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Developing and Assessing a Workshop That Utilizes a Serious Game to Introduce Joint All-domain Operations

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DEVELOPING AND ASSESSING A WORKSHOP THAT UTILIZES A SERIOUS GAME TO INTRODUCE JOINT ALL-DOMAIN OPERATIONS

THESIS

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Abstract

The DoD has begun developing Joint All-Domain Operations (JADO) to prepare for the future of warfare. As complexity and technological capability increases, the U.S. military needs to adapt to provide a more lethal and capable force, able to compete and win against near-peer adversaries. To achieve the proposed changes, the U.S. military services need to educate their servicemembers. General Charles Brown, current Chief of Staff of the Air Force, has issued the CSAF Action Orders to Accelerate Change Across the Air Force emphasizing the need to transform education to emphasize warfighting. Previous research suggested that BattleSpace Next (BSN), a serious game designed to discuss JADO concepts, was an accessible and effective tool to help students engage with JADO ideas. A survey of current educational opportunities for U.S. Air Force members showed a gap in formal introduction to JADO opportunities. This research describes the development of an Introduction to JADO Workshop designed to provide a structured primer into JADO concepts. The research also presents an extension of BSN in the form of BSN scenarios. These scenarios alter the rules to lessen the learning curve for the game and to engage with JADO concepts. Survey and debrief results provide evidence that the workshop was an effective introduction to JADO. More specifically, participants that completed the workshop were confident in their knowledge in the key areas of command and control, fires, information, and logistics. The scenarios provided a gradual introduction and influenced decisions on later playthroughs. The debrief results suggested that the participants took the game play and connected it to the material discussed during the lecture portions. Additional evaluation from JADO SMEs indicated that the workshop could be useful for filling gaps in the education pipeline. This research

proposed a format for future JADO education course, refined the BSN tool to improve effectiveness, measurement of the response to JADO education, and an assessment of the workshop from JADO leaders across the Air Force.

Dedicated to Christ, my Savior,

and Abbey, my wife

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DEVELOPING AND ASSESSING A WORKSHOP THAT UTILIZES A SERIOUS GAME TO INTRODUCE JOINT ALL-DOMAIN OPERATIONS

I. Introduction

1.1 Background

The 2018 National Defense Strategy (NDS) [1] announced a pivot from terrorism to prioritize inter-state competition. The NDS names China and Russia as revisionist powers using economic, political, and military power to increase their regional and global influence [1]. Since the NDS publication, the term "near-peer competitor" also describes these nations [2] [3] [4]. In 2019, General David Goldfein, former Chief of Staff of the Air Force (CSAF), discussed Multi-Domain Operations (MDO) to address the new challenges and complexity of future conflicts, particularly against potential near-peer adversaries [5]. United States (U.S.) military services adopted this idea and renamed it Joint All-Domain Operations (JADO). Including Joint in the term signifies collaboration is necessary to these concepts. The current domains are air, land, maritime, cyber, and space. Additional areas of importance are Electromagnetic Spectrum (EMS) and information operations. JADO seeks to utilize the intersection of the domains, EMS, and information operations to create advantages. In future conflict, the U.S. will need to maintain its freedom of maneuver through the continuum of domains and deny adversaries their freedom of maneuver [6] [7]. The current CSAF, General Charles Brown, has stated the need to transform education to prepare Airmen for the expected inter-state competition and warfighting [8]. The U.S. Air Force requires a greater amount of JADO education opportunities. JADO education

must be agile to incorporate developing concepts. This research recommends and develops an introduction to JADO workshop to address some of this challenge.

1.2 Problem Statement

JADO education is insufficient and, if not addressed, will compromise the U.S.'s future competition ability. The Multi-Domain Command and Control (MDC2) Implementation Plan [9] calls for hands-on education in both current courses and future JADO courses to understand this new concept. The current CSAF Action Orders To Accelerate Change Across the Air Force [8] identifies the need for appropriate levels of educational tools. Despite these calls for more engaging content and new courses, a significant gap currently exists in the education pipeline for widely accessible, structured introductions to JADO concepts that emphasize hands-on education.

1.3 Hypothesis

This research hypothesizes that JADO subject matter experts (SME) will have a positive assessment of the workshop measured through a survey. The research also hypothesizes that Department of Defense (DoD) participants will respond positively to an introductory JADO workshop leveraging a serious game and tailored scenarios. This hypothesis is based on previous serious game research discussed in Chapter II and the need for JADO education.

1.4 Research Objectives

This research creates and evaluates a workshop to teach basic JADO concepts, engage participants, and advance knowledge of JADO concepts using a serious game. The research leverages the serious game BattleSpace Next BSN to facilitate discussions among participants across multiple learning objectives. The research method-

ology creates BSN scenarios that adjust game rules. The changes connect game mechanics to specific JADO concepts. This extends BSN by reducing game complexity and decreasing ambiguity. The research methodology also creates a workshop to support the CSAF Action Orders to Accelerate Change Across the Air Force. This effort addresses the following research questions (RQ):

RQ1: What benefits can an introductory JADO workshop provide to new JADO learners?

RQ2: Which topics are most important to communicate to facilitate JADO learning?

RQ3: What is the response to the use of BattleSpace Next scenarios to highlight specific learning objectives?

RQ4: What are SMEs' assessments of the effectiveness of a JADO workshop using a serious game?

RQ5: What are participants' assessments of the effectiveness of a JADO workshop using a serious game?

RQ1 is designed to highlight different understandings of what JADO education should entail. The answers provided by SMEs are useful to address DoD needs. The workshop participants provide what they want to learn from an introductory level workshop. RQ2 builds upon RQ1 by describing what is essential in an introductory JADO workshop. SMEs provide information that guides future refinement of the workshop and lessons to focus on. The answers from the workshop participants can indicate some current understandings and priorities from individuals interested in learning about JADO. RQ3 seeks to describe the effects of the scenarios in the BSN framework. SME responses to the question may be theoretical because they will not play through the scenarios. The participants can describe benefits and rec-

ommend specific improvements based on their gameplay experience. RQ4 and RQ5 are included to assess the overall workshop effectiveness. They are separated between SMEs and participants to account for the differences between how SMEs and participants engage with the material.

1.5 Approach

The proposed research performs two experiments to address the RQs. The first experiment is the JADO SMEs assessment of the workshop and BSN scenarios. SMEs are provided the material and participate in a discussion about the workshop. Following that, SMEs provide feedback on their assessment on key parts of the workshop. The second experiment is running an instance of the workshop to evaluate workshop and BSN scenario effectiveness from a learner's perspective. This experiment gathers data through a pre-workshop and post-workshop survey. The data gathered by this project contributes to shaping a structure for Airmen to gain an introduction to JADO. The results from these two experiments provide answers to the above research questions.

1.6 Assumptions and Limitations

The below assumptions are identified in relation to JADO learning and the evaluation of serious games:

- Self-reported learning is sufficient to characterize the learning obtained by participants in the workshop.
- JADO workshop participants have no prior JADO experience.

Specific limitations for each experiment are discussed in Chapter III.

1.7 Contributions

This thesis contributes to the fields of JADO and serious games through 4 primary contributions.

- A proposed JADO introduction format. JADO concepts are rapidly developing and Air Force leadership has emphasized the need for education. Currently, there is not a structured method for servicemembers to find and utilize resources that teach JADO.

- The refinement of an educational framework. Flack [10] showed BSN to be an accessible engaging learning tool. However, some participants struggled with the complexity of the game and with the ambiguity of JADO. This research deconstructs Flack's level 2 of BSN to start with a simplified version and progress to the full BSN game. This approach gives players time to understand the simple game mechanics and adjust to the complex mechanics. Each scenario uses a topic and specific learning objective to help participants tie game mechanics to JADO concepts, thus addressing the ambiguity challenges.

- Measurement of response to JADO education. JADO education requires improvement today. Making the material accessible so that it can be evaluated and improved is the first step to meeting the CSAF's goals.

- Assessment from JADO leaders across the Air Force. JADO requires the cooperation of many different programs and people to reach U.S. objectives. This research sought out partnerships and feedback to take input and consideration from these experts.

1.8 Document Overview

This thesis document is arranged in five chapters. Chapter II discusses the nature of JADO, serious games and wargaming, and learning theory. Chapter III describes the creation of the introductory workshop, the SME assessment experiment, and the human subjects research. Chapter IV presents the results from both experiments with analysis of the data. Chapter V summarizes the research, discusses its significance and presents suggestions for future research.

II. Background and Literature Review

The purpose of this chapter is to provide a review of the relevant literature for this research. Section 2.1 describes MDO and JADO, Section 2.2 describes learning theory, and Section 2.3 describes serious games.

2.1 MDO, JADO, JADC2

2.1.1 The Call for Change

A recent pivot described in the 2018 National Defense Strategy stated that, "Interstate strategic competition, not terrorism, is now the primary concern in U.S. national security" [1]. Additionally, the threat is deemed long term, suggesting that it requires constant improvement and effort to maintain advantages to defend the U.S. and its allies. While the focus is on near peer adversaries, such as China and Russia, rogue regimes, including Iran and North Korea, are an increasing priority [1]. Synergistic effects between domains are essential to maximize effectiveness and overcome situations where the U.S. does not expect consistent supremacy in all domains [11].

Instead of explicitly discussing domains, current Joint Doctrine on operations instead describes operational environments as "physical domains of the air, land, maritime, and space domains; as well as the information environment (which includes cyberspace) as well as the electromagnetic spectrum" [12]. A lack of defining terms in Joint doctrine creates ambiguity for servicemembers [13]. This is insufficient as General Eric Wesley, then director of Futures and Concepts Center and deputy commanding general of U.S. Army Futures Command, stated, "You just can't have different services have their own MDO concepts and federate them together" [14]. Consider the similarities and differences between the following definitions. Air Force doctrine's working definition of domain is "A sphere of activity of influence with com-

mon and distinct characteristics in which a force can conduct joint functions" [15]. This definition is fairly broad and may not indicate key characteristics of domains. Army doctrine uses the Merriam-Webster Dictionary definitions of domain to split into different focuses. The definition used for leadership and training purposes is "a territory over which dominion is exercised" [16]. The operational definition is "a sphere of knowledge, influence, or activity" [16]. While the Army's second definition partially overlaps with the Air Force's definition, the services need to be in lockstep to succeed in preparing for JADO. Another definition proposed by Dr. Jeffrey Reilly, a JADO leader at the Air Command and Staff College (ACSC), "A domain is a critical macro maneuver space whose access or control is vital to the freedom of action and superiority required by the mission" [17]. This definition has greater detail than the current Air Force and Army definitions. Fortunately, both Army and Air Force doctrine agree that the warfighting domains consist at least of air, land, maritime, space and cyberspace [15] [16]. However, the EMS is emphasized as an independent key entity in both Air Force and Joint doctrine [12] [15]. A potential additional domain is termed the cognitive or human domain. The rising focus on information warfare and the inherent importance of the human aspect of war has led to some, including leading JADO thinkers such as General Robert Brown and Dr. Reilly, calling it the most important domain as well [18] [19]. One recent experiment in this area took place in 2019 where some researchers participated in a North Atlantic Treaty Organization (NATO) military exercise. Within four weeks, the researchers were able to gather information through social engineering and social media that allowed them to compromise individuals taking part in the exercise. This compromise ranged from gaining sensitive information on their activities to persuading them to disobey orders. These compromises happened even though social media sites such as Facebook were actively attempting to decrease this kind of abuse. A key finding was that human

weaknesses and mistakes were significant vulnerabilities despite military training to address them. Stricter training in this regard was suggested to help protect troops from future attacks [20].

Understanding that there has been a need for the services to work together in a joint fashion is not new. The U.S. Strike Command was formed to integrate the separate services' capabilities together in 1961. However, the services fought the Strike Command. By 1972, they had removed much of its power, and renamed it the U.S. Readiness Command [21]. The Joint Forces Command (JFCOM) was officially established on 1 October 1999 and would be the United States' main force integrator and in charge of joint training and experimentation [22]. By 2010, there was belief that "Jointness is such an accomplished fact among the services... that it no longer needed a four-star champion" [21]. This claim was made based on 10 years of operations focused on the counter-terrorism mission. One aspect of that claim was that the individual services could establish dominance in their primary domains more easily than against a near-peer adversary. Furthermore, "semi-official concepts like 'rapid, decisive operations' and 'effects-based operations' have contributed to doctrinal confusion", which made officials question the command's importance [21]. Due to questionable relevance and the need to save money, JFCOM was deactivated on 31 August 2011 [22]. Killebrew noted that JFCOM provided three functions that would still be needed after JFCOM was deactivated: the monitoring and promotion of joint readiness and the integration of technology between services; concept development with our allies; and development of effective joint doctrine [21]. Today those three functions are all atrophied relative to what the military needs to compete against near-peer enemies [1] [15] [16] [23] [24].

The NDS has called for the U.S. military to prepare for potential conflict against near-peer adversaries. Due to the additional complexities of modern warfare and

potential benefits from cyber, information warfare, and the EMS, failure to adopt JADO principles could put our military at risk.

2.1.2 Key Terminology and Ideas

An early description of the JADO operational concept was MDO, which the Army initially called Multi-Domain Battle. By late 2019, the Joint Staff took charge and updated this term to JADO [25]. The change reflects the fact that operations could be in multiple domains but not joint. One example would be an operation that included army helicopters and ground troops. While this operation consists of utilizing different domains, it is not a joint operation. In order to achieve the highest levels of effectiveness, maximizing joint synergy is a requirement [15]. The term changed to JADO, emphasizing this importance. This thesis will utilize the term JADO to encapsulate ideas discussed by MDO, JADC2, and JADO.

Convergence is a key concept to create a system that is greater than the sum of its parts. The fires function is, "to use available weapons and other systems to create a specific effect on a target" [12]. JADO fires seek to achieve convergence, "the synchronization and integration of kinetic and non-kinetic capabilities to create lethal and nonlethal effects" [15]. Operations in different domains require differing amounts of lead time to be effective in operations. For example, cyber operations typically requires a longer lead time due to the high-level authorities involved and the time it takes to infiltrate a network. Bringing different assets together can help overcome traditional mass in battle, thus giving a military force a tangible advantage [15]. Current understandings for the relative timeframes required of operations in differing domains is displayed below.

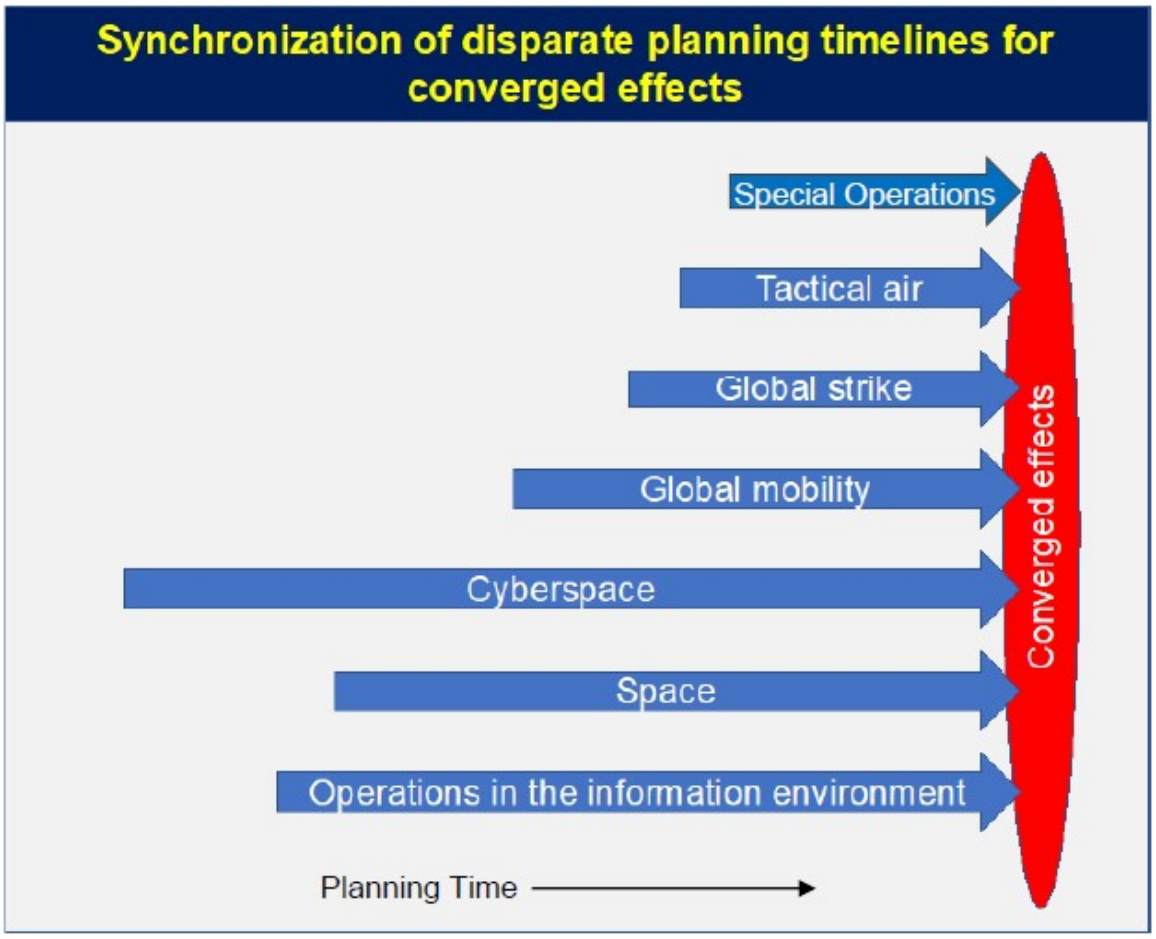


Figure 1: Synchronization of Disparate Planning Timelines for Converged Effects[15]

2.1.3 Enabling Technologies

A contributing factor to support JADO is the emergence of technology that enables increased maneuverability in battle spaces. As technology has developed, the U.S. Military has gained increased access to the domains as well as increased opportunities for cross-domain effects. Understanding and adapting to these changes will be key to maintaining and improving military capability.

2.1.3.1 Distributed Networks and Systems

The concept of storing data in multiple places to offer redundancy and improve performance and availability is not a new concept. Some advantages associated with distributed networks include ease of sharing information, scalability, node redundancy, and resource sharing capabilities [26]. Some drawbacks include complexity, security challenges and initial cost, though it is noted that over time it can become more cost effective [27]. Despite a likely higher operating cost, the adoption of a distributed network adds robustness, and this is an expected tradeoff of warfare in the JADO model [15]. This concept is increasingly important to protect U.S. assets and ensure the U.S. network. Two primary methods of communication over long distance in the Pacific, communications satellites and undersea cables, are at high risk due to a combination of vulnerability to attack and relatively few nodes [28]. Losing communications could lead to disorientation and a slowing of operations, giving an adversary the advantage. Some Air Force alternatives to address this difficulty include using aircraft as couriers and line-of-sight datalink relays [28].

2.1.3.2 Artificial Intelligence

The role of Artificial Intelligence (AI) in JADO is to enhance the warfighter's capabilities and improve decision-making speed, not replace the warfighter [23]. One such example involved a recent Defense Advanced Research Projects Agency (DARPA) led challenge. In the challenge, competitors designed algorithms focused on dogfighting. The system developed by Heron Systems beat a human pilot five times with zero losses. This success was a step in the path "to demonstrate a collaborative relationship with an AI agent handling tactical tasks like dogfighting while the onboard pilot focuses on higher-level strategy as a battle manager supervising multiple airborne platforms" [29]. This could allow the pilot to make sure that information obtained by

the other platforms is being sent and received by other units in the battlespace. An example would be the pilot would not have to focus on the dogfight and instead focus on coordinating with nearby army units about the enemy's position. Other proposed tasks where AI is expected to have an impact include data analysis, airspace deconfliction, and planning aids [23]. The DoD also faces challenges in developing algorithms and providing the necessary training data [30]. Additional challenges include operating in a dynamic environment where decisions must be timely, using datasets that are owned by different organizations, and protecting against adversarial inputs [31].

2.1.3.3 Cloud Computing

Cloud computing provides internet access to computing resources hosted in a remote data center [32]. Cloud computing has several benefits that enable JADO including security, scalability, increased collaboration, and loss prevention [33]. The Air Force has been moving forward with its Cloud One "common development, test and production computing environment" [34]. Cloud One provides four services: "secure cloud hosting, cloud onboarding, cloud migration as a service, and secure cloud data transport" [35]. The Joint Artificial Intelligence Center (JAIC) has also used Cloud One to develop AI for the DoD [36]. In addition to moving hundreds of mission applications to the cloud, the Air Force is investing in enterprise-IT-as-a-service to improve infrastructure and modernize DoD capabilities [37]. The Army has a "long-term objective to reduce the ownership, operation and sustainment of hardware and other commoditized IT" [38]. The improvements from these efforts will help support JADO by enabling the Department of the Air Force to support increased information sharing, integrated planning, and risk mitigation [15].

2.1.4 Challenges

The DoD must overcome several challenges to achieve JADO capabilities. The DoD is working to change its practices to be consistent with JADO principles, such as agility and resilience. Additionally, the military is seeking to modernize and develop JADO concepts.

2.1.4.1 Acquisitions

Traditional methods and practices for acquisitions of systems are no longer sufficient. The F-35 program began in 1992 and did not have a single combat operation until 2018 [39] [40]. Moving forward, that pace is too slow. Additionally, acquisitions will have to balance the emphasis on interoperability and the importance of businesses intellectual property [41]. Systems need to be based on open architecture and the required level of flexibility cannot be provided by a single vendor. Different systems have to share data with the other assets in use [42].

2.1.4.2 Technology

One challenge in the technology field is that the military is seeking to modernize and utilize new technologies, which will take time and effort [43]. A key aspect of enabling a JADO network is interoperability and communication between nodes that have different hardware and software [15]. This is a hard problem because no standard exists and no requirement for a standard is asserted across the services and allies [23].

2.1.4.3 Doctrine

The first challenge regarding doctrine involves several different, relevant authorities writing JADO doctrine. Each service develops doctrine for their members that reflects service level perspectives. Service doctrine needs to be consistent with joint

doctrine and add detail describing how the service contributes to the overall strategic goals. An example is "there are currently three service-level perspectives on air doctrine, but only one joint doctrine on air that is authoritative for joint air operations" [44]. A second challenge is the lack of JADO comprehension and mastery. Doctrine must continue to evolve to describe current best understandings [15]. As previous understandings evolve, doctrine needs to remain flexible. Constant change can also create additional burden on learners that want to understand current best practices. Lieutenant General James Rainey, commander of the Army Combined Arms Center, notes that doctrine needs to be consistent with multidomain operations but also be realistic about capabilities [14]. Current Air Force doctrine discusses JADO impacts and changes for command and control, information, fires, and logistics.

2.1.4.4 Training

Training has two major challenges. The first is overcoming previous notions of how things are as the DoD changes mindsets. For example, "We've got to fight through the tendency to have a service solution only, a single-service solution, which is the way we grew up" [23]. Air Force doctrine calls for changing how the Air Operations Center (AOC) makes orders because the traditional process takes too long and is too centralized to survive the expected conditions of fighting a peer nation [15]. The second major challenge is the need to provide this material in a useful way to large amounts of the force so that it can be understood and implemented.

2.1.5 Current Education Opportunities

Education and training are essential aspects in the DoD's plans to take advantage of JADO concepts. Air Force doctrine states "Experiments, wargames, and exercises will refine JADO operational principles" [15]. In the MDC2 Implementation plan [9],

Air Education and Training Command (AETC) is called on to develop wargames and doctrine to define and iterate on understandings for operating in multiple domains. It also calls for AETC to certify that the "Air Force's Continuum of Learning provides Airmen with a broad understanding of multi-domain operations and Air Force C2 concepts and capabilities" [9]. This suggests the importance of sharing JADO knowledge and spreading it among the force to the highest degree possible. However, the wargames and conferences are limited in how many participants they can afford. The rest of the population is only given the doctrine and articles with some videos of people discussing. This does not provide sufficient interaction for the vast majority of the force [24].

Source	Target Audience	JADO Role	Comments
Doctrine	· Joint: All services · Service-specific: 1 service	· Lay out understanding of best practices · Classified doctrine has increased relevance and detail but lower accessibility	
LeMay Center	· USAF	· Develop authoritative material for USAF and wargames to test concepts	Includes Air Force Doctrine
OTH	· Anyone	· Propose ideas and promote conversation on security topics. Develop in discuss concepts with a large audience.	Most useful for intermediate to advanced learners, but does have some resources for beginners
RAND	· DoD	· Studies to provide data to influence policy. Useful for specific topics.	
JADO APAN site	· USAF	· Supposed to serve as a hub of JADO ideas and discussion	Still seems to be in early stages.
News Articles	· Anyone	· Surface-level updates and quotes about JADO	Can connect learners to other resources and inform on major advances
13O Course	· New 13O Career Field Officers	· Create experts to lead future JADO operations	This course is designed for a specific career field. It has depth and opportunities for learning.
SOS	· USAF Captains	· Educate mid-career officers and develop a Joint awareness	Phase 3 is the JADO phase and includes wargames and a capstone
Advanced Courses	· Military personnel for Advanced topics	· Provide advanced, career-specific training	
Proposed Workshop	· Intro to JADO (DoD)	· Provide a structured introduction to a broad audience	Proposed in this paper

Table 1: Survey of JADO Education Sources

Voltz et al. [45] proposed Table 1 with current educational opportunities to illustrate the current gap in formal education currently available to introduce military members to JADO. Currently the most focused resources are inaccessible to the majority of the DoD. This exclusivity is useful for the courses because it allows greater depth, however, servicemembers that do not have access to these courses could also benefit from learning JADO concepts. While doctrine is essential for grounding ideas, it requires other sources to add substance and engage learners. JADO terms have evolving definitions and there are inconsistencies between the sources [44]. An introductory course can clear up misunderstandings by providing a baseline that learners

across the DoD can reference.

2.1.6 Current Projects and Research

2.1.6.1 Project Convergence

Army's Project Convergence is "a campaign of learning to aggressively pursue an Artificial Intelligence and machine learning-enabled battlefield management system" [46]. Operation Convergence was one of the first major events in Project Convergence. Operation Convergence is a U.S. Army-led operation that has been deemed "this generation's digital Louisiana Maneuvers" [47], figuring out how to use technology to fight in a fundamentally different way. It will focus on practicing maneuvers in accordance with Multidomain concepts and new assets in an attempt to test what is feasible today [47]. Wargames such as this will be essential both to test new concepts and see how Joint Forces will be able to work together in combat type situations. Project Convergence is also attempting to project how currently existing and future technologies can improve operations [48]. The army has emphasized demonstrating technologies quickly to develop AI and networked technologies [46].

2.1.6.2 Advanced Battle Management System

The Advanced Battle Management System (ABMS) is the U.S. Air Force's plan to create an architecture to connect the sensors and move data where it needs to go. One of the main focuses is providing the ability to allow assets from each of the services to communicate among each other quickly and accurately. Currently it is still being planned, and Congress has some worries that it is not sufficiently defined [49] [50]. However, this architecture could be the key to enabling JADO if it can become a reality [51].

2.1.6.3 Project Overmatch

The Air Force and Army have discussed combining their networking efforts together. However, the U.S. Navy is not currently part of that collaboration [52]. The Navy is working to move away from platform-centric capabilities and to network capabilities. Part of that effort is understanding the potential of unmanned naval systems and improving long-range precision fires [53]. The Navy has also emphasized the importance of being able to communicate with the other services when both systems are operational in the future [53] [54]. The Chief of Naval Operations, has assigned Rear Admiral Doug Small, "to develop the networks, infrastructure, data architecture, tools, and analytics that support the operational and developmental environment that will enable our sustained maritime dominance" [55].

2.1.7 Why Educate Now

Doctrine is changing and JADO concepts are not fully understood nor developed. While results from investigating JADO may change what needs to be taught, the DoD cannot wait to begin educating servicemembers. First, the U.S. is attempting to pivot quickly and meet near-term goals. To achieve this, servicemembers need a basic understanding of the new direction to improve collaboration and align efforts. Second, technology is evolving so quickly that the U.S. Military needs a capability to quickly pivot the force when needed. The DoD should not let perfection get in the way of good enough and as it evolves to meet new demands.

2.2 Learning Theory

Understanding how to teach JADO is a major challenge to address to help modernize the force. For a formal education tool, understanding the science behind learning theory is essential to provide and present objectively better content. Relying on

scientifically-related evidence as opposed to the instructor's intuition is likely to be more consistently successful [56]. Section 2.2.1, Section 2.2.2, Section 2.2.3 discuss Behaviorism, Cognitivism, and Contructivism respectively, to address the major schools of thought of learning theory. Section 2.2.4 describes Bloom's taxonomy. Section 2.2.5 section 2.2.6, will discuss Gagné's Theory and Experiential Learning Theory (ELT) which are helpful to consider for gaining learner attention and improving retention. Section 2.2.7 discusses Dale's Cone of Experience. Section 2.2.8 and Section 2.2.9 describe two modern teaching concepts of modularization and the flipped classroom. Finally, Section 2.2.10 describes an Air Force effort list of principles for education.

2.2.1 Behaviorism

Behaviorism is based on the premise that the learner is a blank slate and learns through provided information and outside stimulus [57]. The primary factor is environmental factors while the learner receives less emphasis. Review is required to maintain a learner's ability to respond to a certain stimulus [58]. Transfer is achieved through taking general features from a known stimulus and applying them in new situations. The end goal of a behaviorist instructor is to have the student respond to a stimulus as anticipated [59]. The behaviorist instructor finds an external stimulus creates the desired response and gives it to the student with reinforcement until it is learned [60]. Because JADO is currently in a developing phase and emphasizes flexibility to respond and overwhelm opponents, this theory will likely initially be limited.

2.2.2 Cognitivism

Cognitivism focuses on the students thinking and processing the information as opposed to simply reacting to it [57]. It emphasizes how the student breaks down

information and what information they know [61]. Unlike behaviorism, the learner is not a blank slate and individual characteristics such as thoughts and beliefs are considered important [62]. Transfer occurs when learners apply knowledge they have in new contexts [59]. Feedback and task analyses are key to helping guide the learner to make connections [63]. The cognitivist professor focuses on helping the learner reorganize thoughts in a way that taps into previous knowledge and skills, and reframes them to new ideas [64]. A criticism of JADO is that it is not new but just a new term for old ideas. While JADO does draw on old ideas it seeks to apply new technologies and capabilities to use them more effectively. Thus, cognitivism's focus on taking old knowledge and applying it in new ways seems promising.

2.2.3 Constructivism

Constructivism is a learning theory that believes that individuals make new ideas created from their personal experiences. Since it is not the best method for consistent outcomes, it is not the most common military approach [57]. However, encouraging military members to apply their own experiences to help make JADO practices better grounded and more understandable is an important part of developing JADO. It is the interplay of the world and an individual that creates knowledge which means there is not an objectively correct meaning [65]. Transfer occurs when the learner does or experiences something. A constructivist has little hope for learning without experience [59]. While constructivism has the highest focus on the learner, the instructor facilitates learning by framing what should be learned and creating scenarios that give the learner legitimate experiences [66]. A constructivist mindset can be a part of the use of serious games, as learners take elements they learn through play and apply them to past experiences and lessons.

2.2.4 Bloom's Taxonomy

Benjamin Bloom proposed his framework as a way to map different levels of mastery of a subject to specific levels or abilities [67]. This was created to help standardize test items among different instructors to help measure the same objectives. It was also designed to give educators a common language to discuss learning material. This original taxonomy presupposed that mastery of a lower category was a prerequisite to mastery of subsequent levels.

Later, Krathwohl [68] proposed a revision to Bloom's original to further differentiate the levels. Figure 2 shows the Krathwohl's modifications [69]. Krathwohl kept 6 categories but changed them to better fit the vernacular used by instructors. Additionally, he modified what was the knowledge category as it was different in substance from the other levels. Krathwohl's revision is still a hierarchy however, it is no longer strict and some subsections of a lower level may still be considered a higher complexity than a subsection in a higher level. This research will use Krathwohl's revision to help classify learning objectives.

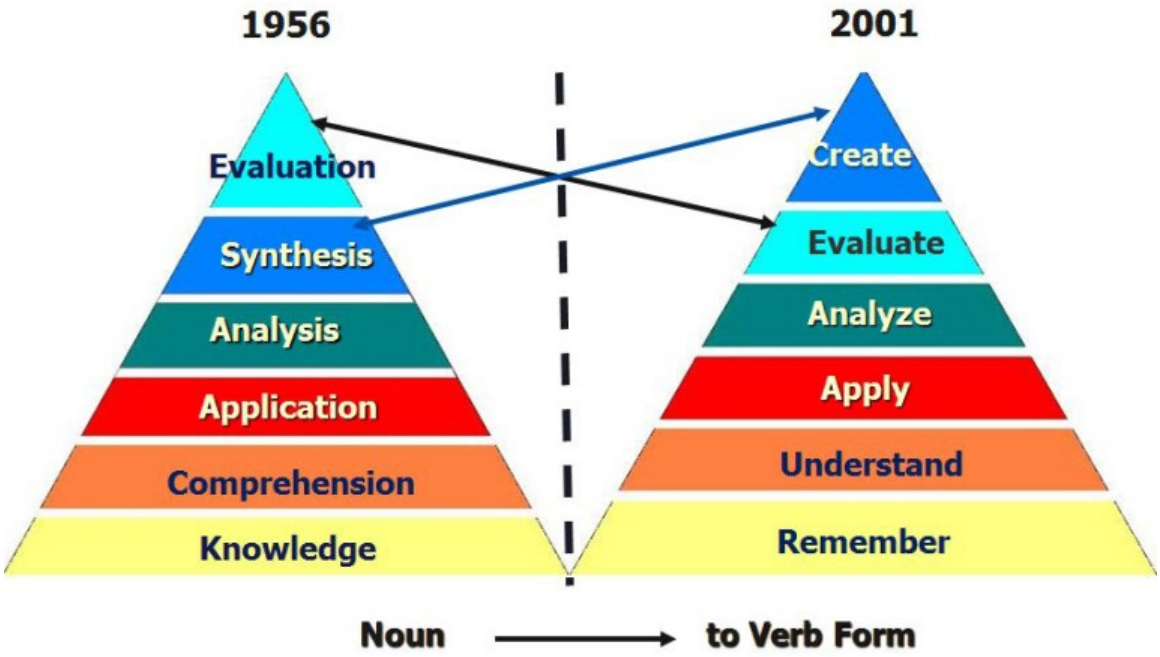


Figure 2: Bloom's Taxonomy and Krathwohl's Revision

2.2.5 Gagné's Theory

Gagné's Theory includes 9 different events to satisfy the requirements for learning. His 9 different events are useful for planning a lesson of instruction and can also assist in selecting the best way to transmit the information [70] [71]. Gagné's 9 steps are:

1. Gain attention of the students
2. Inform students of the objectives
3. Stimulate recall of prior learning
4. Present the content
5. Provide learning guidance
6. Elicit performance (practice)

7. Provide feedback

8. Assess performance

9. Enhance retention and transfer

Working to include progression through Gagné's 9 steps when using digital learning can help the instructor include the materials for a student to achieve beneficial levels of learning. Since the proposed workshop will be delivered in a digital format, these steps will need to be considered for each module.

2.2.6 Experiential Learning Theory

(ELT) presupposes that "Ideas are not fixed and immutable elements of thought but are formed and re-formed through experience" [72]. This lines up with current JADO doctrine, "Near-term approaches are grounded in operational experience... Experiments, wargames, and exercises will refine JADO operational principles" [15]. The idea that this field will be a continually changing process means that ELT is likely a closer fit for learning the new aspects of JADO. ELT will be included in the workshop through the use of BSN, scenarios, and discussions.

2.2.7 Dale's Cone of Experience

Active participation is necessary to assist the military in learning and applying JADO concepts. Dale's cone of experience proposes that learners better retain information from doing when compared to traditional methods of teaching such as listening, hearing, and observing [73]. The higher ends of the cone or pyramid graphically illustrates the activities that correlate to lower recollection. Experiences towards the bottom represent activities that, according to Dale, have higher retention. Figure 3 shows Dale's Cone of Experience and retention rates. It also describes learning outcomes [74]. Some of these activities, such as role-play a situation, model or simulate

a real experience, or participate in a hands-on workshop are methods that the DoD is focused on utilizing for the instruction of JADO topics. Serious Games may provide a sufficient hands-on experience that is more accessible than some of the larger events that the DoD has planned for teaching these subjects.

Figure 3: Dale's Cone of Experience

2.2.8 Modularized Education

One of the challenges in modern education is to develop people who are knowledgeable in multiple evolving disciplines. Modular learning helps people learn in shorter amounts of time by breaking the information into smaller "chunks" and allowing students to set their own pace [75]. Additionally, AETC has noted that modular learning makes information more "consumable" and allows Airmen to focus on spe-

cific learning objectives [76]. With JADO being such a rapidly evolving field with many different concepts, modular learning can help Airmen target new information and allow them to learn and engage at a pace where they can take the time they need to understand.

2.2.9 Flipped Classrooms

Bishop [77] discusses the concept of flipped classrooms through defining the term and breaking down the goals and benefits of the educational tool in his survey paper. Bishop's efforts covered research efforts through 2013. He begins with the history leading up to predecessors of the flipped classroom such as Khan Academy. He describes theoretical frameworks to justify and explain the basis for the idea of the flipped classroom. A flipped classroom operates on the premise that a lecture is possible without interaction and thus fits better as an out of class assignment, while the more challenging, higher level learning from problem solving benefits from peer and instructor interactions. The learning styles Bishop discusses are Peer-Assisted, Collaborative and Cooperative Learning and Problem-Based Learning. Bishop argues the use of these styles, emphasized by the flipped classroom, assist students with the higher levels of engagement. Herreid [78] also emphasized that the flipped classroom allowed for greater customization of content and higher levels of interest in the material from the students.

Bishop does not sufficiently discuss criticisms that could be levied at flipped classrooms and says that the flipped classrooms have an overall positive reception. Specifically, video lectures and pre-quizzes were noted as more successful than reading before class [77]. The case study on flipped classrooms by Herreid discussed two challenges being student reluctance and instructor difficulty finding sufficient resources for the students to use in the out of class portion. The second problem can cause additional

challenges due to quality and instructor time issues [78]. Initially, student reluctance may stem from a fear of being more responsible for their learning. However, once the students are exposed and can see that flipped classrooms tend to lead to more engaging learning activities students show high rates of approval [79].

The flipped classroom concept may be useful in an introductory JADO workshop. The provided materials for a given lesson can provide a common basis for discussion and other instructor-led activities.

2.2.10 Developing the Airmen We Need-Education (DAWN-ED)

The Air Force has created a list of priorities regarding education in the DAWN program [80]. It is broken down into 3 major sections of People, Learning Design and Development, and Technology. The first principle under People is early access programs. A workshop on JADO that is widely available, particularly for new members is essential. A current challenge that is faced in the return to joint-centric operations is all the branches working together. Placing an emphasis on joint operations and the new doctrinal ideas such as essential technologies and importance of convergence early in one's career helps prevent the development of bad habits. Additionally, a workshop that utilizes modular sections allows Airmen to rapidly learn the parts they need and develop no matter what stage of their career. An effective way to utilize technology in this workshop area would be to host the workshop online so that the resources can be accessed anywhere when the learner has time [80].

2.3 Serious Games

Serious Games are games designed for purposes beyond entertainment [81] [82] [83] [84]. Some common purposes include training, advertising, simulation, and education [85]. While many serious games are digital [81] [85], serious games can also be physical

games. Serious Games can serve as a relevant tool for reaching current learners and improving engagement [81].

2.3.1 History

Abt [86] is one of the first to use the term serious game in his book Serious Games in a way referring to the understood definition of today. Abt also created games, such as T.E.M.P.E.R., that the military used for training during the Cold War [87]. Current literature surveys [88] [89] evaluated serious game studies to strengthen the empirical evidence of the effects of serious games. Most study results showed positive results. Positive results in skill acquisition, higher-level cognitive skills are promising for the support of education and training in the military. Some studies also found unexpected benefits beyond what the primary purpose of the game [90]. The study of serious games gained attention again in 2002 when Sawyer and Rejeski [91] published an initiative promoting serious games [82]. Since then, studies have continued to improve rigor and increase formality, although there are still improvements to be made [82] [92] [93].

2.3.2 Wargaming

Games have long been used as a tool to train military commanders. Classic games such as Go and Chess encourage strategic thought and countering opponent's strategies [94]. Key parts of the wargaming concept are that it simulates an aspect of war and that there is an antagonist in competition. Often, wargaming can be considered an interchangeable term with serious games [95]. This understanding can help contextualize current understandings of the capabilities and benefits that can be associated with this type of tool. Perla discusses how the narrative aspect of games is a core reason for their engaging nature. The "story-living experience" from playing

a game is more similar to real-life than reading an article or watching a video [95]. This potency emphasizes the need to properly frame what the game is doing to limit lessons that are inconsistent with reality. Creators of wargames can frame the game in a presented narrative and enable players to learn through the constructed narrative [95]. Wargames can span from a full military exercise that pits a red team versus a blue team down to a card game or even a conversation discussing a tactical scenario. There are tradeoffs to consider including cost of running the wargame and which elements of reality to abstract. A use of less formal games by the military includes spotter cards. These were classic playing cards but instead of numbers or face cards, they included different enemy and friendly planes. This was sponsored to help servicemembers recognize enemy and ally air assets [96]. A similar idea was later utilized in a "Most Wanted Iraqis" deck of cards. This effort was to share information with warfighters in an engaging way. The team that created the cards were praised with a citation that called the cards the "most successful information operations campaign in the history of the [Defense Intelligence Agency] DIA" [97]. Admiral Nimitz stated that wargaming had prepared the Navy for World War 2 against Japan"that nothing that happened during the war was a surprise- absolutely nothing except the Kamikaze" [98]. In response to poor performance in the Vietnam War, the Air Force established the Fighter Weapons School and the Red Flag exercises [94]. In the early 1980s, the Army noticed a decline in the use of wargaming and made efforts to rebuild the capability culminating in the National Training Center [99]. Wargames from NTC and Red Flag leading up to the Gulf War reportedly challenged servicemembers more than the War itself [94]. Despite their usefulness, refusal to accept and adjust to failures revealed by wargames or deficient assumptions can lead to poor simulation [94]. Recently, a serious game called BattleSpace Next has been proposed [100] and evaluated [101]. Flack's assessment on the game suggests that the participants found

the game engaging and useful for learning about JADO.

2.3.3 Evaluation

Due to different types and genres of serious games, an evaluation of one serious game is unlikely to generalize to all other serious games [102]. One of the challenges involves disagreements on important aspects of serious games. Fokides et al. noted the fragmented serious game assessment and recommended 13 significant factors [103].

Improvement in both the educational rigor and the depth of studies has led to a wider acceptance of serious games [93]. Connolly et al. and Boyle et al. provided large-scale analysis of serious games research to strengthen conclusions of individual serious games [88] [89]. Other studies, such as Blunt, have also strongly refuted skepticism toward the effectiveness of serious games [104].

Assessment methods can be summative or formative. Summative methods are performed at the completion of a learning process and assess results. Formative methods continuously assess throughout the learning process [93]. One of the most common forms of summative assessment is the pre-game and post-game survey [105]. This approach is popular for measuring improvement after modifying the learning process [106]. This approach can assess against a standardized knowledge assessment [107] or a self-report provided by the learner [108]. The standardized knowledge assessment can provide additional rigor, but requires an established evaluation method which may not always available.

Some of the in-game assessment processes include checkpoints, in-game performance, monitoring student progress, and self-reporting [103]. Researchers can also observe learners throughout the learning or use sensors to assess learner reactions throughout use [109]. Operation ARIES! utilizes in-game assessment through questions and conversations with game characters [110].

2.3.4 Debrief

Debriefing is "the occasion and activity for the reflection on and the sharing of the game experience to turn it into learning" [84]. This is an important step to ensure the learner is using the serious game to learn. A debrief can provide correctional or supplemental information. Crookall proposes that real learning comes from the debrief rather than the game and that designers ignoring that reality limit their learners [84]. Thatcher connected Kolb's experiential learning theory to serious games fundamentals, further emphasizing the importance of including a debrief [111].

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

Alan Lin created MDC2 TCG in 2018 as a card game designed to expose learners to air, ground, and cyber assets and multi-domain concepts [112]. The game outlines three learning objectives. The first is to "Demystify cyber terminology and concepts within the context of military operations; cyber is not 'magic dust' and requires steps in a 'kill chain' just like kinetic forces" [112]. This learning objective fits under the Understanding (level 2) of Krathwohl's revision of Bloom's taxonomy. The serious game allows users to execute steps of the kill chain, reaching level 3, Apply, of the taxonomy. The next learning objective is, "Explore touchpoints and force trade- off decisions between cyber and kinetic options (i.e. what to play vs. sacrifice)" [112]. The word explore indicates that this learning objective targets the fifth level of the revised taxonomy, evaluate. Players compare assets to see what fits their strategy and combats their opponent's strategy. The third learning objective is, "Elicit a discussion between Airmen across various functional communities on how to build winning strategies" [112]. This learning objective includes out of game aspects, such as debriefing. It touches upon the sixth level, create, and the fourth level, analyze,

of the revised taxonomy.

2.3.5.1 Game Overview

MDC2 TCG is a 2-player card game utilizing air, cyber, and ground military assets. The game is structured similar to Hearthstone [113] in that there is a base with 20 health that must be destroyed to win the game. Players begin by selecting cards from the available pool to create a 40-card deck. Kinetic capabilities, including the planes and ground units, have health and attack points. These indicate the damage that the units can survive or deal respectively [112]. Cyber capabilities simulate a simplified cyber kill chain described by Lockheed Martin, seen in Figure 4 [114]. The game focuses on reconnaissance, gaining access, and then exploitation. The assets related to these tasks are based on real world capabilities and dependencies. This allows the game to offer players unfamiliar with cyber a high-level understanding of cyber capabilities and their impact in a conflict.

Each turn the player draws cards as appropriate. The player then deploys cards by sacrificing cards according to the card's cost they wish to play. These cards are used to attack the opponent or defend against the opponent's attacks. Different decks lend themselves to different strategies for the player. Play continues with each player taking turns until one player destroys their opponent's base.

2.3.5.2 Strengths and Shortcomings

This game offers several advantages. First, it has similar rules to other commercial games. This lessens the learning curve that players must go through to begin playing. The one-on-one format means that the tool only requires two players. Debriefs following play can help extend lessons to larger groups. It also presents a low-threat environment for students to learn multi-domain concepts. Some abstractions such

Figure 4: Lockheed Martin Cyber Kill Chain [115]

as geography and resources can complicate what players are expected to learn. The game does not include maritime and space assets limiting discussion of operations across those domains.

2.3.6 BattleSpace Next Multi-Domain Operations (BSN)

Nathan Flack developed BSN in 2019. This game uses similar mechanics and structures to MDC2 TCG and included many of the same assets. However, it also added additional domains and cards and it simplified some game elements. Additionally, Flack's results indicated that the target audience for the game is learners with limited military experience [10]. This target audience is similar to military members looking for an introduction into JADO concepts in a formal, structured setting.

2.3.6.1 Learning Objectives

The change in focus to JADO led to a change in the learning objectives as well. The game has modified the kill chain to emphasize both kinetic and non-kinetic capabilities. An additional learning objective emphasizing the balance of cyber defense and attack capabilities. This focus is to ensure the cyber aspect of the game is in the forefront of the learner's mind. Flack added a learning objective to integrate the new game mechanic called the spectrum of conflict. This game mechanic models the progression from neutral to hostile relations. The final learning objective is "Select and combine capabilities to anticipate, adapt, and respond to surprise and uncertainty in near-peer warfare" [10]. This learning objective uses the serious game medium to reach a higher level of learning than would be possible through most typical learning tools.

2.3.6.2 Game Overview

BSN utilizes a similar structure and several assets from MDC2 TCG. The first change is the inclusion of assets in the maritime, space, human, and EMS domains. The game also removed the deck building element to reduce the learning curve. To facilitate a strategy, players instead pick their first hand before shuffling the remaining

assets. The next change is the start of the game the players are low on the spectrum of conflict. This limits which cards the player can use to affect their opponent. Initially, players are limited to non-kinetic efforts. Once the conflict threshold has been reached, players can attack with all assets they have deployed. This mechanism reinforces the importance of planning and gives a section of the game where cyber and other non-kinetic assets can quickly impact an opponent's strategy. The game also portions out resources at the beginning of a turn for deployment instead of sacrificing cards like in MDC2. They deployment and use of cards is still similar to its predecessor. The game ends when one player eliminates the opposing player's Multi-Domain Operations Center.

2.3.6.3 Strengths and Shortcomings

BSN offers several advantages that facilitate the tool's use. The first is that BSN is commercially available. Wide accessibility increases the potential number of learners particularly as the game is developed for a broad audience. Flack also created an instructor guide that helps lead instructors though the game and recommends elements for a targeted debrief. BSN's wide range of assets from different domains gives learners from different backgrounds both information to relate to and information to explore. Finally, BSN pushes players to search for novel synergies between different assets throughout the domain to develop winning strategies and overcome their opponent [10]. BSN does abstract geography which can eliminate some of the challenges to achieving synergy and convergence. Additionally, some assets require die rolls which can imply the idea that non-kinetic attacks are down to chance.

2.3.6.4 Recommended Future Work

In his research, Flack left several opportunities for future work to continue to develop upon the framework he had developed. These ideas included further development and assessment in a course and creating variations of the games at the other levels [10]. Incorporating BSN into the workshop with smaller scenarios and the game as developed is in line with these expected developments. Furthermore, the scenarios can make the game smaller and easier to understand while focusing on learning objectives that players might miss if they played the normal game.

III. Methodology

3.1 Introduction

This research investigates JADO education, specifically at an introductory level. This chapter describes how the workshop was designed, its composition, and the method of its evaluation. Section 3.3 discusses the steps for creating a JADO workshop. Section 3.4 discusses the BSN development in this research. Section 3.6 discusses the methodology for the SME assessment experiment. Section 3.7 discusses the methodology for the Workshop Experiment.

3.2 Research Questions

For the convenience of the reader, the following research questions are provided from Chapter 1.

- What benefits can an introductory JADO workshop provide to new JADO learners?
- Which topics are most important to communicate to facilitate JADO learning?
- What is the response to the use of BattleSpace Next scenarios to highlight specific learning objectives?
- What are SMEs' assessments of the effectiveness of a JADO workshop using a serious game?
- What are participants' assessments of the effectiveness of a JADO workshop using a serious game?

3.3 Workshop Development

This section describes how the workshop was crafted, to include Section 3.3.1 background research, Section 3.3.2 team building, Section 3.3.3 topic selection, Section 3.3.4 creating learning objectives, and Section 3.3.5 assessment considerations for workshop design. This section describes the decisions and justifications that led to the workshop used in the experiments.

3.3.1 Background Research

The first step to developing educational material is understanding the current state of the field. JADO does not currently have a general, introduction class so this step begins with research. One intuitive starting point is doctrine, such as *U.S. Air Force Doctrine Publication (AFDP) 3-99*, an authoritative source of the U.S. Air Force best practices. The *AFDP 3-99* page also points to the All Partners Access Network (APAN) collaboration site. This collaboration site contains some JADO materials but is not intended for education. News articles are another accessible source of JADO information. News articles can link learners to other resources and provide an overview. However, news articles rarely have technical details, which can hinder learning. Beyond those starting points, more information can be found through journals such as *Over the Horizon* and publications by The Rand Corporation. Some military courses incorporate JADO into their curriculum, but they have limited access and fail to be useful for the general military population.

3.3.2 Team Building

JADO education challenges include a wide variety of topics, multiple stakeholders, and rapidly evolving understanding of JADO. These challenges require a team with diverse backgrounds. The first step to building such a team was to consider who

might be interested in collaborating, how those people could contribute, and how this effort could help them. Discussion from the Chennault series concluded that a JADO introductory course is desirable [116]. This research can provide data to inform how their introduction course evolves. A design that purposefully includes new tools, such as BSN, and modern education ideas, such as learning paths and modularization, is of value to Air Force education. Beginning from working with partners from the 13O schoolhouse, connected through BSN, the team grew to include the LeMay Center, SOS, and AF/A3. This variety of perspectives shared resources for the workshop and discussed ideas critical to the formation of the workshop.

3.3.3 Topic Selection

The researchers developed a list of topics to be included in the JADO training. This section outlines the process of selecting topics and provides justification for the choices that led to the decisions. Each subsection goes through one of the learning paths described in the syllabus found in Appendix A.

JADO is a complex subject containing many relevant topics for future operations. Selecting and categorizing these topics can provide new learners some starting points and assistance to ease the learning curve and enable DoD members to quickly start the learning process. There is considerable overlap for some of the topics because of the interconnection of concepts. JADO ideas work together and build on each other. After selecting the topics, planning subtopics for specific learning objectives can help ensure resources are relevant to what the learners require.

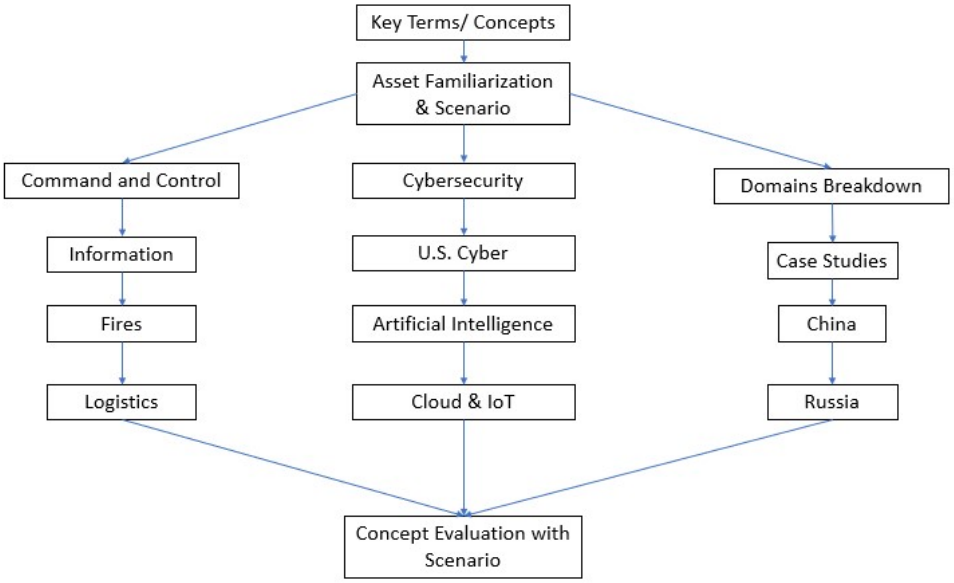


Figure 5: Example of Learning Paths with JADO topics

Figure 5 shows key topics arranged in three learning paths: Doctrine, Supporting Technology, and Supporting Information. The Doctrine Path includes Command and Control, Information, Fires, and Logistics as described in Section 2.1.4.3. The Supporting Technology Path includes Cybersecurity, U.S. Cyber, AI, and IoT as described in Section 2.1.3. The Supporting Information Path includes Domain breakdowns, Case Studies, China, and Russia. The following paragraphs elaborate on each of these paths.

3.3.3.1 Doctrine Path

This section outlines the topics in the doctrine path. Doctrine is essential to grounding JADO understandings for US military members. Doctrine helps layout the topics and ideas that senior leaders envision for JADO. Therefore, deriving a line of topics with additional context for members to better understand the ideas discussed is a key part of designing a JADO workshop. This proposed layout follows

the organization of *AFDP 3-99*.

Command and Control. Command and control is a significant JADO concept. The Air Force's ABMS [51] is a key developmental effort for creating the infrastructure to enable this aspect of JADO. Decentralized execution is heavily emphasized as the DoD transitions to face more complex opponents. The system also needs to connect sensors, which relay information, to shooters, which enact effects against targets. DoD networks need to be robust to withstand adversary attacks, transmit information, and analyze information to provide commanders with the best choices to carry out missions.

Information. Several of the most important changes to support JADO come from an increased emphasis on information. Information needs to be synthesized into actionable intelligence and made accessible to decision makers. A new emphasis on information warfare through all the domains is crucial to enabling JADO. The information and intelligence need to closely link to the command and control networks.

Fires. The core of JADO fires is creating a convergence of effects across the domains. Convergence requires planners to account for different required lead times and operating conditions for different domains. However, once that is accounted for the synergistic effects can cause increasingly effective impacts on opponents. Striking with both kinetic and non-kinetic capabilities can overwhelm the adversary and limit the effectiveness of the adversary's response.

Logistics. The logistics topic covers movement and maneuver, protection, and sustainment. While these are not always in the forefront of a learner's mind, these aspects of battle will determine to what extent JADO can be carried out. Movement and maneuver is the first part of this topic. Opportunistic convergence can only occur if the assets can be maneuvered to deliver their effects. Command and control needs to be capable of ensuring assets are where they should be. Protection is the

second part of this topic. Agile combat employment (ACE) is a proactive and reactive concept of maneuver that seeks to maximize unpredictability and response capability. One part of this concept is the dispersal of forces to protect them and then enabling convergence. Sustainment is the third part of this topic. Commanders need to make sure that their forces can stay and operate long enough to complete the missions assigned to them. This includes making sure forces have the required supplies and US logistics can survive under duress.

3.3.3.2 Supporting Technology Path

This section discusses the supporting technology path, which focuses on introducing learners to cyber concepts and technologies that have been identified as key to realizing JADO. The technological path is included because achieving JADO capability is contingent upon modernizing the military's use of these technologies. Providing a better understanding of what underlies US capabilities prepares the force for these changes.

Cyber Operations. This path begins with Cyber Operations. This first topic introduces learners to cyber concepts that support JADO ideas. This topic focuses specifically on the cyber kill chain, interoperability, and basic cyber defense concepts. The cyber kill chain is linked to the idea of convergence and can help conceptualize the steps of a cyber operation. A comparison of the steps in the cyber kill chain to the steps in operations in other domains can demystify cyber. Interoperability is the ability of computer systems or software to exchange and make use of information. While the DoD currently has interoperability challenges between systems, networks, services, and allies, JADO relies on finding a solution for this problem. Information will need to travel quickly and this will require new standards and other facilitating efforts. Finally, basic cyber defense concepts will discuss some different types of

attacks and an understanding of the defense-in-depth philosophy of cyber defense.

U.S. Cyber. The next topic builds the learners' understanding through inspection of current US posture on the importance of cyber and how cyber affects warfare. Understanding the basics of how the U.S. views cyber norms and cyber expectations is a valuable lesson for members to piece together why technology is so important to JADO. This can also assist evaluations of near-peer countries, such as China and Russia.

Artificial Intelligence. AI is projected to be an essential part in assessing information to turn it into intelligence, serving as a keystone for future JADO operations. The DoD AI Education Strategy discusses different levels of education depending on the service member's needs. For example, technological expertise for creating AI is unlikely to be useful for many positions so a higher level of understanding would be more efficient and applicable. It also lays out categories of information that could be relevant. For this workshop, the expected areas of interest are Foundational Concepts, AI Application: Opportunities and Risks, and Responsible AI. These topics provide an introduction to situations where AI could be effective, where AI may be vulnerable, and the current thoughts on how AI benefits JADO.

Internet of Things and Cloud. The Air Force's ABMS has been referred to a military Internet of Things IoT [117]. Cloud technology is increasingly important for its ability to share information, the storage benefits, and the security benefits. Discussing these changes and how they can affect operations will inform military members of what to expect moving forward.

3.3.3.3 Supporting Information Path

This section discusses the supporting information path. Along with the new technical capabilities and other JADO connections, a better understanding of joint and

other parts of the military are required for JADO. This path is designed to give some insight to some practical applications and operations that have occurred. It helps people visualize strengths and weaknesses as well as near peer adversaries' views. This path provides important context to teach learners about concepts they may not be familiar with from their working within their Air Force Specialty Code (AFSC).

Domain Breakdown. The first topic in this path is the domain breakdown. This step discusses each of the domains and some strengths and weaknesses that apply to operations in that domain. This step can help learners familiarize with domains that they have not interacted with previously. Additionally, it can be helpful for learners to see the interplay of each domain covering other domains' weaknesses.

Case Studies. The second topic in this path is cases studies. The second topic in this path is cases studies. Case studies map concepts on to previous examples of operations. This shows the importance of being leaders in these new concepts and what can happen when the services are not acting jointly. Operation Desert Storm was selected as a case study to show some positives of joint operations. Operation Anaconda is used to highlight some repercussions of failing to act jointly and utilize assets that are best suited for the task.

China. The third topic in this path is China. China is commonly referenced by senior leaders and other threat assessments as one of the leading potential adversaries [24] [1] [4] [118]. China's rapid technological development and other actions have displayed a willingness and a desire to challenge U.S. goals. This topic will investigate some of underlying ideas of Chinese operations to gain an appreciation for what future conflict could look like.

Russia. The fourth topic in this path is Russia. Russia is another important near peer potential adversary. Russian actions in Crimea and the 2016 election, as well as their current views on the importance of information warfare provide important

lessons to the US military's current security picture.

3.3.4 Creating Learning Objectives

The learning objectives serve as framing devices for what goals the leaner should be able to achieve after completing the lesson. The learning objectives are derived from subtopics from each module's topic. The workshop uses the framework outlined in Krathwohl's revision of Bloom's taxonomy described in Section 2.2.4. See Appendix A for the syllabus containing the workshop's learning objectives.

3.3.5 Assessment Considerations for Workshop Design

Assessments measure the knowledge of the participants and their knowledge gain is used as a proxy to determine the effectiveness of the workshop. Due to the emphasis on testing and rapid experiments and exercises, service commitment to how JADO will function is evolving. For these reasons, assessment should focus on observing the learner articulate and evaluate different ideas. BSN serves as a useful medium for beginning conversations and why one might make certain decisions over other ones. Discussion is also a learning component. If a learner can defend positions and explain to others how it could be applied to their daily operations, then furthering the concept as a whole has been achieved. This process shows the learner has taken the concept and thought about real-life applications instead of rote memorization.

3.4 BSN Development

Flack [10] discusses that due to a general lack of understanding of what is considered "right" for JADO, some players struggled to identify how much playing the game improved their military readiness. This section discusses how additional BSN development such as creating scenarios focused on specific learning objectives and creating

a structure around the game can address this challenge. Section 3.4.1 discusses why BSN was included in the workshop. Appendix B describes what a BSN scenario is and the development process. Section 3.4.3 describes an additional use of BSN in the workshop. Section 3.4.4 describes how BSN can benefit from the structure provided by the workshop.

3.4.1 BSN Strengths

The first step of the task was addressed through a serious game, BSN. BSN had results supporting that it was engaging for military members with less experience [10] which has considerable overlap with the workshop's target audience. Also, BSN lends itself to modification, increasing its utility in a workshop that has so many different topics. BSN also provides a way to initiate discussion based on some level of experience and a thought process.

3.4.2 BSN Scenarios

This section discusses the development of game scenarios for BSN. A scenario is defined as a change in the rules or cards used for a playthrough. Scenarios have specific learning objectives connected to the change to enhance learning. The benefits of scenarios could be easier gameplay or more focused learning objectives. These expected benefits address two challlenges of BSN, game complexity and JADO complexity. The general framework is to develop learning objectives that correlate to important lessons for JADO participants. Then, operating within the BSN framework, make modifications to the rules in a way that incentivizes actions that force learners to engage with the concepts. This focuses the experience, and consistent with ELT from Section 2.2.6, can help participants focus on desired takeaways. Brief guides to reinforce ideas can also help serve as a debrief for the serious game experience. See

Appendix B for examples of scenarios.

The process to develop scenarios is based on the Game Design Matrix (GDM) [119], but adapted for the creation of scenarios from an existing game. The first step in the process is to define the educational objectives. Relevant learning objectives will come from either specific topics or laid out in assessment modules. It will be important to consider which learning objectives translate to the game. The next two steps in the process are select game dynamics and then select game mechanics. Game dynamics and mechanics are primarily determined by the original game. To keep the learning curve from becoming too steep, which could frustrate learners, the decision was made to make small changes within that framework. Most modifications will happen with the selection of assets or minor rule changes. The final step is to create the game. This includes the story of the game, the setup, the sequence of play, the win conditions and the components. Each scenario clearly describes each change a particular scenario makes to these elements.

3.4.2.1 Progressive BSN Scenarios

This section describes the progressive BSN scenarios. These scenarios are the primary scenarios in the workshop. The scenarios simplify the base game by removing some complex game mechanics and limiting available assets. As players gain experience, the assets and mechanics are gradually reintegrated. These scenarios are connected to the following topics: Introduction and Key Terms/Concepts, Command and Control, Information, Fires, and Logistics.

The first step in the development process is to decide which mechanics to change or remove. The first consideration is which mechanics can be linked to these JADO topics. The second consideration is which game mechanics are most complex for new players. After playtesting and understanding how BSN communicates JADO

concepts, several mechanics met the above considerations. First, the number of assets and different domains gives players a lot to consider immediately. Players may be drawn to kinetic assets because kinetic assets provide the most direct path to winning the game. To simplify this for the first game, only ground and air assets are included. This allows players to gain an appreciation for the flow of the game and to test out different combinations of these assets. Air and ground are also two domains that have been featured in recent conflicts. Another mechanic is the revealed and unrevealed mechanic in the game. Assets are unrevealed when first deployed. This means they are face-down and opponents cannot attack them until they are used. This mechanic is simplifed by making all cards immediately revealed. This change helps new players see their opponent's cards and make decisions with perfect information. It can also help visualize potential strategies. The next mechanic that was altered was the spectrum of conflict card. This mechanic models the phases of war described in Figure 6. It gives players some time to build assets with less apprehension of losing assets and allows them to utilize non-kinetic attacks early. The third major game simplification was the resources chips. Players receive four resources per turn and use these resources to deploy assets. This mechanic helps simulate some form of logistics. It also causes players to balance powerful but expensive units with less powerful but cheaper units. The simplification instead allows players to deploy up to three cards per turn. The change lets new players test more expensive assets without punishment.

The first scenario serves as an introduction to the game. Players review the rules and play with the above simplifications. Because both players have a small pool of assets, this scenario can draw out to be a longer game. This models that conflict against a near-peer adversary with similar assets could become a war of attrition without multiple domains and striking interdependencies. It also introduces BSN fundamentals

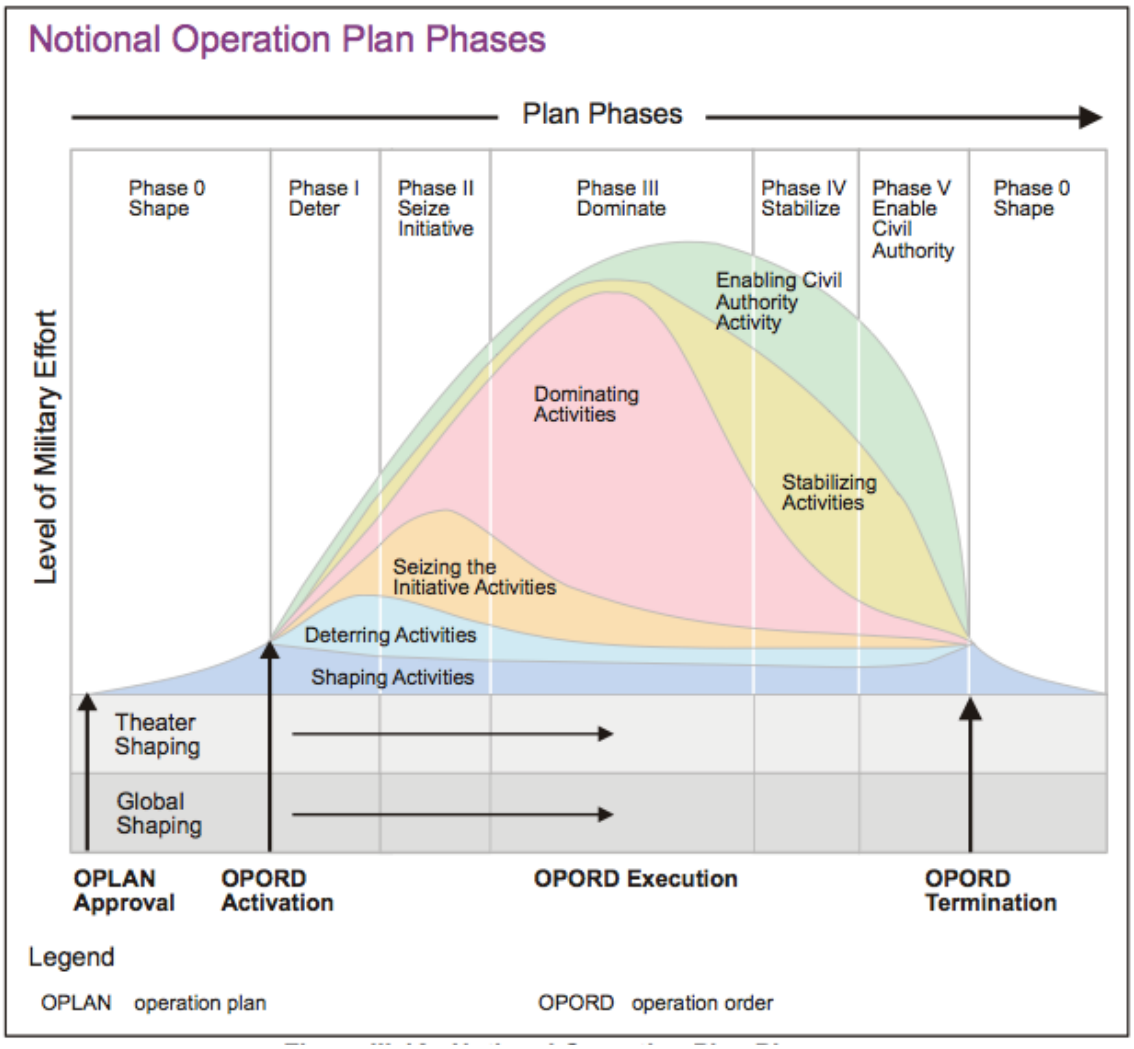


Figure 6: JP 3-0 Notional Phases of War [12]

for players to experiment. The next scenario is the command and control scenario. This scenario does not reintroduce any game mechanics but has two players team together to fight another team. Each partner has control over one domain and communication is limited. This scenario can help new players by partnering them with another player to help explain the game. It also illustrates some of the challenges of an imperfect command and control structure. The information scenario reintegrates the unrevealed mechanic and the rest of the assets. After playing the game a couple of times, players have familiarity with the air and ground assets. Players have

also been operating knowing which cards their opponent is using. The unrevealed mechanic complicates the attack because players no longer have the certainty of how their opponent will respond. Intelligence assets can help players deal with this new uncertainty. This links back to players being the command and control for their forces and teaches the importance of intelligence in operations. Since different assets provide different intelligence on the opponent, players are encouraged to try different combinations. The fires scenario reintegrates the spectrum of conflict cards. Players that used some non-kinetic cards, such as cyber cards, may have struggled to develop the required kill chain. This card creates turns where non-kinetic attacks can have an impact before kinetic attacks and influence players once kinetic attacks are available. Finally, the logistics chips are reintegrated. This helps players reconcile the importance of logistics and getting the assets they need deployed in a timely manner. An optional mechanic of splitting the supply deck by domain is available for experienced players. This mechanic gives players additional control over which types of assets they can deploy and demonstrates how well-planned logistics can develop strategy.

3.4.2.2 BSN Extra Scenarios

Additional scenarios, called Extra Scenarios, add new twists for experienced players. These scenarios are for players that are comfortable with the base game already and want to test some ideas with BSN. The cyber and information operations scenarios emphasize the use of non-kinetic attacks. These scenarios help emphasize less tangible actions that are often considered below the conflict threshold. Forming an understanding of these topics is essential in today's operating environment. A third-party scenario simulates the challenges of an outside entity, potentially a nation-state or terrorist organization, interfereing with conflict between two near-peer adversaries. In the scenario, either player can lose a resource based on a dice roll. This limits de-

ployment capabilities and shows how even minimal effort from an outside force could disrupt U.S. fighting capabilities. Finally, the multiple battles scenario address BSN's space abstraction. In this scenario, players have to fight on three different battlefields and win on at least two of them. This adds complexity and invites new strategy to the game as players try to combine the most useful cards and make prioritization choices.

3.4.3 BSN to Frame Tabletop Wargaming

Participants benefit from BSN because it creates a realistic scenario of capabilities, assets, and options. First, it reminds participants of different options that they have available as a commander. It can serve as a forcing function to try strategies using assets that they might not have previous experience. It can also help to iterate quickly on different combinations and discussion on why one strategy might be more viable than another combination. Using these assets as a framework for tabletop wargaming can also benefit the instructor as it can help them set boundaries on what the participants have available.

3.4.4 BSN as Part of a Structure

This project also seeks to strengthen the application of BSN by adding a structure around the game. Flack [10] created an instructor's guide and several of his tests were as a part of an existing course. This added structure can be helpful for learners to bring attention to specific takeaways that they can gain. This project is built with the intention of including the game. The purpose is to bring learners along on the journey and help them use the game as their own experience, from which they can better understand and discuss new JADO concepts.

3.5 Study Settings

All human studies assessment takes place through the online workshop environment in accordance with the Institutional Review Board (IRB) waiver obtained for the research found in Appendix C. Feedback and refinement was gained through interviews, discussion and assessment with JADO education experts.

3.6 SME Evaluation Methodology

This section explains the methodology used for a JADO expert's assessment of the workshop. Section 3.6.1 describes the experiment layout. Section 3.6.2 describes how the workshop is evaluated. Section 3.6.3 describes the SMEs that participated in this assessment. Section 3.6.4 describes how the data was collected. Section 3.6.5 describes the instructions and timeline for the experiment. Section 3.6.6 describes the limitations of the experiment.

3.6.1 Primary Study

The first experiment consists of JADO SMEs evaluating the effectiveness of the workshop. The purpose of including expert assessment is to gain the perspective from people who understand the topics and can offer critiques based on their understandings. Throughout the development process, feedback was solicited to understand current sources and gather information. The experiment followed this procedure

1. Provide the syllabus and a topic map for the class.
2. Distribute resources and add context as requested.
3. Send interview questions to guide the experts' assessment. Interview questions are in Appendix D.

The following sections will provide the details for this protocol.

3.6.2 Workshop Evaluation

This study evaluated the JADO workshop by collecting expert's feedback. Experts received a seven question survey. The survey used an open response format to get the experts' perception of the workshop content, strengths, and weaknesses. The surveys focused on assessing the choice of topics, material selection, and workshop effectiveness. Electronic data collection tools were provided with each module. This approach was used to gain data relevant to each module and better understand answers to inform conclusions.

3.6.3 Population

The wide variety of audiences are interested in JADO led to seeking evaluation from a variety of sources. The researchers have identified five experts from the 13O Initial Skills Training Schoolhouse, the LeMay Center, and ACSC. Three of the experts came from the 13O Initial Skills Training schoolhouse to engage with instructors familiar with teaching JADO to a specific career field. Their teaching experience involving JADO concepts is acutely relevant. The fourth expert works in the LeMay Center, which serves as the USAF doctrine development center. This perspective can serve as useful, particularly for the doctrine path. The final expert was an a leader of the ACSC's Multi-Domain Operational Strategist Concentration and has published several papers with numerous journals.

3.6.4 Data Collection

After the interview answering questions and clarifying workshop intent and audience, experts could look at the material and assess it, focusing on the questions provided in the survey. Once SMEs evaluate the workshop, they submit their assessments using an email survey. The survey focuses on questions pertaining to the

workshop and their professional analysis. The survey questions are available in appendix D.

After the survey is submitted, responses are gathered and analyzed to describe similarities in the responses. These assessments are used to recommend improvements for the workshop and BSN as an educational tool.

3.6.5 Participant Instructions and Schedule

Due to COVID-19 restrictions, this experiment was limited to an online venue. All information and materials were sent online and any meetings were held over the phone. The experts were given 3 weeks to read through and analyze the workshop and provide feedback. They were asked to send any questions that they might have throughout the process and they would be answered to give extra details.

3.6.6 Limitations

This expert review had a limited number of participants and may not be representative of the entire JADO community. Despite the efforts to include different groups, JADO encompasses the entire DoD meaning that other service leaders may have other viewpoints. Because the experts did not have to take the workshop, they were assessing the quality based upon their own experiences and thoughts and could not see how an instructor-led session would operate. They were also not required to play through all the BSN scenarios so their feedback for that part could be limited. Several of the SMEs admitted to not having experience with the current version of BSN, making it more challenging for them to provide an accurate assessment. Their feedback was also of a more qualitative nature due to the survey layout and the information they provided.

3.7 Workshop Experiment Methodology

This section describes the methodology for the second experiment: participant feedback from the workshop. This experiment used the workshop that was evaluated by the experts to gather an alternate viewpoint. Section 3.7.1 describes the experiment layout. Section 3.7.2 describes how the workshop is evaluated. Section 3.7.3 describes the SMEs that participated in this assessment. Section 3.7.4 describes how the data was collected. Section 3.7.5 describes the environment for the workshop. Section 3.7.6 describes the instructions and timeline for the experiment. Section 3.7.7 describes the conditions the workshop followed. Section 3.7.8 describes the limitations of the experiment.

3.7.1 Primary Study

The second experiment to assess the effectiveness of the workshop was participants going through the workshop and providing their feedback. The workshop needs to be effective for the learners going through it and participant feedback has long been a key metric for determining content effectiveness [120] [121]. The experiment follows this procedure

1. Provide the syllabus and a topic map for the class.
2. Send an optional pre-workshop survey.
3. Distribute module resources and add context as requested.
4. Instructor-led online meetings to discuss concepts and consolidate understandings.
5. BSN scenarios to engage learners.
6. Send an optional post-survey at the end of the workshop.

Instructors are available throughout the workshop for participants to email and discuss ideas. The following sections will provide the details for this protocol.

3.7.2 Workshop Evaluation

This experiment evaluates the workshop through participant self-reported learning and BSN game response. Participants received a pre-survey and post-survey for the workshop. They are designed to take an average of 10-15 minutes each to balance data acquisition with survey fatigue. Surveys collected participants' workshop experience, their view of the effectiveness, and their view of strengths and weaknesses. Surveys were provided before the workshop and on the last day respectively. They were optional surveys and considered outside of the workshop itself.

3.7.3 Population

A JADO introduction workshop needs to reach a large, varied audience. This workshop experiment was a small pilot event advertised and run by the AFIT's School of Systems & Logistics (LS). After analyzing the results of this workshop, plans for scaling to larger, Air Force wide audiences should be developed. The workshop is targeted to DoD affiliated military, civilians, and contractors that have limited experience with JADO.

Participants for the workshop instance used for this research included junior airmen in the 88th Communications Squadron, participants from the Air Force Research Labs (AFRL) Rome, AFIT, and NASIC.

3.7.4 Data Collection

Data is collected through the pre-surveys and post-surveys for the workshop. The main ideas discussed in the BSN scenario debrief section are also captured to as-

sess scenario takeaways and assessment and BSN scenario impact on participants' experiences.

3.7.5 Environment

This experiment takes place in an online workshop hosted by AFIT/LS. This workshop is a traditional online workshop with meeting times where the class comes together to discuss concepts. There were additional materials that participants could access but there was no requirement to do so. All enrolled participants in this workshop volunteered for it. Participants are offered an opportunity to participate in two optional survey. Serious Game scenarios and play were also encouraged to happen outside of class time. The workshop contained no formal assessments in the form of quizzes or written assignments.

3.7.6 Participant Instructions and Schedule

All participants received an email which explained the layout of the class. The first part of the class established the procedures of the class. Participants also received the pre-workshop survey at this time. All participants were expected to obtain the physical card game of BSN. Facilitators were able to assist most participants with obtaining a copy so they did not have to buy their own. Each topic has material that could be read, watched, or otherwise interacted with outside of the class time. However, there was no expectation that the participants were required to engage with material outside of the workshop. The meeting time is used to provide information to the class. Participants had the opportunity to discuss new understandings and interact with the topic's material. Following the discussion, players broke off and played BSN scenarios. After a specified time, players reconvened and had a debrief on the gameplay and discussed how the scenario related to the topic. The workshop

focused on the doctrine based topics and then allowed the participants to vote on which remaining topics to cover based on the time restrictions. The workshop took place over 4 days with 4 hours allocated each day.

3.7.7 Conditions

The study tested the workshop described by the syllabus in Appendix A. The workshop environment is structured as an official workshop giving a unique environment for study. It has the potential to draw in a variety of different backgrounds and utilizes an education environment.

3.7.8 Limitations

This experiment has several limitations. First, the investigators ran one instance of the workshop. This limited the number of participants that could take the workshop and provide assessment. Furthermore, there was no possibility to make changes and improve the workshop based on available feedback. The workshop is designed to be relevant to a variety of backgrounds. The single offering meant that collecting demographic data and comparing across different backgrounds was not feasible. A challenge noted by several of the SMEs was that a formally trained JADO SME would affect the effectiveness of the course. Since, that was not a possibility at the time the workshop was offered, the researchers served as facilitators. While minor changes could be made to the course based on SME input, major changes to either the topics or the use of BSN scenarios was not possible. Further complicating the topics, the Air Force updated AFDP 1, which also influenced AFDP 3-99, less than a week before the workshop began. The changes to the command and control section with regard to JADO concepts meant there was not the same amount of time to gather resources and update the course. While this illustrates the challenges of rapidly

evolving doctrine, the decision was made to include the new material and adapt the material. Additionally, the online venue complicated some of the use of the serious games and limited interaction. Some participants were unable to use their microphones, limiting their engagement to the use of a chat function. The participants also had varying abilities to meet to play BSN scenarios altering the experience. The workshop was limited to 16 total hours. This was insufficient time to discuss all of the available topics. The four topics related to doctrine were chosen and then participants were allowed to select up to four of the remaining eight topics, to improve participant engagement. While there are multiple methods of instruction, including traditional lecture, discussion, presentation, video, serious games, and debrief, there is no control group to compare workshop results against, limiting possible conclusions. Because the author of this experiment also served as the facilitator of the workshop, there was a high level of involvement. While this could influence the participants' responses, this result is unlikely because the workshop is not connected to any authority over any of the participants and all participation was voluntary.

3.8 Summary

This chapter outlines the methods to develop a JADO workshop, further develop an existing a MDO serious game and the experiments to collect data and evaluate proposed research questions. The next chapter analyzes the results from the two experiments discussed in this chapter.

IV. Results and Analysis

4.1 Overview

This chapter describes the results from the SME experiment described in Section 3.6 and the Human Subjects Research (HSR) JADO workshop experiment described in Section 3.7.2. The results are discussed in sections based upon the research question and other items relevant to JADO education and the effectiveness of BSN. Although several factors, particularly limited population size, limit the statistical significance of the data, the data gathered provides evidence to answer the RQ 1-5. Results are discussed to provide information and insight into the response for a JADO workshop that utilizes BSN.

The researchers facilitated one HSR workshop that had a total of 14 participants. The study used a pre-workshop survey and a post-workshop survey. There were 7 participants that completed the pre-survey and 7 participants that completed the post-survey. According to the identifier number generated by participants, 4 people completed both surveys. To address the research questions, this will be considered but some observations will be made with the surveys that are not confirmed to be connected. This experiment does not have a control group due to the limited general JADO educational opportunities.

The SME experiment included an initial one-on-one discussion with each SME. This conversation described the workshop, including intent and scope, and answered any additional questions the SME's needed. Following that conversation, the SME was provided a set of questions to answer about their assessment of the workshop. There were 5 SMEs that went through this process and all 5 of them provided an assessment. SME responses are included in Appendix G.

4.2 RQ 1: What benefits can an introductory JADO workshop provide to new JADO learners?

The Chief of Staff of the Air Force established the need to improve education opportunities. However, courses, workshops, and training takes time, money, and work hours to both create and for learners to participate. Therefore, it is crucial that training is prioritized to help servicemembers maximize utility. JADO's importance makes it a major part of operations moving forward. The lack of current resources further increases an introductory workshop's value.

4.2.1 SME Experts

All SME's agree the primary benefit is that there needs to be a baseline for servicemembers early in their career. One SME suggested that this course needs to come before the first PME experience, but that the commissioning and enlisting sources are likely too early. The longer commissioning sources, particularly the service academies and ROTC, may have time in their program to include a workshop focusing on teaching JADO concepts. An introduction to JADO could be particularly beneficial towards the end of those programs as it would help prepare officer candidates to meet their service's objectives. However, Officer Training School is 9.5 weeks and Basic Military Training is 8.5 weeks long. These courses do not have an appropriate timetable to include such a workshop. This thought process is in line with the pivot to including focus on interdependencies between domains. By providing a baseline early, servicemembers can take that mentality and apply it to problems throughout their career. Waiting too long to introduce a JADO mindset risks facilitating a more "siloed" mentality based on the specific experiences of a given field.

One benefit that is discussed that participants can gain the awareness to ask the right questions to facilitate working in All-Domain environments. This reinforces that

the purpose of an introduction is to help begin the journey. Participants leaving with more questions, as long as they are good questions, can still be deemed a positive response.

Another benefit is understanding the essence of what JADO involves. JADO is an advanced operational maneuver concept that all Service Members should understand. The concept is characterized by complexity, speed, and precision and executed in sophisticated combinations of domains. If a workshop can effectively communicate this objective it could act as a guide, even if participants don't leave the workshop understanding the nuance of potential topics. One of the criticisms levelled at JADO is that it is nothing new. However, the value comes from the emphasis on maneuver and understanding domain interdependencies and EMS importance. The new mentality has to address new complexity and enable operating with high levels of speed and precision.

4.2.2 Workshop Participants

The pre-workshop surveys indicated that participants had a high desire to learn more about JADO. The average response to the question "I am interested in learning more about JADO." was a 4.71 out of 5. Interestingly, this score was higher than the average of the question "JADO is important to me" which was a 4. Because this score was from the pre-workshop survey, some participants may have viewed JADO as future development more than important now. The high value may be biased because participants that volunteered for a JADO workshop are likely to be interested in JADO. However, the high level of interest indicates that there is a demand to have a guided JADO introduction. All participants in the workshop volunteered, so that might have added some positive bias.

The importance of the pivot and the high demand for JADO learning sources, a

system with a number of learning sources with different levels of depth would facilitate DoD objectives. However, for many personnel, current sources are limited. Voltz [45] provided a survey of some current options. In addition to those current options, workshops can help introduce learners at a lower cost. Additionally, workshops could be "personalized" to meet specific organizational needs. This workshop in this experiment was an introduction and strove to help participants with little familiarity with JADO.

4.3 RQ 2: Which topics are most important to communicate to facilitate JADO learning?

The first step in educating the force to prepare for future conflict is deciding what material is the most important. From the learner's perspective, even knowing the topics that are important can be useful because it can decrease the time searching for materials.

4.3.1 SME Assessment

Topic	**Level of Bloom's Taxonomy**	**Number of Recommendations**
Intro to JADO/Terms	2(2); 3	3
AF Domains (air, space, cyberspace)	2(2); 3(2)	4
Land and Maritime Domains	1 (2); 2(2)	4
Non-Doctrine Operating Spaces (EMS, information, etc.)	1; 2; 3	3
Command Relationships and Authorities/ Command and Control	2; 3	2
Near-Peer Adversary Threats, Capabilities, basic strategies	1; 2(2)	3
JADO Capabilities, Limitations, and Applications	2(2)	2
Multi-domain integration or interrelationships	2; 4	2
Emerging Technologies	1	1
Value of officers understanding all-domain	4	1
Domain Synchronization	2	1
EMS priority for enabling maneuver	2	1
The Human domain	2	1
Challenges of cultural change	2	1

Table 2: SME Recommended Topics with Level of Depth

Table 2 describes the range of topics SMEs recommended for a JADO introduction. One of the first topics is an introduction with key terms and definitions. This topic being so common illustrates the fact that there are misconceptions about the topic. The repetition shows the importance of clarity and precision with language. It also speaks to the main benefit that the workshop can provide the baseline to a wide audience of servicemembers.

The next grouping of topics are focused on the domains. It is interesting to note that there were two different approaches for covering the domains. The first approach is to give each domain its own topic. Two SMEs recommended Air, Land, Sea, Space all getting their own lesson. This approach has the benefit of giving each domain time and the distribution could lend itself better to having SMEs for each domain to provide detail and experience. The second approach is to group Air Force domains and then the other domains. This approach is tailored to Air Force servicemembers. This organization calls for more depth for air, space, and cyber with a surface level covering of land and maritime. One challenge is understanding how information operations and EMS fit in this construct. While neither are domains, both underlie JADO. Servicemembers need an understanding of the expected changes and importance of EMS and human considerations even if they are not classified as domains.

Another major grouping of topics is connecting topics. This grouping includes command and control, domain interrelationships, and synchronization. Command and control has already received doctrinal updates, with a shift to mission-type orders and the concept of centralized command, distributed control, and decentralized execution. Understanding the required authorities for given operations and how it can impact operations is emphasized in understanding JADO. Domain interrelationships highlight the pivot from achieving dominance in each domain simultaneously and largely independently. JADO calls for maintaining maneuver and then using cross-domain effects to establish superiority in other domains. Synchronizing the domain effects to create multiple dilemmas for adversaries is the focus of JADO fires. This means planning needs to account for different timelines. Helping servicemembers understand reasoning, such as intelligence requirements, kill chain steps, and authority requirements can improve understanding of what future conflict could entail.

Although the SMEs provided a variety of answers, there were reoccurring topics.

These topics can become a strong foundation for JADO knowledge. Most SMEs recommended staying around level two of Bloom's Taxonomy, the understanding level. This is an appropriate level for an introduction because after completing the workshop, participants will still have to develop their understandings. A workshop based on these recommendations would start with a JADO introduction and terms. It would then proceed to cover the main Air Force domains, air, space, and cyberspace. Following that, a discussion on the remaining domains. These domain discussions would also include the interdependencies and discuss potential interrelationships and interactions. SMEs recommended focusing on JADC2 out of the main doctrinal functions. This makes additional sense considering that the Air Force recently released major updates to this concept. Depending on the workshop tools, this workshop could look different than the experimental workshop. Participants in the experimental workshop discuss major doctrinal ideas and engage with the different domains through BSN. The experimental workshop has one lesson on the domains, however, separating by domain may make the material more effective.

4.3.2 Workshop Participants

As part of the pre-workshop survey, participants were asked "What are 3 topics that you expect from a JADO introductory workshop?" Of the 7 survey responses that were received, 3 of the responses left this question blank. 2 more of the responses had no topics recommended. One response expressed interest in understanding how cyber and non-kinetic operations complicate the theatre of combat. The final response listed the definition and perspective on JADO, the approach to JADO, and JADO benefits and challenges. The lack of clear answers, particularly when compared against what SMEs deemed as most important indicates that the typical airman is unaware of where they should even start looking for information. While this was

the last question on the survey, and survey fatigue could be a factor, this question had fewer answers and the 2 answers it had were less concrete than any of the other questions, further supporting this conclusion.

An additional benefit of a primer workshop is that participants can engage with the basics of the ideas and begin to develop understanding with the direction of the Air Force. To a lesser degree, having a clear layout of information, such as the workshop syllabus, available could help learners begin to conceptualize JADO and look to see how they can apply these ideas to their own work. This idea is not entirely new, the APAN JADO wiki serves a similar purpose. However, the organization of this wiki needs to be improved. Instead of using JADO topics to provide the structure, the site currently separates material by military service. Additionally, some resources are from 2019 or older and need to be updated to reflect new understandings and efforts. Changing the format to topic-based could lead to multiple improvements. First, it could help move away from service approaches to a Joint approach. Next it can make facilitate conversation because instead of going to a service specific page, a user that wants to discuss the command and control aspect can go to that page instead.

4.4 RQ 3: What is the response to the use of BattleSpace Next scenarios to highlight specific learning objectives?

4.4.1 SME Assessment

SME 1	SME 2	SME 3	SME 4	SME 5
5	4	2	N/A	3

Table 3: SME BSN Effectiveness Assessment

Table 3 reports each of the SMEs ratings on BSN effectiveness.

SME 1 mentioned that the tool was very appropriate for the audience. This is in

line with Flack's findings [10]. BSN was most effective when players were inexperienced. Including the scenarios to provide emphasis on topics as participants progress through the workshop, will provide an increased benefit to the target audience of the workshop.

SME 2 expressed that the game provides a rudimentary exposure to JADO capabilities, challenges, and considerations. SME 2 also considered the purpose of the workshop surrounding the BSN scenarios is an introduction. The introduction designation allows for greater amounts of abstraction. It is important to emphasize the importance of debriefing to clarify ideas and correct inaccuracies. The facilitator needs to understand what the scenario is attempting to communicate.

SME 3 stated that their rating was influenced by a lack of experience with the current card content. However, SME 3 also stated that the serious game can only be as good as it is accurate. There is the challenge of applying it as an operational plan to JADO. JADO and BSN have and will continue to grow as the DoD tests different ideas. One of the benefits of BSN is the flexibility that it offers as a framework. However, the critique that the card content needs to be relevant is an important challenge. The balance between gameplay and reality is challenging to maintain. An example of this is the attack points assigned to a particular unit and how it compares relative to other units. One question relating to this is: what does it mean that the tank has three attack points and the F-35 has one attack point? Does that accurately model real-world information? Using the debrief, it is important to remind players that there are abstractions and point out specific interactions and lessons to focus on.

SME 5 approved of the scope and realism given the constraints of the tool. However, they noted that some topics, particularly information operations, may be difficult to scope, given the many factors that apply and overall complexity. This recommendation is partially addressed by attaching the progressive scenarios to specific

lessons. This workshop's approach utilizes a lesson/discussion, gameplay, debrief format. The scenario gameplay part gives participants the opportunity to engage with the material and try some of the new ideas. When setting up the scenario, it is important to constrain the game to specific learning objectives that match with the game mechanics. The debrief section enables participants to come back and discuss their thoughts on the material and any new insights. Facilitators should take these debriefs as a time to help correct any misconceptions from BSN.

4.4.2 Participant Assessment

Prior to the beginning of the workshop, four of the seven participants had used serious games and found them enjoyable and effective. Two people had not played a serious game before and one person strongly disagreed with serious games being enjoyable or effective.

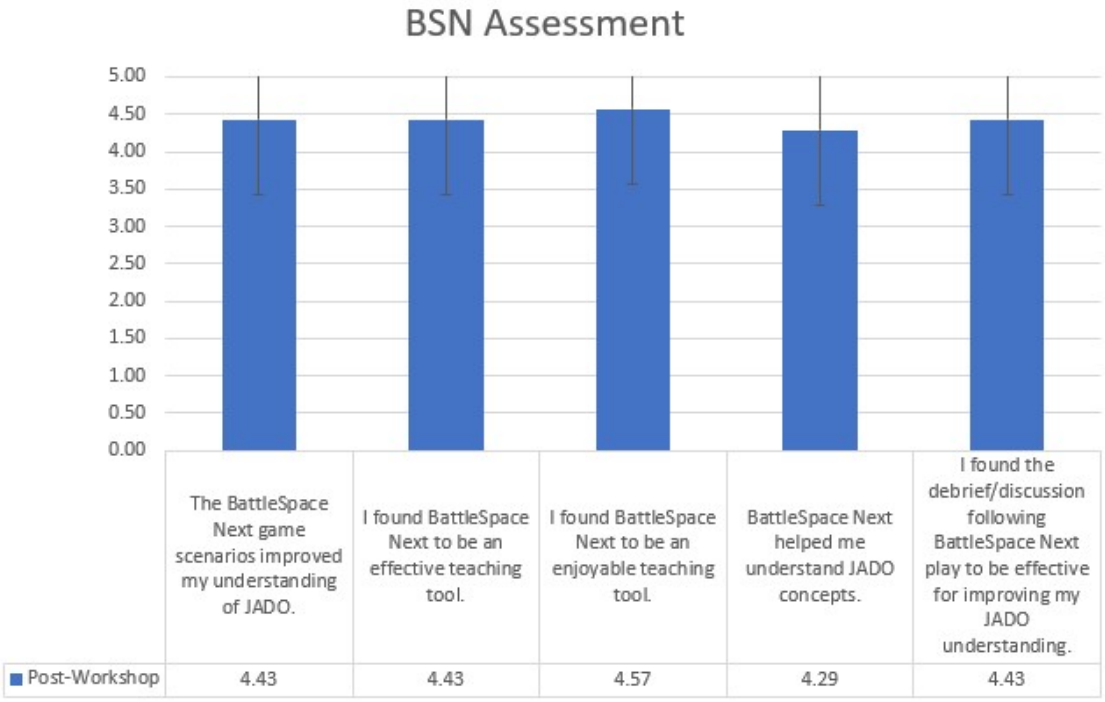


Figure 7: Likert Scale BSN Assessment (N=7)

Figure 7 shows the post-survey responses from participants in the workshop about BSN. The post-workshop survey indicated that BSN was an effective and enjoyable tool. The six participants said that they found the scenarios improved their JADO understanding, while the seventh person was neutral. Comments on the scenarios also indicated they provided a gradual build up of concepts to help participants grow through the workshop. Another comment indicated that the scenarios were helpful for emphasizing the different JADO topics. This shows that this research did meaningfully improve upon previous serious game research designed to teach JADO. Flack [10] suggested that some neutral results may have come from the players struggling with game complexity and the nebulous nature of JADO. The scenarios were developed to address these challenges. Through multiple engagements, the players learned different game mechanics piecemeal, leading to an easier learning curve. The scenarios also tied the game mechanics added in each scenario to the learning objectives. This gave the players a manageable number of concepts to focus on each play-through, reducing the cognitive load that players might get if they only played the full game once or twice.

Each scenario was designed to include a debrief. Appendix H contains a summary of the major comments made from each debrief in the workshop. One comment noted that BSN does not always relate accurately to real world operations. The debrief was a useful time to discuss how the game abstracted some details and also allowed players to discuss the ideas that had been presented in the earlier lecture. In the debrief section, players tied assets back to JADO objectives discussed earlier and how it impacted their decisions. One example was during the Information Scenario (see Appendix H) when the fog of war was introduced, the ORS, a space ISR asset, quickly became one of the most widely used assets. Players that did not have this capability discussed being unwilling to attack for fear of how the opponent would

respond. During the debrief participants could tie this back to how important the large amounts of intelligence were and the need to maintain maneuver in different domains.

Players also engaged with the game at high levels of Bloom's Taxonomy. One example is during the logistics scenario debrief, show in Appendix H, the idea came up that BSN could better reflect the importance of logistics with a Joint Deployment & Distribution Ops Center (JDDOC) card. A game mechanic was discussed where losing the card would cause the player to take two turns to deploy future assets. The participants then discussed the importance of logistics and how a failure to protect key logistical nodes could affect convergence. This discussion hit the levels of both create and evaluate. This level of engagement with the source material supports the Likert Scale evaluations that participants rated.

4.5 RQ 4: What are SMEs' assessments of the effectiveness of a JADO workshop using a serious game?

4.5.1 Topic Coverage and Depth

SME 1	SME 2	SME 3	SME 4	SME 5
4	4	4	4	3

Table 4: SME Rating of Topic Coverage and Depth

Table 2 displays the SMEs' responses to the question: "What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)". Comments included the workshop provided good coverage of topics. One SME noted that it was ambitious depending on audience and time. This statement was validated through the workshop experiment. Covering all the topics outlined in the syllabus was too much for a 16-hour workshop. The

workshop instead decided to focus on quality of discussion for the topics that were possible. One SME also noted that it made doctrinal topics more tangible to participants. As an introductory workshop tool, discussing how the DoD might seek to get to the results of JADO, and discussing the steps can help participants go back and influence change in their organizations.

4.5.2 SME Workshop Assessment

SME 1	SME 2	SME 3	SME 4	SME 5
4	4	4	4	3

Table 5: SME Rating of Workshop Effectiveness

Table 3 displays the SMEs' responses to the question: "5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)". These ratings are based on the fact that it is to serve as an introduction to JADO. One aspect to consider is to make sure that the target audience and intent are clearly defined and communicated. While this is true of many courses, there are several factors that could add complexity. The first is that JADO concepts are still new and developing. This means that the audience of people that might benefit from such an introduction from many different levels of experience and backgrounds. The next factor to address is resisting mission creep where the workshop needs to introduce everything. JADO's vast number of possible topics increases the temptation to try and cover everything. For a general introduction, picking the most important topics to discuss and sticking to defined limitations are essential. Another factor to consider with workshops is fatigue. Filling a workshop with too much material for the allotted time could lead to rushing topics to stick to a schedule. If participants are not given time and clear main learning objectives retention could be limited. The workshop experiment addressed this with a combination of four main topics over doctrinal topics and then allowing

the participants to vote for up to four of the remaining topics. One way to help assess how the workshop's effectiveness, is to consider participant response during debrief and discussion portions. Limited engagement could indicate uncertainty with the ideas that have been covered.

4.5.3 SME Recommendations for Improvement

The first recommendation for effectiveness emphasizes the facilitator. The structure of a workshop requires a facilitator that can answer questions and discuss concepts. The domains all have different strengths and challenges associated with them. Likewise, other aspects such as command and control or logistics also have some differences. Including either guest facilitators or having partners can lessen the load on the main facilitator and provide a diversity of perspectives and experiences throughout the workshop. Another benefit of having multiple facilitator SMEs enables crosstalk conversations about the interrelationships between domains.

The next recommendation is ensuring the content, both for discussions and scenarios, is an accurate representation. For the base game of BSN, this includes using real assets and matching their functionality to what they do in the game. The scenarios can also help add different levels of challenge or new game mechanics to emphasize specific learning objectives. The debriefs have to serve as a way to impress practical lessons that can be acted upon in their roles.

Another recommendation is not to "hand-wave" the accesses and authority requirements for JADO. Currently, this needs to be covered in debrief sessions. The current scenarios and game do not accurately model many of the challenges of gaining the appropriate authority. In the future, additional scenarios could also help address these learning objectives. New doctrine has discussed finding the appropriate level for control of assets and how to adapt to situations. However, the doctrine basis for

mission type orders is new and the workshop will need to evolve to better deal with the concept.

Finally, SMEs recommended continuing to build partnerships, including with other services. As stated above the course needs to reflect reality. The best way to do this is to get feedback and incorporate the other service's needs and ideas and to develop together across the DoD.

4.6 RQ 5: What are participants' assessments of the effectiveness of a JADO workshop using a serious game?

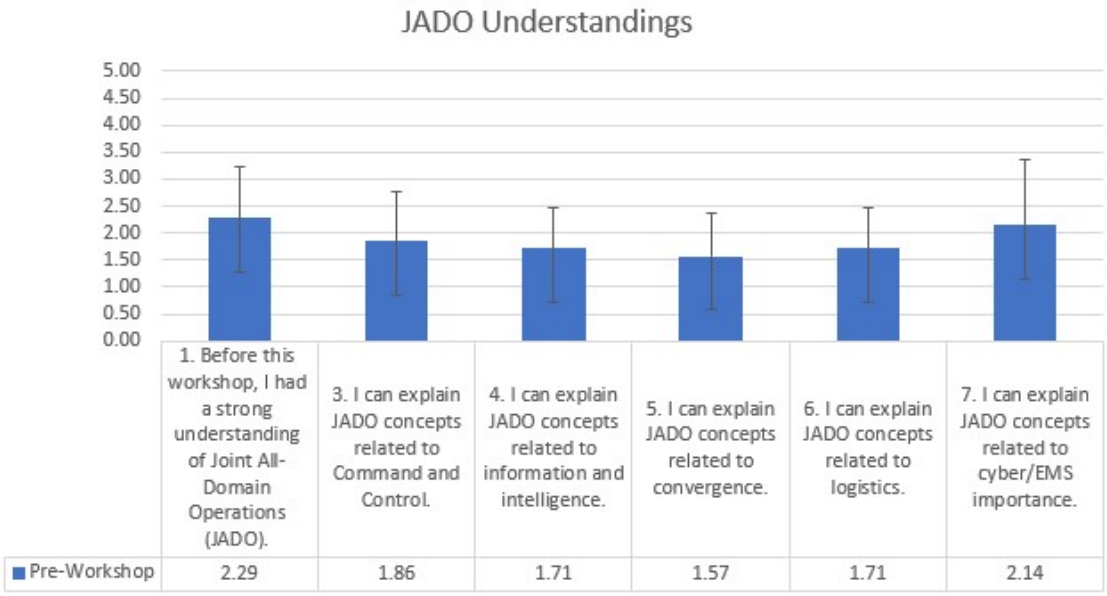
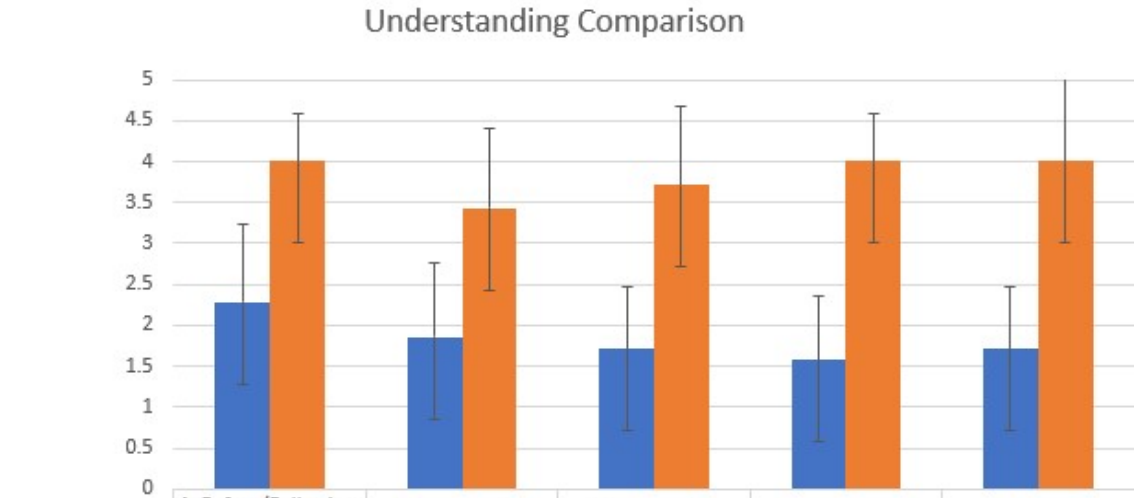


Figure 8: Likert Scale JADO Understanding Confidence (N=7)

Figure 8 displays results from the participant's self-assessment on their JADO knowledge. These results show that participants were a part of the target audience of people that do not have JADO experience. It is interesting to note that the average rating of participant understanding of JADO as a whole, question 1 in Figure 8, was higher than any of the average understandings of the specific JADO topics. One

contributing factor could be participants could have included JADO knowledge that was not encapsulated by the following questions. Another potential contributing factor could be some comfort with the concept at the higher level, but once deeper questions were considered, participants felt less comfortable with the extra detail required.



	1. Before/Following this workshop, I had a strong understanding of Joint All-Domain Operations (JADO).	3. I can explain JADO concepts related to Command and Control.	4. I can explain JADO concepts related to information and intelligence.	5. I can explain JADO concepts related to convergence.	6. I can explain JADO concepts related to logistics.
Pre-Workshop	2.29	1.86	1.71	1.57	1.71
Post-Workshop	4.00	3.43	3.71	4.00	4.00

Figure 9: Likert Scale JADO Understanding Confidence (N=7). Some respondents may not have filled out both surveys

The post-workshop survey results indicate that the workshop was successful for introducing JADO concepts to novice JADO learners. The Command and Control topic showed the least improvement, from the total participants viewpoint, as well as the lowest overall score for the post-workshop survey. Part of this is likely due to the major change in Air Force Doctrine towards mission-type orders and centralized command, distributed control, and decentralized execution. These changes, happened

five days before the workshop started. The workshop was modified to reflect this new understanding but it still is a new concept. Command and control was also one of the first topics. Several participants noted that discussion flow improved throughout the workshop. These comments and the high ratings for BSN indicate that much of the workshop's effectiveness was based in the use of BSN.

One respondent gave the workshop the lowest ratings in nine of eleven Likert Scale questions. Given the low number of participants, these ratings may have had a outsize impact on the overall results. This participant gave serious games a one for both effectiveness and enjoyment in the pre-workshop survey. This participant didn't like serious games and so a workshop that heavily utilized a serious games may not be the right fit for that person. This is in line with previous serious game research that suggests that some people do not learn well through serious games. Despite this challenge, JADO introductory education needs to utilize a variety of types of resources to engage with learners that do not like serious games, so that all learners improve their understandings.

Another interesting result was some of the participant's scores indicated they were less able to explain certain JADO concepts. This change could be a combination of bias and thinking they had a better understanding then they did due to being misinformed or not knowing what they did not know, and exiting the workshop with more questions which is an acceptable outcome of a primer.

Another element of the workshop to consider is the online nature of the course, required due to COVID-19 constraints. Several participants said that the overall organization of the workshop mitigated challenges presented by the online environment well. However, it was also noted that engaging the participants in discussion was challenging due to lag and microphone difficulties. The online format also complicated the scenario gameplay as some participants had to talk each other through their

moves, adding an additional level of complexity. It is relevant to note that despite this additional complexity, the scenarios built in a way that still made playing and learning through BSN possible and effective.

V. Conclusions

5.1 Overview

This chapter summarizes the results found through experimentation from this research effort. Section 5.2 reiterates the conclusions from the SME experiment and the HSR workshop experiment in Chapter IV. Section 5.3 discusses the significance of the research and implications for future JADO education and use of serious games. Section 5.4 identifies potential avenues for future research.

5.2 Research Conclusions

This research analyzes a novel introductory-level JADO workshop and provides 3 contributions: first creating a workshop for JADO introduction with relevant topics; second, gathering responses from SMEs and the target audience; and third, continued development to improve BSN as an educational tool.

Currently, accessible JADO education is limited. Most of the accessible material is either from news articles or publications. Some military courses are including JADO in their curriculum and some organizations are developing their own workshop to provide some introduction to their members. One challenge to delivering JADO concepts to the masses involves selecting which topics need to be included.

The participants' pre-workshop responses indicated that 85% of participants wanted to learn more about JADO, despite all responses saying they had a neutral to weak understanding of JADO. This imbalance could be explained through the current tools that participants could access. The participants listed strategic level doctrine, quick conversations, and other limited documents.

As hypothesized, the majority of responding workshop participants responded positively to the use of serious games in the workshop. The one response that was not

positive had also indicated that they generally did not like the use of serious games. Additionally, those ratings were still higher than that participant's pre-workshop response to other serious games, suggesting that BSN has some potential even among those that dislike serious games.

The addition of scenarios to BSN also was positively received. Flack [10] noted that many players commented on the complexity of the game. After following the progressive scenarios, players described the scenarios as helpful acclimating into the game. They also showed a greater appreciation for the complexity of the game play by the time they were able to play the full game. Some players even suggested rule changes that increased BSN complexity but gave them greater control. Players then justified the change through real-world comparisons. Players also reported that scenarios helped them focus on specific learning objectives related to JADO topics.

The importance of the debrief time was validated by workshop response. The debriefs had the most active conversation amongst participants and it also helped correct inaccuracies from the game. It also helped emphasize the learning objectives for each scenario. One example of this was the Intelligence Scenario when the hidden assets mechanic was introduced. Players expressed how important ISR capabilities were to executing their strategies and how it influenced their in-game behavior. The debrief conversation then led to the importance of maintaining ISR and the command and control to utilize incoming information.

5.3 Research Significance and Synthesis

JADO is still a new and developing concept to address the complexity of modern battlefields and take advantage of cross-domain opportunities. This work attempts to address the limited educational opportunities available to many DoD affiliated members. Although some DoD affiliates do not enjoy serious games or find them useful

due to abstraction choices, many do and debriefs were shown to help address that realism challenge. The proposed workshop is designed to fill a gap in current JADO education to be more accessible and provide a stronger framework. The workshop results suggest that the workshop was effective and that the use of BSN was effective and engaging. This study has implication for future JADO education and serious game design and implementation.

5.3.1 JADO Education

The research suggested four significant implications for JADO education.

1. The DoD has a need for introductory-level JADO material. As the DoD works to pivot to JADO concepts, providing some structure so that people can learn about these changes will help organize efforts to evolve. As people gain experience, they will form habits and ideas based on those experiences. Discussing concepts that are outside of an individual's speciality can help overcome the "silo" mentality of a specialist that might not otherwise consider those factors. If a JADO "mentality" can be fostered early in a servicemember's career, they can continue to nature that all-domain thinking as opposed to having to relearn it later.

2. The SME facilitator will impact the overall effectiveness of any course. In the workshop experiment, several participants noted that the topic lectures earlier in the workshop were less effective but that they improved by the end of the workshop. One factor to this was it was the first run and feedback helped improve the facilitators' presentation style. Another potential factor was that participants could reference previously discussed topics in the later discussions giving the facilitators a wider range of concepts and experiences to draw upon.

3. JADO concepts are rapidly developing and JADO education needs to reflect this reality. Between the services' development efforts, new doctrine, and the advancement of technology, JADO material will continue to change and need updates. This requries a tool to have flexibility to update with these changes. An example of this is five days before the workshop experiment started the Air Force released new doctrinal concepts for command and control. The doctrine contained new ideas including on mission-type orders and centralized command, distributed control, and decentralized execution [122] [15]. In that time, the facilitators had to update the course to reflect the change. These types of changes are expected to continue, so keeping up-to-date will be key for any educational material to remain relevant.

4. Continued conversation can help address new developments. Having a discussion is helpful for learners to engage with the material. If the DoD had a place that had some educational material with some learning objectives and then a discussion board, it could help serve as a hub to stay current or engage with the new material. This idea would work with an introductory workshop to provide the groundwork and then a place to develop upon these ideas. The JADO APAN wiki could help serve in this role.

5.3.2 Implementation of Serious Games

The research suggested four significant implications for serious game implementation and development.

1. Serious games are useful complements to discussion. The workshop experiment was a sixteen hour course spread over four days. Due to the time restraints, breaks longer than 10 minutes were not practical. However, the scenario gameplay broke up the time so that students could engage with material and practice.

After each gameplay session, participants came back and were ready to discuss the ideas and concepts from the scenario. 85% of the participants reported that they found BSN to be enjoyable and in debriefs several participants indicated they would play the game outside of work hours or as part of a game night. This leads to additional time engaging and discussing new concepts which can help solidify lessons in the learner's head.

2. Slower buildup can help manage complexity. Flack [10] reported that many BSN players commented on the complexity of the game and that the focus on gameplay could change focus from learning JADO lessons. The scenarios took out some of the game mechanics and gradually reintroduced them to the game. This approach created a simple game to gain familiarity and it also helped players associate game mechanics with real-world application.

3. Potential benefit of connecting to specific learning objectives. Flack [10] mentioned that neutral results could be a result of JADO being unclear. This possibility was reinforced through this workshop where pre-workshop participants had trouble picking specific topics that were important. The scenarios used in the workshop experiment connect around three learning objectives for players to focus on each playthrough. This gives a narrow focus for players and points players in the direction of what might be important for JADO learning.

4. Finally, the debrief session is essential for consolidating learning. Each debrief session, participants would discuss what they learned and how it related to the JADO topic discussion. This debrief was also valuable because participants would also mention some ways that the game did not align to reality. This is a promising step. Serious games have to make some choice of abstractions so participants being able to notice and apply how real life considerations might

further affect their decisions indicates a strong engagement level with the material. Facilitators could also help consolidate the learning objectives by leading the discussion to include key takeaways.

5.3.3 Workshop Development

This research has suggestions for workshop development in the Air Force.

1. Teamwork. This research emphasized the importance of networking with SMEs outside of the researcher's organization. This was essential to workshop development due to increasing interconnection and need to provide accurate information to learners even outside of developers experience. Team building can help overcome blind spots and provide higher quality education.

2. Today, gathering information is challenging and continuous process. JADO education material is constantly evolving and there are several sources that contribute to the overall understanding. These materials are not always consistent so selecting the materials that best model specific assets in an important skill.

3. Modularization of topics can improve the agility of a workshop. Workshops need to convey current information which frequently changes. The use of modules keeps the information contained to facilitate rapid updates. Modularization is possible despite topics influencing each other. An example of this influence is command and control needs to be informed by intelligence. However, focusing on the core tenants of each topic and then using a tool, such as conversation or BSN, to help connect the topics can help ease the challenge of remaining current.

5.4 Future Work

Our research suggests the workshop with serious game components and rapidly changeable curriculum show promise to teach students about JADO. Several potential paths to continue this research exist. The most relevant areas are:

1. The workshop and BSN scenarios can be further refined and evaluated using additional trials of the workshop. This study would provide validation to the effectiveness of such a workshop and inform best practices for helping the military train and educate its members. The target audience for these trials would remain Airmen with no prior JADO experience.

2. A digitized version of BSN would provide several benefits. First, the workshop was offered online so the physical game added some complexity and restrictions to participants. A digital game could also enforce game rules to reduce the learning curve. Finally, an online version could help set up scenarios and provide discussion guides.

3. If BSN was digitized, AI technology could be useful to provide a single player capability. AI could also provide suggestions for new players or recommend scenarios based on choices a player makes.

4. Development of new scenarios to address developing JADO doctrine. New scenarios can alter or add game rules to add realism or influence player decisions to discuss JADO ideas as they are developed.

5. Create an asynchronous workshop option. The workshop proposed in this research is based on conversation and a facilitator. Each scenario's debrief is a key part of the learning process. However, this adds time constraints and a schedule. An asynchronous introductory workshop that learners can do on their own

time and focus on topics they find interesting or important.

6. Addition of adversary cards or assets to BSN. One of the challenges of BSN is the idea of mirror imaging potential adversaries. Creating cards that better reflect adversary capabilities can lead to new conversation and development of ideas.

7. An objective evaluation to assess the workshop would also improve conclusions. This research assumed that self-reported knowledge is sufficient. However, a formal assessment could further validate findings from this research.

Appendix A. Class Syllabus

The Class Syllabus provides the an outline of the workshop. It includes learning objectives, key resources, and quick breakdowns of each of the topics. This breakdown has much of the thought process that went into the development of the workshop. The links and resources are useful for the time that the workshop was first run but may lose relevance as time progresses.

Class Syllabus

Class Information

Class Target Audience

This class's target audience is any Airman that does not have JADO experience.

Class Intent

The intent of this class is to serve as a primer. It points learners in the direction of relevant topics and helps explain some key terms at a basic level. This class does not have the depth of more complex courses and it is not intended to develop students into JADO SMEs.

Class Motivation

- Requirement to work together:
    - Army and Air Force agreed to work together in "two-year" collaboration agreement in Combined Joint All-Domain Command and Control (CJADC2) in October 2020 (https://www.af.mil/News/Article-Display/Article/2369626/army-air-force-form-partnership-lay-foundation-for-cjadc2-interoperability/)
        - Intends to combine Project Convergence and ABMS together.
        - "Ultimately, such close coordination between Army and Air Force leaders only happens once in a generation, said Army Secretary Ryan McCarthy" (https://www.c4isrnet.com/digital-show-dailies/ausa/2020/10/20/the-army-and-air-force-are-finally-on-the-same-page-with-a-plan-to-connect-the-military-what-happens-next/?utm_source=Sailthru&utm_medium=email&utm_campaign=EBB%2010.21.20&utm_term=Editorial%20-%20Early%20Bird%20Brief)
    - Navy and Air Force have a "handshake deal" (https://news.usni.org/2019/11/13/navy-air-force-reach-handshake-agreement-to-develop-joint-battle-network) but
- Conflict between the services does happen, further complicating the relationships and cooperation.
    - The Chief of Naval Operations publicly declared the Navy needed a larger share of the budget and the Army Secretary responded that the Army is already getting less than it deserves (https://breakingdefense.com/2020/01/army-to-navy-hey-we-already-get-less-than-you/)
        - This challenge between budgets can incentivize competition between branches as opposed to cooperation
    - AFGSC chief says the Army's long-range strike vision is stupid. He says it is a waste of money and their capabilities would take years to reach what the AF and Navy can already do better. This speaks to a challenge between mission appropriateness and conflict and lack of cooperation between the services. (https://www.airforcemag.com/armys-long-range-strike-vision-is-stupid-afgsc-chief-says/#:~:text=The%20Army%20also%20won't,and%20can%20react%20almost%20instantly)

Class Learning Objectives

- Understand JADO doctrine concepts
- Explain how new technology capabilities will enable JADO
- Explain how JADO theories can help the US counter near-peer threats

Other Information

- Key resources are important for understanding and being able to discuss the topics. Optional resources provide either extra detail or other viewpoints.

Learning Paths

- Learning Path 0 – the base learning path for the branches
- Learning Path 1 – The doctrine-based path
- Learning Path 2 – The technology-based path
- Learning Path 3 – The application assist path

LP0 – Lesson 1 – Key Terms/Concepts Introduction

Topics

- Introduction
- What are domains
- Key Definitions

Purpose

Familiarize the learner with some key definitions and ideas. Particularly important for setting the stage for later topics

Motivation

Directly ties to AF doctrine. One of the larger criticisms of JADO is that it is a rebranding rather than anything new/that we aren't already doing. Clear definitions will help mitigate some misunderstandings

Learning Objectives

- Recognize key terms associated with enabling JADO
- Recall definitions and enabling factors for JADO
- Understand what terms mean in a JADO context
- Be able to discuss motivation for the shift to Joint All-Domain

Key Resources:

1. Understanding the Requirement for Forging a Multi Domain Operational Concept – Jeffrey Reilly
    a. Provides a history and clear thoughts on general basics
2. How to Win Future War! JADO & JADC2 Strategy w/ Scott Van Dewater ½
    a. https://www.youtube.com/watch?v=x-ZI5FIYsgo
3. JADO201v1 0 1
    a. https://www.youtube.com/watch?v=U6WZpOoLWOg

Optional Resources:

1. Dust – OTH by Nicholas Narbutovskih (print)
    a. Sci-fi scenario helps bring a why and vision to discuss possibilities
2. Potentially Relevant Term Definitions
    a. A mini-dictionary of relevant terms used in conversation

LP0 – Lesson 2 – Asset and Concept Familiarization

Topics

- BSN intro
- BSN beginning scenarios
- JADO concepts

Purpose

Initial demonstration of JADO ideas. Scenarios to help familiarize with the game as well as illustrate specific learning objectives.

Motivation

This module focuses on the playing of BSN. Recommended starting with each domain by themselves and culminating in playing all of them. Serves as both a primer for ideas and starts engaging learners to try using different strategies.

Learning Objectives

- Recall advantages proposed from JADO
- Classify different assets into the domains they affect/operate in
- Compare the value of different assets to a strategy
- Organize assets to achieve an objective
- Plan a strategy to win the game/overwhelm the opponent

Resources/Evaluation

- Battlespace Next – Game Instructions
- Battlespace Next – Instructor's Guide
- BSN Scenarios
    - Only Land and Air

LP1 – Lesson 1 – Command and Control

Topics

- Command and Control Intro
- Decentralized Execution
- JADC2 considerations

Purpose

Tie a major section of doctrine and help break it down to be more palatable and spur conversation. Understanding where the C2 wants to go can inform how the lower level needs to develop.

Motivation
Specific section of AFDP 3-99, that learners may want a resource to better understand.

Learning Objectives
- Recognize Rules of Engagement can affect JADO
- Understand non-kinetic capabilities reusability
- Analyze conditions that lead to delegation
- Explain the benefits of decentralized execution
- Explain how decentralized execution aids convergence
- Plan how to account for second/third order effects
- Analyze impacts of losing allies on geographically-focused capabilities

Key Resources
1. AFDP 3-99 DAF Role in JADO (pg. 6-10)
2. ADFP -1 Mission Control
3. Second-Order effects dominate our world and are worth thinking about deeply (pg. 1-5)
4. 2021_USAlliancesCrucialEnablersInGreatPowerCompetition (pg. 1-6)

Optional Resources
1. Why Centralized Control Decentralized Execution Works
2. Joint All Domain Operations Is Missing All Domain Command And Control Support
3. Centralized Control And Decentralized Execution (pg. 1-3)

LP1 – Lesson 2 – Information

Topics
- Information Warfare
- Information Sharing
- Intelligence synthesis

Purpose
Tie a major section of doctrine and help break it down to be more palatable and spur conversation. JADO's emphasis on the flow of information, influenced by the digital age, makes this chapter one that a learner might misunderstand.

Motivation
Specific section of AFDP 3-99, that learners may want a resource to better understand.

Learning Objectives
- Recall what information warfare encompasses
- Understand that AI/machine learning can assist classification of information
- Understand how cyber can enable intelligence gathering and prevent adversary ISR
- Analyze benefits brought by space and cyber for information
- Explain potential losses of information if space/cyber not maintained
- Compare how different domains can perform ISR

- Understand information needs to be shared between domains
- Explain how events in one domain could affect abilities in others

Key Resources

1. AFDP 3-99 DAF Role in JADO (pg. 11-15)
2. Information Warfare And Joint All Domain Operations - A Primer For Integrating And Prioritizing Data Requirements (pg. 1-7)
3. 2021_The Intelligence Posture America Needs In An Age Of Great Power Competition (skim)

Optional Resources

1. Intelligence Surveillance And Reconnaissance Design For Great Power Competition
2. Maintaining The Intelligence Edge

LP1- Lesson 3 – Fires

Topics

- Convergence
- Synergistic Effects

Purpose

Tie a major section of doctrine and help break it down to be more palatable and spur conversation. Fires emphasizes the ideas of convergence of effects across domains. Interoperability is another key aspect so this section is key for future operations.

Motivation

Specific section of AFDP 3-99, that learners may want a resource to better understand.

Learning Objectives

- Convergence
    - Remember using different domains can lead to a sum greater than the parts
    - Remember cross-domain effects require synchronization
    - Compare how long an effort might require relative to a different type of effort
    - Explain why the different types of efforts might take a longer period of time
    - Analyze the different effects from different domains for the reason the associated relative prep time is long/short
    - Differentiate between effect capabilities within a domain
    - Analyze how an action in one domain might affect the another's timeline
    - Critique the current estimates and see what inefficiencies could be mitigated
    - Evaluate an existing plan for weaknesses/strengths that enable/challenge convergence

Key Resources

1. AFDP 3-99 DAF Role in JADO (pg. 16-18)
2. Protection WFF (Warfighting Function) –Multi-Domain Operations (MDO), Enable Division River Crossing
    a. Link: https://www.youtube.com/watch?v=844g4FfyBiw

    b. short example video (visualization)
3. 2019 Air, Space, & Cyber Conference – General David Goldfein (39:05-53:00)
    a. Link: https://www.youtube.com/watch?v=wyQG29uiiy8

Optional Resources

1. The U.S. Army in Multi-Domain Operations in 2028

LP1- Lesson 4 – Logistics

Topics

- Logistics before conflict
- Protection
- Sustainment

Purpose

Tie a major section of doctrine and help break it down to be more palatable and spur conversation. Movement and maneuver are a key part of any conflict and the doctrine emphasizes EMS, cyber, and space which some might not consider when preparing for warfare and the physical tangible assets are simpler to focus on.

Motivation

Specific section of AFDP 3-99, that learners may want a resource to better understand.

Learning Objectives

- Understand how resilient planning is required to protect movement
- Understand how logistics affect convergence capabilities
- Analyze how electromagnetic spectrum operations affect maneuver in different domains
- Recognize that JADO requirements require new avenues of protection
- Explain how convergence principles can apply for protection as well
- ACE
    - Analyze how ACE enables operations to continue in degraded environments
    - Critique risks and increased costs required for ACE
- Summarize the importance of interoperability for JADO sustainment
- Compare the different types of Maneuver Logistics (Logistics under attack, limited duration self-sustainment, dispersed sustainment)
- Explain how partnerships with allies enable sustainment logistics
- Recognize that effectiveness is valued over efficiency

Key Resources

1. AFDP 3-99 DAF Role in JADO (pg. 19-24)
2. The Nature Of Logistics (pg. 3-8)
3. A CRISIS Exists An Easy Mnemonic To Remember The Sustainment Principles (pg. 1-4)

Optional Resources

1. The Nature Of Logistics (the rest of the article)
2. NATO Logistics

3. Smart Logistics For Future Armed Forces
4. Future Logistician – Logistics In War
5. Logistics Agility & Resiliency - Training the Supply Chain – OTH (pg. 1-6)

LP2 – Lesson 1 – Cybersecurity

Topics

- Cyber Kill Chain
    - Steps
    - Reasoning for longer timeline
- Interoperability
    - Current failure (examples)
    - Different types (between different systems, different services, different countries)
    - Need to establish standards
- Cyber Defense Concepts
    - A few types of attacks to be wary of
    - Defense in depth (layered)

Purpose

This module will discuss cybersecurity in general. This includes why there is a cyber kill chain, as well as examples for the longer time required. It will have information on some basic steps to help a member become educated on steps to improve efforts/understand certain protocols (no removeable media?).

Motivation

Cyber/EMS bind the other domains together. Cyber will also be an important part of the synthesis of information. Protecting the ability to send the information where it is needed and protect it will be crucial for JADO.

Interoperability in computer science is the ability of computer systems or software to exchange and make use of information. Interoperability in military is the ability of military equipment or groups to operate in conjunction with each other. This ability is not currently present even in some inter-service assets (see F-22 and F-35 comm problems). Standards need to be set so that systems/assets can communicate with each other and integrate to serve the big picture.

Learning Objectives

- Recognize different steps of the cyber kill chain
- Explain how a cyber attack progresses through the cyber kill chain
- Recognize what cyber interoperability means
- Summarize how cyber interoperability could impact operations
- Explain some different types of cyber attacks
- Compare how zero trust network concepts improve cybersecurity

Key Resources

1. What is the Cyber Kill Chain and How to Use it Effectively (pg. 1-7)
2. Cyber interoperability is a must for federal agencies (pg. 1-4)
3. 8 Common Cyber Attack Vectors and How to Avoid Them (pg. 1-7)

4. No More Chewy Centers (pg. 1-12)

Optional Resources

1. The Basics of Defense in Depth Cybersecurity
2. What is the cyber kill chain Why it's not always the right approach to cyber attack
3. Interoperability Is Key To Cybersecurity – A Conversation at CSIS
4. Cybersecurity and the Problem of Interoperability
5. Jericho Forum Commandments

LP2 – Lesson 2 – US Cyber

Topics

- US posture
    - What could be lost if cyber domain is lost
    - Defense For the nation (more aggressive posturing) (google something about active defense from a statement)
- Potential Impacts on operations
    - Benefits of non-kinetic
    - Long reach
    - Synergistic effects
    - Importance in linking/connecting domains as well as sensors and shooter

Purpose

This module will build upon some of the concepts above and further tie them to JADO. It will be focused more on the US view of cyber/uses.

Motivation

This module will help describe some of the DoD's practices and ideas that they will operate on going forward. Some of these ideas, such as defending forward may be are due to the traits of the cyber domain. Understanding U.S. policy on this topic can help to clarify JADO discussion.

Learning Objectives

- Summarize the key aspects of the US posture that rely on the cyber domain
- Compare benefits offered by non-kinetic operations to kinetic operations
- Explain how cyber capabilities can serve as a force multiplier to US operations
- Provide an example using of how a cyber action can help a US operation
- Recognize the cyber connections between sensors and shooters
- Understand how cyber can facilitate information operations
- Analyze how cybersecurity impacts your job/mission
- Understand how ubiquitous cyber has become

Key Resources

1. How to Compete in Cyberspace _ Foreign Affairs (pg. 1-11)
2. DOD2018_CYBER_STRATEGY_SUMMARY_FINAL (pg. 1-10)

Optional Resources

1. How To Strengthen America's Cyberdefenses _ The Heritage Foundation
2. Systemic Cyber Risk And Aggregate Impacts
3. Cyberspace Solarium Commission (especially pg. 23-30)

LP2 – Lesson 3 – Artificial Intelligence

Topics

- Foundational Concepts
- AI Application: Opportunities and Risks
- Responsible AI

Purpose

Provide learners an introduction into AI topics as identified in the 2020 DoD AI Education Strategy

Justification

Artificial Intelligence is a tool that is getting significant attention. A basic understanding of what the tool can be useful for and other expectations will strengthen a service member's understanding when the topic is discussed.

Learning Objectives

- Recognize potential use cases for AI in JADO
- Understand basic ethical AI uses and concerns
- Summarize some risks of AI use

Key Resources

1. Harnessing Artificial Intelligence – AI and Strategy (8:01-16:37)
    a. Link: https://www.youtube.com/watch?v=dx6rtzbO9UM
2. AI in Multi-domain Operations: Future Artificial Intelligence War
    a. https://www.youtube.com/watch?v=FIxFhhKj9LA

Optional Resources

1. Lessons from the Naval Postgraduate School Harnessing AI Course
    a. Link: https://nps.edu/web/ai-group/harnessing-ai-course
2. Summary of the 2018 DoD AI Strategy

LP2 – Lesson 4 – Cloud & Internet of Things (IoT)

Topics

- Cloud Security Benefits
- Cloud Information Sharing/Accessibility Benefits
- Intro IoT Concepts

Purpose

Familiarize learners with benefits that are possible with Cloud technology and current Cloud efforts.

Motivation

Cloud and IoT show promise for promoting greater connectivity and computing power. They have their own set of risks and rewards. Providing a basic understanding of these concepts will help learns critically analyze where they fit into the overall picture. JADC2 networks and ABMS have been described as "military IoT"

Learning Objectives

- Explain how Cloud information sharing and accessibility helps enable JADO
- Recognize some use cases for cloud technology
- Recall some security benefits provided through using cloud systems
- Understand some Internet of Things basics

Key Resources

1. What is Cloud Computing_ _ IBM (pg. 1-11)
2. 4 Biggest Cloud Security Benefits – CDNetworks (pg. 1-6)
3. What is the Internet of Things_ WIRED explains _ WIRED UK (pg. 1-4)

Optional Resources

1. 7 cloud security controls you should be using _ CSO Online
2. Oracle_What Is the Internet of Things (IoT)_
3. What is the IoT_ Everything you need to know about the Internet of Things right now _ ZDNet

LP3 - Lesson 1 - Domain breakdown

Topics

- Air
- Ground
- Maritime
- Space
- Cyber
- EMS + Human

Purpose

Show the learner that each domain/branch has strengths and weaknesses and a unique culture that they bring to the fight

Motivation

Important familiarization for some benefits to strengths and weaknesses of domains/branches when separate. This can better inform how focusing on Joint is a force multiplier.

Learning Objectives

- Summarize differences between domains
- Compare strengths and weaknesses of different domains

Key Resources

1. An Overview of Land Warfare (pg. 1-11) (skim)
2. The Naval Warfare Domain (pg. 1-12) (skim)
3. The Air Domain and the Challenges of Modern Air Warfare (pg. 1-11) (skim)
4. National Defense and the Cyber Domain (pg. 1-12) (skim)
5. Space 201: Thinking About the Space Domain (pg. 1-9) (skim)

Optional Resources

1. Electronic Warfare – The Forgotten Discipline
2. The Human Domain and Influence Operations in the 21st Century
3. SOF, the Human Domain and the Conduct of Campaigns

LP3 - Lesson 2 – Case Studies

Topics

- Desert Storm
- Operation Anaconda

Purpose

Case Studies, even older ones, can show the highs that can be reached when the services can achieve synergy. Likewise, Operation Anaconda, which wasn't against a near-peer adversary shows what can happen when joint capabilities aren't fully utilized.

The Operation Desert Storm instances that other entities observed and have an impact on how other's view US military operations.

Motivation

Not tied to any official doctrine, but both have been referenced by leadership in talks. Also referenced as influential to foreign powers assessing US operations.

Learning Objectives

- Provide examples of information warfare in Operation Desert Storm
- Recognize how planning enabled convergence of effects in Operation Desert Storm

- Explain how an unequal C2 structure can hinder synergy through the domains
- Infer how failure to utilize earned military advantages could harm future operations
- Understand that different assets may have different required lead times for convergence

Key Resources

1. Andres Anaconda Flawed Joint Planning
2. The Advent Of Jointness During The Gulf War

Optional Resources

1. DESERT STORM_ THE FIRST INFORMATION WAR
2. Operation Anaconda Lessons For Joint Operations

3. Operation Anaconda Chapter 5: Air Power Against Terror – Americas Conduct Of Operation Enduring Freedom

LP3 – Lesson 3 - China Lesson

Topics

- China views of warfare
- China views of information
- China views on competition

Purpose

Give an introduction to Chinese principles and ways of warfare. Show the difference in Chinese views of warfare and the state of the world.

Motivation

CSAF recently emphasized the need to have a "deep institutional understanding" of near peer adversaries in his "Accelerate Change or Lost"

Learning Objectives

- Understand how China views the United States
- Analyze some of the ways that China would seek to increase their own power/amplify military power
- Understand some of China's strategic influences

Key Resources

1. China's Concept Of Military Strategy (pg. 1-10)
2. Chinese Views of All-Domain Operations (pg. 1-9)
3. China's Strategic Culture (pg. 2- 11) (skim)
    a. Chinese Traditional Culture: The Influence of Confucian Thought. - Ideology and Principles as Part of Chinese Strategic Culture.

Optional Resources

1. China's Application of the 'Three Warfares' in the South China Sea and Xinjiang
2. The US Army War College Quarterly (of interest are the 4 articles between pages 11 and 62)
3. China's Dual Use Technologies IISS
4. 36 Stratagems

LP3 – Lesson 4 - Russia Lesson

Topic

- Russia views of warfare
- Russia views of information
- Russia views on competition

Purpose
Give an introduction to Russia principles and ways of warfare. Show the difference in Russian views of warfare and the state of the world.

Motivation
CSAF recently emphasized the need to have a “deep institutional understanding” of near peer adversaries in his “Accelerate Change or Lost”

Learning Objectives
- Understand how Russia views the United States and NATO
- Analyze some of the ways that Russia would seek to increase their own power/amplify military power
- Understand some of Russia's strategic influences

Key Resources
1. Putin's Russia and US Defense Strategy (pg. 2-13)
2. Russia's Approach To Cyber Warfare (pg. 3-6, 19-23)
3. Understanding Russian Hybrid Warfare And What Can Be Done About It (pg. 2-4, 7-10)

Optional Resources
1. Russian Hybrid Warfare and Other Dark Arts
2. The Russian Way of Warfare A Primer

LP0 - Lesson 15 – Asset and Concept “Evaluation” (2nd run through)

Topics
- Combination assessment of discussed ideas
- Create synergy through convergence of effects
- Test previous concepts
- Debrief to consolidate learnings

Purpose
Allows the learner to tie the concepts they reviewed/learned and work to apply them. Different strategies and scenarios can emphasize more advanced ideas.

Motivation
A second set of playing the game should give further and deeper insights than the first play through. Additionally, now the ideas are understood, better informed conversation based on what happens is facilitated.

Learning Objectives
- Recall advantages proposed from JADO
- Classify different assets into the domains they affect/operate in
- Compare the value of different assets to a strategy

- Organize assets to achieve an objective
- Plan a strategy to win the game/overwhelm the opponent

Resources/Evaluation

- Battlespace Next
- Add Analysis and what they learned/ noticed

Appendix B. BSN Scenarios

The BSN scenarios were developed as described in chapter III. The scenarios begin with progressive scenarios. These scenarios begin with a simplified set of rules and then progressively add the rules to better model the real world. Following that are several scenarios that change the rules from the base game. New players should start with the progressive scenarios and build up to the full game.

BSN Progression Scenarios

Intent: This takes each lesson in the workshop and provides a workshop for them. It begins by changing the rules of BSN to simplify it. As different parts of the workshop are explored rules will be added to culminate in the full game.

Rule updates will revert changes listed below to the ones explained in the base game instructions for that scenario and all the following ones.

Rule Changes are only for the specific scenario.

It is recommended to play with/against people that are roughly equivalent BSN experience.

Base Rule Changes Listed

A. Setup

Each player starts with the following cards face-up in level 2 of their playing area:

1. Multi-Domain Operations Center
2. IADS Command Center – Ground Domain

B. Select Starting Hand

No changes

C. Turn Overview

1. Reset Turn Time
   1.1. Note: The timer is not a strict guideline but rather a tool for maintaining the tempo of the game. Both players should agree on grace periods prior to the start of the game.
2. Resource Acquisition
   2.1. No resources used
3. Deploy Cards
   3.1. Take a card from your hand and place it in front of you (in playing level 1). **No resource cost but limit to 3 cards deployed per turn.** 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
   4.1. No change
5. Assign Forces
   5.1. No change
6. Discard remaining cards (optional)
   6.1. No change

D. Home Station Readiness and Battlefield Intelligence

All cards will be played face-up and remain that way through the game.

E. Attacking & Defending

No change

F. Advanced Rules and Concepts

1.1. Stealth – no change

1.2. Long-Range Fires – no change

1.3. Cruise Missiles – no change

1.4. Cyber Attacks – no change

G. Example Scenarios

No change

Scenario #1: Air and Ground Only

Learning Objectives

- Familiarization with BSN basic rules
- Recognize different Land-based assets
- Recognize different Air-based assets
- Critique the strengths/weaknesses of an approach that neglects certain domains

Rule Changes

- Asset Restriction: Only Land and Air assets
    - Infantry, Stryker, M1A2 Abrams Tank, Forward Operating Base, Deployable Air Base System, Surface to Air Missile (SAM), MIM-104 Patriot
    - KC-135 Stratotanker, RC-135V/W Rivet Joint, E-3 Sentry (AWACS), EA-18G Growler, E-2D Advanced Hawkeye, B-1B Lancer, B-2 Spirit, F-15E Strike Eagle, F-22 Raptor, F-35A Joint Strike Fighter
- Place destroyed cards at the bottom of the draw pile

Rule Updates

- None

Learning Goals

This scenario serves a multi-purpose set of objectives. First it serves as an intro to the game, as a quick way with minimal complexity, players can try out the mechanics and come to an understanding of the basic rules for preparation for the more complex scenarios and base game. Furthermore, as part of the asset familiarization, the limited card set breaks the game down to help ensure players look over options and think about ground assets.

Debrief Questions and Conversation Guides

- What are some advantages for ground operations? Some weaknesses?
    - Consider staying power, interactions, flexibility, information potentials
- What are some advantages for air operations? Some weaknesses?
- After recognizing how the defense and offensive requirements interact, would this change how you selected your cards at the start of the game?
- Did using only two domains make you feel limited as the "commander"?
- How did you achieve success/failure and what factors influenced that?

Scenario #2: Command and Control

Learning Objectives

- Interact with the different domains
- Understand the challenges of integration through different commanders
- Understand how differing priorities can complicate dispersal and use of forces

Rule Changes

- Asset Restrictions: Land and Air domain cards only (as described in scenario 1)
- Team Up (at least 2 per side) and split the domains between you and your teammate(s) (1 controls air assets, 1 person controls ground assets)
    - When a card is drawn the player that controls that domain holds it. 6 cards total should be held between the both the players
- Pick a player that makes final decisions for game choices
    - If there is a third person in the team, give them this role
- Each card that is drawn goes to the player that "controls" that domain
- Aim for 15 seconds per turn to discuss with teammate(s)
- All decisions in the game (which cards to deploy, which asset attacks which target, which asset defends against an opponent, etc.) are made by the final decision player
- Play cards and work together to crush the opponent

Rule Update

No change

Learning Goals

Command and control is a challenging balance of which level of command should a decision be made. Higher levels may have a better view of the overall picture and can help coordinate. However, requiring authorization from too high of a level can hamstring operations and grind operations to a halt. Additionally, Joint Forces usually have component commanders in charge of forces adding another level of complexity. JADO calls for a new understanding of command and control that is more integrated.

Debrief Questions and Conversation Guides

- What were some challenges from not being able to control the cards?
- Were there systems that helped improve integration?
- How did you choose to split domains? Why did you choose this split?
- What takeaways did you get from this?
- How did constraining teamwork affect your decisions?
- Was there a domain owner that got more control?

Alternate Scenario #2: Command and Control

Learning Objectives

- Interact with the different domains
- Understand how dispersal of forces can add resiliency to the command structure
- Understand how differing priorities can complicate dispersal and use of forces

Rule Changes

- Asset Restrictions: Land and Air domain cards only (as described in scenario 1)
- Each player chooses to organize your command system as
    - 1 MDOC with 12 health
    - 2 MDOCs with 6 health each
    - 3 MDOCs with 4 health each
- Win by eliminating all your opponent's MDOCs

Rule Update

No change

Learning Goals

Command and control is a challenging balance of which level of command should a decision be made. Higher levels may have a better view of the overall picture and can help coordinate. However, requiring authorization from too high of a level can hamstring operations and grind operations to a halt. Additionally, Joint Forces usually have component commanders in charge of forces adding another level of complexity. JADO calls for a new understanding of command and control that is more integrated.

Debrief Questions and Conversation Guides

- Which choice did you make for distribution of MDOCs? Why?
- This scenario kept MDOCs at the same capability despite size change. What possible changes would impact a smaller MDOC?
- How could mission-type orders and decentralized execution connect to BSN?
    - Strikes to take advantage of temporary openings from the enemy? Clear commander's intent?
- What are some possible drawbacks for dispersal of MDOCs?
    - Potential communication issues, limited resources, challenges to convergence?

Scenario #3: Information

Learning Objectives

- Compare ISR capabilities offered through different domains
- Execute Intelligence operations to enable JADO
- Explain how fog of war can affect risk acceptance

Rule Changes

- Asset Restrictions: None

Rule Update

- From section D. Home Station Readiness and Battlefield Intelligence
    - All cards will be played face-down and will follow the rules about revealed and unrevealed assets.

- From Section A
    - 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

Learning Goals

This scenario introduces some fog-of-war and highlights how intelligence affects military operations. In many recent conflicts, opponents do not have the technological capabilities to thwart many US intelligence gathering operations. This allows the US to plan operations that are lower risk to US personnel. In this scenario, players do not know what an unrevealed asset may be meaning that an attack that was previously safe may turn out to lose an asset and change the battle.

Debrief Questions and Conversation Guides

- Which assets could gather information/data? How does that relate to the modern battlefield?
- How can uncertainty affect decision making? Were you more cautious now that you could not see opponent assets?
- How does intelligence impact command and control?

Scenario #4: Fires

Learning Objectives

- Execute convergence of effects across multiple domains
- Exploit weaknesses in an opponent's strategy
- Compare benefits offered by different assets
- Create synergistic effects across different domains

Rule Changes

- Asset Restrictions: None

Rule Update

- From Section A
    - 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

Learning Goals

This scenario calls for the learner to use the experience gained in previous lessons to bring it together. Create a strategy based on how certain cards strengthen other cards or counter opponent's assets strengths. There are different lengths of kill chains for some assets which can provide power capabilities but the kill chain could provide weaknesses to attack.

Debrief Questions and Conversation Guides

- Which domains did you focus on?
- Why did you choose assets you did?
- What synergistic effects did you attempt to create?
- Did you see any weaknesses to your opponent's strategy?

Scenario #5: Logistics

Learning Objectives

- Summarize how logistics (cost, time, etc) can limit JADO concepts being practiced
- Execute convergence across domain given limited logistics

Rule Changes

- (optional) After selecting your original 6 cards, separate the supply deck by domains. When resupplying you can pick from whichever deck you prefer.

Rule Update

- From section C subsection 3
    - When deploying assets pay the number of resource chips designated by the number on the card (next to the golden coin icon).
    - No limitation on number of cards can play (now limited by resources chips)

Learning Goals

Several logistics challenges are somewhat abstracted in BattleSpace Next. Distance is not in the game but because the U.S. military is expeditionary that is unlikely to be the case in future conflicts. While the reduction of resources as the game progresses can simulate the challenge of logistics capabilities being worn down, some games may not progress there. Additionally, there are not many assets that can affect the supply chain whereas destroying friendly assets could drastically affect logistic capabilities. Finally, in the game only one of a unit is purchased and used which is not the case in real life. While this scenario has limitations there are important conversations to consider.

Debrief Questions and Conversation Guides

- The game provides consistent, eventually waning, logistical capability through the resource markers. How might an alternating resource amount per turn affect strategy?
- Logistics are also affected by distance which is abstracted out of BattleSpace Next. What are some distance considerations that could affect your asset choices?
- Logistics decrease in the game over time, after going through the deck. How does this relate to real-world logistics?

Extra Options

Information Operations Scenario

Learning Objectives

- Recognize how Information Operations can affect military operations
- Execute a strategy using Information Operations
- Compare different information warfare strategies

Rule Changes

- Beginning with the player that goes second, alternate selecting one information operations card. Each player gets that card in addition to their starting hand
- First use of selected card has no resource cost
- Cards that the opponent selects are placed in the discard pile.

Learning Goals

The USAF has recently created the 14F AFSC, indicating a greater value placed on psychological operations. Annex 3-99 defines information warfare as, " the employment of military capabilities in and through the information environment to deliberately affect adversary human and system behavior and preserve friendly freedom of action during cooperation, competition, and conflict." This definition implies both defensive and offensive operations. It emphasizes the importance of information in modern conflicts. This scenario highlights some examples of information operations for students to conceptualize and consider.

Debrief Questions and Conversation Guides

- Discuss how information warfare can affect the US population. Consider public support, morale, and other challenges.
- How can information warfare affect partnerships? (industry, international, alliances, etc?)
- How can those changes manifest in military operations?
- What can you do to help protect yourself in from an information operation?

Cyber Advantage Scenario

Learning Objectives

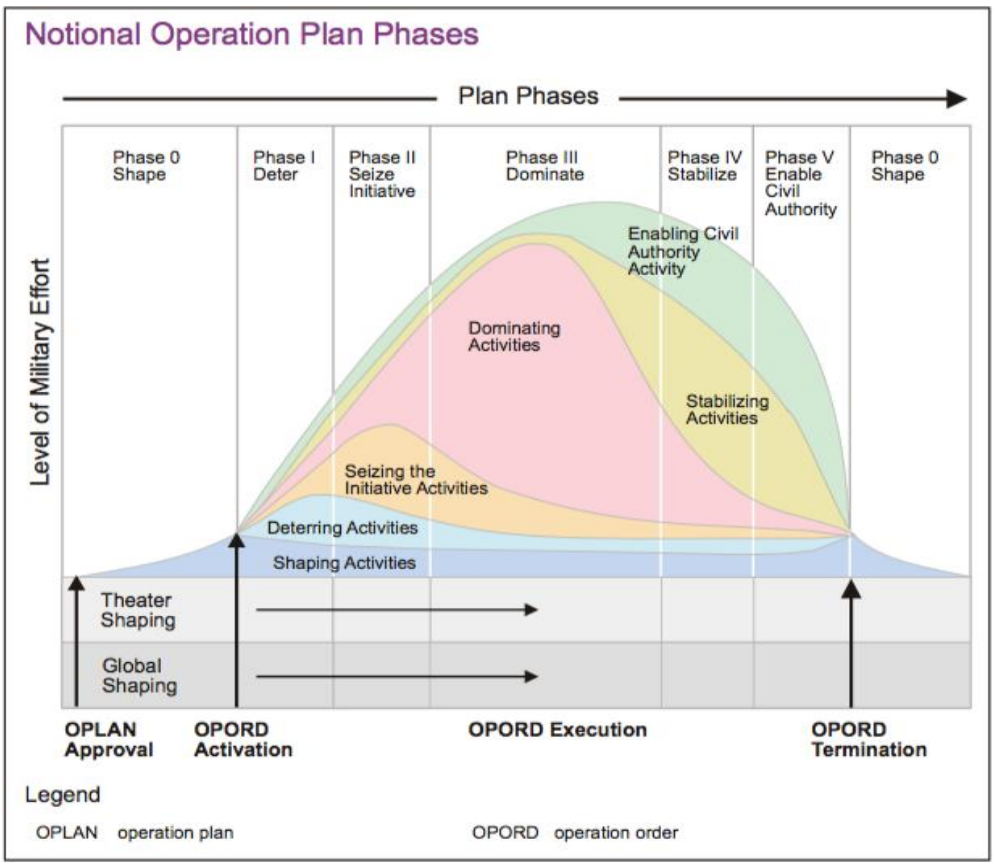
- Recognize different steps of the cyber kill chain
- Understand how ubiquitous cyber has become
- Explain different types of cyber attacks

Rule Changes

- Option 1
    - Pick 3 cyber cards to be deployed for free on the first turn (at most 1 defensive cyber card)
- Option 2
    - Modify the Spectrum of War duration and restrictions so that only certain cards can be deployed before a certain number

Learning Goals

Using the phase system established in JP 5-0, cyber advantages established in the phase 0 can provide the greatest utility over the course of a conflict. This scenario gives players extra cyber capabilities with a real-world parallel where the commander spent effort in the theater shaping phase to enable their cyber capabilities. This version helps players use these extra assets without having to give up something from another strategy they might prefer. It also pushes the player to consider the kill chain when selecting their initial hand as cyber capabilities need to be properly set up to be used.



Debrief Questions and Conversation Guides

- What phases in warfare lead to the most effective use of cyber?
    - Reference JP 5-0 for information about phases
- What are the steps of the cyber kill chain/does the prep relate to other operations or life experiences?
- What are some capabilities at your job that depend on the cyber domain?

Third Party Scenario

Learning Objectives

- Recognize that conflicts may not be against one enemy
- Adapt to scenarios where the enemy may have an advantage

Rule Changes

- At the end of each turn roll the die. If the die is 1 or 2 then the first player loses 1 resource for their next turn. If the die is 5 or 6 the second player loses 1 resource for their next turn. If the die is 3 or 4 then nothing happens.
    - Note: players can agree on a different effect or odds at the beginning of the game if they choose
- (optional) After selecting your original 6 cards, separate the supply deck by domains. When resupplying you can pick from whichever deck you prefer.

Learning Goals

If the United States were be in conflict with a near-peer adversary there could be additional parties that seek to take advantage of the situation to achieve their objectives. This scenario puts players in a situation where non-kinetic attacks may create weaknesses in their strategy without warning.

Debrief Questions and Conversation Guides

- How can committing resources to a significant conflict impact US defensive capabilities?
- What are some actors that could seek to push an advantage if the US had to divert resources?
- This scenario simulates a information warfare attack against players but what other scenarios could be possible?

Challenge Scenario– Multiple Battles

Learning Objectives

- Plan a strategy to win in multiple battlefields
- Implement a strategy that maximizes synergies and domain strengths
- Recognize the limitations associated with C2 and the importance of intelligent use of limited assets

Rule Changes

- Instead of one game it becomes 3 smaller ones (called battlefields in this scenario)
- 3 total MDOCs, one on each battlefield. Each one has 5 health
- Cyber, Space, and Information Warfare cards affect all 3 battlefields
- Pick which battlefield to place your Cyber Operation Center and Space Operation Center
    - They can be on the same battlefield or different ones
    - If they are eliminated, then affects all cyber/space capabilities for that player
- IADS Early Warning is assigned to one battlefield at the beginning of the game
    - Can be moved later but only affects its current battlefield
- Deployment
    - Asset Deployment follows the same structure as base game
    - Deployment happens to one of the 3 battlefields.
- Moving between battlefields
    - Before Winning the battlefield: Moving an asset to another battlefield costs 1 resource. It is then in the deployed state and can be used in the following turn.
    - After Winning that battlefield: Moving an asset to another battlefield costs no resources. It is then in the deployed state and can be used in the following turn.
- Victory when one player wins 2 out of the 3 battlefields.

Learning Goals

This is a challenging scenario and shouldn't be attempted before at least one playthrough of the base game. This scenario challenges players to balance competing in several different battlespaces. There is a high benefit to dominating a battlespace quickly and pushing your enemy back. Considering logistics, the benefits of non-kinetic events and convergence to maximize synergy can turn the tide of the overall game quickly. There are logistical concerns and attacking through different domains can place your opponent in dilemmas and lead to opportunities.

Debrief Questions and Conversation Guides

- Did you follow an aggressive/offensive strategy, a defensive strategy, or a mixture? Why?
- How did you use a convergence of effects to overwhelm your opponent?
- How did ideas discussed in earlier modules affect your approach to the game?

Appendix C. IRB Waiver

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) 219.104 (d)(1). This exemption covers research involving educational tests and survey procedures. This package was approved on 19 April 2021, Protocol Number: "REN2021002" Title: Learning Impact of Serious Games on JADO Education.

Appendix D. SME Survey

Following the SMEs spending time looking over the workshop and asking questions to the investigator in a discussion each SME was provided the below survey. The survey asked open-ended questions so the SME could provide an assessment of the workshop and reasoning behind their decisions. All surveys were Word documents sent via email and SMEs returned them after they had been filled out.

Survey questions for SME (After exposure to workshop)

Note: for Likert scale questions 1 is the lowest/worst and 5 is the highest/best

1. What potential benefits could an introductory JADO workshop provide to Airmen?

2. What are the top 7 topics you deem essential to include for any JADO introductory course and corresponding level of depth (Bloom's taxonomy; 1 - remember; 6 – create)

3. What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)

4. Based on your experience with BattleSpace Next, what is your assessment of the proposed scenarios outlined for this workshop? (please rate 1-5, and why)

5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)

6. What are some changes you would recommend to improve effectiveness?

7. Any other feedback or comments on the workshop?

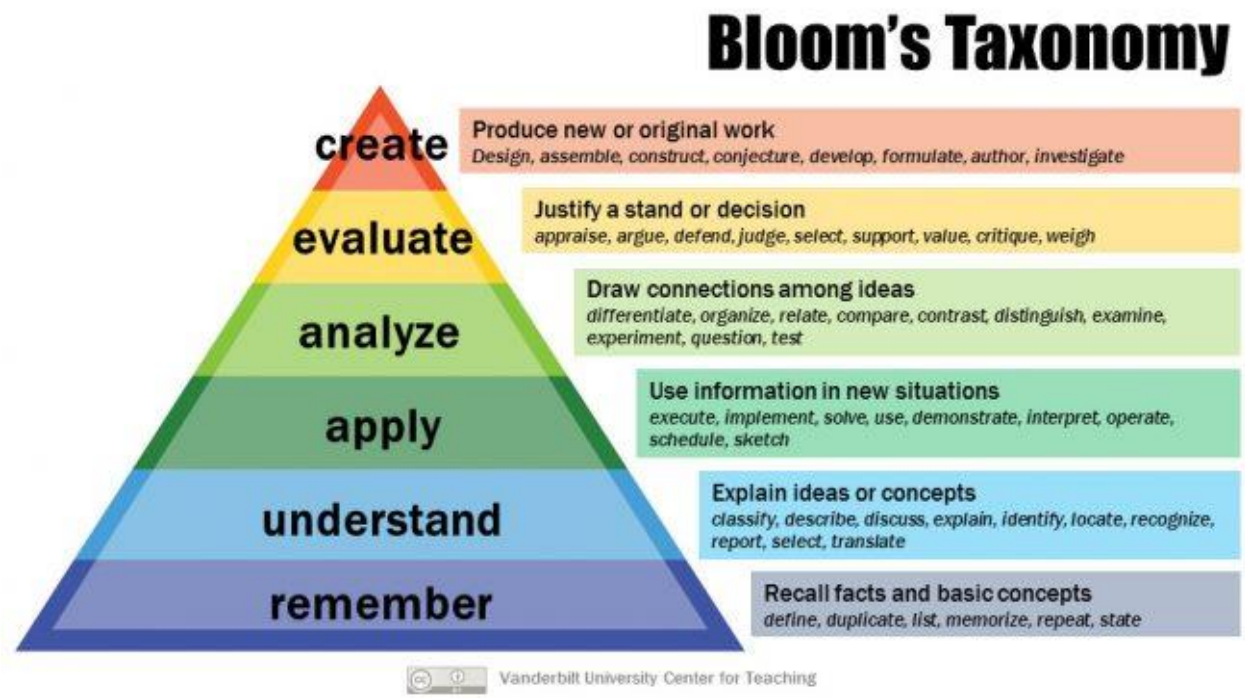


Figure 1: From https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Appendix E. Participant Pre-Survey

For the workshop experiment, an electronic pre-survey was provided. The survey collected participants assessment of their JADO knowledge, their motivation, and views on serious games. It included open-ended questions. Participants were provided the link via the class home page on milSuite. Participants had the option to generate their own 6 digit number to match with the post survey.

Initial Workshop Survey

This survey is optional and anonymous. The form will not save emails and we are not asking for PII.

The intent of this survey is to gather information about this workshop and the use of BattleSpace Next for analysis in Lt. Christopher Voltz's thesis.

For the purposes of the survey please consider Joint-All Domain Operations (JADO) and Multi-Domain Operations (MDO) to be equivalent terms.

A serious game is a game that is designed for purposes beyond entertainment. An example is BattleSpace Next

1. *OPTIONAL* If you do not want to do this step, please continue to the Question 1. Please pick a 6 digit number. This would be used to connect survey responses together while maintaining your anonymity. If you do this please remember the number and use it on future surveys for this workshop.

_____

2. 1. Before this workshop, I had a strong understanding of Joint All-Domain Operations (JADO).

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

3. 2. JADO is important to me.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

4. 3. I can explain JADO concepts related to Command and Control.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. 4. I can explain JADO concepts related to information and intelligence.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. 5. I can explain JADO concepts related to convergence.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. 6. I can explain JADO concepts related to logistics.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. 7. I can explain JADO concepts related to cyber/EMS importance.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. 8. I am interested in learning more about JADO.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. 9. I have played a serious game before and found it an effective teaching tool. (Please put 0 if never played before)

Mark only one oval.

	0	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	◯	Strongly Agree

11. 10. I have played a serious game before and found it an enjoyable experience. (Please put 0 if never played before)

Mark only one oval.

	0	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	◯	Strongly Agree

12. 11. What are your current main sources for learning about JADO? How would you describe their effectiveness (if applicable)?

13. 12. Explain your opinion on the value of JADO.

14. 13. What do you hope to gain from this JADO introductory workshop?

15. 14. What are 3 topics that you expect from a JADO introductory workshop?

Appendix F. Participant Post-Survey

The post-survey was created in Google Forms prior to the workshop experiment. It collected participants' response to the workshop and the BSN scenarios. It included Likert scale questions and open-ended questions to gather what players learned., players' assessment of effectiveness, and recommendations for improvement. The below version is shown as exported from Google Forms.

Workshop Post Event Survey

This survey is optional and anonymous. The form will not save emails and we are not asking for PII.

The intent of this survey is to gather information about this workshop and the use of BattleSpace Next for analysis in Lt. Christopher Voltz's thesis.

For the purposes of the survey please consider Joint-All Domain Operations (JADO) and Multi-Domain Operations (MDO) to be equivalent terms.

A serious game is a game that is designed for purposes beyond entertainment. An example is BattleSpace Next

1. *Optional* If you chose a 6 digit number in the first survey, please enter it here

_____

2. Following this workshop, I have a strong understanding of Joint All-Domain Operations (JADO).

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

3. I can explain JADO concepts related to Command and Control.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

4. I can explain JADO concepts related to information and intelligence.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. I can explain JADO concepts related to convergence.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. I can explain JADO concepts related to logistics.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. The BattleSpace Next game scenarios improved my understanding of JADO.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. I found BattleSpace Next to be an effective teaching tool.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. I found BattleSpace Next to be an enjoyable teaching tool.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. BattleSpace Next helped me understand JADO concepts.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

11. I found the debrief/discussion following BattleSpace Next play to be effective for improving my JADO understanding.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

12. I found this workshop to be an effective JADO introduction.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

13. How did the use of scenarios with BattleSpace Next affect your workshop experience?

14. To what extent did the online format affect your learning?

15. What recommendations do you have for improving this workshop?

Appendix G. SME Survey Responses

The below responses are the responses the SMEs provided about the workshop. The SMEs answered these questions without participating in the workshop.

SME 1

Survey questions for SME (After exposure to workshop)

Note: for Likert scale questions 1 is the lowest/worst and 5 is the highest/best

1. What potential benefits could an introductory JADO workshop provide to Airmen?
   JADO is an advanced operational maneuver concept that all Service Members should understand. The concept is characterized by complexity, speed, and precision and executed in sophisticated combinations of domains.

2. What are the top 7 topics you deem essential to include for any JADO introductory course and corresponding level of depth (Bloom's taxonomy; 1 - remember; 6 – create)
   a. Definition of a domain (revolves around control)– 2 Comprehend
   b. Supporting interrelationships between domains – 2 Comprehension
   c. Importance of synchronization of domains – 2 Comprehension
   d. JADO is executed in combinations of domains – 2 comprehension
   e. Control of the EMS is the first priority of future maneuver warfare – 2 comprehension
   f. The Human domain is always the focus of military operations – 2 comprehension
   g. Cultural change is always difficult – 2 comprehension

3. What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)
   4. See attached comments…overall very impressive work on a complex topic, however, refinement of a few areas would significantly enhance the effectiveness of your work.

4. Based on your experience with BattleSpace Next, what is your assessment of the proposed scenarios outlined for this workshop? (please rate 1-5, and why)
   5. Very good for intended audience

5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)
   4. Based on my attached comments, I think this workshop could be greatly improved by examining JADO concepts with a different lens.

6. What are some changes you would recommend to improve effectiveness?
   Joint and JADO are very different. Joint is about additive Service capabilities, cooperation, and collaboration. JADO is an advanced maneuver concept focused on destruction of the adversary's system.

7. Any other feedback or comments on the workshop?
   KEEP THE OUTSTANDING WORK!!!!

SME 2

Survey questions for SME (After exposure to workshop)

Note: for Likert scale questions 1 is the lowest/worst and 5 is the highest/best

1. What potential benefits could an introductory JADO workshop provide to Airmen?

An introductory workshop can help level the playing field WRT JADO in the USAF/USSF.

2. What are the top 7 topics you deem essential to include for any JADO introductory course and corresponding level of depth (Bloom's taxonomy; 1 - remember; 6 – create)

3: JADO/JADC2 Terms
3: Air, Space, Cyber Domain
3: Ops in the Info Environment
1: Land/Maritime domain Understanding
2: JADO Application to USAF Mission
3: Command and Control
1: NDS-Threats / Near Peer Adversary Capabilities

3. What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)

4: Your topic quickly get technical; I would recommend staying high-level and talk about how to integrate the domains vice technicalities of cyber.

4. Based on your experience with BattleSpace Next, what is your assessment of the proposed scenarios outlined for this workshop? (please rate 1-5, and why)

2: The card game will be only as good as the card content. Having not seen the newest card deck, I understand it is better. The rule set will be hard to apply as an operational plan to MDO. You only get a relative number strength of attack versus a dynamic assessment.

5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)

4: as an intro do JADO, this workshop can be good. The key to success will be the Q&A session after material delivery. The second key to success will be a debrief after the scenarios. Without these sessions, you will be unsure if the participant retains the information.

6. What are some changes you would recommend to improve effectiveness?

Ensure that the facilitator of the workshop has experience with JADO. Make sure the card game cards are accurately representing the capabilities available to the warfighter.

7. Any other feedback or comments on the workshop?

SME 3

Survey questions for SME (After exposure to workshop)

Note: for Likert scale questions 1 is the lowest/worst and 5 is the highest/best

1. What potential benefits could an introductory JADO workshop provide to Airmen?

   A basic foundational knowledge and appreciation for the interactions, considerations, interdependencies, challenges, processes, and technologies they are likely to come across over the course of their careers.

2. What are the top 7 topics you deem essential to include for any JADO introductory course and corresponding level of depth (Bloom's taxonomy; 1 - remember; 6 – create)

   Air Capabilities, Limitations, Threats - Understand
   Land…"" - Remember
   Sea…"" - Remember
   Space…"" - Remember
   Cyber, EMS, Information…'''' - Remember
   Emerging Technologies - Remember
   Basic Adversary Military Strategies - Understand

3. What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)

   4 - Makes concepts addressed in emerging doctrine (e.g. AFDP 3-99) more tangible to Airmen.

4. Based on your experience with BattleSpace Next, what is your assessment of the proposed scenarios outlined for this workshop? (please rate 1-5, and why)

   4 – Gives participants a very rudimentary exposure to capabilities, challenges, and considerations within the various domains

5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)

   4 – It's an "introductory" workshop. In introducing and discussing these topics, it is effectively meeting its purpose.

6. What are some changes you would recommend to improve effectiveness?

   Seek participation and feedback from the various Services.

7. Any other feedback or comments on the workshop?

   None come to mind.

SME 4

Survey questions for SME (After exposure to workshop)

Note: for Likert scale questions 1 is the lowest/worst and 5 is the highest/best

1. What potential benefits could an introductory JADO workshop provide to Airmen?
   - Will give Airmen more awareness of the right questions to ask when working in All-Domain environments
   - Will help Airmen with a basic familiarity with the guiding physical laws which govern domains
   - Will help airmen with an understanding of the feasibility and applications of a domains course of action.

2. What are the top 7 topics you deem essential to include for any JADO introductory course and corresponding level of depth (Bloom's taxonomy; 1 - remember; 6 – create)
   1. Be able to explain Basic governing rules of air
   2. Be able to explain basic governing rules of land
   3. Be able to explain basic governing rules of maritime
   4. Be able to explain basic governing rules of space
   5. Be able to explain basic governing rules of cyber space
   6. Analyze the need for multi domain integration
   7. Analyze the value of joint officers understanding of all-domains

3. What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)
   Likely 4

4. Based on your experience with BattleSpace Next, what is your assessment of the proposed scenarios outlined for this workshop? (please rate 1-5, and why)
   N/A

5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)
   4

6. What are some changes you would recommend to improve effectiveness?
   Make this a formal course and a digitally available course

7. Any other feedback or comments on the workshop?
   Lt Voltz is on to something here… more work needs to be done but he has laid the foundation for achieving what LtGen Hecker was tasked to do… make AU a center of intellectual leadership for JADO and JADC2

SME 5

Survey questions for SME (After exposure to workshop)

Note: for Likert scale questions 1 is the lowest/worst and 5 is the highest/best

1. What potential benefits could an introductory JADO workshop provide to Airmen?

Establishing a baseline level of understanding on the importance of JADO (and C/JADC2) for Airmen – that simplifies complex concepts and presents in an unclassified environment – will be critical to meeting the CSAF's "accelerate change" challenge. Basically, we need some education on JADO early in an Airman's career (prior to their first PME experience, e.g. SOS or ALS), but after their commissioning/enlisting source (i.e. ROTC/USAFA/OTS or BMT are too early to tackle JADO).

2. What are the top 7 topics you deem essential to include for any JADO introductory course and corresponding level of depth (Bloom's taxonomy; 1 - remember; 6 – create)

What is JADO? Doctrinal definitions, strategic vision, etc.: 2
Basic intro to the doctrinal domains (i.e. air, land, sea, etc.): 2
Deeper dive into the DAF's domains (air, cyber, space): 3
Focus on operating environments/maneuver spaces that are not doctrinal domains (e.g. EMS): 2
Command Relationships and Authorities required for JADO: 2
Threats to Blue operations in each of the domains: 2
Capabilities and Limitations (Blue) in each of the domains: 2

3. What is your assessment of the coverage of topics and depth proposed in the JADO introductory workshop? (please rate 1-5, and why)

I haven't seen first-hand, so please take with a grain of salt, but based on the syllabus, it looks appropriate (arguably ambitious, depending on the audience and amount of time available). 3

4. Based on your experience with BattleSpace Next, what is your assessment of the proposed scenarios outlined for this workshop? (please rate 1-5, and why)

Again, take with a grain of salt – scenarios look good, proper scope for the audience, and as realistic as you can get given constraints. However, #2 (Information Operations) may be tough to scope, especially if you expand it to how the 16th Air Force is defining Information Warfare (i.e. IO, ISR, EW, cyber all working together). Recommend narrowing the scope of that one. 3

5. What is your assessment on the potential effectiveness of this workshop? (please rate 1-5, and why)

I think it's a solid effort, especially if the audience is clearly defined (i.e. junior Airmen, whether officers or enlisted), and the desired learning objectives are scoped appropriately (i.e. please resist the urge to succumb to "mission creep"). 3

6. What are some changes you would recommend to improve effectiveness?

- Make sure to not “hand-wave” or “white-card” too much of the accesses and authorities required to conduct JADO; some degree of this is inevitable, but the players must understand the nature of the constraints and restraints they’re operating within
- Per the newly-released AFDP 1, airpower’s role in JADO should focus on:
    - Air Domain
    - Information Environment (IE), which includes the Cyberspace Domain
    - Electromagnetic Spectrum

7. Any other feedback or comments on the workshop?

Appendix H. Participant Debriefs

After each BSN scenario playthrough, workshop facilitators led a discussion about the participants' experiences. The participants provided their responses and facilitators maintained summary of the responses and discussion. Before finishing the conversation, participants were provided the opportunity to add or change any of the points on the discussion summary. All points were initiated by the participants in the debrief.

Key Thoughts (First Game)

- Equal forces (red vs. blue) may make it difficult to “win”
- Some capabilities have requirements, thus forming a “kill chain”
- Some capabilities require mastery of more than one domain
- Each capability takes time to learn
- Takes time to setup the first hand… similar to the US forces spinning up for a Joint fight after not using it for several years
- First-hand sets up strategy for the rest of the game
- Language & cultural service barriers (acronyms) perhaps between services and groups of participants

Key Thoughts (C2 Scenario)

- Better decisions when information is easily shared (one commander or close coordination of commanders); we suspect the converse is true.
- Initiative (directly a C2 concern) seems to tip the balance in one's favor
- Multiple fiefdoms (C2 elements) create tension between autonomy and coordination
- Escalation of conflict constraints limits early play
- Explicitly state assumption of competition/conflict state for scenario
- Splitting decks into domains to simulate stovepipes (current reality)
- Potentially adjust rate of supply cards to represent local vs. distance forces (extra cards or penalty)
- Reactive vs. proactive decision-making
- Different forces for different teams (e.g. Red team 30% air, 70% ground vs Blue team 50-50); specific country military cards

Key Thoughts (Info Scenario)

- Many domains, much more complexity
- Lack of ISR substantially increases difficulty
- OSR-1 tends to be a potent card
- Better learning experience when playing as a couple
- Realism check: OSR-1 only reveal one domain (or geographic area) at a time
- Level of progression helped address complexity; challenge to balance new domains with old domains
- Felt the “fog of war”; caused shift in strategy to react to adversary
- Non-kinetic effects not guaranteed; fragile, especially if part of kill chain or strategy
- Enhancement idea: more damaging assets decreases probability of future reuse; patched
- Enhancement idea: more control over supply deck order; multiple domain supply decks; add multiples of card types

Key Thoughts (Video)

- It seems like a flow chart that could be used in the game: preserve, deny, enable access. Preserve: setup mission critical assets, deny: put up defenses for projected risks, enable access: create openings in enemy defenses. Then for further rounds you work on each of those aspects.

Key Thoughts (Fires)

- Increased use of cyber capabilities and need for defenses
- Early deception helped gain initiative
- Spectrum of Conflict provided more time to develop defenses and kill chain
- Availability of cyber capabilities changed strategy due to the potency of effects; randomness of rolls could have significantly pivoted outcome
- Initial strategy may change in the heat of battle; “the enemy gets a vote”
- ISR critically important to target adversary
- Sometimes the countermeasure doesn’t show up in time
- Resources are an important factor in strategy building
- Cyber may require an “all or nothing” strategy to be useful
- Game encourages attrition, despite unrealistic strategy
- Game reinforces “mirror imaging” bias (enemy thinks like us)
- Enhancement idea: counter mirror imaging by random distribution of capabilities
- Learning by building up through levels (scenarios) was helpful

Key Thoughts (Logistics)

- Earlier stage of game was slower to get desired card set as people massed forces
- IO may be used to slow down adversary and provide early advantage
- Separating supply chains may provide more decision-making space; may make the game faster/efficient (and possibly more complex)
- Gameplay: how to handle discard while using separate supply chains; consider recycling back to supply vs. dead card
- Gameplay: consider saving cards to deal with later vulnerabilities
- Enhancement idea: TRANSCOM Ops Center card; when destroyed adds to deployment time (+2 turns) or decreases number of deployable cards (Joint Deployment & Distribution Ops Center – JDDOC)
- Strategy: cycling through supply deck to find the needed card

Key Thoughts (Last Game)

- Foreign nation taking a resource was a pain; couldn't deploy needed assets to counter opponent
- Multiple supply lines useful but more complexity
- Stealth can provide a distinct advantage
- Even a small reduction in resources can have an over-sized effect due to choked supply lines
- Cost of productivity from computers might include potential disruptions; redundancy may decrease one type of risk and increase another

Ideas

- Taking out satellite changes air and ground engagements from guaranteed to probabilistic (die roll) since no precision engagement.

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Acronyms

ABMS Advanced Battle Management System. 18, 41, 43

ACE Agile combat employment. 42

ACSC Air Command and Staff College. 8, 53

AETC Air Education and Training Command. 16, 25

AFDP Air Force Doctrine Publication. 38, 41, 58

AFSC Air Force Specialty Code. 44

AI Artificial Intelligence. 12, 13, 18, 43

AOC Air Operations Center. 15

APAN All Partners Access Network. 38, 67, 81

BSN BattleSpace Next. 2, 3, 4, 5, 24, 37, 39, 45, 46, 47, 48, 50, 51, 54, 56, 57, 58, 59, 60, 66, 67, 68, 69, 70, 71, 73, 76, 77, 78, 79, 80, 82, 83, 84, 85

CSAF Chief of Staff of the Air Force. 1, 2, 3, 5

DARPA Defense Advanced Research Projects Agency. 12

DoD Department of Defense. 2, 3, 13, 14, 15, 19, 25, 39, 41, 42, 43, 79, 80

ELT Experiential Learning Theory. 20, 24, 46

EMS Electromagnetic Spectrum. 1, 8, 10

GDM Game Design Matrix. 47

IoT Internet of Things. 43

JADC2 Joint All-Domain Command and Control. viii, 7, 10, 66

JADO Joint All-Domain Operations. viii, x, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 52, 53, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 70, 71, 72, 73, 74, 75, 76, 78, 79, 80, 81, 82, 83, 84

JAIC Joint Artificial Intelligence Center. 13

JFCOM Joint Forces Command. 9

MDC2 Multi-Domain Command and Control. 2, 15

MDO Multi-Domain Operations. viii, 1, 7, 10, 59

NATO North Atlantic Treaty Organization. 8

NDS National Defense Strategy. 1, 9

RQ research question. 3, 4

RQ1 research question 1. 3

RQ2 research question 2. 3

RQ3 research question 3. 3

RQ4 research question 4. 3, 4

RQ5 research question 5. 3, 4

SME subject matter experts. 2, 3, 4, 6, 37, 52, 53, 55, 58, 60, 61, 64, 65, 66, 67, 68, 71, 72, 73, 74, 83

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14. ABSTRACT

The DoD has begun developing Joint All-Domain Operations (JADO) to prepare for the future of warfare. As complexity and technological capability increases, the U.S. military needs to adapt to provide a more lethal and capable force, able to compete and win against near-peer adversaries.This research describes the development of an Introduction to JADO Workshop designed to provide a structured primer into JADO concepts. The research also presents an extension of BSN in the form of BSN scenarios. These scenarios alter the rules to lessen the learning curve for the game and to engage with JADO concepts. This research proposed a format for future JADO education course, refined the BSN tool to improve effectiveness, measurement of the response to JADO education, and an assessment of the workshop from JADO leaders across the Air Force.

15. SUBJECT TERMS

Joint All-Domain Operations (JADO), Wargamming, Serious Games, Education

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