

## **Preparing for the future of war - M&S driven operational exercises in support of Joint All-Domain Command and Control**

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### **ABSTRACT**

Operational-level Modeling and Simulation (M&S) receives little fanfare or attention; but the important role of M&S driven operational exercises cannot be understated, particularly as Joint All-Domain Command and Control (JADC2) emerges from concept to fundamental doctrine and capabilities.

Simulating combat outcomes within a single domain, and then across domains via various methods of federation, has become a matter of math between available development resources and good enough fidelity to achieve training outcomes. To this extent, realism and integration of non-kinetic enablers within M&S-driven operational exercises takes a back-seat to a train-to-process mindset with highly scripted scenarios that do not place a focus on a win-or-lose outcome; particularly in relation to effects from the cyber, electromagnetic, and space domain. Layered between the operational sim and the training audience is a host of functional cells that interpret and craft the battlefield environment and sets stages for the scenario to progress through. This has led to exercise planners fielding complaints that our exercises are not developing tactics and procedures that can be relied upon in wartime.

This paper provides examples to portray critical capability gaps in our ability to conduct all-domain exercises and presents the challenges inherent in current operational simulations that may prevent us from fully realizing the ability of the operational Headquarters (HQ) to train and win across all domains. There are several facets of this problem that this paper explores. How do we conduct exercises now versus anticipated changes to come with JADC2 capability development? Do we require more fidelity or more robust integration of Joint effects within the kinetic models? Can we continue process-oriented training, or do we need greater realism and fidelity to create better instinctual application of Joint All-Domain C2? To conclude, this paper conceptualizes proposals for industry, policymakers and acquisition programs to grow operational M&S capabilities.

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### **INTRODUCTION**

Theories concerning the use of Multi-Domain and All-Domain Operations to dominate the battlefield are quickly developing into functional concepts. Abstract articles and publications are integrating these concepts into Joint All-Domain Operations (JADO) doctrine, while the practical application of all-domain theory in battle and Joint All-Domain Command and Control (JADC2) quantifies efforts to create better synergy between sensors and kill mechanisms. Both work together to provide the Commander and headquarters the ability to prevail over enemies equipped with rapidly evolving technology and strong access and area denial capabilities.

As JADO doctrine matures, and JADC2 capabilities begin to change the nature of war on the tactical and operational level, we assume the role of leaders and their staffs must evolve at all levels. Our focus is developing a conceptual picture of how simulated exercises may evolve to train staffs in a JADC2 environment.

Recommendations in this paper, which are readily applicable to contemporary operational exercises and technically feasible, are worth consideration. A critical piece of integrating JADC2 and touched upon briefly in this paper, concerns development and investment in data standards and open Joint architectures enabling forward software compatibility during new development.

### **EXERCISES AT THE OPERATIONAL LEVEL**

Operational exercises are driven by models and simulations that determine outcomes of battlefield engagement as well as populating the common operating picture (COP), presenting the current “reality” of the game to the headquarters’ staff and commander (the training audience). The common operating picture is both tangible and intangible. It may be a mental concept shared by all participants through messaging and communication or it may be a physical display through digital or analog mapping means and message sorting tools. The simulation is ordinarily operated by professional operators or operators tasked for temporary duty; these operators maneuver the simulation to provide information back to the training audience.

Echelons lower than the training audience are represented by a response cell. Response cells, composed of appropriate subject matter experts, use orders produced by the training audience to maneuver forces within the simulation and report those movements. Additionally, most operational-level models publish tactical messaging auto-generated by simulated entities based on observations and engagements, these tactical messages are transcribed by tactical information systems to populate the COP.

Operational exercises vary between services, but overall orient on receipt and task organization of appropriate forces to accomplish assigned missions, production of orders to subordinate forces, coordinating intelligence, fires, logistics and other functions while also tracking progress of the battle. Placement and support of forces are accomplished through combat orders developed by the training audience. In the US Army this orders process is called the MDMP and results in the issue of an operations order (or OPORD). The US Air Force uses the Air Operations Directive (AOD) and Air Tasking Order (ATO) cycle.

In the course of executing orders in the simulation, the response cells provide feedback on engagements, gathered intel, logistical requirements, and other required data. The training audience headquarters processes this information to adjust movement of combat enablers while also developing the next orders cycle. Additionally, organic and joint-

assigned intel assets report collected intel (referred to in various articles as “sensors”). The bulk of this information is used in the Joint Targeting process to realign effects and key assets (referred to commonly as “shooters”)

Response cells maneuver their forces inside of service-centric simulations. The Army utilizes the Joint Land Component Constructive Training Capability (JLCCTC), AF – Air Warfare Simulation Model (AWSIM), and Navy – Joint Semi-Automated Forces (JSAF). The fidelity of these simulations is low to reduce resource requirements and more easily distribute the exercise globally. Within ground formations, the simulations follow a very low-fidelity construct known as an “aggregate” force.

Most aggregate simulations conduct combat calculations at the unit level rather than between individual combat platforms. Within the air models, engagements remain between platforms but follow broad engagement metrics rather than detailed physics to determine outcomes. The result is a lower level of realism but a greater capability to field theater-level forces and distribute simulation feeds over global networks to units geographically separated units. To fill the realism gap response cells and exercise control cells interpret or alter outcomes if captured in time (before reaching the training audience).

Within this exercise environment operational HQs can train large operations with echelons of forces impossible to achieve in live training. This in and of itself is an enormous technological achievement.

### **Staff training during operational exercises**

Operational processes generally focus on planning efforts involving intel analysis, targeting, allocation of assets against targets, developing maneuver schemes, integration of combat enablers (artillery, electronic warfare assets, Intelligence, Surveillance and Reconnaissance (ISR)) both within the service and Joint. Prior to an exercise the staff conducts planning exercises to produce an operations order. After start of the simulated exercise the training audience moves on to prosecution of the battle itself, which involves battle tracking as well as hasty planning processes to produce change orders as necessary. These processes are driven by battle rhythm events that walk the staff through the process of collecting and processing relevant information.

Operational exercises prioritize process-oriented training as opposed to outcome-oriented training. The outstanding goal is to train the staff, not to win the war. Staffs emerge from exercises armed with greater procedural knowledge and become comfortable with processes involved. Additionally, staff members experience the type of combat stress found exclusively in operation centers and HQs during active wartime engagements. Process-oriented training is relied upon since many theaters tailor Joint and service-level doctrine and operations to fit their regional environment. Another factor is that the simulations utilized are low-fidelity models are not generally reliable for judging the efficacy of command and staff decision-making.

However, there are shortfalls in the ability to integrate across domains including cyber, electromagnetic spectrum, and space. These shortfalls are addressed through scripted events that follow an if-this-then-that storyline to spur staff analysis and decision-making. The current framework of operational simulations has been utilized for what can now be numbered in decades, and, despite the age of the basic structure, these simulations still carry weight and are continually tested and updated as the technology of the battlespace changes. Efforts are underway to improve integration across domains and JADC2 is postured as a catalyst to move these efforts forward along with other major overhauls in operational-level M&S capability. In the following sections we analyze where these concepts may fundamentally change operational-level training requirements.

### **ALL DOMAIN OPERATIONAL DOCTRINE**

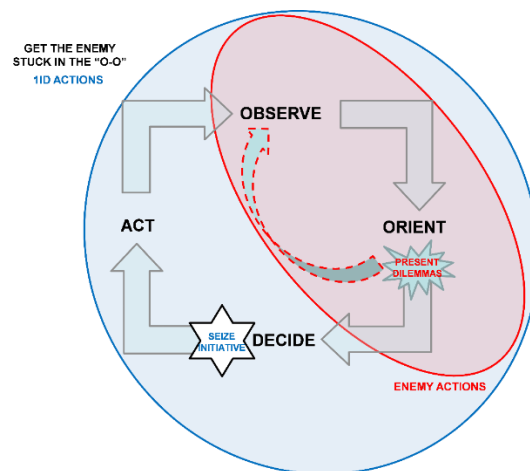
All-domain operational concepts are emerging as the military shifts from battling insurgents to the traditional role of preparing for war against state competitors. New area denial and domain attack technology has evolved and proliferated during the United States focus on training for wars in Afghanistan and the Middle East (USAF Curtis E. Lemay Center, 2020). The modern battlefield is viewed as “Increasingly interconnected, interdependent, and challenged”. This premise holds adversaries are more capable of stunting a single domain attack, and services must be prepared to quickly react across other domains to maintain momentum. Additionally, convergence of domain

effects is important to enable coordinated attacks against an enemy in heavily denied terrain (whether that terrain be ground, space, cyber, electromagnetic, etc.).

Another aspect of all-domain warfare envisions movement and maneuver through multiple domains simultaneously, creating conditions preventing an enemy from moving beyond the “Observe-Orient” cycle of the “Observe-Orient-Decide-Act” decision methodology. The Army refers to this concept as Multi-Domain Operations (MDO) with the Air Force capturing JADO in the recently published doctrinal Annex 3-1. Theoretically similar, the JADO concept is a doctrinal framework for operational planning that orchestrates all-domain capabilities in planning and decision-making. In this article we imply Army MDO operations as well when referring to JADO.

Within the Air Force, JADO doctrine continues to develop along a central theme of planning and executing operations in multiple domains with a weighted effort towards presenting multiple dilemmas to an adversary and seeking dominance throughout one domain when access to another is denied. The Air Force Doctrine Note 1-20 states “Air Force Components support JADO by conducting operations in, from and through the domains of air, space, cyberspace and the electromagnetic spectrum (EMS) to enable convergence of effects in all domains.” (USAF Curtis E. Lemay Center, 2020). Army MDO places emphasis on the Corps and Division HQs returning to a more involved role in battle to receive and maneuver key enablers with delegated authorities to subordinates for all-domain effects (Feickert, 2020).

Complementary to JADO, JADC2 is a supporting concept that describes the mechanisms and systems required to execute all-domain operations. JADC2 builds upon previous C2 architectures and is a system-of-systems approach that seeks to improve the ability of platforms to directly share tactical information while harnesses developments in Artificial Intelligence (AI). The intent is to enable leaders at all levels with the ability to make rapid and well-informed decisions to pre-empt or disrupt the enemy OODA loop as modeled in Figure 1 (Taylor & Kay, 2019).



**Figure 1. Interrupting the Cycle of Observe-Orient-Decide-Act (Taylor & Kay, 2019)**

### **Joint All-Domain Command and Control**

JADC2 encompasses DOD efforts to remove barriers between sensors and shooters as well as flattening communications and speeding up critical information flow. The preponderance of recent experimentation focuses on the tactical interoperability problem. Management and delegation of decision authorities presents a challenge between HQs competing for capabilities. Confidence in pulling assets and capabilities from one domain to enable success in another is critical. The end-state of these concepts is to win and defeat an adversary in a fluid environment where the main effort shifts rapidly as attacks stall or meet success. These are covered in detail to further develop a concept of JADC2 exercise requirements.

In a contemporary exercise, assets are allocated via the joint targeting process based on collected intel estimates, to target a specific enemy unit or capability. However, the target may not be where envisioned or the capability to prosecute may become neutralized in some fashion. It is normally on the operational headquarters to process target

movements and approve fires against them. In a JADC2 construct, sensors cross-communicate with shooters, with forward C2 systems enabling rapid analysis of information. Based on knowledge of mission the forward commanders, aircraft commanders, or special operations forces can quickly adjust priority and target of Joint effects based on delegated authorities. It is envisioned that all domain effects can be quickly approved forward, including cyber, space, and electronic warfare.

The Air Battle Management System (ABMS) was and is the Air Force contribution to build upon JADC2 (Hitchens, 2020). “ABMS is not envisioned as a single program of record, but rather an open architecture family of systems that enables capabilities via multiple integrated platforms,” the Air Force industry day solicitation says. “ABMS will realize the vision of Joint All Domain Command and Control (JADC2) to enhance and expand capabilities by enabling any sensor to inform any shooter in any domain—land, sea, air, space, and cyberspace.” (Hitchens, 2020).

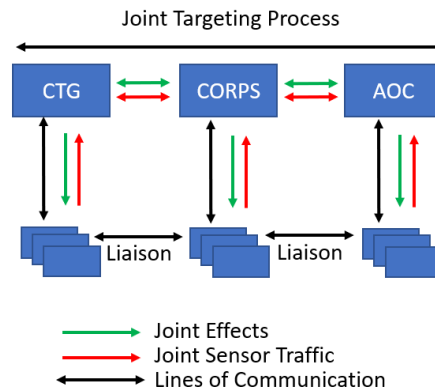
The Army JADC2 approach is primarily a force structure and equipping approach while concurrently supporting AF JADC2 efforts (Feickert, 2020; Underwood, 2020). The Army seeks to involve directed energy short range air defense (DE-SHORAD), assured positioning, navigation, and timing, long-range precision fires, and incorporating JADC2 capabilities to bring all-domain capabilities to bear from other services or to supplement another service as needed (South, 2019).

The Navy is dedicated to building JADC2 capability and connecting to domain partners (US Navy, 2018). The Navy JADC2 focus is platform interconnectivity of C2 elements, sensors and shooters while connecting with joint partners; another effort is partnering with the Air Force on development of a joint network (Smagh, 2020).

### **JADC2 in an exercise environment**

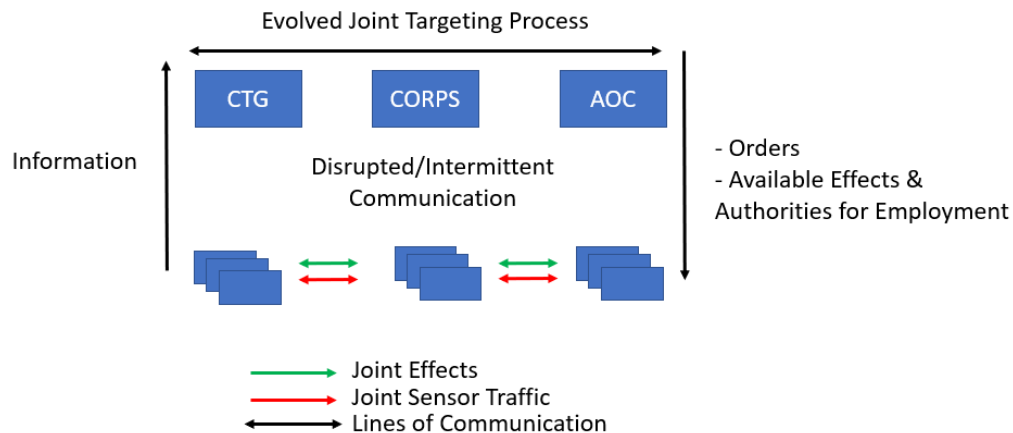
Expending effort to consider how to exercise these concepts now is putting another question on top of a question, but it is prudent to consider. M&S software development is a matter of prioritization and allocation of resources over long periods of time. Development decisions made sooner rather than later provide a bigger payoff; especially if there are broad and immediate benefits to be realized. Our approach to the question is to consider how the role of the operational HQ evolves in a fully operational JADC2 construct.

We anticipate a reduced need for the operational headquarters to directly manage critical assets and target allocation during battle. In modern operations, a unit commander and staff allocate and apportion within the task organizational structure to enable mission success and enable either coordination between forces or to augment organic combat power (See Figure 2). For example, a Marine JTF (Joint Task Force) may organize Marine ANGLICO (Air Naval Gunfire Liaison Company) units between assigned Army forces to call in joint strikes from Navy, Marine, and Air Force units. In this example one may see the primary challenge inherent in current operations, we task human forces to serve as intermediaries between the domains. During the execution of an operation targets are collected through sensors and reported for analysis by intelligence capabilities. Ground forces have access to a variety of non-kinetic and kinetic effects through this process to prosecute against identified targets.



**Figure 2. A simple model showing movement of service-owned communications traffic providing intel to the Operational-level HQs (depicted here, a Carrier Tactical Group (CTG), Army Corps HQ, and the AOC) with authorized effects delegated back. Liaison between tactical HQs serves to coordinate effects.**

In a conceptual JADC2-enabled structure the ANGLICO may not be present at all and is replaced with sensor-shooter capabilities that assign and recommend targets to pilots based on ingested ground reports or direct request as authorized (see Figure 3). JADC2 demands all forward sensors and shooters share information. Front line warfighters quickly summon capabilities to maintain pace of operations. Assets are re-oriented quickly, without a headquarters-based approval process because authorities are granted prior to execution. For example, the conceptual Army Multi-Domain Task Force (MDTF), equipped with appropriate capabilities and authorities, can directly call assets as required from all domains to maintain pace of maneuver on the ground independent or out of contact with its higher headquarters.



**Figure 3. In a JADO scenario, intermittent contact with forward elements prohibits full control of Joint fires at the operational level. Delegated authorities and target priorities are enabled by advanced JADC2 systems at the tactical level; advanced network and automation pass sensor/shooter traffic directly between forward elements. Orders and information are passed from operational HQs as communications are available.**

In another example an Air Force F-35, serving as the quarterback of the air domain, is served immediate targets from a forward MDTF through the JADC2 network. Based on the AOD (which includes prioritization and authorities) the pilot (or unmanned aircraft) can employ capabilities and payloads at near push-button fashion to include cyber and space effects. The key result of enabling JADC2 technologies is target analysis and decision occur less at the operational level and more at the tactical level with a high tactical pace. A supporting concept is the “devolution” of command and control (USAF 705th Training Squadron, 2020). As forward elements are in and out of contact with the AOC momentum is maintained through multi-day AODs that provide the forward quarterbacks with knowledge of mission, available effects, and authorities. This theory is the current driver for development of future C2 doctrine and we expect this to be a key requirement of staff training in the near future.

Rather than go through an operational process to find the target or reallocate an asset, JADC2 sensors will cross-communicate while forward deployed and machine-learning C2 systems analyze available information. Commanders, aircraft commanders, or SOF can quickly action targets based on pre-determined authorities. It is envisioned that all domains can be quickly approved forward, including cyber, space, and electronic warfare. We anticipate this driving several changes to how the HQs conducts business.

We expect JADC2 systems to generate an immense amount of digital tactical traffic that is eventually relayed in total to the operational HQs. This may be a continuous stream or arriving in bulk should the HQ be out of contact.

Operational AI programs assists operators in analyzing this traffic (plus information from other sources) to generate mission knowledge required to drive the orders process.

We expect that the future operational headquarters needs all-domain proficiency beyond what can be trained by scripted events and simple effects. Networking capabilities and digital communications must become imbedded into the kinetic model in a meaningful fashion to fully stimulate JADO processes as well as populate the breadth of JADC2 capability. The message traffic and cross-communication between platforms is essential for exercising the operational HQs abilities to develop comprehensive but flexible mission plans and orders.

## **CONSIDERATIONS FOR M&S DEVELOPMENT**

Using our conceptual lens for future operational exercises the following considerations for M&S development are provided:

**#1 Develop operational-level M&S beyond kinetic kill chain and battle tracking. Operational level simulations must provide the breadth of cross-domain capabilities and non-kinetic effects inherent to each service and develop a reliance on application of all-domain effects to succeed in training scenarios.**

Current M&S solutions struggle to inherently stimulate non-kinetic capabilities without additional white cell scripting. Story-line scripts may prove insufficient at producing trained units and staffs prepared for all-domain warfare. JADC2 pushes a large amount of in-the-moment operational-level decision-making to the tactical level. The downward push of decision making not only introduces speed and flexibility to operations, but also recognizes the new reality of a battlefield dense with EW and cyber capabilities leading to likely communication loss between HQs and forward forces for hours or even days... A real-time common operating picture becomes a nice to have rather than a need to have. Given these optics we surmise the ability to conduct fully integrated analysis, planning, and assessment across domains while equipping and informing forward forces, takes priority over real-time battle management in the JADC2 exercise environment. M&S solutions that inherently replicate domain complexity ensure the best training environment.

A single simulation cannot meet the needs of all services Title X requirements or the requirements of JADC2 training, therefore services rely on their independently procured training systems and federations. The focus of model improvement is with the services. In this respect a robust and capable Joint Federate of Models (FOM) solution remains a key enabling priority. Modern database techniques, coding technology, and even machine learning should be leveraged to create FOMs and supporting data structures capable of quickly incorporating new models and new objects. Our current iteration of a Joint FOM is the Joint Live Virtual Constructive (JLVC) FOM. Services investing in a single FOM demonstrates the best use of development dollars and the JLVC should provide the starting point.

A joint FOM would need to act as an architecture allowing for rapid on-boarding of new models from the various services. Data standards providing faster integration of new models and simulations are critical to speeding M&S innovation. Currently on-boarding a new model into a federation is a months to years long affair, with proper data standards and architectures in place developers can quickly provide new capabilities while reducing impact to training time.

We may be required to blur lines between ABMS development and Operational M&S development. Traditional C2 systems are developed to produce and/or ingest message traffic standardized by either the service, Joint, or multi-national agreements. Operational M&S systems are developed to produce this message traffic for ingestion by the respective C2 systems during training. The Air Force has recently started down this pathway by consolidating AFMSTT and Block 20 ABMS development under one chief.

**#2 Sim-generated tactical messaging is not enough to stimulate advanced AI analytical systems. Information feeds to operational HQ training audiences should be massive and include an extensive representation of real-world sensors (i.e., real-time video from micro-UAS, commercial security systems, and free-text communication between combat forces).**

In contemporary model-supported exercises much of the battle information is provided through simple line reports consisting of basic information about enemy location, equipment type and general activity. These reporting formats are simple in nature and further contextual information is regularly required. The additional information is currently received via human coordination between operational and tactical HQs. For example, a ground reconnaissance unit encounters an enemy ground vehicle. The reconnaissance unit typically generates a contact report that is fed to the training audience's C2 systems. If ground combat is enabled, the reconnaissance unit engages and destroys the ground vehicle; subsequently publishing another report seen only by the human sim operator. Eventually, the report reaches the HQ following publication by the simulation to the C2 network. Unlike the sharing of information in a JADC2 structure, current simulations "stovepipe" reports in this method and nearby simulated assets are oblivious to what other units are seeing. However, the enemy ground vehicle will populate for visibility by other friendly human operator screens. If, within this example, the reconnaissance unit cannot engage the target due to kinetic limitations then a human operator must work through command channels to summon an asset capable of destroying the asset. Within a JADC2 construct the reconnaissance report populates across all forward elements in vicinity or within range, and available assets can immediately action the enemy force (provided the target fits the published priorities by the operational HQ and authorities are met).

In another example, a friendly UAS spots a high value target such as a theater ballistic missile launcher. The simulated UAS generates a report that is fed through the simulation to the C2 systems. The human operator moving the UAS might see the system, but that is not a typical scenario. The launcher's location is highlighted by human analysts in the training audience and, if seen in enough time, assets are moved to destroy the launcher. In a JADC2 environment the report would immediately be sent through the forward tactical network likely resulting in target prosecution by an available asset. This becomes an operational problem-set, highlighting the need for forward entities to possess the network capacity required for cross-messaging.

A major component of JADC2 consists of AI integration and machine-learning enabled analytics. It is conceivable a JADC2-enabled operations center would not require subject matter experts to sift data, but rather refine algorithms that parse and compare data against mission requirements and quickly arrive to informed conclusions. JADC2 incorporates a robust tactical network feeding massive sensor/shooter data across forward forces at a higher level of detail than current tactical messaging systems.

Messaging standards have begun to grow beyond the standardized formats currently in place. The F-22 and F-35 have shrugged off the common link-16 standard for proprietary standards that pass information to a higher detail. Replicating this growth across the services and individual weapon systems will vastly increase the amount and type of information received by operational HQs.

Modern Air Force ABMS will most likely use image recognition in photo reconnaissance, FMV feeds, along with "reading" free text reports and listening to voice traffic, all capabilities resulting in massive amounts of data flowing in and out. A robust M&S solution able to stimulate ABMS (or any service fielded JADC2 capability) is essential for realistic staff training in a JADC2 environment. A modern operational M&S will need to fully replicate this information flow (both in bulk and proper fidelity).

The JADC2 network will be a significant asset to the warfighter and a capability that adversaries would focus cyber and electronic warfare in an attempt to disrupt. The ability to replicate the cohesion of platforms found on a JADC2 network is a critical function of future M&S stimulated exercises. The JADC2 network is the centerpiece of successfully conducting JADO. Keeping this network active, as well as utilizing it for the movement of battlefield traffic, is an important objective for the operational HQ. Planning redundant nodes and proper placement of network enabling assets should provide a significant payoff or detriment to achieving objectives. The exercise training audience needs an M&S solution allowing them to achieve these objectives in a "no risk" environment.

Finally, when considering effects on a network, we take in to account the extreme classification of some capabilities. Many classified capabilities produce unclassified end-effects. It is entirely feasible for a cyber unit to conduct an exercise linked with an operational exercise and allow the associated effects to cross between simulations seamlessly and at the appropriate classification. These concepts are essential for the ability to provide the breadth of problem sets to consider when planning for all-domain operations, as well as enabling the communication pathways funneling information to JADC2 battle management systems during exercise execution.

**#3 Implement behavior models that understand target priorities and authorities and replicate JADC2-enabled networks to allow entities to communicate.**

Operational M&S systems require control by human simulation operators. It is difficult to conceive human operators being capable of replicating the level of platform to platform communication potentially occurring in a full JADC2 construct. Interactions of sim operators would not generate the high level of digital traffic, involving thousands of platforms communicating, found in a real-life JADC2 construct. A viable option is for individual platforms to behave autonomously and communicate across the virtualized tactical network.

Using this construct provides additional benefits as well. The virtual tactical network becomes a suitable playing field for information, cyber, and electronic warfare simulations. Simulated entities should rely on the presence of this networking capacity to relay sensor-shooter information. If the network is hacked the information passing between entities becomes vulnerable to enemy access or denial. It should also be susceptible to EW interference, depending on the capabilities of the enemy counter-emissions. The concept for integration of cyber within kinetic models in the IITSEC 2019 paper “A Roadmap to Achieve Cyber Modeling & Simulation Interoperability” is an ideal model for this interaction.

This construct requires an entity to be aware in the sense of basic automation. The automated entities require understanding of mission objectives, target priorities and be able to communicate mission status in accordance with published orders. In requesting fires, the entity establishes priorities for shooters delivering effects with pre-determined target lists and priorities driven by published orders.

In this situation a simulation operator can still maintain positive control using aggregate units, but individual entities will move autonomously based on the mission orders. Automated behaviors also introduce the ability for entities to move and behave tactically. Entities within models tend to only regard terrain as a speed limiter and aircraft tend to simply take the assigned route to a target. With behavior models in play, an entity can use the terrain and threat knowledge to its advantage as a trained Soldier would do. As mentioned previously, this level of fidelity is not so much of a requirement for the current operational training paradigm, but were an operational model able to achieve an element of realism (while retaining cost effectiveness) then outcome-oriented operational training can begin. The former produces capable staffs that understand how to manage and move information to arrive at command decisions; the latter produces staffs proficient at recognizing battlefield patterns and steeped in fighting their systems. Additionally, it produces greater trust that procedures and machine learning/AI algorithms developed during exercises will be relevant in the real-world fight.

In an ideal JADO-supported M&S, the sim operators set the appropriate doctrine of opposition forces, equipment readiness, and troop morale along with population parameters. These forces receive an input of free-text mission orders and then conduct the battle near autonomously. In this situation, the simulation is suitable for not just operational training but contributing to operational readiness by providing training repetitions in a manner to build proficiency that is beyond knowledge of process. These continuous repetitions become helpful for developing and training, in a sense, the machine-learning algorithms that JADC2 systems will rely upon in wartime.

## **CONCLUSION**

The purpose of this paper is to provide a conceptual view of operational exercises in a JADC2 environment. This view includes proposals on M&S capabilities that enhance training and provide a basis for all-domain representation within the exercise environment. The intent is to provide a trainer-level perspective on operational training simulations and a path forward to evolve our models to train capable and mission-ready staffs. We expect this paper to serve as a launch-point for future dialogue across DoD, industry, and academia on JADO exercises conducted by the JADC2-enabled operational-level HQs.

## **ACKNOWLEDGEMENTS**

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