT or local game development cell.

Figure 7. High-Level Experiment Procedures

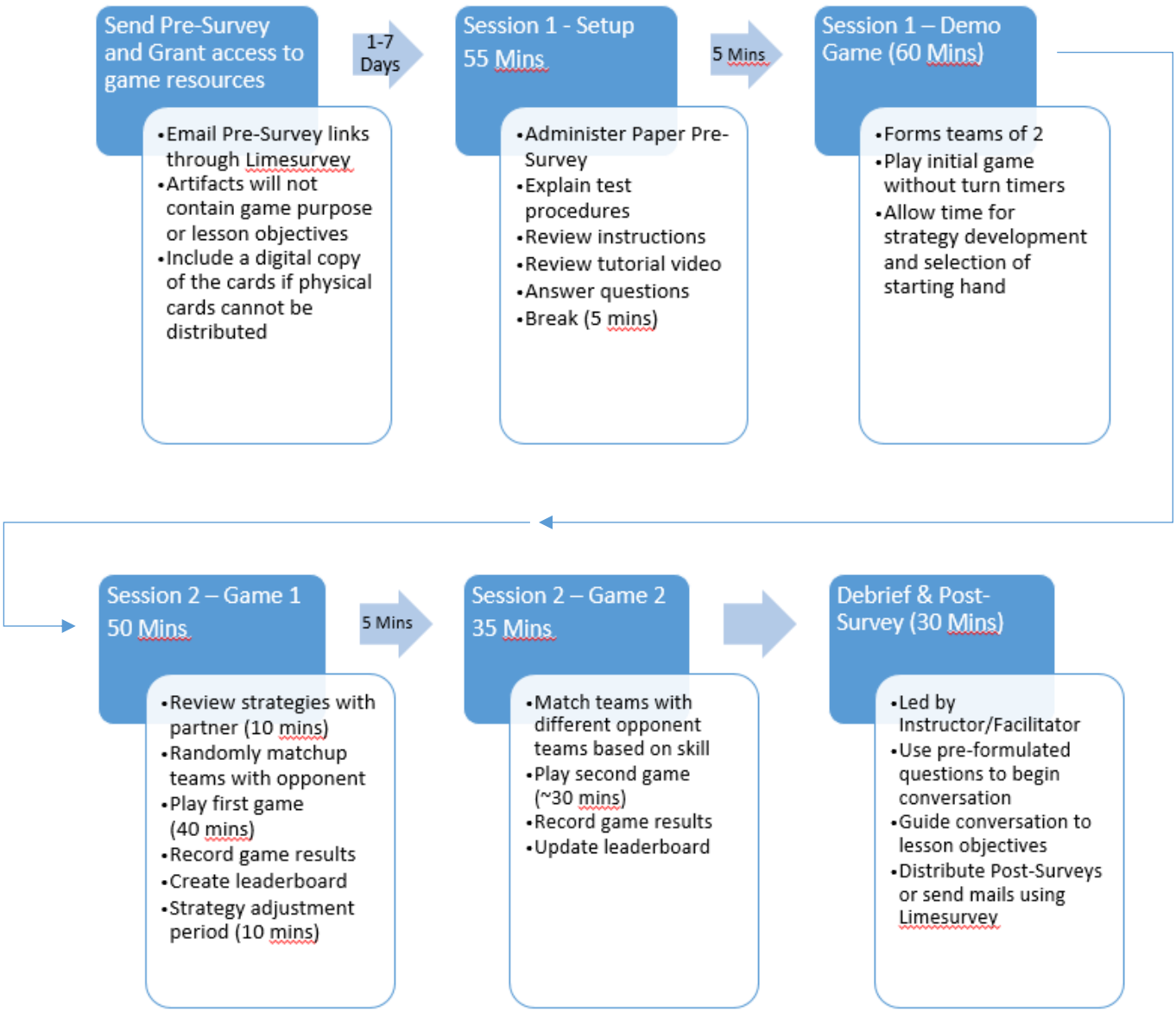


Figure 8. Detailed Experiment Procedures

APPENDIX C:
Sources and MDO/MDC2 Recommended Reading List

Goldfein, D. (2017) "Our Military Must Harness the Potential of Multidomain Operations", Defense News, 17 September 2017, https://www.defensenews.com/outlook/2018/12/10/us-air-force-chief-of-staff-our-military-must-harness-the-potential-of-multidomain-operations, retrieved 23 February 2019.

CSAF Address to Air War College and AU Faculty/Staff All Call (start at 32 minutes): https://youtu.be/LAW-3VDNOmM

CSAF's MDO Explanation and Vignette at AFA's 2019 Air, Space, & Cyber Conference: https://go.afa.org/e/285922/f43Z0-jk-LQ/71h23s/694054381?h=G47HT_JSCloeP0OPFJqpGFwuZw-OW67XRrkbaJoyklU. The full remarks can be found here: https://youtu.be/wyQG29uiiy8

Over The Horizon - MDO Journal https://othjournal.com/author/overthehorizonmdos

https://go.afa.org/e/285922/f43Z0-jk-LQ/71h23s/694054381?h=G47HT_JSCloeP0OPFJqpGFwuZw-OW67XRrkbaJoyklU

Wilson, H., Goldfein, D. L., and Wright, K. O. (2018) "Multi-Domain Command and Control (MDC2) Implementation Plan," official memorandum signed 25 June 2018.

Multidomain Operations: A Subtle but Significant Transition in Military Thought (Dr. Jeffrey M. Reilly) https://apps.dtic.mil/dtic/tr/fulltext/u2/1003670.pdf

Zadalis, T. (2018). Multi-Domain Command and Control: Maintaining Our Asymmetric Advantage. *Joint Air Power Competence Centre*, 26, 10–15. https://doi.org/10.17226/25316

Saltzman, B. C. and Rothstein, M. D. (2019) "Doolittle Series 18: Multi-Domain Operations Air Force Lessons Learned," 9 January 2019, https://www.airuniversity.af.edu/AUPress, accessed 11 March 2019.

Alberts, D. S. (2018) "Multi-Domain Operations: What's New, What's Not, and the Implications for Command and Control", Institute for Defense Analysis, 26 March 2018.

Office of the Secretary of Defense, "Summary of the 2018 National Defense Strategy of the United States of America," Washington, DC: Department of Defense (2018), https://www.defense.gov/Portals/1/Documents/pubs, retrieved on 8 August 2018.

Air Superiority 2030 Flight Plan (2016) https://www.af.mil/Portals/1/documents/airpower, retrieved on 11 March 2018.

Goldfein, D. (2018) "Air Force Association Air, Space & Cyber Conference Remarks, 18 September 2018" https://www.af.mil/Portals/1/documents/Speeches/GenGoldfeinAFA, retrieved on 26 February 2019.

Competing in Space – Report published by the National Air & Space Intelligence Center (NASIC) https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF\

Challenges to Competing in Space – Report published by DIA https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf

At Our Own Peril: DoD Risk Assessment in a Post-Primacy World
https://ssi.armywarcollege.edu/pdffiles/PUB1358.pdf

The U.S. Army in Multi-Domain Operations 2028
https://www.tradoc.army.mil/Portals/14/Documents/MDO/TP525-3-1_30Nov2018.pdf

Winning the Airwaves: Regaining America's Dominance in the Electromagnetic Spectrum - CSBA
https://csbaonline.org/uploads/documents/CSBA6292-EW_Reprint_WEB.pdf

OTH: Vulnerabilities of Multi-Domain Command and Control
https://othjournal.com/2019/03/04/vulnerabilities-of-multi-domain-command-and-control-part-1/

OTH: Multi-Domain Operations at the Strategic Level
https://othjournal.com/2018/03/02/multi-domain-operations-at-the-strategic-level/

Richards, C. (2011). Boyd's OODA Loop (It's Not What You Think). Proceedings of Lean Software and Systems Conference 2011, 127–136.

McCoy, K. (2018). In the Beginning there was Competition: The Old Idea behind the New American Way of War. Retrieved November 3, 2019, from Modern War Institute website: https://mwi.usma.edu/beginning-competition-old-idea-behind-new-american-way-war/

Harry Foster, Bob Martinage, and Jim Thomas (2019) "Counter-C4ISR and Kill-Chain Warfare in Great Power Competition," October 1, 2019. Telemus Group.

Crookall, D. (2010). Serious Games, Debriefing, and Simulation/Gaming as a Discipline. Simulation and Gaming, 41(6), 898–920. https://doi.org/10.1177/1046878110390784

L. W. Anderson, D. R. Krathwohl and B. S. Bloom, (2001) A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, New York: Longman.

Flack, N. and Reith, M. (2019) "Self-Directed Learning Tools in USAF Multi-Domain Operations Education," *European Conference on Cyber Warfare and Security*, 752-759.

Appendix C. BSN Game Cards

There were two versions of the BSN game cards printed through Print & Play Games.[1] The final version of the cards is provided below. A set of cards (2 decks) and associated game supplies can be purchased at cost at Print & Play Games.[2]

[1] https://www.printplaygames.com

[2] https://www.printplaygames.com/product/battlespace-next

SPECTRUM OF CONFLICT:

9+ 8

CONFLICT
No Restrictions

THRESHOLD

7 6 5 4 3 2 1

COMPETITION
No Kinetic Attacks

Roll die after each round:
1-2: +1 to level of conflict
3-4: +2 to level of conflict
5-6: +3 to level of conflict

$ 3 Multi-Domain Ops Center

Multi-Domain Command & Control

TRAITS: Can only be targeted by cards with "ATK: Ground"

"The MDOC would operate as a planning cell in direct support of the JFACC to integrate effects. This MDOC would include liaison officers from the functional combatant commands…The MDOC would require robust Multi-Domain integration elements. A key aspect would be knowledgeable people enabled by technology" (Doolittle Series 18 Multi-Domain Operations, LeMay Paper 3)

-/12

$ 1 IO Campaign – Social Media

Corrupt – Information Operations (IO)

ATK: Roll die -- enemy loses 1 resource per turn as dictated by the roll; Discard after use

(1-2) 1 round; **(3-4)** 2 rounds; **(5-6)** 3 rounds

Information-Related Capability (IRC): Use social media feeds to discredit enemy's leaders and influence public--eroding their support for the conflict.

Target Audience (TA): enemy's home country

IO refers to the joint force employing IRCs to affect the information provided to or disseminated from the TA in the physical or informational dimensions of the information environment to affect decision making (JP 3-13)

-/-

$ 1 Military Deception (MILDEC)

Disrupt – Information Operations (IO)

ATK: (4 or higher) Enemy loses a turn; Discard after use (on success or failure)

The picture above is an inflatable tank modeled after the M4 Sherman that was used by the "Ghost Army" as part of a intricate MILDEC campaign during World War II. "MILDEC is intended to deter hostile actions, increase the success of friendly defensive actions, or to improve the success of any potential friendly offensive action. Use of MILDEC during any phase of an operation should help to mislead adversaries as to the strength, readiness, locations, and intended missions of friendly forces. In combat situations, the focus is on driving the adversary to culmination and achieving the objectives defined by the JFC." (Joint Publication 3-13.4)

-/-

$ 1 IO Campaign – Identity Theft

Disrupt – Information Operations (IO)

ATK: Roll die - All enemy assets receive -1 ATK points (on defense and offense) for as many rounds as dictated by number rolled; Discard after use

(1-2) 1 round; **(3-4)** 2 rounds; **(5-6)** 3 rounds

Information-Related Capability (IRC): Use acquired Personally Identifiable Information (PII) to manipulate financial data to disrupt operations.
Target Audience (TA): enemy combatants.
IO refers to the joint force employing IRCs to affect the information provided to or disseminated from the TA in the physical or informational dimensions of the information environment to affect decision making (JP 3-13).

-/-

$ 1 IO Campaign – News Media

Influence – Information Operations (IO)

ATK: Roll die – Gain 1 extra resource on your next 1-3 turns; Discard after use

(1-2) 1 turn; **(3-4)** 2 turns; **(5-6)** 3 turns

Information-Related Capability (IRC): Use news outlets in home country and host nation to bolster support for the conflict. This campaign targets the general population and decision makers. Success garners more funding for the war effort
Target Audience (TA): General population

IO refers to the joint force employing IRCs to affect the information provided to or disseminated from the TA in the physical or informational dimensions of the information environment to affect decision making (JP 3-13)

-/-

$ 2 Cyber Operation Center

Command & Control - Cyber

TRAITS: Each player begins the game with this card in their deployed area; If this card is destroyed, return it to your hand. If destroyed all cyber assets lose their effect and must be rerolled on a subsequent turn.

A cyber operations center is the focal point of military cyber operations. It is home to the personnel and equipment to command and control cyberspace forces to operate, defend, and engage in the cyber domain (https://www.afcyber.af.mil/About-Us/Units/624th-Operations-Center/).

-/3

$ 1 Firewalls

Defense - Cyber

DEF: Remove existing Worm ATK and -3 decrease to future enemy Worm ATK attempts; this card MUST be used for defense if deployed at the time of enemy's attack

Firewalls provide protection against outside attackers by shielding your computer or network from malicious or unnecessary network traffic and preventing malicious software from accessing the network. Firewalls can be configured to block data from certain locations or applications while allowing relevant and necessary data through. Firewalls do not guarantee that your computer will not be attacked. Firewalls primarily help protect against malicious traffic, not against malicious programs (malware), and may not protect you if you accidentally install malware on your computer.

(https://www.us-cert.gov/ncas/tips/ST04-004)

-/-

$ 1 Encryption

Defense - Cyber

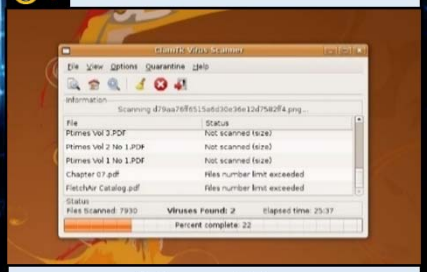
DEF: -3 decrease to enemy Spoofing ATK attempts

Encryption is a way to send a message in code. The only person who can decode the message is the person with the correct key; to anyone else, the message looks like a random series of letters, numbers, and characters. Encryption is especially important if you are trying to send sensitive information that other people should not be able to access. Because email messages are sent over the internet and might be intercepted by an attacker, it is important to add an additional layer of security to sensitive information.

(https://www.us-cert.gov/ncas/tips/ST04-019)

-/-

$1 Anti-Virus



Defense - Cyber

DEF: Remove existing Backdoor Trojan and Rootkit ATK and -1 decrease to future enemy Backdoor Trojan and Rootkit ATK attempts;

This card MUST be used for defense if deployed at the time of enemy's attack

Anti-virus software scans files or your computer's memory for certain patterns that may indicate the presence of malicious software (i.e., malware). Anti-virus software (sometimes more broadly referred to as anti-malware software) looks for patterns based on the signatures or definitions of known malware. Anti-virus vendors find new and updated malware daily, so it is important that you have the latest updates installed on your computer.

(https://www.us-cert.gov/ncas/tips/ST04-005)

-/-

www.afit.edu/CGR

$1 Backups

Mitigation - Cyber

DEF: -3 decrease to enemy Ransomware ATK attempt.

All users should back up the critical data they have on their desktops, laptops, servers, and mobile devices. To increase your chances of recovering lost data, follow the 3-2-1 rule:

3 – Keep **3** copies: 1 primary and 2 backups
2 – Keep the files on **2** different media types
1 – Store **1** copy offsite

(www.us-cert.gov/sites/default/files/publications/data_backup_options.pdf)

-/-

www.afit.edu/CGR

$1 Redundant Servers

Mitigation - Cyber

DEF: -4 decrease to enemy DDoS attacks

TRAITS: +1 to your Distributed Denial of Service (DDoS) attacks

Server redundancy refers to the amount and intensity of backup, failover or redundant servers in a computing environment. It defines the ability of a computing infrastructure to provide additional servers that may be deployed on runtime for backup, load balancing or temporarily halting a primary server for maintenance purposes. It is implemented in an enterprise IT infrastructure where server availability is of paramount importance. To enable server redundancy, a server replica is created with the same computing power, storage, applications and other operational parameters. (https://www.techopedia.com/definition/14718/server-redundancy)

-/-

www.afit.edu/CGR

$1 Distributed Denial of Service

Exploit - Cyber

REQ: Redundant Servers or 1 resource chip

ATK: (3 or higher) Enemy cannot deploy cards on their next turn

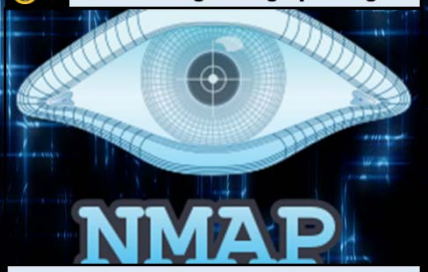
TRAITS: Discard after use (on success or failure)

In a distributed denial-of-service (DDoS) attack, an attacker may use your computer to attack another computer. By taking advantage of security vulnerabilities or weaknesses, an attacker could take control of your computer and then force your computer to send huge amounts of data to a website or send spam to particular email addresses. The attack is "distributed" because the attacker is using multiple computers, including yours, to launch the denial-of-service attack. https://www.us-cert.gov/ncas/tips/ST04-015

-/-

www.afit.edu/CGR

$1 Scanning & Fingerprinting



Reconnaissance - Cyber

ATK: +1 to Worm ATK attempt

DEF: -1 to all enemy "Gaining Access" attempts

Nmap ("Network Mapper") is a free and open source utility for network discovery and security auditing. Nmap uses raw IP packets in novel ways to determine what hosts are available on the network, what services (application name and version) those hosts are offering, what operating systems (and OS versions) they are running, what type of packet filters/firewalls are in use, and dozens of other characteristics. (https://nmap.org/)

-/-

www.afit.edu/CGR

$1 Sniffing (Packet Analysis)

Reconnaissance - Cyber

TRAITS: +2 to Spoofing ATK attempt

Packet sniffing, or packet analysis, is the process of capturing any data passed over the local network and looking for any information that may be useful. Most of the Internet runs in plain text, which means that most of the information you look at is viewable by someone with a packet sniffer. This information ranges from the benign to the sensitive. Tools like Wireshark, Ettercap or NetworkMiner give anybody the ability to sniff network traffic with a little practice or training. (http://www.linuxjournal.com/content/packet-sniffing-basics).

-/-

www.afit.edu/CGR

$1 Worm

Gaining Access - Cyber

REQ: Scanning & Fingerprinting

ATK: (3 or higher) grants Gained Access; enemy discards one card per turn (without looking) during supply draws; Discard on a failed roll if 'Firewall' is used for defense

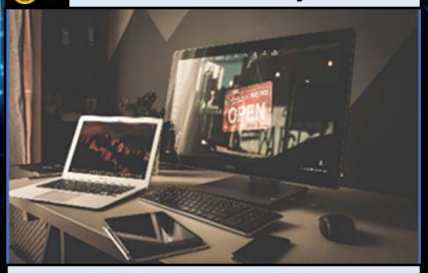
TRAITS: Effect continues until card is discarded

A computer worm is a standalone malware computer program that replicates itself in order to spread to other computers. Often, it uses a computer network to spread itself, relying on security failures on the target computer to access it. Unlike viruses, they don't need a cybercriminal's guidance, nor do they need to latch onto another computer program. http://www.pctools.com/security-news/worm

-/-

www.afit.edu/CGR

$1 Backdoor Trojan



Gaining Access - Cyber

ATK: (3 or higher) grants Gained Access; At the start of the enemy's turn (before draw), look at the top 3 cards of their supply pile; Discard on a failed roll if 'Anti-Virus' is used for defense

TRAITS: Effect continues until card is discarded

A backdoor Trojan computer virus is a piece of malicious software that usually finds a way into its victim computers without the knowledge or consent of the owners. Once one of these viruses gets to work in a victim computer, it can enable the computer to be accessed and controlled remotely. This puts all data stored on the computer at risk, as well as endangers anyone who may enter personal information into the computer.

-/-

www.afit.edu/CGR

$2 Rootkit

Gaining Access - Cyber

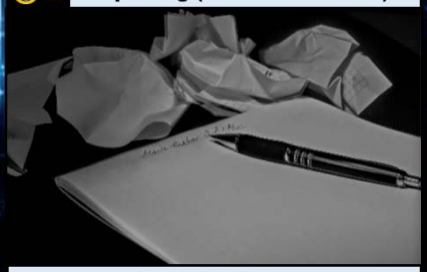
ATK: (3 or higher) grants Gained Access; Enemy cyber defenses lose -1 DEF; Discard on a failed roll if 'Anti-Virus' is used for defense

Rootkits have two primary functions: remote command/control (back door) and software eavesdropping. Rootkits allow someone, legitimate or otherwise, to administratively control a computer. This means executing files, accessing logs, monitoring user activity, and even changing the computer's configuration. Rootkits can't propagate by themselves, but are just one component of a *blended threat*. Blended threats typically consist of three snippets of code: a dropper, loader, and rootkit (http://www.techrepublic.com/blog/10-things/10-plus-things-you-should-know-about-rootkits/).

-/-

www.afit.edu/CGR

$2 Spoofing (Man-in-the-Middle)



Exploit - Cyber

REQ: Sniffing or Scanning & Fingerprinting

ATK: (5 or higher) Confuse enemy C2 – choose any revealed card in Level 3 and return it to your opponent's hand.

A re-roll is required each turn for this exploit to take effect. Discard on a failed roll if 'Encryption' is used for defense.

A man-in-the-middle (MITM) attack occurs when someone between you and the person with whom you are communicating is actively monitoring, capturing, and controlling your communication transparently (https://technet.microsoft.com/en-us/library/cc959354.aspx).

-/-

$1 Ransomware

Exploit - Cyber

REQ: Gained Access

ATK: (2 or higher) They paid -- discard ½ of the enemy's hand on their next turn (without looking); Discard on a failed roll if 'Backups' is used for defense

TRAITS: Discard on success

In a ransomware attack, victims click on an attachment containing malicious ransomware code or an URL directed to a website that infects their computer. Once infected, the malware begins encrypting files and folders on local drives, any attached drives, backup drives, and potentially other computers on the same network. Users are generally not aware they have been infected until they can no longer access their data or until they begin to see demands for a ransom payment in exchange for a decryption key. (https://www.fbi.gov/news/stories/incidents-of-ransomware-on-the-rise)

-/-

$2 ICS Attack

Exploit - Cyber

REQ: Gained Access

ATK: (5 or higher) Enemy Ground and Maritime assets are disabled for 1 round (your current turn and the enemy's next turn)

TRAITS: Do not discard on a failed roll

Cyber attacks against Industrial Control Systems (ICS) can effect power, water sanitation, financial services, and many other functions that are vital to human life and military operations. https://www.us-cert.gov/ics

-/-

$2 Cyber Intelligence

ISR - Cyber

REQ: Gained Access (if gained access is lost this card loses its effect, but it is not discarded)

TRAITS: +1 to all cyber exploits; Reveal all enemy cyber cards

Cyber Intelligence refers to the gathering of information about cyber activities or with cyber capabilities to both characterize threats (cyber threat intelligence) and gather information on enemy actions. https://www.bankinfosecurity.com/blogs/cyber-intelligence-what-exactly-it

-/-

$2 Combined Space Ops Center

Command & Control - Space

TRAITS: Each player begins the game with this card in their deployed area; If this card is destroyed it returns to the players hand and all space assets lose their effect(s) – except GPS II Satellite Constellation

"The Combined Space Operations Center (CSpOC), reports to the Joint Force Space Component Commander (JFSCC) and executes the operational C2 of space forces to achieve theater and global objectives. It is continuously coordinating, planning, integrating, synchronizing and executing space operations; providing tailored space effects on demand to support combatant commanders and accomplishing national security objectives." https://www.stratcom.mil/Portals/8/Documents/CSpOC_Factsheet_2018.pdf

-/3

$2 GPS II Satellite Constellation

Support (PNT) - Space

TRAITS: Medium Earth Orbit (MEO); Enables global navigation and precision kinetic ground strikes

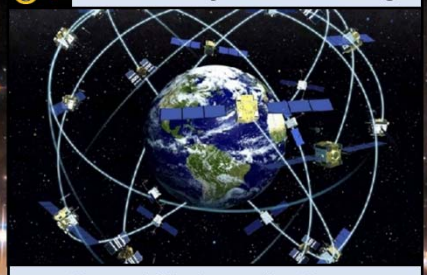
Pre-position this card in the middle of the table at the beginning of the game. Both players can leverage this card's capabilities. If destroyed then all ground strikes and cruise missile attacks receive -3 to die roll.

The Global Positioning System (GPS) satellite constellation allows GPS receivers to calculate location. At least 4 satellites are needed to determine 3-D location (latitude, longitude, and altitude).

Created by Doug Ruyle

-/1

$1 GPS Military Code Processing



Support (Equipment) – Space

REQ: GPS II Constellation

TRAITS: Anti-Jam capabilities; +2 to any roll required by GPS jamming.

GPS is designed to provide greater signal strength for military applications. The conflict over navigation signals, referred to as navigation warfare (NAVWAR), seeks to ensure access to GPS for US forces, our allies, and civilian applications while preventing hostile use of GPS. Military systems can access the Military Code (M-Code) encrypted signal if they have a keyed receiver designed to process the signal.

-/-

$3 Advanced EHF (AEHF)

MILSATCOM - Space

REQ: Combined Space Operations Center

TRAITS: Anti-Jam capabilities -- ground units receive a +2 to die roll when required by a ground communications jamming attack

The Advanced Extremely High Frequency (AEHF) satellites join the Milstar constellation to form a military satellite communication (MILSATCOM) constellation in Geosynchronous orbit shared by the US, Britain, Canada, and the Netherlands. AEHF provides survivable, global, secure, protected, and jam-resistant communications for high-priority military ground, sea, and air assets.

-/1

$3 ORS-1

ISR - Space

REQ: Combined Space Operations Center

TRAITS: Reveals all enemy Air, Ground, and Maritime (surface) cards; Fulfills requirement for ELINT Collection Site.

Operationally Responsive Space-1 (ORS-1) provides an extra eye over the battlefield in the CENTCOM Area of Responsibility (AOR). It is the first military spy satellite to incorporate the processes and software that were originally developed for the U-2 aircraft https://www.afspc.af.mil/News/Article-Display/Article/249605

-/1

$ 4

USS Gerald R. Ford

Aircraft Carrier – Maritime (Surface)

The USS Gerald R. Ford is a Ford Class Aircraft Carrier that boasts of a 4,500+ member crew and a capacity of 75+ aircraft. It is the premier forward asset for crisis response and early decisive striking power in a major combat operation. Gerald R. Ford-class aircraft carriers and carrier strike groups will provide the core capabilities of forward presence, deterrence, sea control, power projection, maritime security and humanitarian assistance.
https://www.history.navy.mil

-/6

www.afit.edu/CCR

$ 3

AEGIS Weapon System (AWS)

ASAT & Missile Def – Maritime (Surface)

REQ: (ATK) Carrier and Combined Space Operations Center (CSpOC)

ATK: (3 or higher) Anti-Satellite (ASAT)

DEF: Air;
(4 of higher) Cruise Missile Defense

TRAITS: 'Long Range Fires' (does not require an IADS Command Center)

The AWS is a C2 and weapons control system that was designed to operate independently from detection to kill.

2/2

www.afit.edu/CCR

$ 4

USS Mississippi

Submarine – Maritime (Subsurface)

REQ: Advanced EHF (AEHF)

ATK: Cruise Missile Launcher;
Ship (Surface and Subsurface)

DEF: Ship (Surface and Subsurface)

TRAITS: -2 to enemy Cruise Missile Defense rolls; Card MAY be turned over at the end of your turn.

USS Mississippi is a Virginia-Class submarine designed to gather intelligence, deploy special forces, and attack land targets.

3/2

www.afit.edu/CCR

$ 3

Arleigh Burke Class Destroyer

Guided Missile Destroyer - Maritime

REQ: (ATK) Carrier

ATK: Cruise Missile Launcher;
Ground Strike (removes 1 HP);
Anti-Sub Warfare – Maritime (Sub);
Anti-Surface Warfare – Maritime (Surface)

DEF: Maritime (surface and subs)

TRAITS: 'Long Range Fires' for Ground Strike only; -1 to enemy Cruise Missile Defense rolls;

2/2

www.afit.edu/CCR

$ 2

EA-18G Growler

Electronic Attack – Air (EW)

REQ: Refueler, Carrier, or DABS

ATK: Offensive Counter Air (Air);
(2 or higher) Radar Jamming - Disable 1 enemy IADS shooter for 1 turn. This attack operates like a Long Range Fires attack as it cannot be intercepted.

DEF: Defensive Counter Air (Air);

The Navy's EA-16G is the most advanced airborne EA platform and is the only one in production today.

1/1

www.afit.edu/CCR

$ 4

E-2D Advanced Hawkeye

Airborne Early Warning – Air

REQ: Refueler or Carrier

TRAITS: Reveals deployed enemy air and maritime (surface) units. Detects stealth aircraft on attack and defense.

The E-2D Advanced Hawkeye enhances the Navy's battle management command and control. The Hawkeye manages the mission and keeps the net-centric carrier battle groups out of harms way. The E-2D gives the warfighter expanded battlespace awareness, especially in the area of information operations delivering battle management, theater air and missile defense, and multiple sensor fusion capabilities in an airborne system.
https://www.northropgrumman.com/Capabilities

-/1

www.afit.edu/CCR

$ 3

E-3 Sentry (AWACS)

Airborne C2 - Air

REQ: Refueler or DABS

TRAITS: Reveals deployed enemy air units and all subsequently deployed enemy air units; detects stealth aircraft on attack and defense

The E-3 Sentry is an airborne warning and control system, or AWACS, aircraft with an integrated command and control battle management (C2BM) surveillance, target detection, and tracking platform. It provides an accurate, real-time picture of the battlespace to the Joint Air Operations Center. AWACS provides situational awareness of friendly, neutral and hostile activity, command and control of an area of responsibility, battle management of theater forces, and all-weather operations.

-/1

www.afit.edu/CCR

$ 2

F-15E Strike Eagle

Multi-Role Strike Fighter - Air

ATK: Offensive Counter Air (Air)
(1 or higher) Ground Strike

DEF: Defensive Counter Air (Air)
(1 or higher) Ground Strike

F-15E is a two-seat, dual-role, totally integrated fighter for all-weather, air-to-air and deep interdiction missions. Superior maneuverability and acceleration are achieved through high engine thrust-to-weight ratio and low wing loading.

2/1

www.afit.edu/CCR

$ 4

F-22 Raptor

Fighter – Air

REQ: (ATK) Refueler, DABS, or Carrier

ATK: Offensive Counter Air (Air)

DEF: Defensive Counter Air (Air)

TRAITS: Stealth

The combination of stealth, integrated avionics and super cruise drastically shrinks surface-to-air missile engagement envelopes and minimizes enemy capabilities to track and engage the F-22. Advances in low-observable technologies provide significantly improved survivability and lethality against air-to-air and surface-to-air threats. The F-22 brings stealth into the day, enabling it not only to protect itself but other assets.

2/2

www.afit.edu/CCR

$ 4 F-35A Joint Strike Fighter

Multi-Role - Air

REQ: (ATK) Refueler or DABS

ATK: Offensive Counter Air (Air)
(1 or higher) Ground Strike

DEF: Defensive Counter Air (Air)
(1 or higher) Ground Strike

TRAITS: Stealth, Tactical Data Links (TDL) grant other units a +1 ATK point (⌖) on attack and defense (does not effect HP)

F-35A combines stealth, sensor fusion, and unprecedented situational awareness and is designed to provide the pilot with unsurpassed situational awareness, positive target identification and precision strike in all weather conditions.

⌖1/1

www.afit.edu/CCR

$ 2 RC-135V/W Rivet Joint

Support (ISR) - Air

REQ: Refueler or DABS

TRAITS: Reveals deployed enemy ground units and subsequently deployed enemy ground units; Fulfills "ELINT Collection Site" if a Refueler is revealed

The RC-135V/W Rivet Joint reconnaissance aircraft supports theater and national level consumers with near real time on-scene intelligence collection, analysis and dissemination capabilities. Its on-board sensor suite allows the mission crew to detect, identify and geolocate signals throughout the electromagnetic spectrum. The mission crew can then forward gathered information in a variety of formats to a wide range of consumers via Rivet Joint's extensive communications suite.

⌖-/1

www.afit.edu/CCR

$ 4 B-2 Spirit

Multi-Role Bomber - Air

REQ: Refueler

ATK: (1 or higher) Ground Strike

TRAITS: Stealth

The B-2 Spirit is a multi-role bomber capable of delivering both conventional and nuclear munitions. It provides the penetrating flexibility and effectiveness inherent in manned bombers. Its low-observable (LO) characteristics give it the unique ability to penetrate an enemy's most sophisticated defenses and threaten high valued and heavily defended targets. The revolutionary blending of LO technologies with high aerodynamic efficiency and large payload gives the B-2 freedom of action at high altitudes, thus increasing its range and a better field of view for the aircraft's sensors. Its unrefueled range is approximately 6,000 nautical miles (9,600 km).

⌖4/1

www.afit.edu/CCR

$ 3 B-1B Lancer

Conventional Bomber – Air

REQ: Refueler or DABS

ATK: (1 or higher) Ground Strike

(1 or higher) Anti-Ship (Surface); Both ATK actions affected by GPS jamming

Carrying the largest conventional payload of both guided and unguided weapons in the Air Force inventory, the B-1B is the backbone of America's long-range bomber force. It can rapidly deliver massive quantities of precision and non-precision weapons against any adversary, anywhere in the world, at any time. These capabilities, when combined with its substantial payload, excellent radar targeting system, long loiter time and survivability, make the B-1B a key element of any joint/composite strike force.

⌖4/2

www.afit.edu/CCR

$ 2 KC-135 Stratotanker

Support (Refueler) - Air

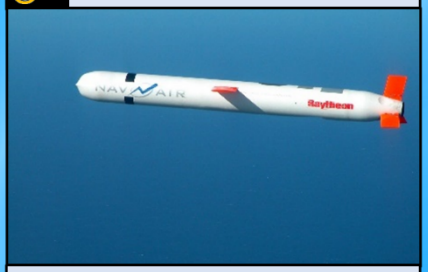
TRAITS: Provides aerial refueling to support other assets

The KC-135 Stratotanker provides the core aerial refueling capability for the USAF and has excelled in this role for more than 50 years. This unique asset enhances the AF's capability to accomplish its primary mission of global reach. It also provides aerial refueling support to Navy, Marine Corps, and allied nation aircraft. Some aircraft have been configured with the multipoint refueling system, which consists of special pods mounted on the wingtips. These KC-135s are capable of refueling two receiver aircraft at the same time.

⌖-/1

www.afit.edu/CCR

$ 1 Cruise Missile



Long Range Fires – Maritime/Ground

REQ: Cruise Missile Launcher; May be moved between launchers for free

ATK: (1 or higher) Ground;
(1 or higher) Maritime (Surface)

TRAITS: Long-Range Fires; Do not discard in any scenario; Costs 1 resource for each use; ATK Points not effected by modifiers

There are many different cruise missile models. The BGM-109 TLAM (Tomahawk Land Attack Missile) used primarily by the Navy is pictured here.

⌖3/-

www.afit.edu/CCR

$ 3 Deployable Air Base System

Airborne Command & Control - Ground

The Deployable Air Base System (DABS) allows for rapid, flexible response to threats to generate sorties and cut the time necessary to support combat operations from the air. DABS will enhance pre-positioned equipment in theater and cuts the amount of airlift you would need to bring over additional air assets.

Photo Credit: SrA Chris Willis, 86 AW/PA

⌖-/2

www.afit.edu/CCR

$ 2 IADS Command Center

IADS C2 + Early Warning Radar - Ground

TRAITS: Supports IADS shooters; Includes an Early Warning Radar system;

An Integrated Air Defense System (IADS) consists of 4 generic components: sensors, data fusion and command centers, weapons, and communications. The Command Center is the focal point where information is gathered and orders are issued by decision makers.

The U.S. Army photo by Amy Walker, PEO C3T

⌖-/2

www.afit.edu/CCR

$ 2 Surface to Air Missile (SAM)

IADS Shooter - Ground

REQ: 'Long Range Fires' capability requires an IADS Command Center

DEF: Air;
(4 or higher) Cruise Missile Defense

TRAITS: Long Range Fires; Detects stealth on DEF only; Cannot be discarded by Spoofing attack

⌖2/1

www.afit.edu/CCR

$3 MIM-104 Patriot

IADS Shooter - Ground

REQ: 'Long Range Fires' capability requires an IADS Command Center

DEF: Air;

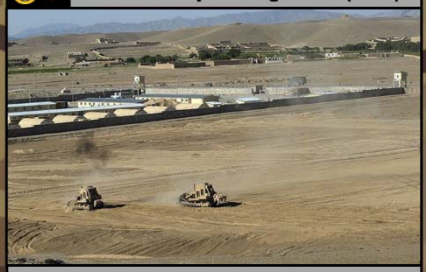
(3 or higher) Cruise Missile Defense

TRAITS: Long-Range Fires; CANNOT detect stealth on offense or defense; At the end of your turn, you MAY turn this card facedown;

2/1

www.afit.edu/CCR

$3 Forward Operating Base (FOB)



Command & Control - Ground

DEF: Ground (Cannot intercept, place at L2)

TRAITS: Provides backup for IADS Command Center

A forward operating base (FOB) is any secured forward military position, that is used to support tactical operations. The base may be used for an extended period of time. FOBs are traditionally supported by Main Operating Bases. A FOB also improves reaction time to local areas as opposed to having all troops on the main operating base. In its most basic form, a FOB consists of a ring of barbed wire around a position with a fortified entry control point, or ECP. More advanced FOBs include an assembly of earthen dams, concrete barriers, gates, watchtowers, bunkers and other force protection infrastructure.

1/4

www.afit.edu/CCR

$2 BGM-109G Gryphon TEL

Cruise Missile Launcher - Ground

REQ: Forward Operating Base

ATK: Cruise Missile Launcher – can support 4 launches (then discard)

The Ground Launched Cruise Missile (GLCM) was developed during the cold war under the Intermediate-Range Nuclear Forces (INF) Treaty. This Transportable Erector Launcher (TEL) was needed to counter the threat posed by the Soviet Union in Eastern Europe. GLCM is a generic term used for any ground-launched cruise missile. The Gryphon was taken out of service in 1991. The US withdrew from the INF Treaty on August 2nd, 2019 and development of a new ground-launched, intermediate-range cruise missile is reported to be ongoing to counter current threats.

-/1

www.afit.edu/CCR

$1 ELINT Collection Site

Electronic Support - Ground (EW)

TRAITS: Reveals enemy Electronic Warfare (EW) assets.

Electronic Intelligence, or ELINT, is information derived primarily from electronic signals that do not contain speech or text (called Communications Intelligence or COMINT). There are two branches:

1. Technical (TechELINT) describes the signal structure, characteristics, and functions.
2. Operational (OpELINT) seeks to located specific targets and determine operational patterns informing battlefield planners and commanders.

(*Electronic Intelligence at NSA* – nsa.gov)

-/2

www.afit.edu/CCR

$2 Ground-Based Jammer

Electronic Attack – Ground (EW)

REQ: ELINT Collection Site

ATK: Choose 1 option each round (your current turn and enemy's next turn):

GPS Jamming -- Both players receive a decrease of -3 to die rolls for airborne ground strikes and cruise missile attack and defense actions

Tactical Data Link (TDL) Jamming -- Enemy cannot intercept attacks against L3 cards with airborne assets; Removes F-35A's bonus

-/1

www.afit.edu/CCR

$1 Mobile Jammer

Electronic Attack – Ground (EW)

REQ: FOB or DABS;

and ELINT Collection Site

ATK: Choose 1 option for each use;

(2 or higher) **EWR Jamming** -- enemy loses 'Long-Range Fires' capability for ground based anti-air assets for 1 round

(2 or higher) **Ground Comms Jamming** -- enemy ground units receive -3 to rolls for ground ATK actions on their next turn

TRAITS: Card may be turned over during the player's turn (all jamming effects cease)

Photo Credit: Cpl. Jonathan G. Wright

-/1

www.afit.edu/CCR

$3 M1A2 Abrams Tank

Armored BCT - Ground

REQ: (ATK) FOB or DABS

ATK: (1 or higher) Ground

DEF: (1 or higher) Ground

The ABCT's role is to close with the enemy using fire and movement to destroy or capture enemy forces, to repel enemy attacks by fire, to engage in close combat, and to counterattack to control land areas. It organizes to concentrate overwhelming combat power. Mobility, protection, and firepower enable it to conduct offensive tasks with great precision and speed. The ABCT conducts offensive tasks to defeat, destroy, or neutralize the enemy and defensive tasks to defeat an enemy attack and develop favorable conditions for offensive actions. During stability, the ABCT's commitment of time, resources, and forces establish & reinforce diplomatic and military resolve to achieve a safe, secure environment and a sustainable peace.

3/3

www.afit.edu/CCR

$2 Stryker

Stryker BCT - Ground

REQ: (ATK) FOB or DABS

ATK: (1 or higher) Ground

DEF: (1 or higher) Ground

The Stryker BCT is an expeditionary combined arms force organized around mounted infantry. The units operate effectively in most conditions due to their rapid strategic deployment and mobility. Their role is to close with the enemy by means of fire and movement, to destroy or capture enemy forces, or repel enemy attacks by fire, close combat, and counterattack to control land areas, including populations and resources. The SBCT can gain the initiative early, seize and retain key terrain, any locality, or area, the seizure or retention of which affords a marked advantage to either combatant (JP 2-01.3), and conduct massed fire, fire from a number of weapons directed at a single point or small area (JP 3-02), to stop the enemy.

2/2

www.afit.edu/CCR

$1 Infantry

Infantry BCT - Ground

ATK: (1 or higher) Ground

DEF: (1 or Higher) Ground

The IBCT is an expeditionary, combined arms formation optimized for dismounted operations in complex terrain. The role of the IBCT is to close with the enemy using fire and movement to destroy or capture enemy forces, or to repel enemy attacks by fire, close combat, and counterattack. Fire and movement is the concept of applying fires from all sources to suppress, neutralize, or destroy the enemy, and the tactical movement of combat forces in relation to the enemy (as components of maneuver applicable at all echelons).

1/1

www.afit.edu/CCR

Appendix D. Game Instructions

Many iterations of the Game Instructions were created as game changes were tested and implemented. The significant game versions are provided in Section 3.2.7. Lt Col Alan Lin is the author of the first version of the The Multi-Domain Command and Control Trading Card Game (MDC2 TCG) instructions with edits and clarifications added by the author. Versions 2 and 3 of the MDC2 TCG Game Instructions were referred to by the name BSN, but the game mechanics still mapped to MDC2 TCG. The current version of the BSN Game Instructions is available at https://www.afit.edu/ccr. The major versions for each game are included below:

- MDC2 TCG Game Instructions Versions 1-3
- BSN Game Instructions Versions 1-3

Multi-Domain Command & Control Card Game (v1.1) Instructions (2019-08-21)

Principle Investigator: Major Alan Lin, Assistant Professor of Computer Science, AFIT
Editor: Lt Col Mark Reith, Director of the Center for Cyberspace Research, AFIT
Updated by Capt Nathan Flack, Student, Cyber Operations, AFIT

I. INTRODUCTION

Multi-Domain Command and Control (MDC2) Trading Card Game is a 2-player, deck-building game that features air, ground, and cyber units. The goal of the game is to defeat the opposing player by reducing the opponent's hit points (HP) to zero.

Figure 1. MDC2 Trading Card Game

II. EQUIPMENT DESCRIPTION

The basic deck is comprised of 59 cards with various unit types and capabilities. This deck may be augmented with new cards creating more options for game play. Each player must have their own deck.
Each card in the deck has some basic features as illustrated in Figure 2. These include:

- Name
- Resource Cost – the cost in number of cards for deploying this card
- Card Type
- Attack (ATK) – the type of attack
- Defense (DEF) – the type of defense
- Required Support (REQ) – the type of support required to be previous deployed in order to use this card
- Traits – provides game modifying effects
- Description – real world concept
- Attack Value – amount of damage inflicted on the enemy target (either offense of defense)
- Health Points (HP) – maximum damage the unit can receive before being removed from the playing area. Partial damage can be marked using black chips.

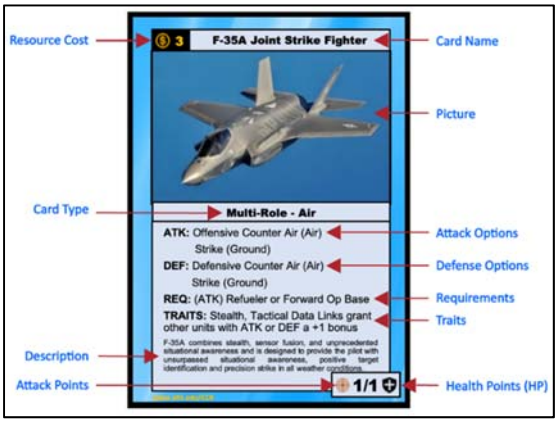


Figure 2. Card Overview

Additionally, a standard six-sided die 1D6 die is required for randomness to game play.

III. RULES

This section describes general game play. In cases where the rules on the card conflict with the rules noted here, the cards should take precedence. Each of the following game phases represents a warfare concept. Figure 3 illustrates the head-to-head layout of the cards.

A. Strategic Investment

This phase represents strategic investment decisions from senior leaders into capabilities and technologies that may influence the game's outcome. Out of the available cards, each

player chooses 40 different units and types they will bring to the conflict. This resource pile must:

- Have exactly 40 cards
- Have no more than 2 of the same card

The resource pile can mix capability types (e.g. cyber and air cards) and experimentation is encouraged. Players will be more successful if they chose complementing capabilities. Cards not selected should be stored in the box as they will not be used during game play.

Figure 3. Game Layout

Each player selectively picks 6 cards from their resource pile for their starting hand. This group of cards signifies the capabilities a commander takes with them to the initial fight. The remaining cards are shuffled and placed face down on the table. Do not mix resource piles.

This phase requires planning and forethought ahead of actual game play to create a resource pile and initial capabilities that support a specific strategy.

B. Force Deployment & Employment

Each player starts with 20 hit points (HP). This can be tracked using pen and paper. Play alternates until a player reaches 0 hit points. If both players reach 0 HP on the same turn, there are no winners (i.e. mutual destruction). Roll the die to see who will go first.

On each turn, a player follows these steps:

1. Acquire Resources

Draw 3 cards from your resource pile and place in your hand (EXCEPT on the first turn for the first player). If a player does not have enough cards in the resource pile, the player takes 1 damage for each card that cannot be drawn (simulates war weariness).

2. Take Action(s)

a. Do nothing.

b. Deploy one or more capabilities:

Take a card from your hand and place it in front of you if you can pay the cost. Most cards are deployed face-down and horizontally to show that they were deployed on this turn, as most deployed cards cannot be used the same turn they are deployed (the exception to the rule is charge cards which can be used immediately). Optionally, the card may be played face up to intentionally let the opponent know what card was deployed.

Activation: Cards can be deployed without the necessary pre-requisites (REQ), but they cannot be activated or used without meeting the pre-requisite conditions. Deployed units do not satisfy pre-requisite conditions during current turn.

Cost: For each deployed card, you must pay its resource cost by immediately discarding the same number of cards from your hand as denoted on the deployed card. For example, to deploy a card with a resource cost of 2 means the player must discard two cards to pay for the deployed card.

c. Employ Capabilities:

From your deployed capabilities, turn a card face up where it will remain revealed for the rest of the game. Follow the

instructions on the card. Attacking and defending are explained in further detail in the following section.

3. Mobilize Capabilities:

Turn all deployed cards vertically to show that they are now on the tasking order. This is primarily for units that have defensive capability so that they are usable for defense before the opposing player's turn.

4. Repair Units:

Remove damage counters from all units (if used). Any partially damaged unit is fully repaired.

5. End-of-Year (EOY) Accounting

From the cards in your hand, discard down to 8 cards. The max carryover from one turn to the next is 8 cards.

C. Home Station Readiness and Battlefield Intelligence

The resource pile represents capability investments made at home station, but not yet ready to deploy. Readiness is determined randomly by deck shuffle. Cards in hand represent those capabilities ready to deploy. The orientation of the card has a specific meaning, as illustrated in Figure 3:

Horizontal cards – newly arrived in theater, but not yet on a tasking order

Vertical cards – deployed to theater and on a tasking order

Face-up cards – adversary has identified capability. Once revealed, the card remains face-up until discard.

Face-down cards – adversary cannot discern the type of capability deployed

D. Attacking & Defending

Attacking or defending with a capability requires the card to have an ATK or DEF designation. Sometimes, the ATK or DEF will have a specifier that denotes which type of units can be attacked—this will require looking at the type of card on the target.

An employed capability is destroyed when its HP drops to zero. Partial damage only needs to be tracked during a player's turn and does not need to be tracked between player turns because step 4 of the turn order is to fully repair all damaged units.

When attacking, a mobilized capability can only attack one target (without modifiers) and the full amount of damage is applied. Some capabilities require a roll of the die and the requirement is specified on the card (i.e. must roll a 4 or higher).

Without defenses, the opposing player represents the C2 element and is a valid target (with 20 HP to start). Their C2 element can only be targeted by cards with "ATK: Ground." Excess damage (damage that decreases a card HP to less than 0) is ignored and is not applied to another target. Cards with a "—" for attack value cannot attack using attack points and "—" for HP cannot be killed by an attacker with attack points (target icon).

Priority (also known as "initiative") determines which player and capability gets to play. Higher priority dictates the order of events. All attack and defense actions will be between two cards, multiple cards cannot attack 1 card at the same time. Attack and defend priority are as follows:

1. Unrevealed (face-down) Defender
2. Attacker
3. Defender

Unrevealed (face-down) Defender. If a defender flips a card over to intercept the

attack then the attacker will be damaged or destroyed before having the chance to do any damage to the original target or the intercepting card (the element of surprise). If the attacking card survives, then it may continue to the original target. No other defensive cards may be revealed to intercept the attack.

Attacker: If an attack is not intercepted, the attacker has priority. The attack will succeed against the original target. For example, a bomber would "get through" previously revealed defenses to successfully attack a Forward Operating Base (FOB) or C2 element (opposing player). The card being attacked can always counter-attack if its DEF options match the attacking card's type.

Defender: a revealed defender cannot intercept another aircraft before it damages the target (unless it is part of the same force package), but it can damage the attacking card after the attack is complete. Also, the defending card can always apply its attack value to the attacking card if the defensive options apply. Therefore, if an F-22 attacks a (revealed) F-35 (and they can both detect stealth), then the F-22 will shoot down the F-35 (2 attack points vs 1 health point), but the F-22 will only be damaged (1 attack point vs 2 health points).

E. Advanced Rules and Concepts

Given the diversity of cards, some of the cards can be played slightly differently in the *Take Action* turn of play. Due to the limited space available on the cards, they are not necessarily explicitly outlined on the cards.

1. General Characteristics

a. Pre-positioned – Cards with a "charge" can be used on the turn it is deployed, providing all requirements are met.

b. Single use – Cards denoted as "single use" are discarded once used. It may be recovered from the discard pile if another card has that ability.

c. Stealth – Cards with stealth cannot be targeted or defended from attacking if there is no unit or ability that can detect the stealth unit. Capabilities with stealth that are performing a counter-attack cannot be targeted by the attacker unless they can detect stealth.

2. Air-Specific Characteristics

a. Force Package – Air units may be put together in a force package by stacking the cards together. The purpose of doing so is to represent the effect of fighter escort or defensive counter-air. When attacking, it forces the defender to engage the most suitable attacker. For example, an F-15 and B-52 force package attacks the opponent with (facedown) F-16 defense—the F-16 can counter only the F-15 in the force package, letting the B-52 continue onto its target. If the F-15 and B-52 attack separately, the F-16 can defend against both the F-15 and B-52 (because a defensive card can be used multiple times). Assembling or disassembling a force package can be done on the same turn. Support units (e.g. AWACS, KC-130) provide their capabilities whether they are part of force package or not.

b. Air Superiority – Units REQ this cannot be used unless there are no revealed opposing player assets that have ATK (Air). If used, they are still vulnerable to unrevealed defenders with ATK (Air), so escorts are recommended using Force Packages. Both players may have Air Superiority at the same time if the above conditions are met.

3. Ground-Specific Characteristics

a. Brigade Combat Teams (when deploying) – Cards denoted as BCT that are deployed together save logistical costs. For each additional BCT card deployed in the same turn, reduce the cost of deployment by 1. These are automatically deployed as a formed BCT (see below)

b. Brigade Combat Teams (when attacking & defending) – Cards denoted as BCT can form a combined arms group. When attacking, the BCT attacks a defender or the opposing player's C2 element with the highest damage unit. When defending, the BCT defends using the unit of the BCT player's choice. If a unit is lost within the BCT, the rest of the BCT survives.

4. Cyber-Specific Characteristics

Compromised Capabilities – For the purpose of the game, employing a cyber card requires a successful six-sided dice roll that can be modified by the attacking and defending player's cards. If successful, the card can be put into play. On failure, the failed card is discarded. This is to model an adversary detecting the cyber attack and then reconfiguring their systems.

IV. EXAMPLE SCENARIOS

This section describes some common scenarios that might be conceptually difficult during game play.

A. Air Force Packages & Engagement

As illustrated by Figure 4, this scenario describes the use of air packages and attack/defend engagement.

Figure 4. Example Air Attack/Defense Scenario

Blue has the following aircraft revealed:

1. A single F-22 Raptor
2. A force package containing a KC-135 Stratotanker and an E-3 Sentry

Red has the following aircraft:

1. A single F-22 Raptor
2. A single E-3 Sentry
3. A single RQ-4 Reaper
4. A single F-35 Joint Strike Fighter (mobilized, but not revealed)

On Blue's turn, Blue can target Red's F-22, RQ-4, or E-3. If Blue attacks the E-3, Red cannot use the F-22 to intercept because the F-22 is not packaged with either unit and it is revealed, so it has lower priority than Blue's F-22. Red's unrevealed F-35 can be used to intercept Blue's F-22 because it is higher priority.

Blue's F-22 (2/2) will shoot down Red's F-35 (1/1) but will not be able to engage another target until next turn. Had Red's F-35 survived, it would be revealed for the remainder of the game.

B. Cyber Engagement

As illustrated by Figure 5, this scenario describes the use of cyber capabilities.

Figure 5. Cyber Attack/Defense Scenario

Red has the following cyber defenses:

1. Backups
2. Anti-virus

Blue has the following cyber capabilities:

1. Rootkit
2. Ransomware

Blue must first Gain Access before she can activate her Ransomware. Typically, she would activate her Rootkit by rolling a 3 or higher, but she needs to consider Red's defenses. If Blue rolled a 3, she would need to subtract 1 due to Red's Anti-Virus. In other words, she failed to activate Rootkit unless she rolls a 4 or higher.

Now suppose Blue was successful and activated her Rootkit. Now Blue can employed her Ransomware by rolling a 2 or higher, but unfortunately she needs to consider Red's defenses. If Blue rolls a 3, she would need to subtract 2 due to Red's Backup. In other words, Blue failed to activate her Ransomware because her roll with modifiers doesn't satisfy the attack threshold. If Blue had been successful, Red must randomly discard half of his hand representing assets that were lost (round down -- if Red has 7 cards in hand, he must discard 3. However, if Red only has 1 card it must be discarded).

Modifiers are applied to the die roll, not the activation threshold.

V. STRATEGY NOTES

An air-heavy deck may use 4th generation aircraft early to provide an inexpensive offense and defense while building up to stealthier and long-range bombers that have 6 ATK on the opponents HP. Aircraft are fragile, so force packaging is critical to success.

A cyber-heavy deck primarily focuses on using cyber offensively to maintain information dominance and impair the opponent from being able to effectively execute their strategy. Some air assets may be needed to fend off kinetic attacks.

Land forces can pack a punch and be deployed inexpensively with BCTs. However, air cover will be needed in most scenarios.

VI. FREQUENTLY ASKED QUESTIONS

1. How many times can the same card attack in one turn?

   Answer: Once

2. How many times can the same (or any) card defend?

   Answer: No limit

3. Why are blank cards included in the deck?

   Answer: Blank cards are intended to provide a player with the ability to develop new capabilities for game play. Use of these new capabilities must be agreed upon by both players as they may create game imbalances.

4. How many capabilities can be deployed/employed at one time?

   Answer: You can deploy as many as you can afford based on resource cost. The resource cost indicates the number of cards you must discard (i.e. payment) to deploy this capability. You can employ as many capabilities as you currently have deployed and activated this turn.

5. Can cards be used multiple times if they are not identified as a single use card?

   Answer: Yes. Capabilities generally exist until they are destroyed (such as air and ground assets) or they are discovered (cyber assets).

6. How do you ensure that cards being placed in the theater facedown are being paid for correctly at their cost?

   Answer: While it is possible to cheat initially, at some point the asset will be revealed and the number of discarded cards can be compared to employed capabilities.

7. What are the advantages of creating/using a force package?

   Answer: Force packages provide an escort capability and give defenders more options of where to take damage.

VIII. CORRECTIONS

1. APT Cyber Exploit – ATK should read "(4 or higher) On adversary's next turn, they must randomly discard one card from their resource pile draw.
Note: A re-attack is required each turn for this to be successful. If a re-attack (re-roll) fails, then this card must be discarded.

2. Spoofing (The Man in the Middle) – This must be re-rolled on each turn for the attack to be successful. If a re-attack is unsuccessful discard Spoofing card.

3. FOB Runway is needed to meet "Forward Op Base" requirement on air assets. This means that a player must have the FOB and FOB Runway cards to support refueling operations for F-22, F-35A, B-1B, and E-3.

4. AC-130U "Spooky" Gunship – ignore ATK/DEF options. The card should have 1 Health Point instead of 0.

5. Ignore Close Air Support (CAS) on any card and do not use the A-10 Thunderbolt II or the Tactical Air Control Party (TACP) cards.

Multi-Domain Command & Control Card Game (v2.0) Instructions (2019-06-27)

I. INTRODUCTION

Battlespace Next is a 2-player, card-based deck-building game that features air, ground, space, and cyber units. The goal of the game is to defeat the opposing player by reducing the opponent's Health Points (HP) to zero. Figure 1 shows the game layout.

Figure 1. Battlespace Next: Multi-Domain Operations

II. EQUIPMENT DESCRIPTION

The basic deck is comprised of 59 cards with various unit types and capabilities. This deck may be augmented with new cards creating more options for game play. Each player must have their own deck of 59 cards. The bank cards will not be used for this activity.

Each card in the deck has some basic features as illustrated in Figure 2:

- Resource Cost: the cost in number of cards needed to deploy this card
- Card Name
- Picture
- Card Type
- Attack (ATK) Options – the type of attack
- Defense (DEF) Options – the type of defense
- Requirements (REQ) – the type of support required to be previous deployed in order to use this card
- Traits – provides game modifying effects
- Description – real world concept that inspired the card

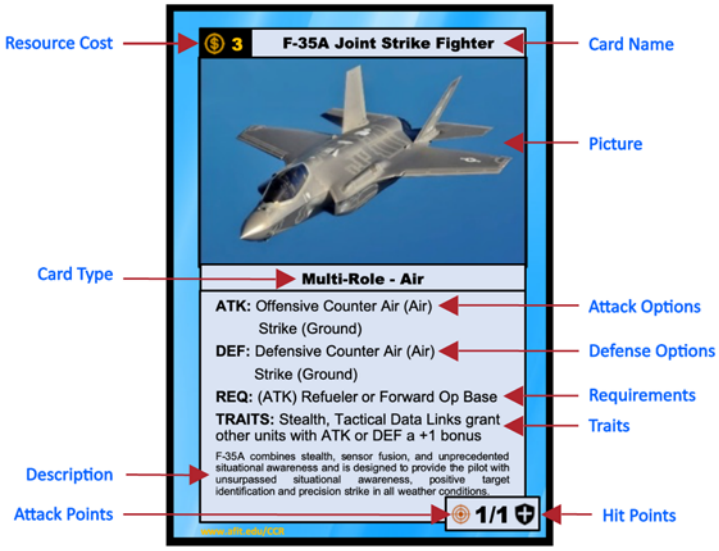


Figure 2. Card Description

- Attack Value – amount of damage inflicted on the opponent's target (either offense or defense)
- Hit Points (HP) – maximum damage the unit can receive before card is removed from playing area

Additionally, a standard six-sided di is required for randomness to game play. 

III. RULES

This section describes general game play. In cases where the rules on the card conflict with the rules noted here, the cards should take precedence. Each of the following game phases represents a warfare concept. Figure 3 illustrates the head-to-head layout of the cards.

A. Strategic Investment

This phase represents strategic investment decisions from senior leaders into capabilities and technologies that may influence the game's outcome. Out of the available cards, each player chooses 40 they will bring to the conflict. This resource pile must:

- Have exactly 40 cards
- Have no more than 2 of the same card

The resource pile can mix capability types (e.g. cyber and air cards) and experimentation is encouraged. Players will be more successful if they chose complementing capabilities. Cards not selected should be stored in the box as they will not be used during game play.

Each player *selectively* picks 6 cards from their resource pile for their starting hand. This group of cards signifies the capabilities at a commander's disposal at the beginning of a conflict. The remaining cards (34) are shuffled and placed face down on the table. Do not mix resource piles.

This phase requires planning and forethought ahead of actual game play to create a resource pile and initial capabilities that support a specific strategy.

B. Force Deployment & Employment

Each player (or Player's C2 element) starts with 20 health points (HP). This can be tracked using pen and paper. Play alternates until a player reaches zero HP. If both players reach zero HP on the same turn, there are no winners (i.e. mutually assured destruction). Roll to see who will play first (highest roll goes first).

On each turn, a player follows these 6 phases:

1. Resource Acquisition

Draw 3 cards from your resource pile and place in your hand (EXCEPT on the first turn for the first player). If a player does not have enough cards in the resource pile, the player takes 1 damage (-1 HP) for each card that cannot be drawn (simulates war weariness).

2. Deployment

Take a card from your hand and place it in front of you if you can pay the cost. Most cards are deployed face-down and horizontally to show that they were deployed on this turn, as most deployed cards cannot be used the same turn they are deployed (the exception to the rule is

"charge" cards which can be used on the same turn). Optionally, the card may be played face up (but still horizontally) to intentionally let the opponent know what card was deployed. Cards can be deployed without the necessary pre-requisites (REQ) in play.

Cost: For each deployed card, you must pay its resource cost by immediately discarding the same number of cards from your hand as denoted on the deployed card. For example, to deploy a card with a resource cost of 2 means the player must discard two cards to pay for the deployed card.

3. Execute Tasking Order

During this phase the player employs cards from their employed capabilities by turning them face up and taking the appropriate actions. This is to simulate planning and executing an MDO Tasking Order (T.O.) similar to the Air Tasking Orders (ATO) used in current operations at Air Operations Centers (AOC).

Employ cards by turning them face up OR declaring to your opponent that you are using a card that is already revealed. Cards cannot be activated without meeting the pre-requisite conditions (REQ). Deployed units do not satisfy pre-requisite conditions during current turn.

Once a card is employed it will remain face up (revealed) for the rest of the game. Follow the instructions on the card. Attacking and defending are explained in further detail in the following section.

4. Repair Units

At the end of each turn (both players) Remove damage counters from all units (if used). Any partially damaged unit is fully repaired.

5. End-of-Year (EOY) Accounting

From the cards in your hand, discard down to 8 cards. The max carryover from one turn to the next is 8 cards.

6. Employment

The last action of each player's turn is to rotate all deployed cards vertically to show that they are now employed. These cards are usable for defense during the opposing player's turn.

C. Home Station Readiness and Battlefield Intelligence

The resource pile represents capability investments made at home station, but not yet ready to deploy. Readiness is determined randomly by deck shuffle. Cards in hand represent those capabilities ready to deploy. The orientation of the card has a specific meaning, as illustrated in Figure 3:

1. Horizontal cards (Deployed) – in transport to battlefield. Cannot be used for defense or placed on the MDO Tasking Order.

2. Vertical cards (Employed) – available in theater and can be placed on the MDO Tasking Order.

3. Face-up cards (Revealed) – card has been employed or adversary has identified capability. Once revealed, the card remains face-up until discard (unless otherwise specified).

4. Face-down cards (Unrevealed) – adversary cannot discern the type of capability is deployed/employed.

Figure 3. Game Layout with Labels

D. Attacking & Defending

Attacking or defending with a capability requires the card to have an ATK (to attack) or DEF (to defend) designation. Sometimes, the ATK or DEF will have a specifier that denotes which type of units can be attacked—this will require looking at the type of card on the target.

An employed capability is destroyed when its HP drops to zero. Partial damage only needs to be tracked during a player's turn and does not need to be tracked between player turns because step 4 of the turn order is to fully repair all damaged units.

Excess damage (damage that decreases a card HP to less than 0) is ignored and is not applied to another target. Cards with a "-" for attack value cannot attack. Cards with a "-" for HP cannot be targeted by an attacker with attack points.

When attacking, an employed capability can only attack one target (without modifiers) and the full amount of damage is applied. Some capabilities require a roll of the die and the requirement is specified on the card (i.e. must roll a 4 or higher).

The cards attack points (by the target icon) are applied to the opponents card whether on offense or defense.

Attacking Opponent's HP – Without defenses (vertical cards either face-up or face-down that can intercept the attack or are not used to intercept the attack by the defender), the opposing player

represents the C2 element and is a valid target. To strike the opposing player, the attacking card must have "ATK: (Ground)." Some units (such as CAS) cannot strike the opponent's C2 element.

Counter-Attack – Cards that have the correct defensive attributes, weather revealed or unrevealed, can intercept an attack. In this case the attacker must engage the defender instead of the original target if possible (an exception may be if the defender card has stealth or a different attack qualifier [ground vs air]). This is called a counter-attack. If both attack values are greater than or equal to the defensive HP (shield icon), both cards will be removed from the game. Therefore, if an F-22 counter-attacks an attacking F-35 (and they can both detect stealth), then the F-22 will shoot down the F-35 (2 attack points vs 1 health point), but the F-22 will only be damaged (1 attack point vs 2 health points).

Note: Air assets with "ATK: (ground)" cannot counter-attack an *unrevealed* MIM-104 Patriot to simulate the Patriot shooting the plane down before detection.

E. Advanced Rules and Concepts

Given the diversity of cards, some of the cards can be played slightly differently in the *Execute Tasking Order* turn of play. Due to the limited space available on the cards, they are not necessarily explicitly outlined on the cards.

1. General Characteristics

a. **Pre-positioned** – Cards with a "charge" can be used on the turn it is deployed, providing all requirements are met.

b. **Single use** – Cards denoted as "single use" are discarded once used. It may be recovered from the discard pile if another card has that ability.

c. **Stealth** – Cards with stealth cannot be targeted or intercepted while attacking if there is no unit or ability that can detect stealth. Capabilities with stealth that are performing a counter-attack cannot be targeted by the attacker unless they can detect stealth (on offense).

d. **Force Packages or "Plays"** – Attacking units (from a single domain or multiple domains) may be combined into a force package by placing the cards together before attacking. This is called an attack "wave." The purpose of this is to represent the effect of escort, defensive counter-air, and/or simultaneous attack. When attacking, it forces the defender to engage the most suitable attacker. For example, an F-15 and B-52 force package attacks the opponent with F-16 defense—the F-16 can counter only the F-15 in the force package (attacker's choice), letting the B-52 continue onto its original target. Players must assemble any force package before attacking. Once an attack wave has begun the player cannot add cards to the wave. Support units (e.g. E-3 Sentry, KC-130) provide their capabilities whether they are part of force package or not (support units must be revealed). Air assets may also be packaged with land forces to provide fighter cover or close air support as applicable. When attacking and defending all assets in a force package can attack and defend (in the case of a counter-attack).

2. Air Specific Characteristics

a. **Air Superiority** – Units REQ this cannot be used unless there are no revealed opposing player assets that have ATK (Air). If used, they are still vulnerable to unrevealed defenders with ATK (Air), so escorts are recommended using Force Packages. Both players may have Air Superiority at the same time if the above conditions are met.

b. **Close Air Support (CAS)** – Units designated with Close Air Support (CAS) in the ATK or DEF field may intercept an attacking ground unit. If used for offense, CAS assets must be paired with the ground forces like a force package or BCT. If offensive CAS is used, the defender can employ counter-air assets to attack the CAS asset. In this case the CAS asset would be destroyed before attacker (unless it also has counter-air ATK capability). If CAS is used defensively, attackers must have packaged their Counter Air assets with the ground forces to intercept CAS assets.

Note: A-10 Thunderbolt II can attack low altitude Air Units (such as the AH-64 Apache). This is not true for AC-130U or B-52.

3. Ground-Specific Characteristics

Brigade Combat Teams – When deploying, cards denoted as BCT that are deployed together save logistical costs. For each additional BCT card deployed in the same turn, reduce the cost of deployment by 1.

4. Cyber-Specific Characteristics

Compromised Capabilities – For the purpose of the game, employing a cyber card requires a successful six-sided dice roll that can be modified by the attacking and defending player's cards. If successful, the card can be put into play. On failure, if the opponent had any capability that provided a defense against the cyber-attack, then the failed card must be discarded. This is to model an adversary detecting the cyberattack and then reconfiguring their systems. Any modifiers remain, given no specific instructions on a cyber defense/attack card.

Note: If a single player has duplicate cyber cards activated with a modifier, only one modifier can take affect at a time. For example, if one player activates two "Sniffing (Packet Analysis)" cards the "Spoofing (Man-in-the-Middle)" exploit will only receive a +2 bonus. However, if the opponent plays the "Encryption" card, only one "Sniffing" card is discarded. This only holds for cyber modifiers on offense and defense. All other modifiers can stack.

IV. EXAMPLE SCENARIOS

This section describes some common scenarios that might be conceptually difficult during game play.

A. Air Force Packages & Engagement

As illustrated by Figure 4, this scenario describes the use of air packages and attack/defend engagement.

Figure 4. Air Scenario (Blue's Turn)

Blue has the following aircraft revealed:

1. A single F-22 Raptor
2. A KC-135 Stratotanker
3. An E-3 Sentry

Red has the following aircraft:

1. A single F-22 Raptor
2. A single E-3 Sentry
3. A single RQ-4 Reaper
4. A single F-35 Joint Strike Fighter (mobilized, but not revealed)

On Blue's turn, Blue can target either Red's RQ-4 or E-3. Red can use the F-22 to F-35 to intercept. If red chooses the F-35 to counter-attack he must reveal the card. At this point Blue's F-22 (Attack 2/Defense 2) will shoot down Red's F-35 (1/1) but will not be able to engage another target until next turn. Had Red's F-35 survived, it would be revealed for the remainder of the game.

B. Cyber Engagement

As illustrated by Figure 5, this scenario describes the use of cyber capabilities.

Red has the following cyber defenses:

1. Backups
2. Anti-virus

Blue has the following cyber capabilities:

1. Rootkit
2. Ransomware

Figure 5. Cyber Attack/Defense Scenario (Blue's Turn)

Blue must first Gain Access before she can activate her Ransomware. Typically, she would activate her Rootkit by rolling a 3 or higher (2/3 chance), but since Red has Anti-virus, Blue must roll a 4 or higher (1/2 chance), thus decreasing her odds of success. Next turn, Blue could have employed his Ransomware by rolling a 2 or higher (5/6 chance), but unfortunately Red has Backup, so Blue must roll a 4 or higher (1/2 chance). If successful, Blue may randomly discard half of Red's hand representing assets that were lost (round down – if Red has 7 cards in hand, Red must discard 3).

V. STRATEGY NOTES

An air-heavy deck may use 4th generation aircraft early to provide an inexpensive offense and defense while building up to stealthier and long-range bombers that have 6 ATK on the opponents HP. Aircraft are fragile, so force packaging is critical to success.

A cyber-heavy deck primarily focuses on using cyber offensively to maintain information dominance and impair the opponent from being able to effectively execute their strategy. Some air assets may be needed to fend off kinetic attacks.

Land forces can pack a punch and be deployed inexpensively with BCTs. However, air cover will be needed in most scenarios.

VI. SCORING

In a one-on-one game, the player with HP remaining at the end of the game is the winner. If both players are reduced to zero HP on the same turn, then the game results in a draw. For this activity, players will be compared against one another using the following score chart:

Victory Points: 20 points for winning match, 0 points for a loss
Margin of victory: 1 point for each remaining HP
Losing player receives 1 point for every HP taken from opponent (round down)

Example: Player 2 wins a game and has 5 HP points remaining. Player 2 receives 20 points for winning plus 5 points for his 5 remaining HP for a total of 25 points. Player 1 receives 15 points for taking 15 HP from player 2. Table 1 shows the scoring after one game using numbers from the example above.

Player	HP Points Remaining	Total Points
Player 1	5	25
Player 2	0	15

Table 1. Game Scoring Example

VII. FREQUENTLY ASKED QUESTIONS

1. How many times can the same card attack in one turn?

   Answer: Once (unless otherwise specified – i.e. Drop Tank)

2. How many times can the same (or any) card defend?

   Answer: Cyber cards can defend multiple times per tern. Aircraft and ground forces can only be used one (unless otherwise specified). The MIM-104 Patriot can defend twice per turn. However, if it is flipped over (revealed) it is susceptible to counter-attack by air assets with "Strike (Ground)".

3. Why are blank cards included in the deck?

   Answer: Blank cards are intended to provide a player with the ability to develop new capabilities for game play. Use of these new capabilities must be agreed upon by both players as they may create game imbalances.

4. How many capabilities can be deployed/employed at one time?

   Answer: You can deploy as many as you can afford based on resource cost. The resource cost indicates the number of cards you must discard (i.e. payment) to deploy this capability. You can employ as many capabilities as you currently have deployed and activated this turn.

5. Can cards be used multiple times if they are not identified as a single use card?

   Answer: Yes. Capabilities generally exist until they are destroyed (such as air and ground assets) or they are successfully defended against (refers to cyber assets where a failed roll occurs and a defensive modifier was applied).

6. How do you ensure that cards being placed in the theater facedown are being paid for correctly at their cost?

   Answer: While it is possible to cheat initially, at some point the asset will be revealed and the number of discarded cards can be compared to employed capabilities.

7. What are the advantages of creating/using a force package or play?

   Answer: Force packages provide an escort capability and/or force defender to defend against the asset of the attacker's choices. Force packages can overwhelm enemy defenses to increase attack effectiveness.

VIII. CORRECTIONS

1. APT Cyber Exploit – ATK should read…

> "(4 or higher) On adversary's next turn, they must randomly discard one card from their resource pile draw. A re-roll is required each turn for this attack to take effect. . If a re-attack (re-roll) fails and opponent employed cyber defenses then this card must be discarded."

2. Spoofing (The Man in the Middle): add…

> "Note: A re-roll is required each turn for this attack to take effect. If a re-attack (re-roll) fails and opponent employed cyber defenses then this card must be discarded."

3. Bombers cannot attack low altitude air units (such as AH-64 Apache).

4. AC-130U "Spooky" Gunship should have 1 HP (by shield icon).

5. The following cyber cards, if employed, can be used on your turn as an "action" and not a defense. Players do not need to be attacked in order to use these cards. Other cyber defenses may apply once revealed (Anti-Virus, Encryption, etc.)

a. Knowledge Management
b. Data Analytics
c. Automated Task Management (applies to all subsequent turns once revealed)

IX. ACKNOWLEDGEMENTS

Principle Investigator: Major Alan Lin, Assistant Professor of Computer Science, AFIT
Editor: Lt Col Mark Reith, Director of the Center for Cyberspace Research, AFIT
Updated in 2019: Capt Nathan Flack, Student, AFIT

Current as of: 27 June 2019

MDC2 Trading Card Game

QUICKSTART GUIDE (Version 3)

I. INTRODUCTION

Battlespace Next is a 2-player, card-based deck-building game that features air, ground, space, cyber, maritime, Electronic Warfare (EW), and Information Operations (IO) capabilities. The goal of the game is to defeat the opposing player by destroying their Multi-Domain Operations Center (MDOC).

II. EQUIPMENT DESCRIPTION

Cards: the basic deck is comprised of 54 cards. Each player must have their own deck. Cards are divided into the following domains: Air, Cyber, Space, Ground, Maritime, and Human/Cognitive - marked as Information Operations (IO).
Damage Counters: each player needs approximately 25 black chips
Resource Chips: each player needs 5 gold chips
6-Sided Die: a six sided die is required for randomness of gameplay

The content of the cards dictate how each card interacts with the other cards on the battlefield. Each card in the deck has some basic features as illustrated in Figure 2:

- Resource Cost: the number of resources (gold chips) needed to deploy this card
- Card Name
- Picture
- Card Type
- Attack (ATK) Options – the type of attack
- Defense (DEF) Options – the type of defense
- Requirements (REQ) – the type of support required to be previous deployed in order to use this card
- Traits – details game modifying effects
- Description – real world concept that inspired the card
- Attack Value – amount of damage inflicted on the opponent's target (either offense or defense)
- Health Points (HP) – maximum damage the unit can receive before it is discarded

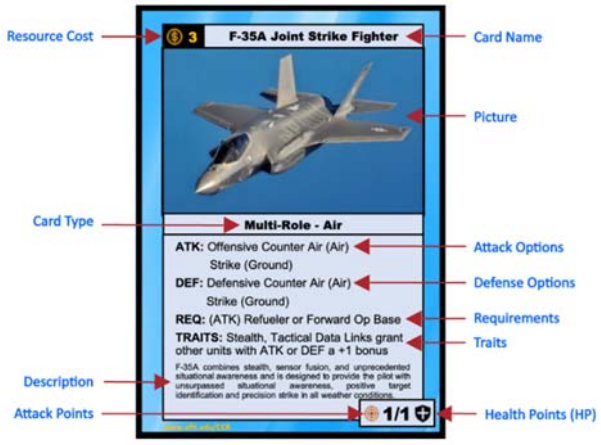


Figure 1. Card Description

III. RULES

This section describes general game play. In cases where the rules on the card conflict with the rules noted here, the cards should take precedence. Each of the following game phases represents a warfare concept.

A. Setup

Each player starts with the following cards face up in their playing area:

(1) Multi-Domain Operations Center (MDOC)
(2) Combined Space Operations Center (CSpOC)
(3) Cyber Operations Center
(4) IADS Command Post
(5) Surface to Air Missile (SAM) – may be turned face down
(6) Place one "GPS II Satellite Constellation" between both players
(7) Place one "Spectrum of Conflict" next to the GPS card

These cards represent assets already in country or supporting the campaign from location that is geographically separated from the battlefield.

B. Select Starting Hand

Each player selects 6 cards from their resource pile for their starting hand. The remaining cards (41) are shuffled and placed face down on the table (this is the starting supply pile)

C. Turn Overview

Roll the die to see who will play first (highest roll goes first). Play alternates until a player's MDOC is destroyed. On each turn, players will select six cards from their supply pile. One the first turn these cards will be hand-selected out of the available 47 cards. On following turns, the cards will be random.

On each turn, a player may take the following actions:

1. Resource Acquisition

Draw 6 cards from your supply pile and place in your hand. If a player does not have enough cards in their supply pile, they must reshuffle their discard pile and draw the remaining cards from the top. At the same time they must reduce the number of resources allocated per turn by one.

Take an additional 4 resource chips. Resource chips can carrier over from turn to turn.

2. Use Command and Control Actions (C2 Actions)

Each player will have a specific number of C2 Actions they can use each turn based on their revealed cards. Using C2 Actions simulates planning and executing a Combined Tasking Order (CTO) similar to the Air Tasking Orders (ATO) currently used in Air Operations Centers (AOC). C2 Actions do not carry over from turn to turn. Each of the following requires 1 C2 action in the appropriate domain:

A. Deploy a card

Take a card from your hand and place it in front of you. At the same time pay the number of resource chips designated by the number on the card (by the gold money symbol). All cards are deployed in the active state which means they can be used on the same turn for ATK/DEF. Cards can be deployed even without the pre-requisites.

B. Activate an inactive card

To activate a card turn it to its vertical position. If it meets the REQs then its TRAITS apply immediately and it can immediately be used for ATK/DEF.

C. Use an active card's ATK options to attack an opponent's card.

During your turn you can use the ATK options on any active card to attack an opponent's card. Attacks are always 1 card versus 1 card, but Attack Waves may be used to engage multiple cards at the same time and have more influence over their actions. You may target any revealed card, regardless if it is active or inactive. Further explanation of attack, defense, and attack waves is provided below.

3. Reveal a card

A card must be revealed to use its TRAITS or ATK/DEF options. A C2 action is *not* required to reveal a card. A card can be revealed any time during the players turn or in response to an opponent's attack. Once a card is revealed it will remain face up for the rest of the game.

4. Discard remaining cards

At the end of your turn, if you still have cards remaining in your hand they must be discarded

D. Home Station Readiness and Battlefield Intelligence

The resource pile represents capability investments made at home station, but not yet ready to deploy. Readiness is determined randomly by deck shuffle. Cards in hand represent those capabilities ready to deploy. The orientation of the card has a specific meaning, as illustrated in Figure 3:

1. Horizontal cards – inactive cards that have previously been used for ATK or DEF.
2. Vertical cards – available for ATK/DEF and TRAITS apply if all requirements are met. These cards may be placed on the CTO.

3. Face-up cards (Revealed) – card has been employed or adversary has identified capability. Once revealed, the card remains face-up until discard (unless otherwise specified).

4. Face-down cards (Unrevealed) – adversary cannot discern the type of capability is deployed/employed. These cards cannot be targeted by the enemy.

D. Attacking & Defending

Attacking or defending with a capability requires the card to have an ATK (to attack) or DEF (to defend) designation. Sometimes, the ATK or DEF will have a specifier that denotes which type of units can be attacked—this will require looking at the type of card on the target.

To initiate an attack the player currently taking their turn will declare their attack actions to their opponent. The opponent can choose to counter-attack (see below) with another active card (either revealed or unrevealed).

Counter-Attack – Cards that have the correct defensive attributes, whether revealed or unrevealed, can intercept an attack. In this case the attacker must engage the defender instead of the original target. If both attack values are greater than or equal to the card's HP (shield icon), both cards will be removed from the game. Therefore, if an F-22 counter-attacks an attacking F-35 (and both players have assets that can detect stealth), then the F-22 will shoot down the F-35 (2 attack points vs 1 health point), but the F-22 will only receive 1 damage (1 attack point vs 2 health points).

Attack Wave - Attacking units (from a single domain or multiple domains) may be combined into a force package by placing the cards together before attacking. This is called an attack wave. The purpose of this is to represent the effect of escort, defensive counter-air, and/or simultaneous attack. When attacking, it forces the defender to engage the card chosen by the attacker. For example, an F-22 and B-52 force package attacks the opponent's Multi-Domain Operations Center (MDOC) and active F-16—the attacker can choose their F-12 to attack the F-16 so that the attacker cannot use the F-16 to intercept the B-52. Players must assemble any force package before attacking. Once an attack wave has begun the player cannot add cards to the wave. Support units (e.g. E-3 Sentry, KC-130) provide their capabilities whether they are part of an attack wave or not (support units must be revealed). Air assets may also be packaged with land forces to provide fighter cover or close air support as applicable. When attacking and defending all assets in a force package can attack and defend (in the case of a counter-attack).

If the attacking player uses an attack wave, the opponent can only counter-attack with cards that are not already engaged. However, if an unengaged or unrevealed asset is available, it could be used for a counter-attack and the attacker would then have to attack the newly revealed card.

Order of Battle:

1. Attacker initiates – declares attack actions and any escorting cards
2. Defender responds – can intercept attack with 1 or more revealed or unrevealed card(s)
3. Attacker assigns escort cards – intercepts counter-attack with escort cards only
4. Resolution – Pairs of cards (1 attacker and 1 defender only) are resolved.

The attacking player can also group cards together into an attack wave and only use one of them for the main attack. The additional cards are called escorts. The escort(s) accompany the attacking card and intercept any counter-attacks. If the defender doesn't use a counter-attack then the assets cannot be given new targets.

An employed capability is destroyed when its HP drops to zero. Partial damage will be marked using the black damage chips.

Excess damage (damage that decreases a card HP to less than 0) is ignored and is not applied to another target. Cards with a "-" for attack value cannot attack. Cards with a "-" for HP cannot be targeted by an attacker with attack points.

When attacking, an employed capability can only attack one target and the full amount of damage is applied. Some capabilities require a roll of the die and the requirement is specified on the card (i.e. must roll a 4 or higher).

The cards attack points (by the target icon) are applied to the opponents card whether on offense or defense.

E. Advanced Rules and Concepts

Given the diversity of cards, some of the cards have unique features. Due to the limited space available on the cards, they are not necessarily explicitly outlined on the cards.

1. **Stealth** – Cards with stealth cannot be targeted or intercepted while attacking if there is no unit or ability that can detect stealth. Capabilities with stealth that are performing a counter-attack

cannot be targeted by the attacker unless they can detect stealth (on offense).

2. **Persistent** – Cards marked as “Persistent” do will not be turn horizontally (marked as inactive) following an ATK or DEF action.

3. **Long-Range Fires** – This trait means that the card can use ATK or DEF options against an opponent’s card being counter-attacked. This simulates a capability that can shoot from a large distance or that has a surprise capability. This usually applies to cruise missiles and surface to air missiles.

4. **Cruise Missiles** – Cruise missiles are a long-range fires capability that must be purchased for each use. The Cruise Missile card only needs to be deployed once and then can be used multiple times with different launchers. The Cruise Missile card will not be discarded even on successful or unsuccessful attacks or if the associated launcher is destroyed. It must be paired with an active “Cruise Missile Launcher” to be used. You can move the Cruise Missile card to another launcher for free when inactive. 1 resource chip plus 1 C2 action must be spent each time you activate the card. If I have an inactive cruise missile card paired with a Destroyer and you want to move it to a ground launcher (Gryphon) then I must use 1 Ground C2 action to move the missile and pay 1 resource chip to activate it. After this, it still requires 1 C2 Action (in the launchers domain) to ATK with the missile.

5. **Failed Cyber Attacks** – For the purpose of the game, employing a cyber card requires a successful six-sided die roll that can be modified by the attacking and defending player’s cards. If successful, the card can be put into play. On failure, IF the opponent had any capability that provided a defense against the cyber attack, then the failed card must be discarded. This is to model an adversary detecting the cyberattack and then reconfiguring their systems. Any modifiers remain, given no specific instructions on the card.

Basic Instructions (AKA Cheat Sheet):

6. Place the following cards in the middle:
    a. GPS II
    b. Spectrum of Conflict
7. Place these cards in your playing area face-up
    a. Multi-Domain Operations Center (MDOC)
    b. Combined Space Operations Center (CSpOC)
    c. Cyber Operations Center
    d. IADS Command Post
    e. Surface to Air Missile (SAM) – may be turned face down
8. Roll to see who goes first – highest roll wins
9. Turn overview:
    a. Gain 4 resources
    b. Draw 6 cards
    c. Deploy cards (1 C2 Action for each move)
    d. Activate cards (1 C2 Action for each move)
    e. Attack Opponent's card (1 C2 Action for each move)
    f. Last action: discard any remaining cards in hand
10. After 1 round (both players take 1 turn each) roll to increase conflict level
11. Deployed cards are always employed in the active state
12. All cards must be marked as inactive (turned horizontally) after using ATK or DEF options
    a. Unless the card is marked as "Persistent" – this means that the card is always active and provides its TRAITS or effects until discarded
    b. Inactive cards will stay that way until the player uses a C2 Action (and a resource in the case of a cruise missile) to activate it.
    c. In the inactive state, none of its traits will factor into the game, however, it can still be targeted (if revealed).
13. Order of Battle:
    a. Attacker forms attack wave and designates an enemy card to target or another attacking card to escort.
    b. Defender chooses assets to intercept (can reveal assets)
        i. Must reveal applicable cyber defenses
    c. Attacker allocates escort (if applicable)
    d. Determine results (always 1 card vs 1 card)
        i. In each pair the cards attack each other unless there is a mismatch of the DEF capabilities versus the attacking card's type.
14. Attack/Defense:
    a. Attack Points (target) go against health points (shield) for both ATK & DEF
    b. Can only attack revealed cards (active or inactive)
    c. Counter attacks are always allowed unless ATK or DEF options do not match
15. Long-Range Fires: means that card can attack or defend and the opposing cannot counter-attack.
16. Die Rolls: All modifiers are added or subtracted to the roll (not the threshold)
17. Once player runs out of supply, they shuffle discard pile which becomes their new supply pile.
    a. Reduce resources gathered per turn by 1 (from 4 to 3 unless other modifiers are in play)

GAME INSTRUCTIONS, Version 1

I. INTRODUCTION

Battlespace Next is a 2-player, card-based deck-building serious game that features air, ground, space, and cyber units. The goal of the game is to defeat the opposing player by reducing the opponent's Health Points (HP) to zero. Figure 1 shows the game layout.

II. EQUIPMENT DESCRIPTION

The basic deck is comprised of 59 cards with various unit types and capabilities. This deck may be augmented with new cards creating more options for game play. Each player must have their own deck of 59 cards. The blank cards provide a way for players to add new capabilities to their decks. See Section VII for more details.

Figure 1. Battlespace Next: Multi-Domain Operations

Each card in the deck has some basic features as illustrated in Figure 2:

- Resource Cost: the cost in number of cards needed to deploy this card
- Card Name
- Picture

- Card Type
- Attack (ATK) Options – the type of attack
- Defense (DEF) Options – the type of defense
- Requirements (REQ) – the type of support required to be previous deployed in order to use this card
- Traits – provides game modifying effects
- Description – real world concept that inspired the card
- Attack Value – amount of damage inflicted on the opponent's target (either offense or defense)
- Health Points (HP) – maximum damage the unit can receive before it is discarded

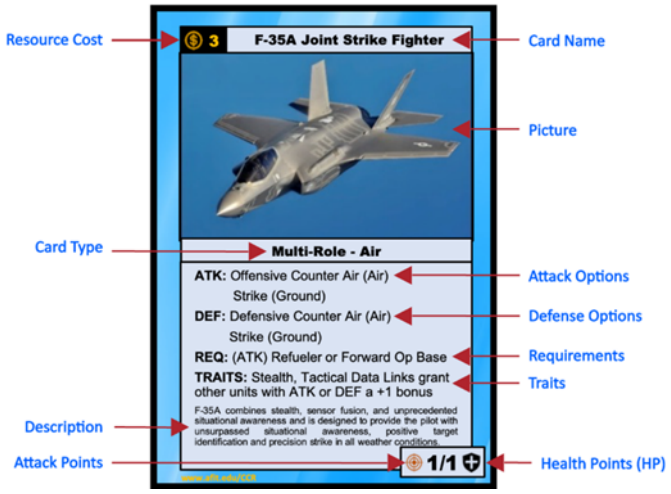


Figure 2. Card Description

Additionally, a standard six-sided die is required for randomness to game play.

III. RULES

This section describes general game play. In cases where the rules on the card conflict with the rules noted here, the cards should take precedence. Each of the following game phases represents a warfare concept. Figure 3 illustrates the head-to-head layout of the cards.

A. Strategic Investment

This phase represents strategic investment decisions from senior leaders into capabilities and technologies that may influence the game's outcome. Out of the available cards, each player chooses 40 they will bring to the conflict. This resource pile must:

- Have exactly 40 cards
- Have no more than 2 of the same card

The resource pile can mix capability types (e.g. cyber and air cards) and experimentation is encouraged. Players will be more successful if they choose complementing capabilities. Cards not selected should be stored in the box as they will not be used during game play.

Each player *selectively* picks 6 cards from their resource pile for their starting hand. This group of cards signifies the capabilities at a commander's disposal at the beginning of a conflict. The remaining cards (34) are shuffled and placed face down on the table. Do not mix resource piles.

This phase requires planning and forethought ahead of actual game play to create a resource pile and initial capabilities that support a specific strategy.

B. Force Deployment & Employment

Each player (or Player's C2 element) starts with 20 health points (HP). This can be tracked using pen and paper. Play alternates until a player reaches zero HP. If both players reach zero HP on the same turn, there are no winners (i.e. simultaneous destruction). Roll the die to see who will play first (highest roll goes first).

On each turn, a player follows these 6 phases:

1. Resource Acquisition

Draw 3 cards from your resource pile and place in your hand (EXCEPT on the first turn for the first player). If a player does not have enough cards in the resource pile, the player takes 1 damage (-1 HP) for each card that cannot be drawn (simulates war weariness).

2. Deployment

Take a card from your hand and place it in front of you if you can pay the cost. Most cards are deployed face-down and horizontally to show that they were deployed on this turn, as most deployed cards cannot be used the same turn they are deployed (the exception to the rule is "charge" cards which can be used on the same turn). Optionally, the card may be played face up (but still horizontally) to intentionally let the opponent know what card was deployed. Cards can be deployed without the necessary pre-requisites (REQ) in play.

Cost: For each deployed card, you must pay its resource cost by immediately discarding the same number of cards from your hand as denoted on the deployed card. For example, to deploy a card with a resource cost of 2 means the player must discard two cards to pay for the deployed card.

3. Execute Tasking Order

During this phase the player employs cards from their employed capabilities by turning them face up and taking the appropriate actions. This is to simulate planning and executing an MDO Tasking Order (T.O.) similar to the Air Tasking Orders (ATO) used in current operations at Air Operations Centers (AOC).

Employ cards by turning them face up OR declaring to your opponent that you are using a revealed card and then following the instructions on the card. 0If the requirements (REQ) are not met, a card may be turned face-up but its effects will not apply until the requirements are available. Deployed units do not satisfy pre-requisite conditions during the current turn.

Once a card is employed it will remain face up (revealed) for the rest of the game. Attacking and defending are explained in further detail in the following section.

4. Repair Units

At the end of each turn (both players) remove damage counters from all units (if used). Any partially damaged unit is fully repaired.

5. End-of-Year (EOY) Accounting

From the cards in your hand, discard down to 8 cards. The max carryover from one turn to the next is 8 cards.

6. Employment

The last action of each player's turn is to rotate all deployed cards vertically to show that they are now employed. These cards are usable for defense during the opposing player's turn.

C. Home Station Readiness and Battlefield Intelligence

The resource pile represents capability investments made at home station, but not yet ready to deploy. Readiness is determined randomly by deck shuffle. Cards in hand represent those capabilities ready to deploy. The orientation of the card has a specific meaning, as illustrated in Figure 3:

1. Horizontal cards (Deployed) – in transport to battlefield. Cannot be used for defense or placed on the MDO Tasking Order.

2. Vertical cards (Employed) – available in theater and can be placed on the MDO Tasking Order.

3. Face-up cards (Revealed) – card has been employed or adversary has identified capability. Once revealed, the card remains face-up until discard (unless otherwise specified).

4. Face-down cards (Unrevealed) – adversary cannot discern the type of capability is deployed/employed.

Figure 3. Game Layout with Labels

D. Attacking & Defending

Attacking or defending with a capability requires the card to have an ATK (to attack) or DEF (to defend) designation. Sometimes, the ATK or DEF will have a specifier that denotes which type of units can be attacked—this will require looking at the type of card on the target.

To initiate an attack the player in the "Execute Tasking Order" phase will assemble their attack wave and declare their attack actions to their opponent. The opponent can choose to counter-attack (see below)

with another employed card (revealed or unrevealed). If the attacking player uses more than one asset to attack, the opponent can only counter-attack with cards that are not already engaged. For example if two red fighters are attacking two blue fighters, the attacker gets to decide which planes will be matched against one another. However, if an unengaged or unrevealed asset is available, it could be used for a counter-attack and the attacker would then have to engage the new asset.

The attacking player can also group cards together into an attack wave and only use one of them for attack. This leaves the other cards in the wave to defeat

An employed capability is destroyed when its HP drops to zero. Partial damage only needs to be tracked during a player's turn and does not need to be tracked between player turns because step 4 of the turn order is to fully repair all damaged units.

Excess damage (damage that decreases a card HP to less than 0) is ignored and is not applied to another target. Cards with a "-" for attack value cannot attack. Cards with a "-" for HP cannot be targeted by an attacker with attack points.

When attacking, an employed capability can only attack one target (without modifiers) and the full amount of damage is applied. Some capabilities require a roll of the die and the requirement is specified on the card (i.e. must roll a 4 or higher).

The cards attack points (by the target icon) are applied to the opponents card whether on offense or defense.

Attacking Opponent's HP – Without defenses (vertical cards either face-up or face-down that can intercept the attack or are not used to intercept the attack by the defender), the opposing player represents the C2 element and is a valid target. To strike the opposing player, the attacking card must have "ATK: (Ground)." Some units (such as CAS) cannot strike the opponent's C2 element.

Counter-Attack – Cards that have the correct defensive attributes, whether revealed or unrevealed, can intercept an attack. In this case the attacker must engage the defender instead of the original target if possible (an exception may be if the defender card has stealth or a different attack qualifier [ground vs air]). This is called a counter-attack. If both attack values are greater than or equal to the defensive HP (shield icon), both cards will be removed from the game. Therefore, if an F-22 counter-attacks an attacking F-35 (and both players have assets that can detect stealth), then the F-22 will shoot down the F-35 (2 attack points vs 1 health point), but the F-22 will only be damaged (1 attack point vs 2 health points).

Note: Air assets with "ATK: (ground)" cannot counter-attack an *unrevealed* MIM-104 Patriot to simulate the Patriot shooting the plane down before detection.

E. Advanced Rules and Concepts

Given the diversity of cards, some of the cards can be played slightly differently in the *Execute Tasking Order* turn of play. Due to the limited space available on the cards, they are not necessarily explicitly outlined on the cards.

1. General Characteristics

a. **Pre-positioned** – Cards with a "charge" can be used on the turn it is deployed, providing all requirements are met.

b. **Single use** – Cards denoted as "single use" are discarded once used. It may be recovered from the discard pile if another card has that ability.

c. **Stealth** – Cards with stealth cannot be targeted or intercepted while attacking if there is no unit or ability that can detect stealth. Capabilities with stealth that are performing a counter-attack cannot be targeted by the attacker unless they can detect stealth (on offense).

d. **Force Packages or "Plays"** – Attacking units (from a single domain or multiple domains) may be combined into a force package by placing the cards together before attacking. This is called an attack "wave." The purpose of this is to represent the effect of escort, defensive counter-air, and/or simultaneous attack. When attacking, it forces the defender to engage the most suitable attacker. For example, an F-15 and B-52 force package attacks the opponent with F-16 defense—the F-16 can counter only the F-15 in the force package (attacker's choice), letting the B-52 continue onto its original target. Players must assemble any force package before attacking. Once an attack wave has begun the player cannot add cards to the wave. Support units (e.g. E-3 Sentry, KC-130) provide their capabilities whether they are part of force package or not (support units must be revealed). Air assets may also be packaged with land forces to provide fighter cover or close air support as applicable. When attacking and defending all assets in a force package can attack and defend (in the case of a counter-attack).

2. Air Specific Characteristics

a. **Air Superiority** – Units REQ this cannot be used unless there are no revealed opposing player assets that have ATK (Air). If used, they are still vulnerable to unrevealed defenders with ATK (Air), so escorts are recommended using Force Packages. Both players may have Air Superiority at the same time if the above conditions are met.

b. **Close Air Support (CAS)** – Units designated with Close Air Support (CAS) in the ATK or DEF field may intercept an attacking ground unit. If used for offense, CAS assets must be paired with the ground forces in an attack wave. If offensive CAS is used, the defender can employ counter-air assets to attack the CAS asset. In this case, the CAS asset would be destroyed before attacking the ground unit. The CAS asset may counter-attack if it also has Counter Air ATK capability). If CAS is used by the defense, then in order to counter-attack, the attackers must have packaged their Counter Air assets into the same attack wave with the ground forces.

3. Ground-Specific Characteristics

Brigade Combat Teams – When deploying, cards denoted as BCT that are deployed together save logistical costs. For each additional BCT card deployed in the same turn, reduce the cost of deployment by 1.

4. Cyber-Specific Characteristics

Compromised Capabilities – For the purpose of the game, employing a cyber card requires a successful six-sided die roll that can be modified by the attacking and defending player's cards. If successful, the card can be put into play. On failure, if the opponent had any capability that provided a defense against the cyber attack, then the failed card must be discarded. This is to model an adversary detecting the cyberattack and then reconfiguring their systems. Any modifiers remain, given no specific instructions on the card.

Note: If a single player has duplicate cyber cards activated with a modifier, only one modifier can take affect at a time. For example, if one player activates two "Sniffing (Packet Analysis)" cards the "Spoofing (Man-in-the-Middle)" exploit will only receive a +2 bonus. However, if the opponent plays the "Encryption" card, only one "Sniffing" card is discarded. This only holds for cyber modifiers on offense and defense. All other modifiers can stack.

IV. EXAMPLE SCENARIOS

This section describes some common scenarios that might be conceptually difficult during game play.

A. Air Force Packages & Engagement

As illustrated by Figure 4, this scenario describes the use of air packages and attack/defend engagement.

Figure 4. Air Scenario (Blue's Turn)

Blue has the following aircraft revealed:

1. A single F-22 Raptor
2. A KC-135 Stratotanker
3. An E-3 Sentry

Red has the following aircraft:

1. A single F-22 Raptor
2. A single E-3 Sentry
3. A single RQ-4 Reaper
4. A single F-35 Joint Strike Fighter (mobilized, but not revealed)

On Blue's turn, Blue can use his F-22 to target Red's RQ-4, E-3, or F-22. Red may use his F-22 or F-35 to intercept. If red chooses the F-35 to counter-attack he must reveal that card. At this point Blue's F-22 (Attack 2/Defense 2) will shoot down Red's F-35 (1/1) but will not be able to

engage another target until next turn. Had Red's F-35 survived, it would be revealed for the remainder of the game.

B. Cyber Engagement

As illustrated by Figure 5, this scenario describes the use of cyber capabilities.

Red has the following cyber defenses:

1. Backups
2. Anti-virus

Blue has the following cyber capabilities:

1. Rootkit
2. Ransomware

Figure 5. Cyber Attack/Defense Scenario (Blue's Turn)

Blue must first Gain Access before she can activate her Ransomware. Typically, she would activate her Rootkit by rolling a 3 or higher, but she needs to consider Red's defenses. If Blue rolled a 3, she would need to subtract 1 due to Red's Anti-Virus. In other words, she failed to activate Rootkit unless she rolls a 4 or higher.

Now suppose Blue was successful and activated her Rootkit. Now Blue can employed her Ransomware by rolling a 2 or higher, but unfortunately she needs to consider Red's defenses. If Blue rolls a 3, she would need to subtract 2 due to Red's Backup. In other words, Blue failed to activate her Ransomware because her roll with modifiers doesn't satisfy the attack threshold. If Blue had been successful, Red must randomly discard half of his hand representing assets that were lost (round down -- if Red has 7 cards in hand, he must discard 3).

Modifiers are applied to the die roll, not the activation threshold.

V. STRATEGY NOTES

An air-heavy deck may use 4th generation aircraft early to provide an inexpensive offense and defense while building up to stealthier and long-range bombers that have 6 attack points on the opponents HP. Aircraft are fragile, so fighter escort and force packaging are critical to success.

A cyber-heavy deck primarily focuses on using cyber offensively to maintain information dominance and impair the opponent from being able to effectively execute their strategy. Some air assets may be needed to fend off kinetic attacks.

Land forces can pack a punch and be deployed inexpensively with BCTs. However, air cover will be needed in most scenarios.

VI. SCORING

In a one-on-one game, the player with HP remaining at the end of the game is the winner. If both players are reduced to zero HP on the same turn, then the game results in a draw. For this activity, players will be compared against one another using the following score chart:

Victory Points: 20 points for winning match, 0 points for a loss
Margin of victory: 1 point for each remaining HP
Losing player receives 1 point for every HP taken from opponent (round down)

Example: Player 2 wins a game and has 5 HP points remaining. Player 2 receives 20 points for winning plus 5 points for his 5 remaining HP for a total of 25 points. Player 1 receives 15 points for taking 15 HP from player 2. Table 1 shows the scoring after one game using numbers from the example above.

Player	HP Points Remaining	Total Points
Player 1	5	25
Player 2	0	15

Table 1. Game Scoring Example

VII. FREQUENTLY ASKED QUESTIONS

1. How many times can the same card attack in one turn?

   Answer: Once (unless otherwise specified – i.e. Drop Tank)

2. How many times can the same (or any) card defend?

   Answer: Cyber cards can defend multiple times per turn. Aircraft and ground forces can only be used once (unless otherwise specified).

3. Why are blank cards included in the deck?

   Answer: Blank cards are intended to provide a player with the ability to develop new capabilities for game play. Use of these new capabilities must be agreed upon by both players as they may create game imbalances.

4. How many capabilities can be deployed/employed at one time?

   Answer: You can deploy as many as you can afford based on resource cost. The resource cost indicates the number of cards you must discard (i.e. payment) to deploy this capability. You can employ as many capabilities as you currently have deployed and activated this turn.

5. Can cards be used multiple times if they are not identified as a single use card?

   Answer: Yes. Capabilities generally exist until they are destroyed (such as air and ground assets) or they are successfully defended against (refers to cyber assets where a failed roll occurs and a defensive modifier was applied).

6. How do you ensure that cards being placed in the theater facedown are being paid for correctly at their cost?

   Answer: While it is possible to cheat initially, at some point the asset will be revealed and the number of discarded cards can be compared to employed capabilities.

7. What are the advantages of creating/using a force package or play?

   Answer: Force packages provide an escort capability and/or force defender to defend against the asset of the attacker's choices. Force packages can overwhelm enemy defenses to increase attack effectiveness.

VIII. CORRECTIONS

1. APT Cyber Exploit – ATK should read…

> "(4 or higher) On the adversary's next turn, they must randomly discard one card from their resource pile draw. A re-roll is required each turn for this attack to take effect. . If a re-attack (re-roll) fails and opponent employed cyber defenses then this card must be discarded."

2. Spoofing (The Man in the Middle): add…

> "Note: A re-roll is required each turn for this attack to take effect. If a re-attack (re-roll) fails and opponent employed cyber defenses then this card must be discarded."

3. Bombers cannot attack low altitude air units (such as AH-64 Apache).

4. AC-130U "Spooky" Gunship:

> a. Should have 1 HP (by shield icon).
> b. Should read "DEF: Close Air Support (Ground units)" instead of "Force Protection."

5. The following cyber cards, if employed, can be used on your turn as an "action" and not a defense. Players do not need to be attacked in order to use these cards. Other cyber defenses may apply once revealed (Anti-Virus, Encryption, etc.)

> a. Knowledge Management
> b. Data Analytics
> c. Automated Task Management (applies to all subsequent turns once revealed)

6. MIM-104 Patriot – Add…

> "Cannot be targeted by enemy assets when first revealed during a counter-attack. If the asset was already revealed, then it is vulnerable to counter-attack."

7. A-10 Thunderbolt II – Cost should be 1 instead of 0.

IX. ACKNOWLEDGEMENTS

Creator: Lt Col Alan Lin, Assistant Professor of Computer Science, AFIT
Editor: Dr. Mark Reith, Assistant Professor of Cyber Systems, AFIT
Updated in 2019: Capt Nathan Flack, Student, AFIT

Current as of: 30 June 2019

Battlespace Next: Multi-Domain Operations
Card Game Instructions – Version 2

I. INTRODUCTION

Battlespace Next is a 2-player, card-based deck-building game that features air, ground, space, cyber, maritime, Electronic Warfare (EW), and Information Operations (IO) capabilities. The goal of the game is to defeat the opposing player by destroying their Multi-Domain Operations Center (MDOC).

II. EQUIPMENT DESCRIPTION

Cards: the basic deck is comprised of 54 cards. Each player must have their own deck. Cards are divided into the following domains: Air, Cyber, Space, Ground, Maritime, and Human/Cognitive - marked as Information Operations (IO).

Damage Counters: each player needs approximately 25 black chips

Resource Chips: each player needs 5 gold chips

6-Sided Die: a six sided die is required for randomness of gameplay

The content of the cards dictate how each card interacts with the other cards on the battlefield. Each card in the deck has some basic features as illustrated in Figure 2:

- Resource Cost: the number of resources (gold chips) needed to deploy this card
- Card Name
- Picture
- Card Type
- Attack (ATK) Options – the type of attack
- Defense (DEF) Options – the type of defense
- Requirements (REQ) – the type of support required to be previous deployed in order to use this card
- Traits – details game modifying effects
- Description – real world concept that inspired the card
- Attack Value – amount of damage inflicted on the opponent's card (either offense or defense)
- Health Points (HP) – maximum damage the unit can receive before it is discarded

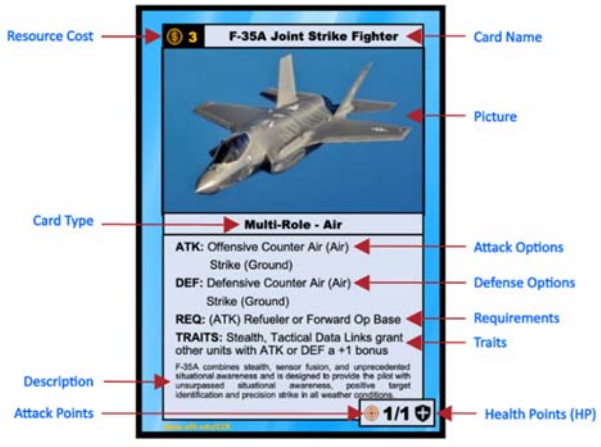


Figure 1. Card Description

III. RULES

This section describes general game play. In cases where the rules on the card conflict with the rules noted here, the cards should take precedence. Each of the following game elements represents a warfare concept.

A. Setup

Each player starts with the following cards face up in their playing area:

(1) Multi-Domain Operations Center (MDOC) – Cyber Domain
(2) Combined Space Operations Center (CSpOC) – Space Domain
(3) Cyber Operations Center – Cyber Domain
(4) IADS Command Center – Ground Domain
(5) Surface to Air Missile (SAM) – Ground Domain - may be turned face down
(6) Place one "GPS II Satellite Constellation" between both players – Space Domain
(7) Place one "Spectrum of Conflict" next to the GPS card

These cards represent assets already in country or supporting the campaign from location that is geographically separated from the battlefield. Figure 2 shows the starting capabilities for each player and a suggested layout to start the game.

Figure 2. Game Layout

B. Select Starting Hand

Each player selects 6 cards from their resource pile for their starting hand. These cards will help the player execute a specific game strategy and should be chosen carefully. The remaining cards (41) are shuffled and placed face down on the table (this is the starting supply pile).

C. Turn Overview

Roll the die to see who will play first (highest roll goes first). Play alternates until a player's MDOC is destroyed. In this game a "round" is defined as both players taking one turn. On each turn, players will draw additional cards from their supply to make a total of six cards in their hand.

Note: Each player will start the game with 6 chosen cards in their hand and 4 resource chips. In the first round neither player will draw additional cards or receive additional resources. **No cyber ATK actions may be used during the first round.**

On each turn, a player may take the following actions:

1. Resource Acquisition

A. Take an additional 4 resource chips

B. Draw cards from the supply pile until a total number of six cards in your hand is reached.

   If a player does not have enough cards in their supply pile, they must reshuffle their discard pile and draw the remaining cards from the top. At the same time they must reduce the number of resources allocated per turn by one.

   This will not apply to the first round – each player starts with six cards in their hand and four resource chips. Do not take additional cards or resources at the start of your first turn.

2. Deploy a card

Take a card from your hand and place it in front of you. At the same time pay the number of resource chips designated by the number on the card (next to the golden money symbol). All cards are deployed in the active state which means they can be used on the same turn for ATK/DEF. Cards can be deployed even if the player does not meet the requirements (REQ) listed.

3. Use Command and Control Actions (C2 Actions)

Each player will have a specific number of C2 Actions they can use each turn based on their revealed cards. Using C2 Actions simulates planning and executing a Combined Tasking Order (CTO) similar to the Air Tasking Orders (ATO) currently used in Air Operations Centers (AOC). C2 Actions do not carry over from turn to turn. The background of the cards determines the domain. Some cards may require a different domain's C2 Actions for play. This will be marked on the card. Each of the following requires 1 C2 action in the appropriate domain.

C. Use an active card's ATK options to attack an opponent's card.

   During your turn you can use the ATK options on any active card to attack an opponent's card. Attacks are always 1 card vs 1 card, but Attack Waves may be used to engage multiple cards at the same time and have more influence over enemy actions. You may target any revealed card, regardless if it is active or inactive. Further explanation of attack, defense, and attack waves is provided below.

D. Activate an inactive card

   To activate a card turn it vertically. If all requirements are met then its TRAITS apply immediately and it can immediately be used for ATK/DEF.

4. Reveal a card

A card must be revealed to use its TRAITS or ATK/DEF options. A C2 action is *not* required to reveal a card. A card can be revealed any time during the players turn or in response to an opponent's attack. Once a card is revealed it will remain face up for the rest of the game (unless otherwise specified).

5. Discard remaining cards (optional)

At the end of your turn, if you still have cards remaining in your hand they MAY be discarded. You would do this in order to pick up more (new) cards on your next turn.

D. Home Station Readiness and Battlefield Intelligence

The resource pile represents capability investments made at home station, but not yet ready to deploy. Readiness is determined randomly by deck shuffle. Cards in hand represent those capabilities ready to deploy. The orientation of the card has a specific meaning, as illustrated in Figure 3:

1. Horizontal cards – inactive cards that have previously been used for ATK or DEF. Any ATK or DEF action will cause the card to be turned to the inactive state (the only exception is cards marked "persistent")

2. Vertical cards – available for ATK/DEF and TRAITS apply if all requirements are met. These cards may be placed on the CTO. If a card's requirements are disabled or discarded, all TRAITS cease immediately. Assets previously revealed by (now) inactive ISR assets will remain revealed.

3. Face-up cards (Revealed) – card has been employed or adversary has identified the capability. Once revealed, the card remains face-up until discard (unless otherwise specified).

4. Face-down cards (Unrevealed) – adversary cannot discern the type of capability is deployed/employed. These cards cannot be targeted by the enemy, but they have no effect on the game until they are revealed. Unrevealed cards cannot meet another card's REQs.

D. Attacking & Defending

Attacking or defending with a capability requires the card to have an ATK (to attack) or DEF (to defend) designation. The ATK or DEF actions will have a specifier that denotes which type of units can be attacked. This this will require looking at the type of card on the target.

For example, Figure 3 shows a B1-B Lancer that has "Anti-Ship (Surface)" listed its ATK options. Therefore, the current attacker can use it to attack the Destroyer. The Destroyer has "DEF: Air" so it can counter attack the B-1B. The defender could also use another plane to intercept the B-1B. If no intercept is used, then the B-1B's ATK Value of 4 (⌖) will be applied to the Destroyers HP of 2 (🛡) and the Destroyers Attack Value of 2 will be applied to the B-1B's HP of 2. If no other modifiers apply, both cards will be discarded.

Figure 3. B-1B Attacking a Destroyer

Figure 4 shows how a defender could use a SAM to defend against an F-22 attack. Because the F-22 initiated the attack, the defender must look at what DEF options are present on his/her active cards. In this case, the defender had has "DEF: Air" so it can target the F-22. Because the F-22 cannot attack Ground targets ("Ground" is not listed in ATK options) the SAM site will destroy the F-22 without taking damage. Additionally, an aircraft with ATK: Ground Strike would not be able to target the SAM because of its "Long-Range Fires" trait. If the enemies IADs Command Center was destroyed or disabled due to an Electronic Warfare (EW) attack, then the SAM loses "Long-Range Fires" and a plane with "Ground Strike" could target the SAM. In this case both the aircraft and SAM would be discarded.

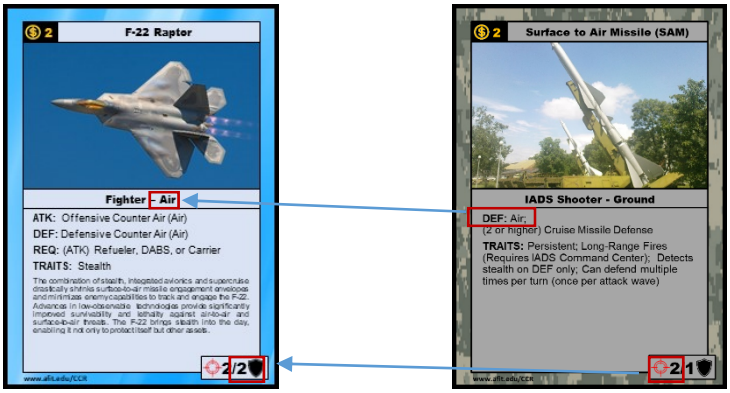


Figure 4. SAM Defending Against F-22 Attack

To initiate an attack the current player currently will declare their attack action(s) to their opponent. The opponent can choose to counter-attack (see below) with another active card (either revealed or unrevealed).

> *Counter-Attack* – Cards that have the correct defensive attributes, whether revealed or unrevealed, can intercept an attacking card.
>
> *Attack Wave* - Attacking assets (from a single domain or multiple domains) may be combined into an attack wave by placing the cards together before attacking. The purpose of this is to represent the effect of escort and/or simultaneous attack. Players must assemble an attack wave before attacking. Once an attack has started the player cannot add cards to the wave. Revealed support units (e.g. E-3 Sentry, KC-135, etc.) provide their capabilities whether they are part of an attack wave or not.

Cards with a "-" for attack value cannot attack. Cards with a "-" for HP cannot be targeted by an attacker with attack points.

Order of Battle - All ATK actions will follow these 4 steps:

> 1. *Attacker initiates* - Attacker must place the attack wave at the top of their playing area and declare either (1) an opponent's card to attack or (2) a card to escort in the attack wave. To avoid confusion, the attacker should place the escorting card(s) just behind the primary attacker.
>
> In Figure 5, Blue has created an Attack Wave with 4 cards. Two cards are escorting Primary Attacker 1 and Primary Attacker 2 has no escorts. Blue chooses the targets for each of the primary attackers.

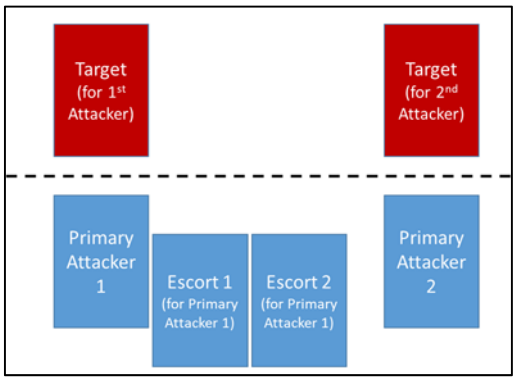


Figure 5. Order of Battle: Step 1

2. *Defender responds* - the defender may intercept the attack with up to the same number of cards as the attack wave. Remember, cards must be active to use them for defense, but you can reveal as many active cards as you would like to intercept attacker actions. The defender chooses which cards will defend against each card in the attack wave (both escorts and primary attackers). The defender cannot intercept with a card that is already engaged by another card in the attack wave.

In Figure 6, Red chooses up to 4 cards to intercept. Red cannot chose Target 1 or 2 to intercept because they are already engaged. Red decides which defensive cards will be matched to each attacker.

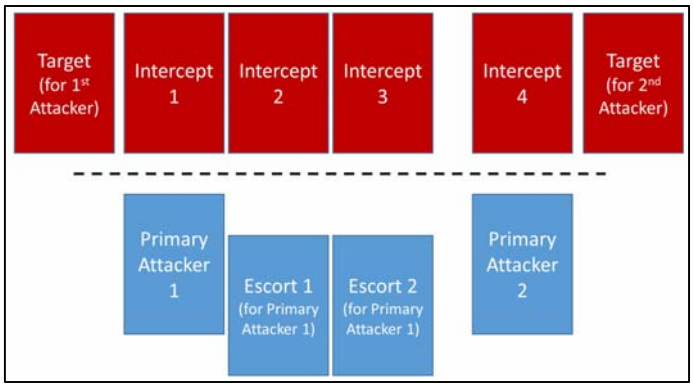


Figure 6. Order of Battle: Step 2

3. *Attacker assigns escort cards* - the attacker can now decide how to allocate the escorting card(s). If no escort was used skip this step. The escort can only choose to change places with the primary attacker. If they chose to do this, the card that was across from the primary attacker will now be paired with the escort and the card across from the escort will be paired with the primary attacker.

In Figure 7, Blue chose to engage Intercept 1 with Escort 1. All other pairings stay the same. Blue cannot change anything with Primary Attacker 2 because no escort was allocated to it.

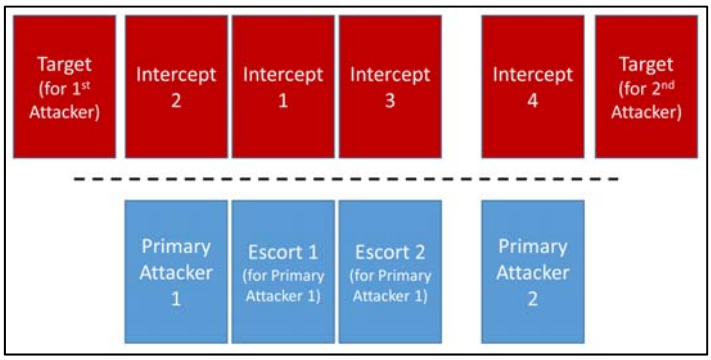


Figure 7. Order of Battle: Step 3

4. *Resolution* - At this point all opposing cards are resolved. Each resolution is only between 1 attacking and 1 defending card. If the intercept card only damages the primary attacker, then it can chose to apply its damage to the intercept OR the original target (not both). Remember, the ATK options must still match the opposing card's type in order to inflict damage.

In Figure 7 above, above each pair of cards will apply their Attack Value to the other card's HP. If Primary Attacker 1 is not destroyed by Intercept 2, then Blue can choose to apply the Attack Value to the original Target or Intercept 2. If Primary Attacker 1 is destroyed by Intercept 2, then the Attack Value will be automatically applied to Intercept 2.

Other Notes on Attack Waves:

- If the defender doesn't use a counter-attack then the assets cannot be given new targets.
- When attacking, a card can only attack one target and the full amount of damage is applied.

Damage:

- An employed capability is destroyed when its HP drops to zero. Partial damage will be tracked using the black damage chips.
- Excess damage (damage that decreases a card's HP to less than 0) is ignored and is not applied to another target.
- The cards attack points (by the target icon) are applied to the opponents card whether on offense or defense.

E. Advanced Rules and Concepts

Given the diversity of cards, some of the cards have unique features. Due to the limited space available on the cards, they are not necessarily explicitly outlined on the cards.

1. **Stealth** – Cards with stealth cannot be targeted or intercepted while attacking if there is no unit or ability that can detect stealth. Stealth cannot detect other stealth cards. Capabilities with stealth that are performing a counter-attack cannot be targeted by the attacker unless they can detect stealth (on offense).

2. **Persistent** – Cards marked as "Persistent" will not be turned horizontally (marked as inactive) following an ATK or DEF action. Defensive cards marked "Persistent" can be used for defense multiple time per turn (if in different attack waves).

3. **Long-Range Fires** – This trait means that the card can use ATK or DEF options against an opponent's card. This simulates a capability that can shoot from a large distance or that has a surprise capability. This usually applies to cruise missiles and surface to air missiles.

4. **Cruise Missiles** – Cruise missiles are a long-range fires capability that must be purchased for each use. The Cruise Missile card only needs to be deployed once and then can be used multiple times with different launchers. The Cruise Missile card will not be discarded even on successful or unsuccessful attacks or if the associated launcher is destroyed. It must be paired with an active "Cruise Missile Launcher" to be used. You can move the Cruise Missile card to another launcher for free when inactive. 1 resource chip plus 1 C2 action must be spent each time you activate the card. If an inactive cruise missile card is paired with a Destroyer and you want to move it to a ground launcher (Gryphon) you can do so for free. However, 1 resource chip and 1 C2 Action in the Ground domain is required to activate it. After this, it still requires 1 C2 Action (in the launchers domain) to ATK with the missile.

5. **Cyber Attacks** – For the purpose of the game, employing a cyber card requires a successful six-sided die roll that can be modified by the attacking and defending player's cards. All applicable cyber modifiers apply to each attack or defense action. If the roll is successful, the card can be put into play. On failure, the card will provide specific actions to take (if any). A discard may be required if the opponent used cyber defenses successfully. This is to model an adversary detecting the cyberattack and then reconfiguring their systems. Any modifiers remain, given no specific instructions on the card.

IV. EXAMPLE SCENARIOS

A. Air Attack Wave & Engagement

As illustrated by Figure 8, this scenario describes the use of air packages and attack/defend engagement.

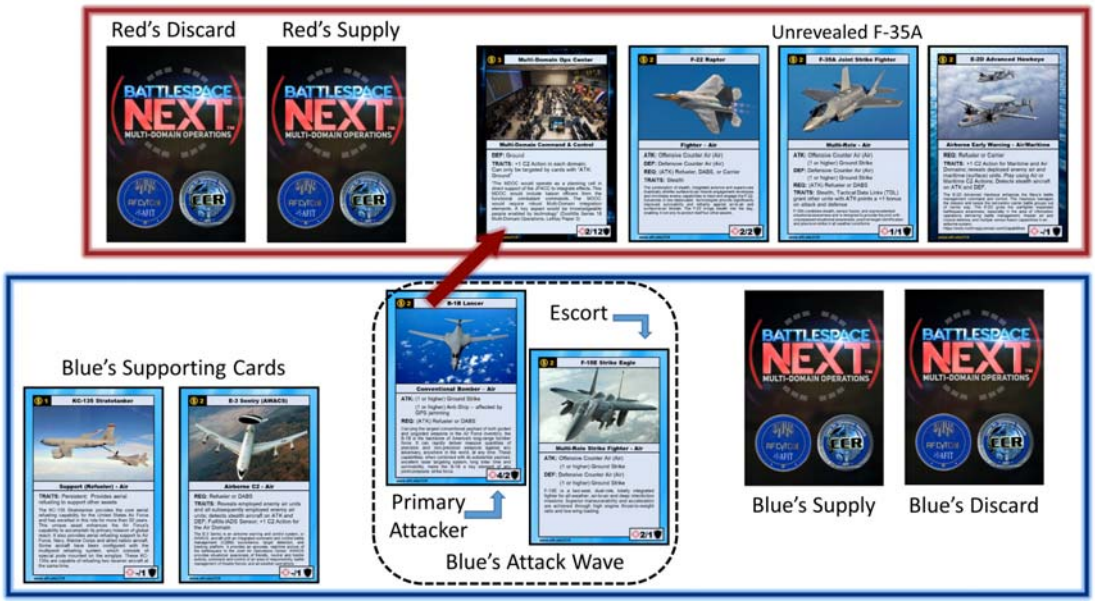


Figure 8. Air Attack/Defense Scenario (Blue's Turn)

Blue has the following assets revealed:

1. KC-135 Stratotanker
2. E-3 Sentry
3. B-1B Lancer
4. F-15E Strike Eagle

Red has the following assets:

1. F-22 Raptor
2. F-35A Joint Strike Fighter
3. E-2D Advanced Hawkeye
4. Red also has a Stratotanker or Carrier (not pictured) to use the Hawkeye's traits

On Blue's turn, Blue can use create a force package with their B-1B and F-22 if they have at least two C2 Actions. As shown above, the B-1B is the primary attacker targeting Red's MDOC and escorted by the F-15. Red may intercept with the F-22 or F-35 because they both have "DEF: Air". Red also selects a second card to defend against the escort. Red would place these cards directly across from the attack wave in the order he/she chooses. Blue could use the F-22 to intercept the B-1B and the F-35 to intercept the escort. Blue can now choose how to play the escort. If the F-16 is used to attack the F-22, then the F-35 will be moved and paired with the B-1B. All conflicts will now be resolved. Red's F-22 (which has a +1 ATK and +1 DEF) will destroy Blue's F-16 and receive 2 damage. Blue's B-1B will receive 1 damage, but will not be destroyed. Therefore, it's Attack Value (4) may be applied to Red's MDOC (add 4 black damage chips to the card). In this scenario, the F-15 will be discarded and the F-22, F-35A, and B-1B will be turned horizontally to

B. Cyber Engagement

As illustrated by Figure 9, this scenario describes the use of cyber capabilities.

Red has the following cyber defenses:

1. Backups
2. Anti-virus

Blue has the following cyber capabilities:

1. Rootkit
2. Ransomware

Figure 9. Cyber Attack/Defense Scenario (Blue's Turn)

Blue must first Gain Access before she can activate her Ransomware. Typically, she would activate her Rootkit by rolling a 3 or higher, but she needs to consider Red's defenses. If Blue rolled a 3, she would need to subtract 1 due to Red's Anti-Virus. In other words, she failed to activate Rootkit unless she rolls a 4 or higher.

Now suppose Blue was successful and activated her Rootkit. Now Blue can employed her Ransomware by rolling a 2 or higher, but unfortunately she needs to consider Red's defenses. If Blue rolls a 3, she would need to subtract 2 due to Red's Backup. In other words, Blue failed to activate her Ransomware

because her roll with modifiers doesn't satisfy the attack threshold. If Blue had been successful, Red must randomly discard half of his hand representing assets that were lost (round down -- if Red has 7 cards in hand, he must discard 3). However, if red only has 1 card it must be discarded.

Modifiers are applied to the die roll, not the activation threshold.

VI. SCORING

In a one-on-one game, the player with a surviving MDOC at the end of the game is the winner. For this activity, players will be compared against one another using the following score chart:

Victory Points: 1 point for each HP taken from opponent's MDOC
Margin of victory: 1 point for each remaining HP on MDOC

Example: Player 2 wins a game and has 5 HP points remaining on their MDOC. Player 2 receives 12 points for destroying player 1's MDOC plus 5 points for the 5 remaining HP for a total of 17 points. Player 1 receives 7 points for taking 7 HP from player 2's MDOC. Table 1 shows the scoring after one game using numbers from the example above.

VII. FREQUENTLY ASKED QUESTIONS

1. How many times can the same card attack in one turn?

    Answer: Once

2. How many times can the same (or any) card defend?

    Answer: Cards with a "Persistent" trait can defend once per attack wave and multiple times per turn (if the opponent uses multiple attack waves). All applicable cyber cards will apply for every ATK or DEF action. If a card is used for DEF and is not marked "persistent" then it must be immediately turned inactive.

4. Does it cost anything to reveal a card?

    Answer: No, you can reveal cards on your turn or to defend against an ATK (if the DEF actions apply)

5. What are the advantages of creating/using an attack wave?

    Answer: Attack waves provide an escort capability and/or force defender to defend against the asset of the attacker's choice. Force packages can overwhelm enemy defenses to increase attack effectiveness and open vulnerabilities in the enemy's defenses.

IX. ACKNOWLEDGEMENTS

Creator: Captain Nathan Flack, Student, AFIT
Principle Investigator: Dr. Mark Reith, Assistant Professor of Cyber Systems, AFIT
Based on the Multi-Domain Command and Control Trading Card Game created by Lt Col Alan Lin, Assistant Professor of Computer Science, AFIT

Special thanks to all the play testers who provided valuable feedback.

Current as of: 23 Aug 2019

Basic Instructions (AKA Cheat Sheet):

1. Place the following cards in the middle (only 1 of each per game):
    a. GPS II
    b. Spectrum of Conflict
2. Place these cards in your playing area face-up
    a. Multi-Domain Operations Center (MDOC) – Cyber Domain
    b. Combined Space Operations Center (CSpOC) – Space Domain
    c. Cyber Operations Center – Cyber Domain
    d. IADS Command Center – Ground Domain
    e. Surface to Air Missile (SAM) – Ground Domain - may be turned face down
3. Roll to see who goes first – highest roll wins
4. Turn overview:
    a. Gain 4 resources
    b. Draw additional cards until you have 6 in your hand
    c. Deploy cards – place vertically in a reveled or unrevealed state. Pay the cost. Any card can be played in the "unrevealed" state, but it will not have any effect until revealed
    d. Activate cards (1 C2 Action for each move)
    e. Attack Opponent's card (1 C2 Action for each move)
        i. No ATK actions are allowed in the first round. No kinetic ATK actions are allowed before the conflict level crosses the threshold
    f. Last action: You MAY discard 1 or all remaining cards in hand
5. Each player starts with 4 resources and 6 selected cards in their hand, therefore no additional resources will be collected and no additional cards will be drawn
6. After each round (both players take 1 turn each) roll to increase conflict level. Once the Conflict Level reaches 8 or higher, you can stop rolling
7. Deployed cards are always deployed in the active state, but player choses revealed/unrevealed
8. All cards must be marked as inactive (turned horizontally) after using ATK or DEF options
    a. The exception is for cards marked as "Persistent" – this means that the revealed card is always active until discarded
    b. Inactive cards will stay that way until the player uses a C2 Action to activate it
    c. In the inactive state, none of its traits are effects will factor into the game, however, it can still be targeted (if revealed)
9. Order of Battle:
    a. **Attacker** forms attack wave and designates an enemy target or another attacking card to escort
    b. **Defender** chooses up to the number of attacking cards to intercept the attack (she can reveal active assets for defense). All applicable cyber defenses must be revealed
    c. **Attacker** allocates escort (if applicable). This allows the attack to switch their cards to better match-up with defenders cards
    d. **Resolution** (always 1 card vs 1 card) - In each pair the cards attack each other unless there is a mismatch of the DEF capabilities versus the attacking card's type
10. Attack/Defense:
    a. Attack Points (target) go against health points (shield) for both ATK & DEF
    b. Can only attack revealed cards (active or inactive)
    c. Counter attacks are always allowed unless ATK or DEF options do not match
11. Long-Range Fires: means that card can attack or defend and the opposing cannot counter-attack. Cruise Missile can still be defended by an applicable card but no defensive counter attacks are allowed against the attacking card.
12. Die Rolls: All modifiers are added or subtracted to the roll (not the threshold)
13. Once player depletes their supply, they must shuffle discard pile which becomes their new supply pile. Reduce resources gathered per turn by 1. This applies to each time a play cycles through their supply (the first time players will only receive 3 resources at the beginning of their turn instead of 4).

Battlespace Next: Multi-Domain Operations
Card Game Instructions – Version 3

I. INTRODUCTION

Battlespace Next is a 2-4 player, card-based strategy game that features air, ground, space, cyber, maritime, Electronic Warfare (EW), and Information Operations (IO) capabilities. The goal of the game is to defeat the opposing player by destroying their Multi-Domain Operations Center (MDOC).

A comprehensive game tutorial can be accessed here:
https://www.youtube.com/watch?v=GIEq3LNekXw

A trailer promoting the game can be found here:
https://www.youtube.com/watch?v=2niX5l_MSBY

The game is available for the cost of supplies here:
https://www.printplaygames.com/product/battlespace-next/

II. EQUIPMENT DESCRIPTION

Cards: the basic deck is comprised of 54 cards. Each player must have their own deck. Cards are divided into the following domains: Air, Cyber, Space, Ground, Maritime, and Human/Cognitive - marked as Information Operations (IO). If playing in partners, each pair of players will share a deck and a strategy. The partners must work together to defeat the opposing team.

Damage Counters: each player needs approximately 25 black chips

Resource Chips: each player needs approximately 8 gold chips

6-Sided Die: a six sided die is required for randomness of gameplay

Turn Timer: a 60 second sand timer or smartphone app is optional

The content of the cards dictate how each card interacts with the other cards on the battlefield. Each card in the deck has some basic features as illustrated in Figure 2:

- Resource Cost: the number of resources (gold chips) needed to deploy this card
- Card Name
- Picture
- Card Type
- Attack (ATK) Options – the type of attack
- Defense (DEF) Options – the type of defense
- Requirements (REQ) – logistical support required to use this card
- Traits – details game modifying effects
- Description – real-world concept
- Attack Points – amount of damage inflicted on the opponent's card (either offense or defense)
- Health Points (HP) – maximum damage the unit can receive before it is discarded

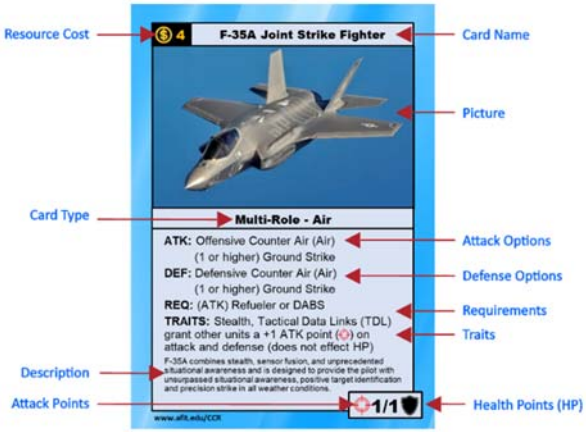


Figure 1. Card Description

III. RULES

This section describes general game play. In cases where the rules on the card conflict with the rules noted here, the cards take precedence. Each of the following game elements represents a warfare concept.

A. Setup

Each player starts with the following cards face-up in level 2 of their playing area:

(1) Multi-Domain Operations Center (MDOC) – Ground Domain
(2) Combined Space Operations Center (CSpOC) – Space Domain
(3) Cyber Operations Center – Cyber Domain
(4) IADS Command Center – Ground Domain
(5) Place one "GPS II Satellite Constellation" between both players – Space Domain
(6) Place one "Spectrum of Conflict" next to the GPS card

These cards represent assets already in country or supporting the campaign from location that is geographically separated from the battlefield. Figure 2 shows the starting capabilities for each player and a suggested layout to start the game.

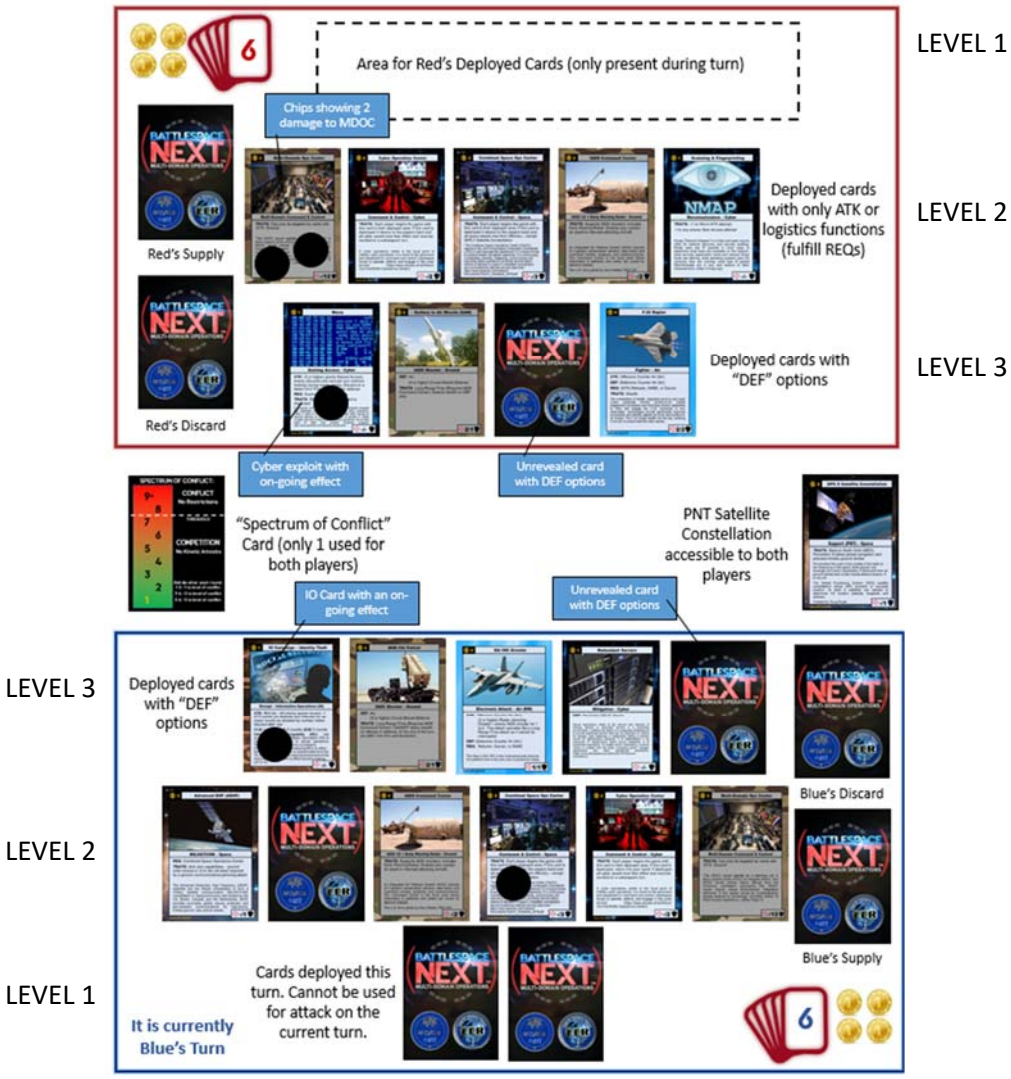


Figure 2. Game Layout and Playing Areas

As shown above, there are three key areas of the playing area. (1) Your playing area, (2) your opponent's playing area, and (3) the space between these areas for the Spectrum of Conflict and GPS cards. Each player will have a place for their supply and discard piles, their available resources, and three levels of cards. These levels signify the state of cards and clarify available actions.

Level 1 – The area closest to the player is for cards deployed on the current turn. The last action of each turn should be to take the cards from this level and place them in level 2 or 3.
Level 2 – The middle area is for previously deployed cards that do **not** have any DEF options (if space allows this level can be two cards deep).
Level 3 – The area closest to the opponent is only for cards that have DEF options.

B. Select Starting Hand

Each player selects 6 cards from their resource pile for their starting hand. These cards will help the player execute a specific game strategy and should be chosen carefully. The remaining cards (42) are shuffled and placed face-down on the table (this is the starting supply pile).

C. Turn Overview

Roll the die to see who will play first (highest roll goes first). The player who goes second starts the game with 1 additional resource chip. Therefore the player who goes first starts with 4 resource chips and the player who goes seconds starts with 5 resource chips. Play alternates until a player's MDOC is destroyed. In this game a "round" is defined as both players taking one turn. On each turn, players will draw additional cards from their supply to make a total of six cards in their hand.

Note: Each player will start the game with 6 chosen cards in their hand and 4 or 5 resource chips. In the first round neither player will draw additional cards or receive additional resources. **No ATK actions in any domain may be used during the first**

On each turn, a player may take the following actions:

1. Reset Turn Timer

2. Resource Acquisition

A. Take an additional 4 resource chips

B. Draw cards from the supply pile until a total number of six cards in your hand is reached. This step may be completed during the opponents turn to speed up gameplay. If a player does not have enough cards in their supply pile, they must reshuffle their discard pile and draw the remaining cards from the top. At the same time they must reduce the number of resources allocated per turn by two. If a player cycles through their supply pile twice they immediately lose the game (if they can't start a turn with 6 cards because their supply pile is depleted).

3. Deploy cards

Take a card from your hand and place it in front of you (in playing level 1). At the same time pay the number of resource chips designated by the number on the card (next to the golden coin icon). Deployed cards cannot be used on the current turn. Cards can be deployed even if the player does not meet the requirements (REQ) listed.

4. Attack – Reveal Cards & Use ATK Actions for Cards in Levels 2 & 3

The attack actions players take each turn simulates planning and executing a Combined Tasking Order (CTO) similar to the Air Tasking Orders (ATO) currently used in Air Operations Centers (AOC). During your turn you may turn cards face-up (revealed) and use the ATK options listed any revealed card. You may target any revealed enemy card. Each card can only use one ATK option per turn. Further explanation of attack and defense is provided below.

Traits and other effects cannot be used unless the card is revealed. Once a card is revealed it will remain face up for the rest of the game (unless otherwise specified).

5. Assign Forces – Cards in the deployed area must be moved to levels 2 or 3. These cards cannot be revealed until the player's next turn, however all cards are now available for defense.

6. Discard remaining cards (optional) – At the end of your turn, if you still have cards remaining in your hand they MAY be discarded. You would do this in order to pick up more (new) cards on your next turn.

D. Home Station Readiness and Battlefield Intelligence

The resource pile represents capability investments made at home station, but not yet ready to deploy. Readiness is determined randomly by deck shuffle. Cards in hand represent those capabilities ready to deploy. The orientation of the card has a specific meaning, as illustrated in Figure 3:

1. Face-up cards (Revealed) – card has been turned face-up by the player or adversary has identified the capability through ISR. Once revealed, the card remains face-up until discard (unless otherwise specified). These cards traits apply to the game if all requirements are met.

2. Face-down cards (Unrevealed) – adversary cannot discern the type of capability is deployed. These cards cannot be targeted by the enemy, but they have no effect on the game until they are revealed. Unrevealed cards cannot meet another card's REQs.

E. Attacking & Defending

Attacking or defending with a capability requires the card to have an ATK (to attack) or DEF (to defend) option. The ATK or DEF actions will have a specifier that denotes which type of units can be attacked. This this will require looking at the type of card on the target.

For example, Figure 3 shows a B1-B Lancer that has "Ground Strike" listed its ATK options. Therefore, the current player can use it to attack the MIM-104 Patriot. The Patriot has "DEF: Air" so it can counter attack the B-1B. If the defender has a revealed IADS Command Center or FOB, it will shoot the B-1B down before receiving any damage. If no IADS Command Center is present then the B-1B's Attack Points of 4 (⌖) will be applied to the Patriot's HP of 1 (🛡) and the Patriot's Attack Points of 2 will be applied to the B-1B's HP of 2. If no other modifiers apply, both cards will be discarded.

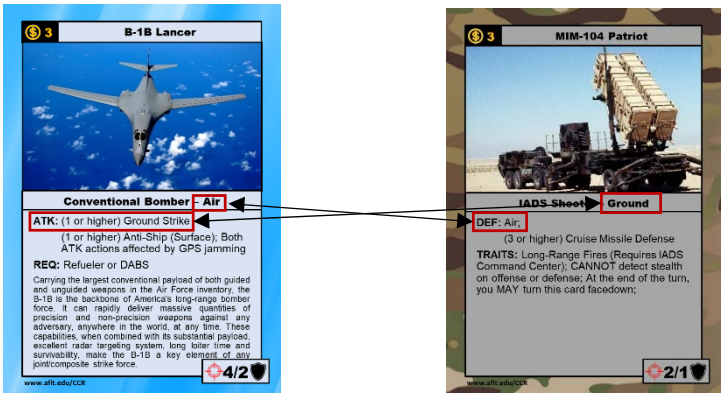


Figure 3. B-1B Attacking a Destroyer

Order of Battle - All attack actions will follow an established order.

1. *Attacker initiates* – the player currently taking their turn initiates an attack by choosing a single card to attack and declaring the target card. IF the target chosen has a DEF option that applies to the attacker, then skip immediately to the resolution phase.
2. *Defender Intercepts* - IF the target does not have applicable DEF options, the defender may intercept with one other card (she may reveal a card for interception). All applicable cyber defenses MUST be revealed once the attack is declared (before any die roll). If the target has applicable DEF options, but is disabled due to another enemy action, then NO intercept may be used.
3. *Resolution* - The players determine the outcome of the battle and roll the die as required. IF the attacker is not destroyed by the interceptor, it will continue to the original target. In this case its Attack Points (target icon) is applied to both the interceptor and the original target if the ATK options apply to both. In some cases the attacking card may damage or destroy two assets

(target and interceptor) in the same attack action. Resolve the interceptor first (1 card-vs-1 card) and the original target second (1 card-vs-1 card).

Damage:

- When attacking, a card can only attack one target and the full amount of damage is applied (the only exception is when the attacker survives an intercept action).
- A deployed capability is destroyed when its HP drops to zero. Partial damage will be tracked using the black damage chips.
- Excess damage (damage that decreases a card's HP to less than 0) is ignored and is not applied to another target.
- The cards Attack Points (by the target icon) are applied to the opponent's card whether on offense or defense.

F. Advanced Rules and Concepts

Given the diversity of cards, some of the cards have unique features. Due to the limited space available on the cards, they are not necessarily explicitly outlined on the cards.

1. **Stealth** – Cards with "stealth" in its traits cannot be targeted or intercepted while attacking if there is no unit or ability that can detect stealth. Stealth cards cannot detect other stealth cards. Capabilities with stealth that are performing an intercept cannot be targeted by the attacker unless they can detect stealth (on offense).

2. **Long-Range Fires** – This trait means that the card can use ATK or DEF options against an opponent's card without receiving damage from the target. This simulates a capability that can shoot from a large distance or that has a surprise capability. This usually applies to cruise missiles and surface-to-air missiles.

3. **Cruise Missiles** – Cruise missiles are a long-range fires capability that must be purchased for each use. The Cruise Missile card only needs to be deployed once and then can be used multiple times with different launchers. The card will not be discarded even on successful or unsuccessful attacks or if the associated launcher is destroyed. It must be paired with a "Cruise Missile Launcher" to be used. You can move the Cruise Missile card to another launcher for free, but can only be used to attack once per turn. One resource chip is required for each use. Turn the card horizontally after use until 1 resource is paid. If a cruise missile card is paired with a Destroyer and you want to move it to a ground launcher (Gryphon) you can do so for free.

4. **Cyber Attacks** – Using a cyber card requires a successful six-sided die roll that can be modified by the attacking and defending player's cards. All applicable cyber modifiers apply to each attack or defense action. If the roll is successful, the card can be put into play. On failure, the card will provide specific actions to take (if any). A discard may be required if the opponent used cyber defenses successfully. This is to model an adversary detecting the cyberattack and then reconfiguring their systems. Any modifiers remain, given no specific instructions on the card.

IV. EXAMPLE SCENARIOS

A. Air Engagement

As illustrated by Figure 8, this scenario describes the use of air assets for and attack and defense.

Blue has the following assets revealed:

1. KC-135 Stratotanker
2. E-3 Sentry
3. B-1B Lancer
4. F-15E Strike Eagle

Red has the following assets:

1. F-22 Raptor
2. F-35A Joint Strike Fighter (unrevealed)
3. E-2D Advanced Hawkeye
4. Red also has a Stratotanker or Carrier (not pictured) to use the Hawkeye's traits

Figure 4. Air Attack/Defense Scenario (Blue's Turn)

On Blue's turn, Blue can attack with the B-1B and/or the F-15. As shown above, the B-1B is chosen to attack Red's MDOC. The MDOC does not have applicable DEF options, so Red may intercept with their F-22 or F-35 because they both have "DEF: Air".

(1) If Red chose the F-35 to intercept, then Blue's B-1B would receive 1 damage and the F-35 would receive no damage because the B-1B does not have "Air" in its attack options. However, Blue's B-1B would continue to the original target and inflict 4 damage on the MDOC. 4 black chips should be placed on the MDOC and 1 on the B-1B. The B-1B would return to Blue's area, but can't be used again this turn.

(2) If Red chose the F-22 to intercept, then the B-1B would receive 2 damage and must be discarded. The F-22 can be used again for defense on the same turn. No damage would be applied to the F-22 or the MDOC.

Using this same scenario, Blue could have used the F-15 to attack any of the revealed cards. They may choose to attack Red's F-22. In this case, Blue has the ability to detect stealth aircraft on offense (E-3 Sentry) so it would inflict 2 damage on the F-22. No other assets may be used to intercept the attack since the F-22 has "DEF: Air". The F-22 will also inflict damage on the F-15. In this case, it will apply 3 damage to the F-15 because of the +1 bonus provided by the F-35.

B. Cyber Engagement

As illustrated by Figure 5, this scenario describes the use of cyber capabilities.

Red has the following cyber defenses:

1. Backups
2. Anti-virus

Blue has the following cyber capabilities:

1. Rootkit
2. Ransomware

Blue must first Gain Access before she can activate her Ransomware. Typically, she would activate her Rootkit by rolling a 3 or higher, but she needs to consider Red's defenses. If Blue rolled a 3, she would need to subtract 1 due to Red's Anti-Virus. In other words, she failed to activate Rootkit unless she rolls a 4 or higher.

Figure 5. Cyber Attack/Defense Scenario (Blue's Turn)

Now suppose Blue was successful and activated her Rootkit. Now Blue can deployed her Ransomware by rolling a 2 or higher, but unfortunately she needs to consider Red's defenses. If Blue rolls a 3, she would need to subtract 2 due to Red's Backup. In other words, Blue failed to activate her Ransomware because her roll with modifiers doesn't satisfy the attack threshold. If Blue had been successful, Red must randomly discard half of his hand (usually 3) at the beginning of his next turn, representing assets that were lost.

Modifiers are applied to the die roll, not the activation threshold.

V. FREQUENTLY ASKED QUESTIONS

1. How many times can the same card attack in one turn? Answer: Once

2. How many times can the same (or any) card defend? Answer: Multiple times per turn.

3. Does it cost anything to reveal a card? Answer: No, you can reveal cards on your turn or to defend against an attack at no cost.

4. Can stealth assets detect other stealth assets? Answer: No, to damage or destroy a stealth aircraft, the player must have a revealed asset that can detect stealth.

5. Can unrevealed cards detect stealth assets? Answer: On offense, you must reveal the card that can detect stealth in order to target stealth cards. On defense, if the player has an ability that can detect stealth it must be revealed during the intercept phase of the order of battle in order to intercept the attacking aircraft. In this case multiple cards may be revealed in response to an attack (interceptor, ISR asset, and supporting aircraft if required).

6. What if two stealth aircraft attack one another? Answer: If both players can detect stealth then they will do damage to each other. If one person cannot detect stealth then only the player that can

detect stealth will do damage. Remember, the attacker must have assets that can detect stealth on offense to target stealth aircraft or damage intercepting stealth aircraft.

7. **If a card in level 3 is disabled, but has applicable DEF options, can the player use another asset to intercept?** Answer: No, if the DEF options match, no intercept may be used. This rule holds even if the target is disabled by an EW or cyber exploit.

8. **Is "DEF: Ground Strike" a defense against ground unit attacks? For example can F-15 defend against Infantry?** Answer: Yes, but only if the attacking ground unit can be intercepted. Intercepts can only be used when the defender does not have applicable defensive options. So if a ground unit is attacking another ground unit (with "DEF: Ground") then an air asset cannot be used to intercept. However, if the attack is against a ground unit without DEF: Ground (SAM Site, Patriot, etc.) or any asset in Level 2, then the air asset can be used to intercept. Note: if the attacking ground unit is not destroyed by the air intercept, it still continues to its original target.

9. **When do "traits" activate? For example, if I deploy "ORS-1" face up in Level 1, does it immediately take affect or at end of turn when moved to Level 2?** Answer: Traits apply when (1) the card is revealed and (2) all requirements are present and revealed. A card's traits in Level 1 never apply because it is still in the deployment process. Cards in Level 2 and Level 3 can only be revealed on the next turn, instead of at the end of the current turn. However, all cards are available for defense if the opponent attacks. Therefore, traits can only take effect on the turn after the card is deployed.

10. **Does a disabled "SAM" still detect stealth?** Answer: No, a disabled card will always lose its traits. Also, if a disabled card is attacked the intercept rules still apply. Therefore, if an air asset attacks a disabled SAM Site, you cannot intercept with another asset since the SAM Site has "ATK: Air." This is to model that a jamming or other disabling effect may not be detected by the opponent (even though the player knows they are being jammed or disabled in the game).

11. **Does the Destroyer require a Carrier to perform a Cruise Missile Attack?** Answer: Yes

12. **Does launching "Cruise Missile" consume the launcher's attack for the turn?** Answer: Yes, only one attack action per card may be used on each turn. This forces a player to choose which option they will use.

13. **How long does "Gain Access" last? Specifically if "Rootkit" is lost, do I lose "Gain Access"?** Answer: Gain Access lasts indefinitely unless the opponent takes action to successfully remove it. If the Rootkit is removed or your cyber operations center is destroyed, you will lose Gain Access (unless you have another card that was also giving you gained access (such as a worm).

14. **When does the player discard a card when "Worm" is successful? In other words, do they only have 5 cards for that turn?** Answer: If the worm is successful, the opponent must discard from 6 down to 5 after the resource acquisition phase of their next turn and every subsequent turn. This is a double hit, the opponent must discard a card each turn while also working from a smaller hand each turn (5 instead of 6). Once the worm is successful, it does not need to be rolled again (unless removed by the Firewall card).

15. **Which cards are "satellites"? Specifically what can "ASAT" hit?** Answer: Only the AEHF Constellation, ORS-1, and GPS II Constellation are considered satellites. The ASAT can only hit these three assets.

16. What kinds of attacks can hit the "Cyber Operations Center" and "Combine Space Ops Center"?
Answer: Only “ATK: Ground” attacks can damage these assets.

17. If "Cyber Operations Center" is destroyed, can the owner reuse cyber attacks without replaying the "Cyber Operations Center"? Answer: No, the Cyber Operations Center must be deployed and paid for again for the cyber capabilities to take effect. It requires two turn for this to happen as the first turn the player would purchase and deploy the card and then turn it over on the second turn during the “Attack” phase. All cyber cards should have “Cyber Operations Center” as a requirement. However, to avoid adding this to all the cards, instructions were added to the Cyber Ops Center card. These instructions should also include that the cyber operations center must be re-deployed to use cyber assets again.

VI. ACKNOWLEDGEMENTS

Creator: Captain Nathan Flack, Student, AFIT
Principle Investigator: Dr. Mark Reith, Assistant Professor of Cyber Systems, AFIT
Based on the *Multi-Domain Command and Control Trading Card Game* created by Lt Col Alan Lin, Assistant Professor of Computer Science, AFIT

Special thanks to all the play testers who provided valuable feedback. Special thanks goes to Doug Ruyle, Brad French, Jake Orner, Zach Conger, Kyle Morse, Albert Taglieri, Christopher Voltz, Andrej Lysak, Vincent Bownes, and Connor Paw for their input.

Current as of: 23 December 2019

Game Instructions Summary:

1. Place the following cards in the middle (only 1 of each per game):
    a. GPS II
    b. Spectrum of Conflict
2. Place these cards in your playing area face-up (level 2)
    a. Multi-Domain Operations Center (MDOC) – Ground Domain
    b. Combined Space Operations Center (CSpOC) – Space Domain
    c. Cyber Operations Center – Cyber Domain
    d. IADS Command Center – Ground Domain
3. Roll to see who goes first – highest roll wins (2nd player receives 1 additional resource chip on first turn)
4. Turn overview:
    a. Reset turn timer
    b. Gain 4 resources
    c. Draw additional cards until you have 6 in your hand
    d. Deploy cards – pay the cost and place on the table nearest to you (level 1) in an unrevealed state. These cards cannot be used for the remainder of this turn.
    e. Attack opponent's cards with previously deployed cards
        i. Note: No kinetic ATK actions are allowed before the conflict level crosses the threshold
    f. Move any deployed cards from level 1 to levels 2 or 3 (depending on DEF options). These cards will remain in the unrevealed state. They are available for defense on your opponents turn. However, the traits will not apply until the card is revealed on your next turn (during the "Attack" phase)
    g. You MAY discard some or all remaining cards in your hand
5. Each player starts with 4 resources and 6 selected cards in their hand, therefore no additional resources will be collected and no additional cards will be drawn on the first turn. The player who goes second will receive 5 resource chips on their first turn (1 additional resource chip)
6. After each round (both players take 1 turn each) roll to increase Conflict Level. Once the Conflict Level reaches 8 or higher, you can stop rolling
7. Order of Battle:
    a. **Attacker** chooses 1 card to attack and chooses a revealed enemy card as the target
    b. **Defender Intercepts -** IF the target does not have applicable DEF options, the defender may intercept with another card (she can reveal cards for interception). All applicable cyber defenses MUST be revealed before the die roll. If a card with applicable DEF options is disabled, no intercept may be used
    c. **Resolution** - The players determine the outcome of the battle. IF the attacker is not destroyed, it will continue to the original target. In this case its Attack Points (target icon) is applied to both the interceptor and the original target (if the ATK options apply)
8. Attack/Defense:
    a. To attack, your card's ATK options must match the target card's type. To defend or intercept, the DEF options must match the attacking card's type
    b. Attack Points (target) go against Health Points (shield) for both ATK & DEF
    c. Attacker can only attack revealed cards
    d. Both cards will take damage unless "Long Range Fires" or another element is present (stealth, domain mismatch, disabled card, etc.)
9. Long-Range Fires: means a card can attack or defend and the opposing card cannot do damage back. Cruise Missiles can still be defended against if an asset possess "Cruise Missile Defense" but cannot damage the launcher
10. Die Rolls: All modifiers are added or subtracted to the roll (not the threshold)
11. Once player depletes their supply, they must shuffle the discard pile which becomes their new supply pile. Reduce resources gathered per turn by 2. If player depletes their supply pile twice, they automatically lose the game. For example, the first time a player cycles through their supply, they will only receive two resources at the beginning of each turn instead of four

Appendix E. Pilot Study Surveys

The two documents shown below are the participant surveys used for Pilots A and B. The first two pages were drafted by Dr. Mark Reith and the author for use in Cyber Warfare and Security (CSCE 525) in October 2018. The next two pages show an updated version, adapted from the first, to gather more targeted participant feedback.

MDC2 Pre-Game Survey Questions

Please rate the following statements on scale of 1-5 as described below.

1 – Strongly Disagree	2 – Disagree	3 – Neither Agree or Disagree	4 – Agree	5 – Strongly Agree

Pre-Game Questions:	**Rating:**
1. I can satisfactorily explain the concept of Multi-Domain Operations to others (government or civilian personnel).	
2. I can give specific examples of how cyber is both a supported and supporting capability.	
3. I can satisfactorily explain how Multi-Domain Operations differ from Joint Operations to others (government or civilian personnel).	
4. I enjoy learning through games and believe they can be a useful teaching aid.	
5. I can satisfactorily explain concepts such as deploy, employ, ISR (intel, surveillance, reconnaissance) and supply from a military/warfighting context.	
6. I can satisfactorily explain the various offense and defense capabilities of air, space, ground and cyber.	
7. I can satisfactorily explain how air, ground, space and cyber capabilities can be blended to create more potent effects.	

Please answer the following questions with a “Yes” or “No”.

Pre-Game Questions:	**Yes/No:**
8. Have you played this MDC2 Card Game before?	
9. Have you played other deck-building games before (Magic the Gathering, Ascension, Dominion, Star Realms, etc.)?	
10. Have you deployed to a Joint environment before?	
11. Have you ever served in an Operations Center or within the Command & Control field?	
12. Have you ever served as a Cyber Offensive/Defensive Operator?	

MDC2 Post-Game Survey Questions

Please rate the following statements on scale of 1-5 as described below.

1 – Strongly Disagree	2 – Disagree	3 – Neither Agree or Disagree	4 – Agree	5 – Strongly Agree

Post-Game Questions:	**Rating:**
1. I can satisfactorily explain the concept of Multi-Domain Operations to others (government or civilian personnel).	
2. I can give specific examples of how cyber is both a supported and supporting capability.	
3. I can satisfactorily explain how Multi-Domain Operations differ from Joint Operations to others (government or civilian personnel).	
4. I enjoy learning through this particular game and believe it is a useful teaching aid.	
5. I can satisfactorily explain concepts such as deploy, employ, ISR (intel, surveillance, reconnaissance) and supply from a military/warfighting context.	
6. The game was easy to learn how to play.	
7. I can satisfactorily explain the various offense and defense capabilities of air, space, ground and cyber through this game.	
8. I can satisfactorily explain how air, ground, space and cyber capabilities can be blended to create more potent effects.	

Please answer the following open-ended and multiple choice questions.

Post-Game Questions:
9. How could this game be improved?
10. Would you recommend this game to others? Why or why not?
11. This game was_____ (circle one answer below to fill in the blank): a. More fun than educational b. Balanced fun and education c. More educational

MDC2 Pre-Game Survey Questions

Please rate the following statements on scale of 1-5 as described below.

1 – Strongly Disagree	2 – Disagree	3 – Neither Agree or Disagree	4 – Agree	5 – Strongly Agree

Pre-Game Questions:	**Rating:**
1. I can explain the concept of Multi-Domain Operations.	
2. I can give examples of how cyber is a supported and supporting capability.	
3. I can explain how Multi-Domain Operations differ from Joint Operations.	
4. I enjoy learning through games and believe they can be useful teaching tools.	
5. I can explain concepts such as deploy, employ, ISR (intelligence, surveillance, reconnaissance) and supply in a military context.	
6. I can explain various offensive and defensive capabilities of land, sea, air, space, and cyber forces.	
7. I can explain how air, land, sea, space and cyber capabilities can be blended to create more potent effects.	

Please answer the following questions with a “Yes” or “No”.

Pre-Game Questions:	**Yes/No:**
8. Have you played this MDC2 Card Game before?	
9. Have you played other deck-building games before (Magic the Gathering, Ascension, Dominion, Star Realms, etc.)?	
10. Have you worked in a Joint environment before?	
11. Have you worked in an Operations Center or within the Command & Control field?	
12. Have you worked as a Cyber Operator?	
13. List the functional areas in which you have worked in the military. Please use plain descriptions (for example, “Cyber Operations” instead of “1B4”).	
14. Have you played other serious games or educational games in a military environment? If so, what were the games and where did you play them?	

MDC2 Post-Game Survey Questions

Please rate the following statements on scale of 1-5 as described below.

1 – Strongly Disagree	2 – Disagree	3 – Neither Agree or Disagree	4 – Agree	5 – Strongly Agree

Post-Game Questions:	**Rating:**
1. I can explain the concept of Multi-Domain Operations.	
2. I can give examples of how cyber is a supported and supporting capability.	
3. I can explain how Multi-Domain Operations differ from Joint Operations.	
4. I enjoyed learning through this particular game and believe it is a useful learning tool.	
5. I can explain concepts such as deploy, employ, ISR (intelligence, surveillance, reconnaissance) and supply in a military context.	
6. It was easy to learn how to play the game.	
7. The game improved my understanding of Multi-Domain Command & Control.	
8. I can explain how air, land, sea, space and cyber capabilities can be blended to create more potent effects.	
9. The game was fun.	
10. The game was educational.	
11. I would play this game again if given time to play at work.	
12. I would play this game again in my free time while at work.	
13. I would play this game again in my free time while at home.	

Please answer the following open-ended and multiple choice questions.

Post-Game Questions:
14. How could this game be improved?
15. Would you recommend this game to others (unit leadership, co-workers, peers, friends, work-center, etc.)? Why or why not?
16. What did you learn from the game?

Appendix F. Pre-Surveys

Following the Pilot Study, an electronic pre-survey was created to collect participant demographic data, game habits, and views on the use of educational games in military education and training. The survey was hosted in Limesurvey and participants accessed the survey using a link provided in an email. The emails had an embedded link that automatically assigned their response to their random token. The first version of the pre-survey was edited to include academic major prior to the Advanced Cyber Education (ACE) experiment, however, no other significant changes were made. The final version, provided below, was exported from Limesurey as a PDF document, however, participants actually completed an active version with drop down menus for some responses, such as age and military experience, for example.

MDO Integration: Pre-Survey

This pre-survey is for all participents of the "MDO Education and Training Integration Project"

This is the first survey that all participants should complete.

Welcome! Thank you for your participation in this research project. Your responses are highly valued.

Do not enter any classified or FOUO information into this survey. Thank you.

Let's get started!

There are 28 questions in this survey.

Demographics

In which branch (or branches) of the US military have you served?

❗ Check all that apply
Please choose **all** that apply:

- [ ] Army
- [ ] Marine Corps
- [ ] Navy
- [ ] Air Force
- [ ] Coast Guard
- [ ] None

Civilians or contracters list the branch or branches of the military with which you are or have been most closely associated.

What is your military status?

❗ Check all that apply
Please choose **all** that apply:

- [ ] Active Duty
- [ ] Retiree
- [ ] National Guard
- [ ] Reservist
- [ ] DoD Civilian
- [ ] Contractor
- [ ] Cadet

What is your rank/grade?

Please write your answer here:

What is your age?

❗ Choose one of the following answers
Please choose **only one** of the following:

- ◯ 18
- ◯ 19
- ◯ 20
- ◯ 21
- ◯ 22
- ◯ 23
- ◯ 24
- ◯ 25
- ◯ 26
- ◯ 27
- ◯ 28
- ◯ 29
- ◯ 30
- ◯ 31
- ◯ 32
- ◯ 33
- ◯ 34
- ◯ 35
- ◯ 36
- ◯ 37
- ◯ 38
- ◯ 39
- ◯ 40
- ◯ 41
- ◯ 42
- ◯ 43
- ◯ 44
- ◯ 45
- ◯ 46
- ◯ 47
- ◯ 48
- ◯ 49
- ◯ 50
- ◯ 51
- ◯ 52
- ◯ 53
- ◯ 54
- ◯ 55

- ◯ 56
- ◯ 57
- ◯ 58
- ◯ 59
- ◯ 60
- ◯ 61
- ◯ 62
- ◯ 63
- ◯ 64
- ◯ 65
- ◯ 66
- ◯ 67
- ◯ 68
- ◯ 69
- ◯ 70
- ◯ 71
- ◯ 72
- ◯ 73
- ◯ 74
- ◯ 75
- ◯ 76
- ◯ 77
- ◯ 78
- ◯ 79
- ◯ 80
- ◯ 81
- ◯ 82
- ◯ 83
- ◯ 84
- ◯ 85
- ◯ 86
- ◯ 87
- ◯ 88
- ◯ 89
- ◯ 90
- ◯ 91
- ◯ 92
- ◯ 93
- ◯ 94
- ◯ 95
- ◯ 96
- ◯ 97

◯ 98

◯ 99

◯ Prefer not to respond

What is your gender?

❗ Choose one of the following answers
Please choose **only one** of the following:

◯ Female

◯ Male

◯ Prefer not to respond

Operational Experience

What is your current career field, functional area, or academic major?

Please write your answer here:

List a generic area, AFSC, MOS, or other specifier.

How many years of experience do you have in this field?

❗ Choose one of the following answers
Please choose **only one** of the following:

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20
- ◯ 21
- ◯ 22
- ◯ 23
- ◯ 24
- ◯ 25

How many total years of military/government experience do you have?

Choose one of the following answers
Please choose **only one** of the following:

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20
- ◯ 21
- ◯ 22
- ◯ 23
- ◯ 24
- ◯ 25
- ◯ 26
- ◯ 27
- ◯ 28
- ◯ 29
- ◯ 30
- ◯ 31
- ◯ 32
- ◯ 33
- ◯ 34
- ◯ 35
- ◯ 36
- ◯ 37

◯ 38
◯ 39
◯ 40

Select number of years experience in all fields/areas combined. Include active duty and other service. Include time exployed by a contractor if closely associated with a military mission.

Have you worked in the cyber operations, electronic warfare, or information operations fields?

Please choose **only one** of the following:

◯ Yes
◯ No

Briefly describe position and years of experience.

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '9 [CyberExp]' (Have you worked in the cyber operations, electronic warfare, or information operations fields?)

Please write your answer here:

Have you worked in the Information Technology (IT) field?

Please choose **only one** of the following:

◯ Yes
◯ No

Briefly describe position and years of experience.

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '11 [ITField]' (Have you worked in the Information Technology (IT) field?)

Please write your answer here:

Have you worked in a joint environment?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

Briefly describe position and years of experience.

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '13 [Joint]' (Have you worked in a joint environment?)

Please write your answer here:

Multi-Domain Operations Experience

Rank your expertise in the following 6 domains. Place the domain in which you have the most expertise at the top. If you have additional comments or if two domains are tied, please provide comments below.

❗ All your answers must be different and you must rank in order.
❗ Please select at most 6 answers
Please number each box in order of preference from 1 to 6

- [ ] Air
- [ ] Cognitive or Human
- [ ] Cyber
- [ ] Land
- [ ] Sea
- [ ] Space

The human domain is also referred to as the cognitive or social domain. It refers to the human-related aspects of war distinct from the physical and virtual aspects.

(Optional) If desired, provide comments about your rankings above.

Please write your answer here:

Answer the following questions on the 5-point scale below:

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I am an expert in Multi-Domain Operations.	◯	◯	◯	◯	◯
I want to learn about Multi-Domain Operations.	◯	◯	◯	◯	◯
Learning about Multi-Domain Operations will increase my effectiveness in my current position.	◯	◯	◯	◯	◯
I frequently think about how my job impacts other domains.	◯	◯	◯	◯	◯

Rate your current level of readiness in the following areas:

Please choose the appropriate response for each item:

	Not at all	Slightly	Moderately	Very	Extremely
Identification of military capabilities and their general role/function	◯	◯	◯	◯	◯
Military strategy development	◯	◯	◯	◯	◯
Linking cyber threats to corresponding defensive capabilities	◯	◯	◯	◯	◯
Applying Multi-Domain thinking in your operational context	◯	◯	◯	◯	◯
Anticipating enemy actions	◯	◯	◯	◯	◯
Adapting to operational environment and enemy strategy	◯	◯	◯	◯	◯
Continuing to execute a mission through uncertainty	◯	◯	◯	◯	◯

Gaming Experience

Answer the following questions concerning your interaction with digital and physical games.

On average, how many hours per week do you play digital games?

❗ Choose one of the following answers
Please choose **only one** of the following:

- ◯ 0.5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20
- ◯ Other

On average, how many hours per week do you play physical games?

❗ Choose one of the following answers
Please choose **only one** of the following:

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20
- ◯ Other

This includes board games, card games, etc.

The primary reason I play games is _____ (fill in the blank).

Please write your answer here:

Which, if any, of these activities did you do in the last 6 months?

❗ Check all that apply
Please choose **all** that apply:

- [ ] Played a computer game (including on a mobile device, desktop, laptop, or gaming console)
- [ ] Played a physical card game or board game
- [ ] Played a physical deck-building game (Pokémon, Magic the Gathering, etc.)
- [ ] Played a digital deck-building game (Hearthstone, Pokémon, Magic the Gathering, etc.),
- [ ] Played a digital or physical game with a specific educational purpose.
- [ ] Other:

I enjoy playing deck-building games like Pokémon and Magic the Gathering

Only answer this question if the following conditions are met:
-------- Scenario 1 --------
Answer was at question '22 [GameActivities]' (Which, if any, of these activities did you do in the last 6 months?)
-------- or Scenario 2 --------
Answer was at question '22 [GameActivities]' (Which, if any, of these activities did you do in the last 6 months?)

❗ Choose one of the following answers
Please choose **only one** of the following:

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neither Agree Nor Disagree
- ◯ Agree
- ◯ Strongly Agree

I would enjoy learning how to play a deck-building game.

Only answer this question if the following conditions are met:
-------- Scenario 1 --------
Answer was at question '22 [GameActivities]' (Which, if any, of these activities did you do in the last 6 months?)
-------- or Scenario 2 --------
Answer was at question '22 [GameActivities]' (Which, if any, of these activities did you do in the last 6 months?)

❗ Choose one of the following answers
Please choose **only one** of the following:

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neither Agree Nor Disagree
- ◯ Agree
- ◯ Strongly Agree

Have you played any game with a specific educational purpose?

Please choose **only one** of the following:

◯ Yes
◯ No

Briefly describe the educational game(s) and the general timeframe of your participation.

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '25 [EducationalGames]' (Have you played any game with a specific educational purpose?)

Please write your answer here:

Answer the following questions on the 5-point scale below:

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
Formal military education and training needs to be more engaging.	◯	◯	◯	◯	◯
I enjoy strategy games.	◯	◯	◯	◯	◯
I enjoy learning through games.	◯	◯	◯	◯	◯
I want to see more games used in the military for education and training.	◯	◯	◯	◯	◯

Personal Characteristics

You are almost done! This is the last page.

Answer the following questions on the 5-point scale below:

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I pick up on new tasks and activities quickly	◯	◯	◯	◯	◯
I perform better in a team setting.	◯	◯	◯	◯	◯
When faced with a complex task, I am quickly overwhelmed	◯	◯	◯	◯	◯
I usually perform better in educational activities than my peers.	◯	◯	◯	◯	◯
When playing games, I am a competitive person.	◯	◯	◯	◯	◯
Groups produce better ideas and strategies than individuals.	◯	◯	◯	◯	◯
I enjoy learning new things.	◯	◯	◯	◯	◯
I am good at developing a plan and acting on it.	◯	◯	◯	◯	◯

You did it! Thanks for sticking with it to the end. You are now ready for the pre-test
10/16/2019 – 21:27

Submit your survey.
Thank you for completing this survey.

Appendix G. Post-Surveys

The post-survey was created in Limesurvey prior to the Primary Study. It collected participants' response to the game and views of its importance and future use. It also included open-ended questions gathering what players learned from the game and their ideas for game improvement. The survey was edited between experiments leading to three major versions. Edits sought to improve question clarity or remove extraneous questions to combat survey fatigue. Each major version is shown below as exported from Limesurvey:

MDO Integration: Post-Survey (Game)

This post-survey is for all participents who played the card game as part of the "MDO Education and Training Integration Project."

Thank you for playing the MDO card game. Your response to the following questions will help to shape future military education and training and the use of educational games. Thank you for providing your valuable input.

Do not enter any classified or FOUO information into this survey.

Let's go!

There are 15 questions in this survey.

Session Response

Did you review the provided materials (Game Instructions, Card PDF, Tutorial Video) before the in-class session?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

How many hours did you spend reviewing the provided game materials outside of class?

Please choose **only one** of the following:

- ◯ 0.5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ Other

Answer the following questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I enjoyed learning through the game.	◯	◯	◯	◯	◯
I was focused during the game.	◯	◯	◯	◯	◯
In the game, I could choose what I wanted to do.	◯	◯	◯	◯	◯
I was able to influence the session.	◯	◯	◯	◯	◯
I learned more from the game because other students were present.	◯	◯	◯	◯	◯
I am satisfied with the level of learning I achieved in the game.	◯	◯	◯	◯	◯
The game was suitable for learning about Multi-Domain Operations.	◯	◯	◯	◯	◯
I understood the game concepts better than the other students.	◯	◯	◯	◯	◯
The game helped me better understand Multi-Domain Operations.	◯	◯	◯	◯	◯
During the game, I felt connected to the other students	◯	◯	◯	◯	◯
This game offered valuable education and training.	◯	◯	◯	◯	◯

Readiness Evaluation

Please rate the degree of improvement in your readiness in the area of Multi-Domain Operations as a result of the game. Place a mark in the box that corresponds with your perception of how well the game improved your readiness.

Please choose the appropriate response for each item:

	Not at All Improved	A Little Improved	Much Improved	Very Much Improved
Identification of military capabilities and their general role/function	◯	◯	◯	◯
Military strategy development	◯	◯	◯	◯
Linking cyber threats to corresponding defensive capabilities	◯	◯	◯	◯
Applying MDO thinking in your operational context	◯	◯	◯	◯
Anticipating enemy actions	◯	◯	◯	◯
Adapting to operational environment and enemy strategy	◯	◯	◯	◯
Continuing to execute a mission through uncertainty	◯	◯	◯	◯

Answer the following questions on a scale from 1 to 5 using the designations below:

1 - Strongly Disagree
2 - Disagree
3 - Neither Agree nor Disagree
4 - Agree
5 - Strongly Agree

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I would rather have attended a briefing covering MDO concepts than played this game.	◯	◯	◯	◯	◯
I would rather have attended a classroom lecture covering MDO concepts than play this game.	◯	◯	◯	◯	◯
This game improved my ability to process complex situations	◯	◯	◯	◯	◯
This game equipped me to excel in my current position.	◯	◯	◯	◯	◯

What did you learn from this game?

Please write your answer here:

Game Evaluation

Describe your experience with the Multi-Domain Operations card game.

Answer the following questions on a 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
The game cards accurately reflect military capabilities.	◯	◯	◯	◯	◯
The game concepts were realistic to military operations.	◯	◯	◯	◯	◯
This game helps players see the importance of multi-domain operations.	◯	◯	◯	◯	◯
More activities like this should be used in military education and training courses.	◯	◯	◯	◯	◯
I would enjoy playing this game again in my free time.	◯	◯	◯	◯	◯
I would recommend this game to my peers.	◯	◯	◯	◯	◯
The scoreboard increased my motivation to perform better during the game.	◯	◯	◯	◯	◯
My partner and I worked well together.	◯	◯	◯	◯	◯
My partner significantly contributed to my game strategy.	◯	◯	◯	◯	◯
My game strategy was innovative.	◯	◯	◯	◯	◯
I executed my strategy during gameplay without interference.	◯	◯	◯	◯	◯
I excelled at this game.	◯	◯	◯	◯	◯
It was easy to learn how to play the game.	◯	◯	◯	◯	◯

What did you enjoy about the game?

Please write your answer here:

Briefly describe your initial response to playing a game as part of this course.

Please write your answer here:

What is your attitude toward the game now that you have played it?

Please write your answer here:

Briefly describe your game strategy.

Please write your answer here:

What was the biggets obstacle that kept you from executing your strategy?

Please choose **only one** of the following:

- ◯ Order of cards drawn from supply pile
- ◯ Enemy actions (offensive/defensive actions)
- ◯ Unsuccessful dice rolls
- ◯ Lack of knowledge about the game
- ◯ Uncertainty concerning my enemy's actions
- ◯ Other

Did you want more time to play the game?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

If given more time to play the game how would you benefit or what would you learn?

Please write your answer here:

Do you have any other comments about the card game?

Please write your answer here:

You're done! Thank you for your response. Have a great day.
10/16/2019 – 21:27

Submit your survey.
Thank you for completing this survey.

MDO Integration: Post-Survey

This post-survey is for all participents who played the card game as part of the "MDO Education and Training Integration Project."

Thank you for your participation in the MDO Integration study. Your response to the following questions will help to shape future military education and training and the use of educational games. Thank you for providing your valuable input.

Do not enter any classified or FOUO information into this survey.

Let's go!

There are 16 questions in this survey.

Session Response

Which game did you play during the session?

Please choose **only one** of the following:

- ◯ MDC2 Trading Card Game
- ◯ Battlespace Next: MDO

Did you review the provided materials (Game Instructions, Cards, Tutorial Video, etc.) outside of official in-class sessions?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

How many hours did you spend reviewing the provided game materials outside of class?

Please choose **only one** of the following:

- ◯ 0.5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ Other

Answer these questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I enjoyed the game.	◯	◯	◯	◯	◯
I was focused during the game.	◯	◯	◯	◯	◯
I learned more from the game because other students were present.	◯	◯	◯	◯	◯
I am satisfied with the level of learning I achieved in the game.	◯	◯	◯	◯	◯
The game was suitable for learning about Multi-Domain Operations.	◯	◯	◯	◯	◯
The game helped me better understand Multi-Domain Operations.	◯	◯	◯	◯	◯
This game offered valuable education and training.	◯	◯	◯	◯	◯

Readiness Evaluation

Please rate the degree of improvement in your readiness in the area of Multi-Domain Operations as a result of the game. Place a mark in the box that corresponds with your perception of how well the game improved your readiness.

Please choose the appropriate response for each item:

	Not at All Improved	A Little Improved	Much Improved	Very Much Improved
Identification of military capabilities and their general role/function.	◯	◯	◯	◯
Military strategy development.	◯	◯	◯	◯
Linking cyber threats to corresponding defensive capabilities.	◯	◯	◯	◯
Applying MDO thinking in your operational context.	◯	◯	◯	◯
Anticipating enemy actions.	◯	◯	◯	◯
Adapting to operational environment and enemy strategy.	◯	◯	◯	◯
Continuing to execute a mission through uncertainty.	◯	◯	◯	◯

Answer these questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I would rather have attended a briefing covering MDO concepts than played this game.	◯	◯	◯	◯	◯
I would rather have attended a classroom lecture covering MDO concepts than play this game.	◯	◯	◯	◯	◯
This game improved my ability to process complex situations.	◯	◯	◯	◯	◯
This game equipped me to excel in my current position.	◯	◯	◯	◯	◯

What did you learn from this game?

Please write your answer here:

Game Evaluation

Describe your experience with the Multi-Domain Operations card game.

How long did it take you to learn to play the game?

Please choose **only one** of the following:

- ◯ 0.5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6

Answer these questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
The game cards accurately reflect military capabilities.	◯	◯	◯	◯	◯
This game helps players see the importance of multi-domain operations.	◯	◯	◯	◯	◯
The game was implemented in my course in a way that supported the lesson objectives.	◯	◯	◯	◯	◯
I would enjoy playing this game again in my free time.	◯	◯	◯	◯	◯
I would recommend this game to others.	◯	◯	◯	◯	◯
It was easy to learn how to play the game.	◯	◯	◯	◯	◯
More activities like this should be used in military education and training courses.	◯	◯	◯	◯	◯

What did you enjoy about the game?

Please write your answer here:

What changes would you make to the game?

Please write your answer here:

What changes would you make concerning the integration of this game in a classroom environment?

Please write your answer here:

What was the biggets obstacle that kept you from executing your strategy?

Please choose **only one** of the following:

- ◯ Order of cards drawn from supply pile
- ◯ Enemy actions (offensive/defensive actions)
- ◯ Unsuccessful dice rolls
- ◯ Lack of knowledge about the game
- ◯ Uncertainty concerning my enemy's actions
- ◯ Other

Did you want more time to play the game?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

If given more time to play the game how would you benefit or what would you learn?

Please write your answer here:

Do you have any other comments about the card game?

Please write your answer here:

You're done! Thank you for your response. Have a great day.
10/16/2019 – 21:27

Submit your survey.
Thank you for completing this survey.

MDO Integration: Post Survey

This post-survey is for all participents who played Battlespace Next:MDO as part of the "MDO Education and Training Integration Research Project."

Thank you for your participation in this study. Your response to the following questions will help to shape future military education and training and the use of educational games. Thank you for providing your valuable input.

Do not enter any classified or FOUO information into this survey.

Let's go!

There are 17 questions in this survey.

Session Response

Did you review the provided materials (Game Instructions, Cards, Tutorial Video, etc.) outside of official in-class sessions?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

How many hours did you spend reviewing the provided game materials outside of class?

Please choose **only one** of the following:

- ◯ 0.5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ Other

Answer these questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
I enjoyed the game.	◯	◯	◯	◯	◯
I was focused during the game.	◯	◯	◯	◯	◯
Using the turn timer improved the game experience.	◯	◯	◯	◯	◯
I learned more from the game because other students were present.	◯	◯	◯	◯	◯
I am satisfied with the level of learning I achieved in the game.	◯	◯	◯	◯	◯
The game helped me better understand Multi-Domain Operations.	◯	◯	◯	◯	◯
This game offered valuable education and training.	◯	◯	◯	◯	◯

Readiness Evaluation

Please rate the degree of improvement in your readiness in the area of Multi-Domain Operations as a result of the game. Place a mark in the box that corresponds with your perception of how well the game improved your readiness.

Please choose the appropriate response for each item:

	Not at All Improved	A Little Improved	Much Improved	Very Much Improved
Identification of military capabilities and their general role/function.	◯	◯	◯	◯
Military strategy development.	◯	◯	◯	◯
Linking cyber threats to corresponding defensive capabilities.	◯	◯	◯	◯
Applying MDO thinking in your operational context.	◯	◯	◯	◯
Anticipating enemy actions.	◯	◯	◯	◯
Adapting to operational environment and enemy strategy.	◯	◯	◯	◯
Continuing to execute a mission through uncertainty.	◯	◯	◯	◯
Understanding phases of the Spectrum of Conflict	◯	◯	◯	◯

Answer these questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
This game was better than a group briefing on MDO.	◯	◯	◯	◯	◯
This game was better than a classroom lecture on MDO.	◯	◯	◯	◯	◯
This game improved my ability to process complex situations.	◯	◯	◯	◯	◯
This game equipped me to excel in my current position.	◯	◯	◯	◯	◯

What did you learn from this game?

Please write your answer here:

What game element contributed the most to your learning?

Please choose **only one** of the following:

- ◯ Attacking & Defending
- ◯ Deploying Cards (purchasing with resource chips)
- ◯ Intercepting Enemy Attacks
- ◯ Reviewing/Reading Cards (prior to and during games)
- ◯ Drawing Random Cards From Supply Pile
- ◯ Seeking Information Using ISR Cards and Attack Actions
- ◯ Strategy Development (prior to game)
- ◯ Combining Capabilities From Different Domains

Game Evaluation

Describe your experience with the Multi-Domain Operations card game.

How long (in hours) did it take you to learn to play the game?

Please choose **only one** of the following:

- ◯ 0.5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6

Answer these questions on the following 5-point scale.

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
The game cards accurately reflect military capabilities.	◯	◯	◯	◯	◯
This game helps players see the importance of multi-domain operations.	◯	◯	◯	◯	◯
The game was implemented in my course in a way that supported the lesson objectives.	◯	◯	◯	◯	◯
I would enjoy playing this game again in my free time.	◯	◯	◯	◯	◯
I would recommend this game to others.	◯	◯	◯	◯	◯
It was easy to learn how to play the game.	◯	◯	◯	◯	◯
More activities like this should be used in military education and training courses.	◯	◯	◯	◯	◯

What did you enjoy about the game?

Please write your answer here:

What emotions did you feel while playing the game?

Please write your answer here:

What game element was the most fun for you?

Please choose **only one** of the following:

- ◯ Attacking & Defending
- ◯ Deploying Cards (purchasing with resource chips)
- ◯ Intercepting Enemy Attacks
- ◯ Reviewing/Reading Cards (prior to and during games)
- ◯ Drawing Random Cards From Supply Pile
- ◯ Seeking Information Using ISR Cards and Attack Actions
- ◯ Strategy Development (prior to game)
- ◯ Combining Capabilities From Different Domains

What changes would you make to the game?

Please write your answer here:

What environment is this game best suited for?

Please write your answer here:

What was the biggest obstacle that kept you from executing your strategy?

Please choose **only one** of the following:

- ◯ Order of cards drawn from supply pile
- ◯ Enemy actions (offensive/defensive actions)
- ◯ Unsuccessful dice rolls
- ◯ Lack of knowledge about the game
- ◯ Uncertainty concerning my enemy's actions
- ◯ Turn Timer
- ◯ Other

Did you want more time to play the game?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

If given more time to play the game how would you benefit or what would you learn?

Please write your answer here:

You're done! Thank you for your response. Have a great day.
01/31/2020 – 10:34

Submit your survey.
Thank you for completing this survey.

Appendix H. Scorecards

For each experiment in the Primary Study, except for 7 and 8, scorecards were used to capture the outcome of each game played during the in-class session. Participants were asked to complete the scorecards at the end of each game, however, inconsistencies and missing items were a common occurrence. Also, due to time constraints, many games ended in a tie making the scorecard data less relevant to the research objectives. The MDC2 TCG Scorecard is shown in Figure 23 and the BSN Scorecard is shown in Figure 24. The major difference is the final score at the bottom of each column. Players entered the final health points (HP) of their Multi-Domain Operations Center (MDOC) in BSN instead of the player's final HP.

Player 1 – Name: _____	**GAME SCORECARD** Game (circle one): 1 2 3	Player 2 – Name: _____
Played first? ☐		Played first? ☐
Health Points (HP): 20		Health Points (HP): 20
	____ Supply Cards Remaining ____	
	____ Discard Pile ____	
Final HP: ____	☐ Winning player (Check Box) ☐	Final HP: ____

Figure 23: Scorecard used to track outcomes of MDC2 TCG games in experiments 1-3

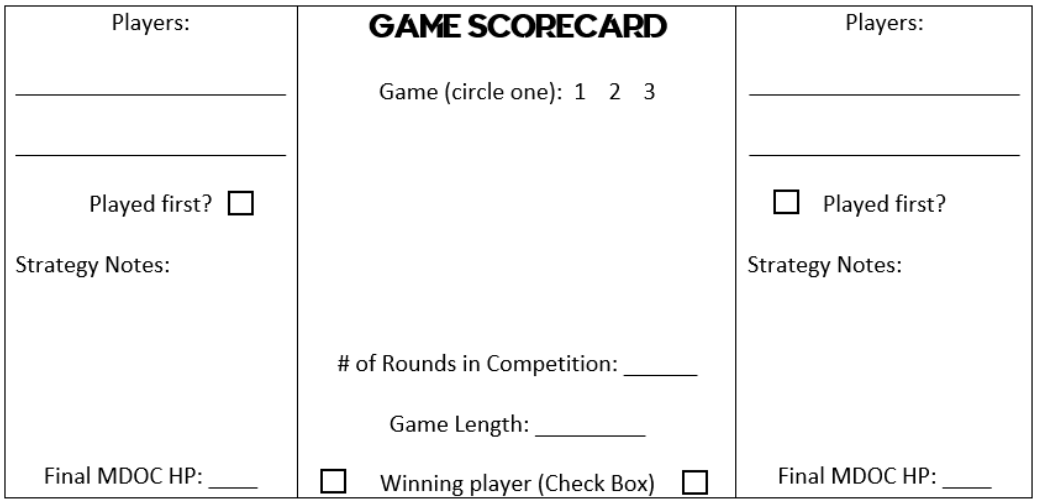


Figure 24: Scorecard used to track outcomes of BSN games in experiments 3-8

Appendix I. Play Test Feedback

Play tests were an important part of the game development process. During informal play tests, individuals were encouraged to play the game, critically review game resources, and experiment to identify potential improvements. Methods of data collecting during play tests improved through the research process. Figures 25 and 26 show the notes taken during Play Test A at the 88th Communications Group (CG).

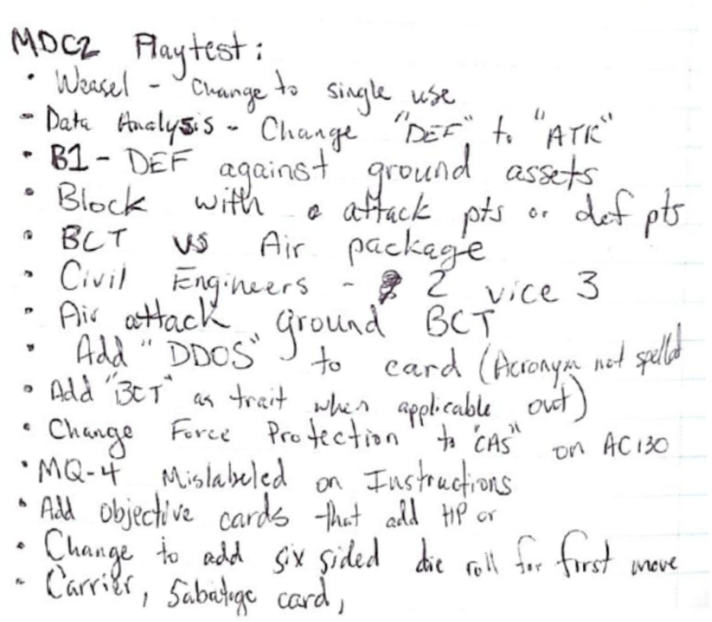

MDC2 Playtest:
- Weasel - Change to single use
- Data Analysis - Change "DEF" to "ATK"
- B1 - DEF against ground assets
- Block with ~~a~~ attack pts or def pts
- BCT vs Air package
- Civil Engineers - 2 vice 3
- Air attack Ground BCT
- Add "DDOS" to card (Acronym not spelled
- Add "BCT" as trait when applicable out)
- Change Force Protection to "CAS" on AC130
- MQ-4 Mislabeled on Instructions
- Add objective cards that add HP or
- Change to add six sided die roll for first move
- Carrier, Sabotage card,

Figure 25: Author's notes from 88 Communications Group play test, page 1

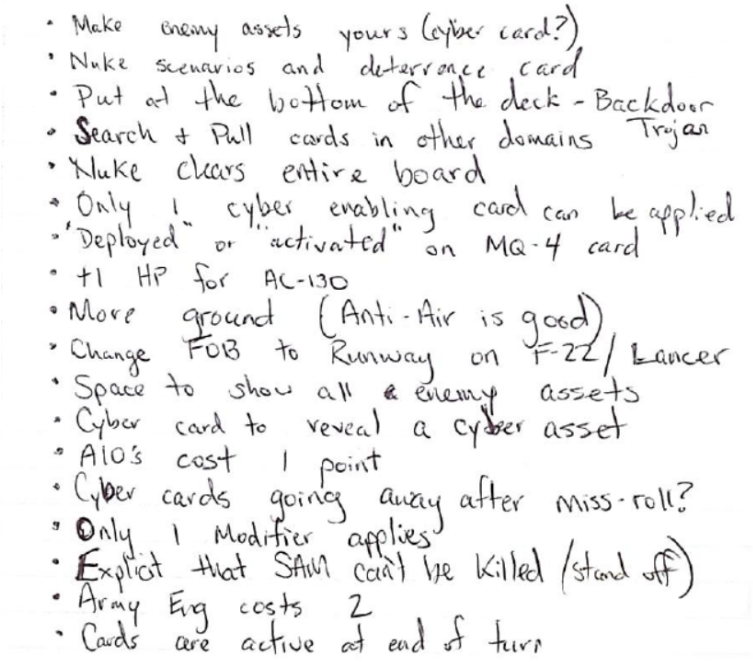


Figure 26: Author's notes from 88 Communications Group play test, page 2

This method of recording feedback and ideas for improvement was improved when the Fail Faster play test feedback form was used. The title refers to a blind test, however, this form was not used for that purpose. Blank areas were included in the published version of the form and custom questions (Q3, Q6, and Q7) were added to gather feedback in specific areas. An example of the form is shown on the next two pages.

GAME:	DESIGNED BY:	DESIGNER EMAIL:
Battlespace Next: MDO	Nathan Flack	nathaniel.flack@afit.edu

PLAYTESTERS: FIRST & LAST NAMES (IN TURN ORDER) ADD EMAIL IF OK TO CONTACT	OK TO NAME IN RULES?	OK TO ADD TO EMAIL LIST?					TOTAL

SETUP LENGTH

RULES LENGTH

GAME LENGTH

RULES QUESTIONS DURING GAME, CONFUSING RULES, MISSING RULES

Q1 HOW MUCH FUN DID PLAYERS HAVE? (CIRCLE MULTIPLE IF PLAYERS HAVE DIFFERING OPINIONS)

NOT FUN **1** **2** **3** **4** **5** **6** **7** VERY FUN

Q2 HOW INNOVATIVE WAS THE GAME? (CIRCLE MULTIPLE IF PLAYERS HAVE DIFFERING OPINIONS)

SEEN IT ALL **1** **2** **3** **4** **5** **6** **7** BRAND NEW CONCEPT!

Q3 How useful would this game be in a classroom to introduce MDO concepts?

1 **2** **3** **4** **5** **6** **7**

Q4 WHAT DID YOU LIKE MOST ABOUT THE GAME?

Q5 WHAT WOULD YOU CHANGE OR IMPROVE ABOUT THE GAME?

Q6 What did you learn by playing the game?

Q7 What would make the game simpler to play or easier to learn?

Appendix J. Game Exposure Feedback Forms

During several interactions with those in operational organizations, anonymous feedback was collected through forms as shown in Figure 27. The purpose of these forms was to collect the initial response from those recently introduced to the game, but would not be able to participate in a formal experiment.

Feedback was collected from the following organizations:

1. Information Warfare (IW) personnel stationed at Langley AFB. Personnel were primarily from the Cyber Operations and Intelligence career fields currently filling positions at Headquarters, ACC from the Communications Directorate (A6) and Intelligence Directorate (A2).

2. Air, Land, Sea Application (ALSA) Center. "ALSA is a multi-Service organization established by the doctrine centers to develop tactical-level solutions of multi-Service interoperability issues consistent with Joint and Service doctrine" [92]. Through a personal contact, the author had the chance to brief nine joint Field Grade Officers (FGOs).

3. Army TRADOC Headquarters located at Fort Eustis, Virginia. A TRADOC employee working on wargamming applications for MDO saw information about the game through internet searches and contacted the author. This lead to a conversation between two TRADOC employees and the author concerning current efforts to model MDO relationships. The author provided feedback forms for completion following the discussion.

The results from the first part of the form capturing quantitative data are provided in Table 6.

Battlespace Next™: Multi-Domain Operations

Please rate the following statements on scale of 1-5 as described below.

1 – Strongly Disagree	2 – Disagree	3 – Neither Agree or Disagree	4 – Agree	5 – Strongly Agree

Question:	Rating:
1. Given what I know about the game, I am interested in playing it.	
2. I would be willing to dedicate at least 2 hours to learning and playing the game.	
3. I am familiar with games like Battlespace Next™.	
4. If I was tasked with educating others on Multi-Domain Operations and had enough time, I would consider using a serious game similar to this one.	
5. This game would enhance MDO education in a military setting.	
6. The military needs to leverage more serious games to enhance education and training.	

Please answer the following open-ended questions.

1. What was your initial reaction to using a game to foster discussion about MDO?
2. What would make the game more useful for military education and training?
3. How difficult would it be to integrate this game into a military course or training seminar? What resources would you need to do so?

Figure 27: BSN feedback form

Table 6: Quantitative data gathered through anonymous surveys following BSN briefs to individuals in operational organizations (N=11). Likert Scale ranged from 1 = Strongly Disagree to 5 = Strongly Agree.

Question	**1**	**2**	**3**	**4**	**5**
Interested in Playing	0%	9%	18%	36%	36%
Would Dedicate 2 Hours to Play	0%	9%	18%	36%	36%
Familiar with Similar Games	18%	18%	9%	36%	18%
Would Consider Using BSN	0%	18%	18%	27%	36%
Use Would Enhance MDO Education	0%	0%	18%	45%	36%
More Games Needed	0%	0%	18%	36%	45%

Appendix K. Human Subjects Research Approval

This research project was approved for use of human participants by the Institutional Review Board (IRB) at AFIT using exemption criteria 32 in the Code of Federal Regulations (CFR) 2.19.104 (d)(2). This exemption covers research involving educational tests and survey procedures. The Pilot Study, which did not include collection of demographic data was approved on 22 January 2019. At a later date, the package was updated to include collection of participant demographic data. This follow-on package was approved on 3 July 2019, Protocol Number: "REN2019P18R Reith," Title: Multi-Domain Operations Education and Training Integration Research.

Appendix L. Pilot Study Experiment Notes

To evaluate the research questions, investigators initially completed two HSR experiments testing the effect of the game and course integration efficiency. This Pilot Study included 58 participants and helped shape the experiment procedures and data collection tools. Additional information is published in [86] A summary of the Pilot Study experiments is shown in Table 7.

Table 7: Summary of Pilot Study experiments

Exp	**Location**	**Total Participants**	**Completed Surveys**	**Study Structure**	**Experiment Duration**	**Participant Experience**
Pilot A (Oct '18)	Air Force Institute of Technology, Cyber Warfare and Security Course (CSCE 525)	14	12 (86%)	Instructor (thesis committee member) led experiment and debriefing	1 Hour & 50 Minutes	Primarily junior AF officers
Pilot B (Feb '19)	Training Seminar at the Rocky Mountain Cyberspace Symposium in Colorado Springs, CO	44	28 (63%)	Session organized and led by author and participants volunteered to participate in training	2 Hours	Mix of DoD military, contractors, and civilians with varied levels of experience
Total		**58**	**40 (69%)**			

12.1 Pilot A: CSCE 525, Fall 2018

Name: Computer Science and Computer Engineering (CSCE) – Cyber Warfare and Security Master's Course (CSCE 525)

Location: Air Force Institute of Technology, Wright Patterson AFB, OH

Date: October 2018

12.1.1 Procedure/Schedule

Day 1 (10 Minutes): Pre-survey distributed; cards and instructions provided to students; instructor emphasized the need to review all material, build deck, and play a practice game prior to the next class.

Day 2-5: No class; players had access to game cards and instructions.

Day 6 (1 hour 50 Minutes): Played game(s) against partner; debrief discussion led by instructor; approximately 5 minutes were dedicated to complete post-surveys. All game cards and instructions were collected at the conclusion of debrief.

12.1.2 Research Notes

Game Card Version: MDC2 TCG, Version 1

Instructions: MDC2 TCG, Version 1

Surveys: Pilot Study Survey, Version 1. Pre-Survey (front-side) and Post-Survey (back-side), paper-based.

- Each player was only given one deck of 59 cards and a die. Some players acquired duplicates of cards because of extra decks provided by instructor.

- No scorecards were used to track game results.

- The author participated in this experiment but his serveys were not included in the data set.

12.1.3 Observations

- Players were eager to start playing and several groups were able to get through multiple games with the same partner before conclusion of class.

- The instructor (thesis committee member) used student questions about the game to initiate classroom discussion. This required that all students stop their games and listen and respond. The instructor used this to help the class think through the real-world implication of the game situation in question.

- It was difficult for the instructor to stop the players from continuing the game and move to the debrief portion of the experiment.

- The debrief was conducted by instructor and focused on workable strategies and

what domain players used during their games. The class represented a wide range of strategies.

- A portion of the discussion focused on the Army participants and what strategies they used as compared to the other members of the class who were primarily members of the Air Force.

- The class commented that the game was relevant to the course and provided a valuable education experience.

12.2 Pilot B: Cyber Symposium

Name: Multi-Domain Operations Training Innovation Seminar at the Armed Forces Communication and Electronics Association (AFCEA) Rocky Mountain Cyberspace Symposium.

Location: The Broadmoor Hotel and Conference Center, Colorado Springs, CO.

Date: 4 Feb 2019

12.2.1 Procedure/Schedule

Day 1 (2 Hours):

- Pre-survey distributed.

- Overview of MDO via slide presentation by the author (20 minutes).

- Cards and instructions provided to participants.

- Review of game rules and instructions (15 minutes).

- Deck-Building and strategy development phase with a partner (20 minutes).

- Played one game with opponent who was different from strategy partner (45 minutes).

- Debriefing (10 minutes).

- Time allocated for participants to complete post-surveys (2 minutes).

12.2.2 Research Notes

Game Card Version: MDC2 TCG, Version 1

Instructions: MDC2 TCG, Version 1

Surveys: Pilot Study Survey, Version 2. Pre-Survey (front-side) and Post-Survey (back-side), paper-based

- Each player was only given one deck of 59 cards and a die. No duplicates were available so all players played with only 1 copy of each card.

- No scorecards were used to track game results.

- Participants varied widely in this study due to the diverse nature of the Cyberspace Symposium audience. They had to sign-up for the training separately from the conference and arrive a day in advance of the main conference. There were several other attractive training options to choose from.

- Author had three individuals with game knowledge help to facilitate the session.

12.2.3 Observations

- Many participants were unfamiliar with card games and deck building games in particular.

- Many games were happening at the same time, so some participant questions were not answered immediately and it was difficult to help participants with specific issues.

- Time was limited so participants were only able to play one game and most did not finish.

Appendix M. Primary Study Experiment Notes

The notes taken during and after experiments are provided below. Specific departures from experiment procedures are noted as well as experiment schedule, details, researcher's observation, and experiment notes. A summary of all Primary Study experiments is provided in Table 8.

Table 8: Summary of primary study experiments

Exp	Location	Total Participants	Completed Surveys	Study Structure	Experiment Duration	Participant Experience
1 (Jul '19)	13O (MDC2 Career Field) Initial Skills Training, Hurlburt Field, FL.	27	15 (55%)	Author invited to lead class with oversight from course instructors	2 Hours & 15 Minutes	Primarily AF Officers, O-4s and O-5s, with 6-15 years of experience
2 (Jul '19)	Advanced Cyber Training (ACE) - Reserve Officer Training Corps (ROTC) cadet summer training program	36	9 (25%)	Requested volunteers to participate in experiment during four lunch periods.	3 Hours (split over 4 days)	College students in their Junior year enrolled in Army or AF ROTC.
3 (Aug '19)	Air Command and Staff College (ACSC) - Multi-Domain Operations Strategist (MDOS) Program	45	21 (47%)	Participants split into four seminars. Two played MDC2 TCG and two played BSN	2 Hours & 30 Minutes (split over 3 days)	AF and Joint officers (O-4s) with 14 years average military experience
4 (Oct '19)	Air Force Institute of Technology - Agile Software Engineering Masters Course (SENG 593)	23	20 (86.9%)	Participants played two games in just under 1 hour, no group finished their game	1 Hour & 30 Minutes (split over 2 days)	AF active duty and DoD Civilian students with limited operational experience
5 (Nov '19)	Air Force Institute of Technology - Cyber Warfare and Security Master's Course (CSCE 525)	16	10 (62.5%)	Participants played in pairs and most finished two full games	2 Hours & 30 Minutes (split over 2 days)	AF Active Duty students enrolled in Graduate Cyber Program
6 (Nov '19)	Army Reserve Officer Training Corps (ROTC) - Wright State University	13	8 (62%)	Requested volunteers to participant in 1 of 2 experiment sessions	2 Hours & 15 Minutes	College students, most with limited military experience
7 (Nov '19)	Information Warfare MDO Challenge - Langley AFB, VA	3	2 (66.7%)	Volunteers requested to participate in MDO play test	2 Hours	Shortened advertising timeline and conflicting base events led to low participation
8 (Jan '20)	Air Force Research Laboratory, Rome Labs, NY	25	18 (72.0%)	Experiment facilitated by AFRL personnel. Event advertised to entire organization	2 Hours	Primarily DoD Civilians and junior officers
Total		**188**	**103 (54.8%)**			

13.1 Experiment 1: 13O Initial Skills Training (13O IST)

Name: 13O – AF Multi-Domain Command and Control Career Field Initial Skills Training (IST)

Location: Hurlburt Field, FL

Date: 2-8 July 2019

13.1.1 Procedure/Schedule

Day 1: Game resources distributed to participants by instructor (digital card file, instructions, and tutorial video). Students were instructed to review these materials before coming to class. Pre-test and pre-survey distributed via direct email to participants.

Day 2-6: No in-class activities related to experiment (included 4-day holiday weekend).

Day 7 (2 Hours and 15 Minutes):

- Review of game rules and instructions (30 minutes).

- Deck-Building and strategy development phase with a partner and demo game (40 minutes).

- Played one game with opponent who was different from strategy partner (45 minutes).

- Debrief led by the author (15 minutes).

- Post-test and post-survey delivered directly to students via email.

13.1.2 Research Notes

Game Card Version: MDC2 TCG, Version 1

Instructions: MDC2 TCG, Version 2

Surveys: Pre-Survey, Version 1 and Post-Survey, Version 1. Electronically executed through Limesurvey.

- Each player was given a deck of cards and a die. Additional card boxes were available for participants who wanted card duplicates in their deck. Players could also take cards from their partner if he or she did not want to use that particular card.

- Participants completed scorecards following each game.

- No internet connection was available, therefore a whiteboard displayed the game match-ups and final scores from the only game. Scores were not recorded for the demo game.

- Participants were focused on learning MDO and MDC2 because they were selected for the new career field focused on these topics. However, this population was also more senior than other studies as several AF senior O-4s and O-5s were present.

- Because of limited space, the experiment was spread out over three rooms. The facilitator had to move between the three rooms to give guidance, announce time constraints, and answer participant questions.

- Because of technical difficulties, the tutorial video was not available during the in-class session. Students were assigned to review the video, cards, and instructions, however in many cases this did not occur and many students were unprepared to start strategy development and play a demo game.

13.1.3 Observations

- About half of the students were not initially excited about playing the game. I believe this was due to the demands of the course and the "experimental" nature of the game session.

- The instructor left the game for an activity after a full day of PowerPoint brief-

ings, a working lunch, and an early morning meeting that required students to be present at 0730. This was much earlier than their typical start date. This left a block at the end of the day to run the experiment. The students were burned out and seemed disappointed that instead of being released early they had to stay and participate in the experiment. I believe these factors affected the results of the experiment.

- The lead instructor communicated that the afternoon would be short and only left 2 hours and 15 minutes for the experiment. This led to a very quick explanation of the game that was not sufficient.

- The lead instructor was not present for the experiment, although two of the assistant instructors were present and engaged in facilitation.

- A few of the students were very excited about the game and seemed to enjoy it despite the long training day.

- One participant showed the author a printout of the cards that he created on his own and organized into a "tech tree" revealing the dependencies of the cards (dictated by the requirements). By observation, this same student effectively leveraged cyber capabilities to hinder their opponent and then blended air and ground capabilities into their strategy to win handily.

- There were several different strategies used and a few innovative ideas. Some players used large initial deployments in the land domain to play a huge force in the first deployment.

- The debrief was conducted by the author and focused on successful and unsuccessful strategies and lessons learned from the game. Participants found that a heavy cyber strategy was unsuccessful against combinations of air and ground forces. This led to quality discussion on the role of cyber capabilities in a kinetic war.

- One participant mentioned that future games would provide strategy refinement and the scores would be closer together. Many agreed with this point.

- One suggestion was to play the game in teams of two or three. Another participant suggested using the game to model a current Command and Control (C2) construct where each person had a domain they controlled and passed possible actions to an overall commander.

- The debrief was lively, but only lasted 15 minutes because of time constraints. It was also clear that the students were burned out after a long day.

13.2 Experiment 2: Advanced Cyber Education (ACE) Program

Name: ACE – AFIT program for cadets in Reserve Officer Training Corps (ROTC) programs

Location: AFIT, Wright Patterson Air Force Base (AFB), OH

Date: 19-25 July 2019

13.2.1 Procedure/Schedule

Day 1:

- Briefed all 44 students on the purpose of the game and requested volunteers to play the game over the next four lunch hours (21-25 July).

- Game cards and instructions were distributed to participants at the end of their training day. Students asked to review the cards and instructions over the weekend before returning on Monday.

- Pre-Test and Pre-survey distributed via direct email to participants.

Day 2-3: Weekend course break.

Day 4 (45 Minutes):

- Remained in computer lab.

- Reviewed tutorial video (30 minutes).

- Walked through sample hand and demoed beginning of the game (15 minutes).

- Answered participant questions (15 minutes).

Day 5 (45 Minutes):

- Transitioned to two separate classrooms with available table space.

- Deck-Building and strategy development phase with a partner (15 minutes).

- Demo-Game (30 minutes).

Day 6 (45 Minutes):

- Transitioned to two separate classrooms with available table space.

- Played first game against random opponent (this opponent was not their strategy partner).

- Recorded scores on scorecard.

Day 7 (45 Minutes):

- Posted leader board in main computer lab.

- Transitioned to a single classroom with available table space.

- Assigned new opponents based on performance from Day 6. This was an attempt to assign players to face opponents who had similar game success.

- Explained a new game variation that used the Spectrum of Conflict. The Spectrum of Conflict card in BSN had not been created yet as this was the first playtest with this mechanic. The facilitator (author) used a white board to show the current spectrum of conflict for all games.

- All 13 games started at once in the competition level. After an unspecified amount of time, the facilitator rolled the die to randomly increase the level of conflict, eventually reaching open conflict. This happened approximately after 10 minutes.

13.2.2 Research Notes

Game Card Version: MDC2 TCG, Version 1

Instructions: MDC2 TCG, Version 3 (Quick-Start Guide)

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 2. Electronically executed through Limesurvey.

- The Pre-Survey was changed slightly to better capture the cadet's academic major for those without military experience.

- The Quickstart Guide removed the requirement for strategic investment by establishing a defined deck for all players to use. To start, players only needed to select six cards for their starting hand. This change was designed to decrease the time it took players to learn the game and start playing.

- Of the 44 students that were enrolled in ACE, 36 of them volunteered to play the game during all four lunch periods. However, only 26 students attended all sessions.

- This was the only experiment that included watching the tutorial video during class time.

13.2.3 Observations

- Students reported playing the game over the weekend (days 2 & 3) and enjoying the experience.

- One player reported that the inclusion of the spectrum of conflict game mechanic changed his strategy and made him consider using more cyber capabilities early in the game.

- The debriefing (on Day 7) was shortened because of the time it took to explain the spectrum of conflict scenario and finish the games. It focused on the participants' game experience and the usefulness in an ROTC training program.

- At least three cadets sent information about the game to their detachments to see if their leadership would be interested in using the game for their cadet training program.

13.3 Experiment 3: Air Command and Staff College (ACSC)

Name: Air Command and Staff College (ACSC) – Multi-Domain Operational Strategist (MDOS) Program

Location: ACSC Facility, Maxwell AFB, AL

Date: 26-28 August 2019

13.3.1 Procedure/Schedule

Day 1 (30 Minutes):

- Sent Pre-Survey to individual email addresses.

- Briefed all 45 students about the experiment procedures and game purpose.

- Distributed game cards, instructions, and links to the tutorial videos.

Day 2 (15 Minutes):

- Followed up with each seminar (approximately 16 students each) to answer questions about the game instructions and Day 3's procedures.

Day 3 (2 Hours):

- All four seminars played two games against opponents based on who was sitting nearby.

- Both game sessions were stopped due to time constraints, however about half of the games were finished before the time limit was reached.

- After each game participants completed paper scorecards.

- Completed 15-minute debrief with 2 seminars at a time (about 32 participants in each debrief).

- Distributed Post-Surveys electronically.

13.3.2 Research Notes

Game Card Version: Treatment A (2 Seminars): MDC2 TCG, Version 1 Treatment B (2 Seminars): BSN, Version 1

Instructions: MDC2 TCG, Version 1 and BSN, Version 1

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 3. Electronically executed through Limesurvey.

- Returned to original instructions to draw clear distinctions between the original game and the new game (BSN) that drew on lessons learned from previous experiments (Pilot Study and Experiments 1-2) and play tests.

- The four seminars used during the event were already established for the entire program and experiment logistics restricted the random distribution of students. However, participants were already assigned to the seminars in order to evenly distribute ability and military experience.

13.3.3 Observations

- Students were extremely busy the week of the experiment and the instructors made the experiment feel like an additional task piled on the students in addition to their term paper and group projects.

- The author observed two students working on their term papers while playing the game. This points to either a lack of interest in the game or over-tasked students. Both instructors and students mentioned that the MDOS program is particularly busy and demanding.

- At one point from the hallway, the author heard "BOOM! Inflatable tank!" from one of the rooms using Treatment B (Battlespace Next). This followed a player's successful roll in a Military Deception attack (one of the Information Operations cards).

This and other observations lead the author to conclude that the game produced heightened emotions in the players.

13.3.3.1 MDC2 TCG Debrief Observations

- Participants mentioned kinetic attacks (especially bombers) were very effective in inflicting a lot of damage.

- The deck building portion of the game make on participant think about "what options are out there" and what could be used in a military operation.

- Cyber was interesting and it requires phases. They thought the cyber cards were accurate and balanced well.

- Wanted cyber attacks and effects to negatively impact the enemy's HP or do more impact.

- The students did not like using other cards as currency within the game. This led to the prioritization of one or two domains, as you could not win with cyber assets alone.

- The game seems imbalanced toward the use of air power over the other domains.

13.3.3.2 BSN Debrief Observations

- Based on the Spectrum of Conflict, participants took away the necessity for the military to know what was available at different points in the conflict. Some thought the Spectrum of Conflict was too artificial.

- Thought cyber was too weighted in the game. Once a player used the cyber attacks the opponent could not recover.

- Cyber defenses buys you decision space if they are played early. This was balanced against having infrastructure later in the game (Forward Operating Bases

(FOBs), Carriers, Refuelers, etc.).

- They thought the cyber capabilities were too numerous for the game.

- The attack and defense actions took too long.

- Dependencies were not always clear and some players missed dependencies during the first time around.

- Wanted a red deck to play against adversaries.

- The game takes some time to learn, but it fits what we are trying to teach with MDO.

- The tutorial video needs to show a sample game in addition to the individual.

13.4 Experiment 4: SENG 593

Name: SENG 593 – Agile Software Systems Engineering

Location: Department of Systems Engineering and Management, AFIT

Date: 9-16 Oct 2019

13.4.1 Procedure/Schedule

Day 1 (50 Minutes): - Pre-survey links sent to all students.

- Overview presentation covering game purpose and procedures provided by the author.

- Cards and instructions provided to participants.

- Brief overview of game rules and instructions.

Day 2-8: Class did not meet. Each set of partners had access to the electronic and physical copies of the game instructions, cards, and the video tutorial.

Day 8 (60 Minutes):

- Started a demo game between randomly assigned teams.

- Post-Survey Links sent to all students.

- Instructor survey link sent to both instructors present during the experiment.

- Debrief (10 Minutes) led by author.

13.4.2 Research Notes

Game Card Version: BSN, Version 1

Instructions: BSN, Version 2

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 4. Electronically executed through Limesurvey.

- Each player was only given one deck of 59 cards and a die. No duplicates were available so all players played with only 1 copy of each card.

- A leader board was only shown at the very end and did not influence match-ups for demo game or the first scored game.

- The class was playing the game to garner an understanding of the game so that they could model it for a class project running throughout the three month class.

13.4.3 Observations

- Approximately half of the players were familiar enough with the game to jump right into the round without significant questions. Some groups had a hard time starting the first game.

- The hour of game play during Day 8 was not enough to effectively complete the experiment. No players completed either the short demo game or the second (longer) game. The shortened time was due to class schedule constraints.

- The Debrief focused on the emotions players were feeling during the game. Many in the class mentioned they felt frustrated at not fully understanding the game and unable to execute their chosen strategy. They were also frustrated by limitations of the card game (as compared to a digital version) because cards had to be continuously

flipped over and it was not obvious what cards a player could use for attack and defense because of the numerous requirements within the game.

- The students communicated the idea that the game was not relevant to their specific career field. This was voiced by military personnel in both the communications/cyber career field and in the software engineering career field. This prompted the instructor to push back on their perceptions and painted a picture of the larger role of their jobs in the Department of Defense.

- In the authors view, students saw more value in the game after the Instructor pointed to the bigger picture.

- The experiment was conducted as part of a larger class project to build a digital twin of the physical card game used in the later experiments (studies 5 and following). This tilted the debriefing toward how a digital game could improve the educational impact of the tool.

13.5 Experiment 5: CSCE 525, Fall 2019

Name: CSCE 525, Cyber Warfare and Security (CSCE 525)

Location: Department of Electrical and Computer Engineering, AFIT

Date: 6-13 Nov 2019

13.5.1 Procedure/Schedule

Day 1 (30 Minutes):

- Pre-survey links sent to all students.

- Overview presentation covering game purpose and procedures provided by researcher (author).

- Cards and instructions provided to participants.

- Brief overview of game rules and instructions.

- Played demo game for 3-4 rounds with a research assistant who knew the game and answered student questions throughout.

Day 2-7: Class did not meet. Each set of partners had access to the electronic and physical copies of the game instructions, cards, and the video tutorial.

Day 8 (110 Minutes)

- Paired teams randomly at the beginning of the class for the first game.

- After the first game finished, students received 10 minutes to adjust their strategy

- Second game was started.

- Debrief (8 minutes) led by author

- Post-Survey Links sent to all students

13.5.2 Research Notes

Game Card Version: BSN, Version 2

Instructions: BSN, Version 3

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 4. Electronically executed through Limesurvey.

- Each team (pair of two) were provided with a physical copy of the game and instructions. All players had electronic access to the game cards and instructions.

- All groups played through two games, most games were completed, but 2 games in round 1 and 1 game in round 2 were stuck in a deadlock when time was called.

- Author and research assistant received questions about gameplay and attack and defense actions throughout. Questions focused on outcomes of card battles and effects of specific cards.

13.5.3 Observations

- Instructor emphasized the importance of preparing for the game, so all participants arrived to the class on Day 8 with an initial strategy.

- Games started slow. 24 minutes into the game, none of the 8 groups had any damage against their MDOS.

- Most of the cards still seemed unfamiliar to the participants and most were taking too long to deploy cards. The turn timers were largely ignored in the first round, although the games did speed up as participants grew in their experience with the game.

- The dice rolls turned into highly emotional events as attack and defense actions were either successful or not.

- After moving from "competition" to "conflict" one player exclaimed, "The gloves are off!"

- Two teams who finished their second game 15 minutes early decided not to play another game.

13.6 Experiment 6: Army ROTC

Name: Army ROTC

Location: Allyn Hall, Wright State University

Date: 13-18 Nov 2019

13.6.1 Procedure/Schedule

Day 1 (20 Minutes):

- Met with 4 of the participants to explain the background behind the game and distribute game instructions and game cards.

- Emailed Pre-Survey Link to all participants.

Day 2-5: No official activities related to experiment.

Day 6 (150 Minutes):

- Played through game with those who were ready.

- Showed tutorial video to those who did not review game resources ahead of session.

- Experiment broken into morning and afternoon session. Students only came to one of the sessions.

13.6.2 Research Notes

Game Card Version: BSN, Version 2

Instructions: BSN, Version 3

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 4. Electronically executed through Limesurvey.

- Only two players in each session were familiar enough with the game to start playing at the beginning of the session.

- All other participants showed up to the session without any knowledge of the game. These participants watched the tutorial video on a laptop and then started playing a game.

- Two participants showed up to the session 1 hour and 40 minutes late, but were still able to watch the tutorial video and start playing a game.

- Due to the few number of participants, players competed as individuals. Additionally, the author was able to provide more help deciphering attack and defense actions during the games.

- Due to the participants' inexperience with cyber capabilities, the debriefing focused on the very basic elements of the game and how the game models real-world cyber implementation.

13.6.3 Observations

- Emotion and rivalry were high during both the morning and afternoon sessions. One participant exclaimed "Yes! We are in conflict!"

- Both sessions followed a very similar progression and had a similar feel.

- Participants discussed the rules a lot during play tests.

- A participant noted that the game escalates quickly, which they liked.

- Another player mentioned that during preparation the turn timer (60 seconds) was not sufficient to complete actions.

- The researcher noted one participant who used a ground unit to attack and disable their opponents cyber operations center, used a Distributed Denial of Service attack once the Redundant Servers were offline, and then followed up that with a stealth bomber strike. This was an example of a Ground + Cyber + Stealth Air capability that was innovative and not obvious to other players.

- One player was demoralized after a defensive roll with a 50% chance of success (against an enemy cruise missile attack) failed 4 times in a row.

13.7 Experiment 7: Air Combat Command (ACC), Langley AFB

Name: ACC Information Directorate (ACC/A6) Information Warfare Tournament

Location: Langley AFB, Virginia

Date: 1-15 Nov 2019

13.7.1 Procedure/Schedule

Day 1: Distributed MDO Challenge Advertisement to key base personnel with a paragraph describing the challenge as a strategy card game.

Days 2-14:

- Interested personnel contacted the author to sign up for the session. When they did, the author provided them with the digital card files, instructions, and links to the tutorial video.

- Only one person signed up prior to the session, but did not attend the in-class session.

Day 15 (120 Minutes):

- Started a game with the local point of contact (POC). Two others arrived, but did not have prior access to game resources. Each were provided a deck and a laptop was used to show them the tutorial video.

- Once the video concluded, the two participants played one game with guidance and rules clarification provided by the author and local POC.

- After the game the author and three others held an informal debriefing.

13.7.2 Research Notes

Game Card Version: BSN, Version 2

Instructions: BSN, Version 3

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 4. Electronically executed through Limesurvey.

- The session was not well attended due to other base events occurring at the same time, the upcoming holiday (Thanksgiving), and the short timeline available to advertise the event.

13.7.3 Observations

- Other personnel stopped by the room and watch a few turns. Additionally, after the formal experiment a demo game was played for a larger audience at a social event for IW personnel. Informal feedback was collected during this event, which is detailed

in Appendix J.

13.8 Experiment 8: Rome Labs, Air Force Research Laboratory (AFRL)

Name: Air Force Research Laboratory (AFRL) Information Directorate (AFRL/RI)

Location: Rome Labs, New York

Date: 23 Dec 2019 – 8 Jan 2020

13.8.1 Procedure/Schedule

Day 1: - Distributed pre-surveys to 25 personnel who expressed interest in the event to the organizer.

- Electronically shared game resources to all registered participants.

Day 2-15: No official activities related to experiment.

Day 16 (165 Minutes): Session 1

- 15 participants total.

- The first game took 1 hour and 40 minutes.

- The second game was played to completion (between 35 minutes to 1 hour and 5 minutes).

Day 16 (120 Minutes): Session 2

- 5 participants total.

- 3 of 5 had played the game together earlier in the week and were much more experienced in trading card games.

13.8.2 Research Notes

Game Card Version: BSN, Version 2

Instructions: BSN, Version 3

Surveys: Pre-Survey, Version 2 and Post-Survey, Version 4. Electronically executed through Limesurvey.

- Facilitated by a DoD civilian who works at Rome Labs.

- The experiment was broken into two sessions. The first session was larger than the second.

- Both sessions did not include a group debriefing, although smaller discussions occurred after the completion of individual games.

- Due to an uneven number of players, games had both pairs and individuals playing against one another.

- One experienced player was assigned to each game to help new players understand game progression and answer questions.

- Some participants had to leave during the session due to other commitments.

- Rome Labs plans to use the game for new employees and interns to help them better understand MDO.

13.8.3 Observations

- Most questions revolved around rules, turn flow, and nuances of card effects.

- Those with more military experience seemed to benefit less from playing.

- Those with less military experience thought it was beneficial and instructive. This group included DoD Civilians.

- Game realism was an area of feedback. Comments included: lack of duplicates, restrictions of capabilities buried in supply pile, wanted stronger cyber attacks, "Competition phase was too short."

Bibliography

1. Irene S Wu. Soft power amidst great power competition. *Washington, DC*, 2018.

2. Clay Wilson. Information operations, electronic warfare, and cyberwar: Capabilities and related policy issues. Library of Congress Washington DC Congressional Research Service, 2007.

3. Heather Wilson, David Goldfein, and Kaleth Wright. Multi-Domain Command and Control Implementation Plan, 2018.

4. Armed Forces of the United States. Joint Publication 1, 2017.

5. U.S. Army. The U.S. Army in Multi-Domain Operations 2028, 2018.

6. Jeffrey Reilly. Over the Horizon: The Multi-Domain Operational Strategist. *Over the Horizon*, 2018.

7. Jeffrey Reilly. Multidomain Operations. *Air & Space Power Journal*, pages 48–65, 2016.

8. David Perkins and James Holmes. Multidomain Battle: A Joint Solution. pages 54–57, 2018.

9. Department of Defense. Summary of the 2018 National Defense Strategy, USA, 2018.

10. Bob Killebrew. Goodbye, Joint Forces Command, 2010.

11. Global Security. US Joint Forces Command (JFCOM).

12. Department of the Army. Information Operations: Doctrine, Tactics, Techniques, and Procedures, 2003.

13. Dave Goldfein. CSAF Focus Area: Enhancing Multi-Domain Command and Control...Tying it All Together, 2016.

14. United States Army. Accelerating Multi-Domain Operations Evolution of an Idea. 2018.

15. Theresa Hitchens. OSD & Joint Staff Grapple With Joint All-Domain Command and Control, 2019.

16. Tim Zadalis. Multi-Domain Command and Control: Maintaining Our Asymmetric Advantage. *Joint Air Power Competence Centre*, 26:10–15, 2018.

17. David Alberts. Multi-Domain Operations: What's New, What's Not, and the Implications for Command and Control. 2018.

18. Jonathan Barber. Over the Horizon: The Multi-Domain Operational Strategist (MDOS). *Over the Horizon*, 1, 2018.

19. Mason Bruza and Mark Reith. Multi-Domain Command and Control: The Need for Capability Transparency. pages 1–13, 2017.

20. James Campbell. Teaching Multi-Domain Operations: The Case of British Field Marshal William Slim. *Real Clear Defense*, pages 1–4, 2018.

21. David Goldfein. US Air Force Chief of Staff: Our Military Must Harness the Potential of Multidomain Operations, December 2018.

22. David Goldfein. General David Goldfein Remarks at the 2019 AFA Air, Space, and Cyber Conference, 2019.

23. David Goldfein. Air Force Chief of Staff's Speech to Air University Faculty and Air War College, 2019.

24. Nathaniel Flack and Mark Reith. Self-Directed Learning Tools in USAF Multi-Domain Operations Education. *Proceedings of the 18th European Conference on Cyber Warfare and Security*, pages 752–759, 2019.

25. Jeffrey Reilly. Multi-Domain Operational Strategist Bullet Background Paper. 2018.

26. Andrew Sarver. WSINT: Integrate, Operate, Graduate, December 2018.

27. Squadron Officer School Lesson Plan: Multi-Domain Operations. 2019.

28. Darryl Roberson and Matthew Stafford. The Redesigned Air Force Continuum of Learning: Rethinking Force Development for the Future. *LeMay Papers*, 1:1–33, 2017.

29. Landon Tomcho, Alan Lin, David Long, Mark Coggins, and Mark Reith. Applying Game Elements to Cyber eLearning: An Experimental Design. *International Conference on Cyber Warfare and Security*, pages 422–XV, 2019.

30. Peter Perla. *The Art of Wargamming: A Guide for Professionals and Hobbyists*. Naval Institute Press, Annapolis, MD, 1990.

31. James Markley. Strategic Wargaming Series: Handbook. Technical Report July, The United States Army War College, Carlisle, PA, 2008.

32. Bradley Saltzman and Michael Rothstein. Doolittle Series 18: Multi-Domain Operations Air Force Lessons Learned. *LeMay Papers*, 3, 2019.

33. Justin Reynolds. Multi-Domain Command and Control is Coming, 2018.

34. Chairman of the Joint Chiefs of Staff. Joint Training Policy for the Armed Forces of the United States, 2014.

35. David Kolb. Experiential Learning: Experience as the Source of Learning and Development. *Journal of Organizational Behavior*, 1984.

36. Edgar Dale. *Audiovisual Methods in Teaching*. Dryden Press, 1969.

37. Unknown. Digital Learning Tools and Learning Theories Continued, 2016.

38. Benjamin Bloom, Edward Engelhart, Peter Hill, and David Krathwohl. *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook 1: Cognitive Domain*. Longmans Green, New York, 1956.

39. David Krathwohl. A revision of Bloom's taxonomy: An overview. *Theory into practice*, 41(4):212–218, 2002.

40. Peter Perla and Edward McGrady. Why Wargamming Works. *Naval War College Review*, 64(3):111–130, 2011.

41. Marc Prensky. The Digital Game-Based Learning Revolution. *Computers in Entertainment*, 1(1):21–21, 2003.

42. Alessandro De Gloria, Francesco Bellotti, and Riccardo Berta. Serious Games for Education and Training. *International Journal of Serious Games*, 2014.

43. David Crookall. Serious Games, Debriefing, and Simulation/Gaming as a Discipline. *Simulation and Gaming*, 41(6):898–920, 2010.

44. Tarja Susi, Mikael Johannesson, and Per Backlund. Serious Games – An Overview. *IKI Technical Reports*, pages 1–21, 2007.

45. Clark Abt. *Serious Games*. Viking Press New York, 1970.

46. Thomas Connolly, Elizabeth Boyle, Ewan MacArthur, Thomas Hainey, and James Boyle. A systematic Literature Review of Empirical Evidence on Computer Games and Serious Games. *Computers & Education*, 59(2):661–686, 2012.

47. Elizabeth Boyle, Thomas Hainey, Thomas Connolly, Grant Gray, Earp Jeffrey, Michela Ott, Theodore Lim, Manuel Ninaus, Claudia Ribeiro, and Joao Pereira. An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers and Education*, 94:178–192, 2016.

48. Michael Hanus and Jesse Fox. Assessing the effects of Gamification in the Classroom: A Longitudinal Study on Intrinsic Motivation, Social Comparison, Satisfaction, Effort, and Academic Performance. *Computers and Education*, 80:152–161, 2015.

49. Maurice Hendrix, Ali Al-Sherbaz, and Victoria Bloom. Game Based Cyber Security Training: Are Serious Games Suitable for Cyber Security Training? *International Journal of Serious Games*, 3(1), 2016.

50. Rebecca Rhodes, Jonathon Kopecky, Nathan Bos, Jennifer McKneely, Jason Spitaletta, Alexander Perrone, Abigail Gertner, and Franklin Zaromb. Teaching Decision Making With Serious Games. *Games and Culture*, 12(3):233–251, 2017.

51. Juan Burguillo. Using Game Theory and Competition-Based Learning to Stimulate Student Motivation and Performance. *Computers and Education*, 55(2):566–575, 2010.

52. Juho Hamari, David Shernoff, Elizabeth Rowe, Brianno Coller, Jodi Asbell-Clarke, and Teon Edwards. Challenging Games Help Students Learn: An Empirical Study on Engagement, Flow and Immersion in Game-Based Learning. *Computers in Human Behavior*, 54:170–179, 2016.

53. Mark Brown. Q&A: Littleloud Talks Guilt and Gaming with Sweatshop. *Wired Magazine*, page 8, 2011.

54. Jeanne B Funk, Margaret Chan, Jason Brouwer, and Kathleen Curtiss. A biopsychosocial analysis of the video game-playing experience of children and adults in the united states. *SIMILE: Studies in Media & Information Literacy Education*, 6(3):79, 2006.

55. Bruce D. Bartholow, Brad J. Bushman, and Marc A. Sestir. Chronic violent video game exposure and desensitization to violence: Behavioral and event-related brain potential data. *Journal of Experimental Social Psychology*, 42(4):532 – 539, 2006.

56. Serious Game Society. Innovation and Play. 2016.

57. C. E. Irvine, M. F. Thompson, and K. Allen. Cyberciege: gaming for information assurance. *IEEE Security Privacy*, 3(3):61–64, May 2005.

58. David Long and Christopher Mulch. *Interactive Wargaming CyberWar: 2025.* PhD thesis, Naval Postgraduate School, 2017.

59. Phil Berube. Air University Elective Broadens SOS Students' Research Experience, 2019.

60. Jeanne M. Holm Center. Guide to Air Force Employment Exercise (AFEX), 2015.

61. Adam Shostack. Tabletop Security Games & Cards, 2019.

62. Benjamin Jensen and David Banks. Cyber Operations in Conflict - Lessons From Analytic War Games. Technical report, Center For Long-Term Cybersecurity, UC Berkeley, 2018.

63. Eddins. Byte-Size Learning. *Airman Magazine*, may 2018.

64. Robin Hunicke, Marc LeBlanc, and Robert Zubek. MDA: A Formal Approach to Game Design And Game Research. *Workshop on Challenges in Game AI*, pages 1–4, 2004.

65. Aki Jarvinen. *Games without Frontiers: Theories and Methods for Game Studies and Design*. Doctoral dissertation, University of Tampere, Finland, 2007.

66. Emmanuel Fokides, Penelope Atsikpasi, Polyxeni Kaimara, and Ioannis Deliyannis. Let Players Evaluate Serious Games. Design and Validation of the Serious Games Evaluation Scale. *ICGA Journal*, 41:1–22, 2019.

67. Wendy Bedwell, Davin Pavlas, Kyle Heyne, Eduardo Salas, and Elizabeth Lazzara. Toward a Taxonomy Linking Game Attributes to Learning. *Simulation & Gaming*, 43(6):729–760, 2012.

68. Laila Shoukry and Stefan Gobel. Reasons and Responses: A Multimodal Serious Games Evaluation Framework. *IEEE Transactions on Emerging Topics in Computing*, (July), 2017.

69. Kendra Graham, Bryce Heitmeyer, Pranav Patel, James Anderson, Scott Nykl, Laurence Merkle, and Alan Lin. Cyber Space Odyssey: A Competitive, Team-Oriented Serious Game in Computer Networking. 2019.

70. Tamara Denning, Adam Lerner, Adam Shostack, and Tadayoshi Kohno. Control-Alt-Hack: The Design and Evaluation of a Card Game for Computer Security Awareness and Education. *CCS '13: Proceedings of the 2013 ACM SIGSAC conference on Computer & communications security*, pages 915–928, 2013.

71. Lisa Pacitto. A Serious Game Enhances Organizational Agility, 2019.

72. Adam Shostack. Elevation of Privilege: Drawing Developers into Threat Modeling. *USENIX Summit on Gaming, Games, and Gamification in Security Education*, pages 1–15, 2014.

73. Louis Deslauriers, Logan McCarty, Kelly Miller, Kristina Callaghan, and Greg Kestin. Measuring Actual Learning Versus Feeling of Learning in Response to

Being Actively Engaged in the Classroom. *Proceedings of the National Academy of Sciences*, 116(39):19251–19257, 2019.

74. Wijnand IJsselsteijn, Yvonne De Kort, Karolien Poels, Audrius Jurgelionis, and Francesco Bellotti. Characterizing and Measuring User Experiences in Digital Games. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology, June 13-15, 2007*, pages 1–4.

75. Jeanne Brockmyer, Christine Fox, Kathleen Curtiss, Evan McBroom, Kimberly Burkhart, and Jacquelyn Pidruzny. The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. *Journal of Experimental Social Psychology*, 45(4):624–634, 2009.

76. Sonam Adinolf, Selen Turkay, and Devayani Tirthali. In Torpor, Not Dead: A Look at a Collectible Card Game That Sticks Around. *Proceedings of Games + Learning + Society*, 8:41–47, 2012.

77. Michael Thomas, Andria Shyjka, Skip Kumm, and Rigel Gjomemo. Educational Design Research for the Development of a Collectible Card Game for Cybersecurity Learning. *Journal of Formative Design in Learning*, 3(1):27–38, 2019.

78. Andreas Stiegler, Keshav Dahal, Johannes Maucher, and Daniel Livingstone. Symbolic Reasoning for Hearthstone. *IEEE Transactions on Games*, 10(2):113–127, 2017.

79. Alysson Ribeiro Da Silva and Luis Fabricio Wanderley Goes. HearthBot: An Autonomous Agent based on Fuzzy ART Adaptive Neural Networks for the Digital Collectible Card Game Hearthstone. *IEEE Transactions on Computational Intelligence and AI in Games*, 10(2):170–181, 2017.

80. Alan Lin and Mark Reith. Multi-Domain Command & Control Card Game Instructions. 2018.

81. Eric Hutchins, Michael Cloppert, and Rohan Amin. Intelligence-Driven Computer Network Defense Informed by Analysis of Adversary Campaigns and Intrusion Kill Chains. *6th International Conference on Information Warfare and Security, ICIW 2011*, (July 2005):113–125, 2011.

82. Kelly McCoy. In the Beginning There was Competition: The Old Idea Behind the New American Way of War, 2018.

83. Andrew Liptak. Israel Launched an Airstrike in Response to a Hamas Cyberattack, 2019.

84. Nathaniel Flack. Personal correspondence, 2019.

85. Chad Raduege. Personal correspondence. Used with permission, 2019.

86. Nathaniel Flack, Christopher Voltz, Richard Dill, Alan Lin, and Mark Reith. Leveraging Serious Games in Air Force Multi-Domain Operations Education: A Pilot Study. *International Conference on Cyber Warfare and Security*, 2020.

87. Anissa All, Nunez Castellar, Elena Patricia, and Jan Van Looy. Assessing the effectiveness of digital game-based learning: Best practices. *Computers and Education*, 92-93:90–103, 2016.

88. Igor Mayer, Geertje Bekebrede, Casper Harteveld, Harald Warmelink, Qiqi Zhou, Theo Van Ruijven, Julia Lo, Rens Kortmann, and Ivo Wenzler. The Research and Evaluation of Serious Games: Toward a Comprehensive Methodology. *British Journal of Educational Technology*, 45(3):502–527, 2014.

89. Yelim Mun, Esther Oprins, Karel Van Den Bosch, Anja Van Der Hulst, and Jan Schraagen. Serious gaming for Adaptive Decision Making of Military Personnel. *Proceedings of the Human Factors and Ergonomics Society*, pages 1168–1172, 2017.

90. Azita Iliya Abdul Jabbar and Patrick Felicia. Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review. *Review of Educational Research*, 85(4):740–779, 2015.

91. United States Air Force. Air Superiority 2030 Flight Plan, 2016.

92. Air, Land, Sea Application Center.

Acronyms

ACC Air Combat Command. 53, 100, 231, 256

ACE Advanced Cyber Education. 21, 52, 58, 186, 244, 246

ACSC Air Command and Staff College. 13, 23, 52, 60, 69, 247

ADWAR Air Doctrine Wargame. 20, 30, 44, 98

AETC Air Education and Training Command. 100

AF Air Force. 1, 2, 8, 10, 30, 100

AFB Air Force Base. 20, 244, 256

AFEX Air Force Expeditionary Exercise. 20, 44, 98

AFIT Air Force Institute of Technology. 14, 21, 48, 49, 100, 101, 234, 244, 250, 252

AFRL Air Force Research Laboratory. 53, 74, 258

AI Artificial Intelligence. 11, 25, 99

BCT Brigade Combat Team. 41

BSN Battlespace Next. iv, 4, 29, 31, 32, 37, 63, 65, 73, 78, 93, 94, 97, 125, 224, 248, 249, 251, 253, 255, 257, 258

C2 Command and Control. 12, 20, 52, 244

CCG Collectable Card Game. 20, 45, 65, 68, 79, 100

CCR Center for Cyberspace Research. 101

CEH Cyber Education Hub. 14

CG Communications Group. 226

CSAF Chief of Staff of the Air Force. 9, 93

CTD Cyber Threat Defender. 20, 25, 44

CyTCoE Cyberspace Technical Center of Excellence. 43, 100, 101

DoD Department of Defense. 1, 5, 38

ELT Experiential Learning Theory. 7, 15, 30

EMS Electromagnetic Spectrum. 7, 8

EW Electronic Warfare. 1, 7, 8, 38, 96

FOB Forward Operating Base. 249

GRILL Gaming Research Integration for Learning Laboratory. 55, 100

HP health point. 27, 224

HSR Human Subjects Research. 24, 32, 42, 48, 62, 63, 91, 92, 98, 235

IADS Integrated Air Defense Systems. 10

IO Information Operations. 1, 8, 38, 96

IRB Institutional Review Board. 48, 234

ISR Intelligence, Surveillance and Reconnaissance. 29

IST Initial Skills Training. 22, 52, 59, 74, 95

JADC2 Joint All-Domain Command and Control. 1, 4, 7, 9, 92, 95, 96, 98, 99

JFCOM Joint Forces Command. 7

LO learning objective. 16, 22, 26, 33, 34, 35, 38, 39, 72, 84, 89, 97

MDC2 Multi-Domain Command and Control. 52

MDC2 TCG The Multi-Domain Command and Control Trading Card Game. 2, 3, 4, 20, 26, 27, 30, 31, 32, 49, 125, 224, 248, 249

MDO Multi-Domain Operations. 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 22, 24, 30, 31, 32, 35, 36, 37, 38, 42, 44, 45, 46, 48, 50, 51, 52, 53, 61, 63, 67, 71, 72, 73, 74, 75, 76, 78, 79, 80, 83, 84, 86, 87, 89, 90, 92, 98, 99, 237, 240

MDOC Multi-Domain Operations Center. 40, 74, 224

MDOS Multi-Domain Operational Strategist. 13, 23, 30, 36, 37, 84, 247, 248, 254

NDS National Defense Strategy. 1

OTS Officer Training School. 20, 53, 61

PME Professional Military Education. 64, 95

POC point of contact. 53, 257

ROTC Reserve Officer Training Corps. 20, 21, 44, 53, 56, 244, 246, 254

RQ research question. 3, 48, 63

SD Standard Deviation. 64

SG serious game. xii, 2, 3, 4, 5, 6, 7, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 30, 32, 42, 48, 49, 50, 52, 55, 58, 62, 63, 66, 68, 76, 81, 85, 87, 89, 91, 92, 94, 95, 97, 98

SME subject matter expert. 31, 79

SOS Squadron Officer's School. 13, 30, 53, 61

TCG Trading Card Game. 25, 45

TRADOC Training and Doctrine Command. 10, 102, 231

U.S. United States. 1, 4, 7, 9, 10, 14

WSINT Weapons School Integration. 13

WWII World War II. 45

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
03/26/2020	Master's Thesis	Sept 2018 - March 2020

4. TITLE AND SUBTITLE
Developing a Serious Game to Explore Joint All-Domain Command and Control

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Flack, Nathaniel W, Capt, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way
Wright-Patterson AFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT-ENG-20-M-019

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Cyberspace Technical Center of Excellence
2950 Hobson Way
Wright-Patterson AFB OH 45433-7765
cytcoeworkflow@afit.edu

10. SPONSOR/MONITOR'S ACRONYM(S)
AF CyTCoE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution Statement A. Approved for Public Release; Distribution Unlimited.

13. SUPPLEMENTARY NOTES
This work is declared a work of the U.S. Government and is not subject to copyright protection in the United States.

14. ABSTRACT
Changes in the geopolitical landscape and increasing technological complexity have prompted the U.S. Military to coin Multi-Domain Operations (MDO) and Joint All-Domain Command and Control as terms to describe an over-arching strategy that frames the complexity of warfare across both traditional and emerging warfighting domains. Teaching new and advanced concepts associated with these terms requires both innovation as well as distinct education and training tools in order to realize the cultural change advocated by senior military leaders. BSN, a Collectible Card Game, was developed to teach concepts integral to MDO and initiate discussion on military strategy.

15. SUBJECT TERMS
Joint All-Domain Command and Control (JADC2); Multi-Domain Operations (MDO); Wargamming; Serious Games;

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Mark G. Reith, AFIT/ENV
					19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	288	937-255-3636 x4603

INSTRUCTIONS FOR COMPLETING SF 298

1. REPORT DATE. Full publication date, including day, month, if available. Must cite at least the year and be Year 2000 compliant, e.g. 30-06-1998; xx-06-1998; xx-xx-1998.

2. REPORT TYPE. State the type of report, such as final, technical, interim, memorandum, master's thesis, progress, quarterly, research, special, group study, etc.

3. DATE COVERED. Indicate the time during which the work was performed and the report was written, e.g., Jun 1997 - Jun 1998; 1-10 Jun 1996; May - Nov 1998; Nov 1998.

4. TITLE. Enter title and subtitle with volume number and part number, if applicable. On classified documents, enter the title classification in parentheses.

5a. CONTRACT NUMBER. Enter all contract numbers as they appear in the report, e.g. F33315-86-C-5169.

5b. GRANT NUMBER. Enter all grant numbers as they appear in the report. e.g. AFOSR-82-1234.

5c. PROGRAM ELEMENT NUMBER. Enter all program element numbers as they appear in the report, e.g. 61101A.

5e. TASK NUMBER. Enter all task numbers as they appear in the report, e.g. 05; RF0330201; T4112.

5f. WORK UNIT NUMBER. Enter all work unit numbers as they appear in the report, e.g. 001; AFAPL30480105.

6. AUTHOR(S). Enter name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. The form of entry is the last name, first name, middle initial, and additional qualifiers separated by commas, e.g. Smith, Richard, J, Jr.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES). Self-explanatory.

8. PERFORMING ORGANIZATION REPORT NUMBER. Enter all unique alphanumeric report numbers assigned by the performing organization, e.g. BRL-1234; AFWL-TR-85-4017-Vol-21-PT-2.

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES). Enter the name and address of the organization(s) financially responsible for and monitoring the work.

10. SPONSOR/MONITOR'S ACRONYM(S). Enter, if available, e.g. BRL, ARDEC, NADC.

11. SPONSOR/MONITOR'S REPORT NUMBER(S). Enter report number as assigned by the sponsoring/ monitoring agency, if available, e.g. BRL-TR-829; -215.

12. DISTRIBUTION/AVAILABILITY STATEMENT. Use agency-mandated availability statements to indicate the public availability or distribution limitations of the report. If additional limitations/ restrictions or special markings are indicated, follow agency authorization procedures, e.g. RD/FRD, PROPIN, ITAR, etc. Include copyright information.

13. SUPPLEMENTARY NOTES. Enter information not included elsewhere such as: prepared in cooperation with; translation of; report supersedes; old edition number, etc.

14. ABSTRACT. A brief (approximately 200 words) factual summary of the most significant information.

15. SUBJECT TERMS. Key words or phrases identifying major concepts in the report.

16. SECURITY CLASSIFICATION. Enter security classification in accordance with security classification regulations, e.g. U, C, S, etc. If this form contains classified information, stamp classification level on the top and bottom of this page.

17. LIMITATION OF ABSTRACT. This block must be completed to assign a distribution limitation to the abstract. Enter UU (Unclassified Unlimited) or SAR (Same as Report). An entry in this block is necessary if the abstract is to be limited.