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WARGAMING



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Cyber Security & Information Systems Information Analysis Center

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Greetings,

Welcome to this special modeling and simulation (M&S) edition of the *Journal of Cyber Security & Information Systems*, published by the Cyber Security & Information Systems Information Analysis Center (CSIAC). This edition focuses on wargaming, a key cylinder of the Department of Defense's (DoD's) innovative engine.

The Department wants to employ wargaming to develop new concepts which can integrate new capabilities, enrich programmatic and acquisition decision processes, and inform discussions on departmental strategies. In a February 2015 memo, Deputy Secretary of Defense (DepSecDef), Robert Work writes that he expects wargames to “pursue an innovative third offset strategy, avoid operational and technological surprise, and make the best use of our limited resources.” Most important the DepSecDef wants to “wargame the kinds of challenges that cross COCOM responsibilities in order to better address threats that would benefit from a more global strategic perspective.” Over the past year, the Department has encouraged more wargaming by hosting two wargaming summits, executing the senior leader wargaming series, developing the wargaming repository, forming the Defense

“Revitalizing Wargaming is Necessary to be Prepared for Future Wars”

Wargaming Alignment Group (DWAG), providing wargaming incentives, and publishing a monthly wargaming report. The wargaming repository (wargaming.osd.smil.mil) was created by Office of the Secretary of Defense (OSD), Cost Assessment and Program Evaluation (CAPE) to provide the wargaming community of practice with a centralized hub for sharing of information as well as identifying number of wargames conducted (including upcoming games), capabilities, capacity, cost, and insights gained. The repository provides an interactive database of wargames, as well as points of contact and listing of support tools. To keep the repository current, in a December 2015 memo, the DepSecDef and Vice Chairman of the Joint Chiefs of Staff (VCJCS), Gen. Paul Selva, directed all organizations to “Update the wargaming repository monthly with future wargames and tabletop exercises, as well as executed games to include insights.” The repository allows users to post files including wargame final reports, tools, and data. Users can also comment on wargames to help the community understand the value of the insights. The wargaming repository currently contains over 550 wargames, 260 organizations and 212 support tools.

In his May 2015 memo (“Wargaming Summit Way Ahead”), the DepSecDef formed the DWAG to “better link wargames with senior leader priorities, with a strong focus on information dissemination.” In addition to these tasks, the DWAG assists the wargaming principle Quad-Chairs (CAPE, Policy, Office of Net



Assessment, and JS-J8) with administrative and organization functions and acts as a conduit between the Department and the wargaming enterprise. The DWAG meets every two weeks and members include representatives from COCOMs, Services, NGB, JS-J7, JS-J4, OSD-AT&L, OSD-CAPE, OSD-Policy, Office of Net Assessment, and Under Secretary of Defense for Intelligence.

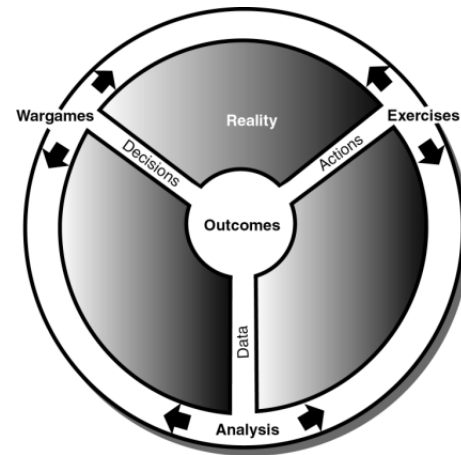
As part of the Department’s wargaming efforts to institutionalize wargaming and better integrate wargaming results with budget development, the DepSecDef created a \$10M per year wargaming incentive fund. This fund incentivizes strategic and programmatic wargames that address Department priorities. The DepSecDef February 2015 memo stated, “Wargaming, in concert with operational analysis, and experimentation, cannot stand apart from the budget process.” Understanding, wargames serve many purposes and vary in purpose, design, size, and scope; the incentive funds intent is to incentivize programmatic and strategic games that provide senior level insights. The incentives aren’t meant to supplement current wargames, but rather to expand wargames to address Department priorities and gaps across regions, Services, and COCOMs. The current criteria for wargaming incentive funds include:

- (1) Addresses senior leader priorities
- (2) Potential for programmatic/strategic insight
- (3) Innovative concepts/capabilities
- (4) Topical coverage gap
- (5) Historical quality of game insights
- (6) Crosscutting
- (7) Incentive fund return on investment (ROI) and postgame assessment

Although, the Department emphasizes strategic and programmatic games, this is not meant to curtail other types of games. To request incentive funding, simply create an upcoming wargame in the repository with all fields completely filled in; then check the box for incentive funding and provide specific rationale on

why funding is required, including the Department cost/benefit. Second quarter, 2017 wargaming incentive fund requests are due by November 28th, 2016.

At the Wargaming Summit II, Gen Selva stated “wargames must be games of consequence and the way to make games of consequence is to have senior leaders involved.” To help address this concern the Department created a wargaming monthly report. The report is populated directly from the repository, and its intent is to inform senior leaders of upcoming wargames and events, provide insights from past wargames, and provide repository summary statistics. The report is sent directly to Department 4-star level leadership, which places additional emphasis on organizations to keep the repository updated.

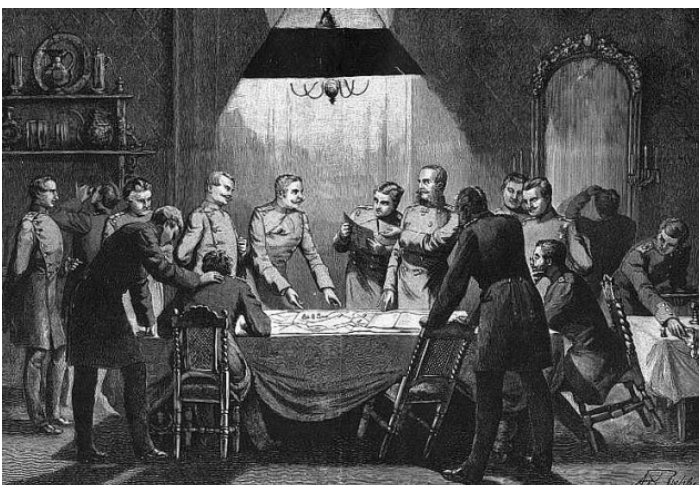


The cycle of innovation consists of the interaction of analysis, modeling and simulation, wargaming, and demonstrations/ exercises. Used together they enable the Department to think outside the box and provide decision space for senior leaders. In the December 2015 “War on the Rocks” article, entitled, “Revitalizing Wargaming is Necessary to be Prepared for Future Wars,” the



DepSecDef and VCJCS stated: “Wargame results are neither shared laterally across the defense enterprise nor up the chain to influence senior level decision-making.” Over the past year the Department has developed the wargaming repository, Defense Wargaming Alignment Group (DWAG), incentives, and a monthly report to better enable both lateral and horizontal information sharing. The Department focus on wargaming is welcomed news to the professional wargaming community; however, this renewed attention also demands results. The Department believes wargaming is an avenue for innovation through strategic and programmatic insights and now the wargaming community must produce. The days of completing a wargame outbrief and calling it good are over. The community must show its worth and be part of the cycle of innovation by producing actionable insights. The Department has provided the structure and resources, and now the wargaming community must showcase its capabilities.

DISCLAIMER: The opinions expressed herein are those of the author, and are not necessarily representative of those of the Office of the Secretary of Defense or the Department of Defense.



ABOUT THE AUTHOR

COL Mark Gorak leads the OSD-CAPE wargaming team, and manages senior wargame analysts and contractors charged with implementing DepSecDef priorities and better connecting wargaming with the DoD planning, programming, and budgeting process. He is a principle member of the Defense Wargaming Alignment Group and serves as OSD-CAPE lead for the wargaming quad-chair council of colonels. He coordinates and leads excursion wargames, manages the wargaming repository, implements policies, training and funding to improve the quality of wargames and directs OSD wargaming conferences.

His previous assignments include the US Army manpower analysis agency where he served as a senior analyst; Army Staff Headquarters G-1 as branch chief for military personnel program and budget branch responsible for program and execution of military pay; headquarters United States Military Entrance Processing Command where he served as lead analyst; and command of Charlie Company 228th theater aviation company. He served as deputy J5 in Iraq with Joint Task Force-Iraq (JTF-I) evaluating US force presence and conducting theater assessments. In addition to his military assignments, Mark chaired the manpower working group for the Military Operations Research Society (MORS) for three years, and is a six-sigma black belt. He earned an electrical engineering degree from Marquette University, applied mathematics master's degree from Naval Post Graduate School, and a Master of Science in national resource strategy from Eisenhower School, National Defense University.

M&S Support to Wargaming

By: John Lawson III
Contractor supporting
Marine Corps M&S Office

***"Wargames
will produce
unimaginative,
inside-the-box
thinking"***

If you deal in computer models and simulations (M&S), and you aim to support wargaming, you need to understand what type of wargame you are supporting, and you need to understand the wargame's purpose. This article is about understanding those two aspects of M&S support to wargaming: wargame type and wargame purpose.

The first thing you need to do is think of wargaming along a spectrum.

One end is more qualitative and subjective. As you move toward this end of the wargaming spectrum, M&S will have a supporting role, a peripheral role, or no role at all.

The spectrum's other end is more quantitative and objective. As you move in this direction, M&S will have a valuable role, a central role, or it may even be the wargame's heart and soul.

It is possible to spend a lot of time arguing over whether a wargame should be run by a traditional wargamer, a numbers-oriented analyst, or some combination of the two. If you are an M&S person, you do not need to worry about that debate. No matter who is running a wargame, it should not be you. You are responsible for a tool or a set of tools supporting a wargame that someone else devised and that someone else will run.

In addition to the different types of wargames, there are different purposes for wargames. A wargame's purpose might involve training, education, experimentation, analysis, or any number of other concerns. The important thing for an M&S person supporting a wargame is to understand the wargame at hand. If it is a decision-making wargame to help senior leaders think through a current crisis, tailor your M&S support to those specific circumstances. If it is a training wargame designed to train numerous battalion staffs over the next several years, tailor your M&S support to those specific circumstances.

Do not let M&S support to wargaming become an entrenched, encumbered, monolithic process. Do not let M&S support to wargaming degenerate into off-the-rack, cookie-cutter "solutions." Wargames are supposed to provide insight into unpredictable topics. If M&S support to wargames gets rigid and highly predictable, then M&S support to wargames will produce unimaginative, inside-the-box thinking. At that point, a successful wargame would be successful despite M&S support, rather than because of it.

Before going any further, it is probably a good idea to define computer models, computer simulations, and wargames. The definitions are deliberately loose, as the purpose of this article is to promote conceptual thinking rather than pedantic hair-splitting.

We will treat a computer model as an algorithm coded into a representation. It could be a representation of a vehicle, a weapons system, a unit of troops, a group of refugees, or any number of other entities.

We will treat a computer simulation as one or more models representing behavior over time. To use the examples above, a simulation might show how a vehicle with a weapons system would attack a unit of troops while trying to avoid harming a group of refugees. The simulation would probably be multi-faceted, which means it would probably illustrate additional considerations, such as how much fuel the vehicle would use and how the refugees might behave if they found themselves on the edge of combat.

We will treat a wargame as a representation of conflict in which the decisions people make are central to the wargame's outcome.

Wargaming has enjoyed a much higher profile over the past two years, starting with a memo from then-Secretary of Defense Chuck Hagel. In 2014, he called for a "reinvigorated wargaming effort" that will "develop and test alternative ways of achieving our strategic objectives."

In 2015, the call for improved wargaming intensified when Deputy Secretary of Defense Bob Work wrote a memo saying wargaming has "atrophied." To better think about concepts, capabilities, and plans, Deputy Secretary Work wrote, it will be necessary "to reinvigorate, institutionalize, and systematize wargaming across the Department."

Shortly after releasing his memo, Deputy Secretary Work gave a speech in which he emphasized the relationship between better wargaming and keeping up with change. Technologies change faster than they used to change; challenges arise more quickly; and our collection of adversaries is wider and more diverse. Wargaming, he said, can "spur innovation" and "provide a mechanism for addressing emerging challenges."

At this point, the best way to think about wargaming and M&S is to temporarily stop thinking about wargaming and M&S. The Department of Defense (DoD) is an enormous sprawl which contains very big organizations which contain big sub-organizations which contain somewhat big sub-sub-organizations, etc., etc., etc. The end result of all that enormity is a legion of specialists and sub-specialists who are so absorbed in the details of their work that they lose track of the larger goals.

So, to reiterate, the best way to think about wargaming and M&S is to temporarily stop thinking about wargaming and M&S. For just a little while, do not think about what the wargame is or what

the M&S support will be. For just a little while, do not think about how the mechanics of the wargame will look, and do not think about how to plug M&S into the wargame.

Instead, think about why someone would ask for the wargame. Remind yourself that whoever asked for the wargame almost certainly is not a wargamer or an M&S specialist. Whoever asked for the wargame undoubtedly has much larger fish to fry.

Writing from the perspective of the Marine Corps M&S Office, it is easiest for us to illustrate the point we are trying to make by using Marine examples, but the ideas are the same, whether you are in the Navy, the Air Force, the Army, the Office of the Secretary of Defense, or whatever.

Right now, in the Marine Corps, one of the most important calls for wargaming comes from the process we refer to as the Marine Corps Capabilities Based Assessment (MC CBA) which in the end produces the Marine Corps Enterprise Integration Plan (MCEIP). So, in this example, when we talk about wargaming and M&S support to wargaming, everything needs to map back to the MC CBA process and the MCEIP.

Again, this is just an example. We are not saying MC CBA is the only activity in the Marine Corps requiring wargame support. And we certainly are not saying MC CBA is the only activity in DoD requiring wargame support. But if you have a good example of something requiring wargame support, it is much easier to think about what M&S support to the wargame should look like.

"Reinvigorated wargaming effort that will develop and test alternative ways of achieving our strategic objectives."

The context of MC CBA helps underscore the fact that wargaming is not an end in itself. Wargaming exists to serve something larger (and M&S also exists to serve something larger).

Before going any further, it is probably a good idea to restate this article's main thesis: The key to successfully using M&S in support of wargaming is to remain keenly aware of the wargame's type and purpose.

Having said all that, consider M&S, wargaming, and the MC CBA.

In the Planning, Programming, Budgeting & Execution (PPBE) process, MC CBA is part of the first "P," which is to say it is the Planning part of the process. The goal, which is important to the Marine Corps as a service, involves reconciling future-focused strategic guidance with the integrated development of capabilities for a given Program Objective Memorandum (POM) cycle. To put all of that in layman's terms, the recommendations the Marine Corps makes to the Secretary of Defense about spending money need to make sense for the present and for the future.

In the big picture, MC CBA helps the Marine Corps be smart about expenditures, and it helps the Marine Corps think within the time constraints of DoD budget cycles.

Wargaming support to MC CBA needs to subordinate itself to those POM forces, which are both significant and largely inflexible. In turn, M&S support to wargaming needs to accommodate wargaming goals. In this type of situation, specialists cannot behave like prima donnas. They need to get with the program – or more accurately, they need to get with the Program Objective Memorandum.

The MC CBA process is conducted in five phases, and the first phase is guidance development and the POM Capabilities Based Assessment (CBA) Wargame. The guidance to be used during the MC CBA will be developed here and the guidance will have a direct influence on the wargame.

So, if wargames are going to matter, and if M&S support to wargames is going to matter, the customer's concerns need to shape the wargames and the M&S support. The biennial Marine Corps CBA Wargame must ensure that capability requirements align with the Commandant's strategic goals for 10 years down the road. Preparation for this biennial wargame runs for 11 months, and the wargame itself occurs in September.

If you want to use M&S to support the biennial Marine Corps CBA Wargame, you need to keep that schedule in mind, and you need to remember that your customer is emphasizing capability requirements. Even if you are not directly involved in the Marine Corps CBA Wargame, you could support inputs to the wargame. In other words, you could support a smaller wargame that supports the larger wargame. That could include assessing operating environments, assisting with experiments, examining concepts, etc.

Again, the point of this article is not to celebrate the MC CBA process as a wargamer's be-all, end-all. Many, many wargamers could have successful careers without getting anywhere near the MC CBA process. But the point of this article is to emphasize the importance of knowing what type of wargame you are supporting and what that wargame's purpose is.

If you are supporting a customer working budget issues, if your customer is on a rigid timeline, and if your customer is crafting recommendations that are or will become quantitative, then all of those considerations need to shape how you support a wargame.

Continuing with our MC CBA example, it helps to know what happens after the wargame. After the Marine Corps CBA Wargame comes Phase II in the MC CBA process, which is capabilities analysis. This phase, which lasts three months, involves identifying and refining capability requirements, along with the associated tasks, conditions, and standards. Inputs for this phase include scenarios,

concepts of operations, authorized strength levels, and the previous edition of the Marine Corps Capabilities List (MCCL). A new, updated MCCL, by the way, is the output of this phase.

The bottom line for Phase II is capability requirements. So any wargaming during or preceding Phase II should have that purpose in mind. And the type of wargaming should match that purpose, too. If you have a really good training war game, that probably will not do you much good here, as the name of the game is capability requirements. You probably want something more analytical in a situation like this.

Again, to keep beating the drum, the two things to remember with M&S support to wargaming are knowing the wargame's purpose and knowing the wargame's type.

"Ensure that capability requirements align with the Commandant's strategic goals for 10 years down the road"

Moving on to Phase III of the MC CBA process, we encounter gap analysis. This phase also lasts three months. One input for this phase is the aforementioned MCCL, i.e., the capabilities list. Other inputs include the current programmed force, integrated priority lists from Marine Corps Force commanders, and the previous year's Marine Corps Gap List (MCGL). An updated MCGL, by the way, is the output of Phase III.

As you can see, whether wargaming precedes this phase or occurs in this phase, the focus is on tighter thinking that addresses gaps between capabilities and requirements. Accordingly, wargaming and any related M&S need to be more focused in order to affect this phase.

Whether it is MC CBA wargaming or other wargaming, if the customer's purpose is coming more clearly into focus, wargaming is more likely to get away from painting broad strokes, which means there could be greater attention to detail, which means M&S might have an opportunity to crunch numbers or grind through details.

As MC CBA moves to Phase IV, the process centers on solutions analysis. This three-month phase draws from a number of inputs, most notably wargaming.

The purpose of Phase IV is to mitigate or eliminate capability gaps. The gaps could be anywhere across the gamut of military affairs, which is to say, anywhere across the gamut of DOTMLPF-P: Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities and Policy.

Because there is a wide variety of purposes in this phase, there could be many types of wargames to support those purposes – conceptual games, data-crunching games, and games in which there is a balance between the players, the M&S inputs, and the M&S outputs.

Phase IV generates the Marine Corps Solutions Development Directive (MCSDD), which feeds Phase V, the final phase of MC CBA. This three-month phase draws on many materials, including the products from Phases II, III, and IV: MCCL, MCGL, and

MCSDD. Phase V, and with it, the MC CBA process, conclude with the Marine Corps Capabilities Investment Plan (MCCIP)

If it seemed a little distracting to examine M&S support to wargaming through the prism of a process such as MC CBA, think for a moment about typical discussions on wargaming. Most discussions about wargaming – never mind M&S support to wargaming – are alarmingly removed from discussions of utility. Most discussions about wargaming (and most discussions about M&S) are discussions in which the specialized means to an end becomes an end in itself.

Far too many discussions about wargaming (and far too many discussions about M&S) are bureaucracy's equivalent to parlor discussions about art for art's sake. You hear far too little about what DoD or a particular service achieved, but you hear more than you ever wanted to hear about how some wargamers or M&S experts really wowed their colleagues at some event five or 10 years back.

The thing is, M&S support to wargames is not something we should be doing for the benefit of people like us – analysts, wargamers, M&S experts, and such. Anyone involved with M&S support to wargames needs to orient on the CUSTOMER!

What are the customer's purposes? What type of M&S support for a wargame would advance those purposes? What levels of time, money, and customer patience are available for the wargame and whatever M&S support goes with it?

If reinvigorated wargaming is supposed to spur innovation and help DoD keep up with emerging challenges, then we need to work backward from that goal. This is not the time to justify ourselves and talk about what a great job we think we have been doing. We need to be talking about the customer's purposes, and we need to be talking about the type of support that promptly addresses those purposes. And the metric for success should probably be something like this: The customer comes back to us in the near future and asks for more. Much more.

ABOUT THE AUTHOR

John Lawson III is a contractor who supports the Marine Corps M&S Management Office. Before that, he was a contractor serving several Air Force entities as an analyst. He has spent more than a decade monitoring commercial game technology and its potential utility for military analysis and military M&S. In the 1990s, he was a newspaper reporter, mainly for The Tampa Tribune; he is also the author of Tom Landry and Bill Walsh: How two coaching legends took championship football from the Packer Sweep to Brady vs. Manning. Lawson served in the Marine Corps Reserve for nine years and reached the rank of staff sergeant. He has a B.S. in mechanical engineering from the University of Maryland; a B.A. from Washington & Lee University for a double major in history and English; and an M.A. from the University of Florida in mass communications.

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Air Force Research Laboratory Innovation

Pushing the Envelope in Analytical Wargaming

By: Jaime J. Bestard

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INTRODUCTION: *The Air Force Research Laboratory has taken steps to revitalize wargaming across its Enterprise to evaluate the military utility of innovative technology concepts in combat. The integration of Modeling and Simulation (M&S) to improve the analytical rigor of wargames is a fundamental part of this effort. In a period of growing strategic challenges and increased fiscal pressure, analytical wargames offer a unique opportunity to evaluate the multi-dimensional capabilities of advanced technologies and overcome technology stovepipes. Concerns on how to operate freely in the primary Air Force domains (i.e., air, space and cyberspace), exploit big data, integrate autonomy, and provide Air Force and Department of Defense leadership with seamless command and control solutions are some of the many issues that can be explored through analytical wargames. Moreover, participation in analytical wargames offers Defense professionals a unique and synergistic opportunity to explore the realm of the possible with advanced technologies while sharpening their operational and strategic thinking skills.*

Background

In February 2015, the Deputy Secretary of Defense, Mr. Robert O. Work, issued a memorandum to “revitalize” wargaming across the Department of Defense in light of the Defense Innovation Initiative (Third Offset Strategy). In his missive Mr. Work acknowledged that “wargames spur innovation” and “can potentially make the difference between wise and unwise investment trajectories and make our forces more successful in future conflicts”. This guidance, coupled with Air Force M&S initiatives in support of strategic developmental planning and experimentation, led the Air Force Research Laboratory (AFRL) Corporate Board to decide, in August 2015, to manage wargaming at the Enterprise level by:

- Establishing a Wargaming Working Group and a corresponding governance structure,
- Creating a vetted AFRL Concept Portfolio,
- Forming a cadre of wargaming technologists,
- Promoting the use of M&S in support of wargames.

Since then, the AFRL Enterprise has established a portfolio of technologies that support the Third Offset Strategy in the primary Air Force domains. In May 2016, the AFRL conducted a workshop to establish a baseline of its M&S capabilities supporting wargames. This initiative led to a general understanding of existing tools available to the Enterprise with the potential to influence wargame outcomes. With this in mind, the AFRL wargaming staff has a vision to incorporate M&S products into game preparation, play, adjudication and analysis and provide an analytical foundation to our wargame outcomes. Most recently, in August 2016, the AFRL conducted the first of a series of events titled Futures Analytical Science and Technology (FAST) wargames with an emphasis on advanced technology concepts operating in an anti-access/area denial (A2AD) environment. This event had multiple objectives, among which was the integration of M&S products into different stages in the wargame process (e.g., concept development, scenario design, game play and adjudication, and post-game analyses).

Models, Simulations and Wargames

Wargames are powerful tools to explore problems where humans must make decisions in challenging situations and generate possible solutions. Wargames offer structured and rigorous environments where participants can evaluate strategies, concepts of operations, and technologies across the different levels of war to identify key limiting factors and expose innovative options. For an Enterprise charged with the scientific and technical innovation of the United States Air Force, wargames offer an exceptional resource for informing strategic investment decisions.

Models offer Defense professionals with abstract representations of future technologies that can improve warfighting capabilities. These representations can help understand how a weapons system will be transported, its payload capacity, the technologies it uses to operate effectively, and the processes necessary to execute its mission. Simulations are the representation of the behavior or characteristics of one system through the use of another system, typically a computer program designed for the purpose. M&S offer opportunities to constructively test a system or system of systems and its behavior without conducting live trials. M&S also provides the option of varying system characteristics, such as adding performance attributes for new technologies into the simulation and evaluating the utility at various levels of play. Virtual M&S includes humans in the loop integrated with mathematical M&S and allows operators “seeing” the constructive picture of war to interact with it, using new technologies within a scenario to evaluate improved performance and develop concepts

of operations (CONOPS) and employment (CONEMP) and tactics, techniques and procedures (TTP). Wargames (military simulations) test warfare theories and human decision-making and are perceived as useful in the development and evaluation of doctrine, organization, training, materiel, leadership, personnel and facilities (DOTMLPF) solutions.

"Evaluate improved performance and develop concepts of operations (CONOPS) and employment (CONEMP) and tactics, techniques and procedures (TTPs)."

Traditional wargames have not depended on science and technology (S&T) to support military decision makers. However, the integration of S&T and skillsets to facilitate data exploitation (e.g., operations research, science and engineering) are the core of analytical wargames and

facilitate the gaming process while making these powerful tools more interactive. Such integration will improve an environment often seen as the realm of historians, political scientists, and military officers with little formal analytical training and awareness of emerging technologies. These improvements will not only increase the quality of wargames and their products, but will facilitate data-driven exploration of military utility for new and integrated S&T concepts. The AFRL Enterprise benefits from analytical game play through feedback of adequate requirements and insights into potential CONEMP for augmenting the strategic, operational, and tactical capabilities of advanced technologies.

Advancing the AFRL Wargaming Enterprise

Wargames follow a pattern that can be divided into three primary phases (i.e., design, execution, and reporting) all supplemented with relevant training (see Figure 1). The AFRL provides general wargaming training to its personnel on an *ad hoc* basis. As the Laboratory moves toward a planned wargaming battle rhythm, additional training will have to be tailored to the different participants in upcoming events (e.g., blue and red players, adjudicators, analysts, concept developers).

Game design is a critical factor of wargaming and it can be roughly distributed into two efforts heavily influenced by M&S, i.e., concept development and game planning. Concept development in AFRL is carried out by scientists and engineers familiar with advanced technologies of game-changing potential that could be operational by the game epoch. Concept development relies on accurate models from the physics and engineering technology levels through associated subsystem and system levels. These models are used to describe system performance¹ through simulations at the engagement and mission levels. Furthermore, the results of mission level simulations along the kill-chain² are essential to an analytical

1 e.g., speed, range, weight, fuel capacity, payload

2 e.g., PS – probability of survival, PK – probability of kill, PK|H – probability of kill given a hit

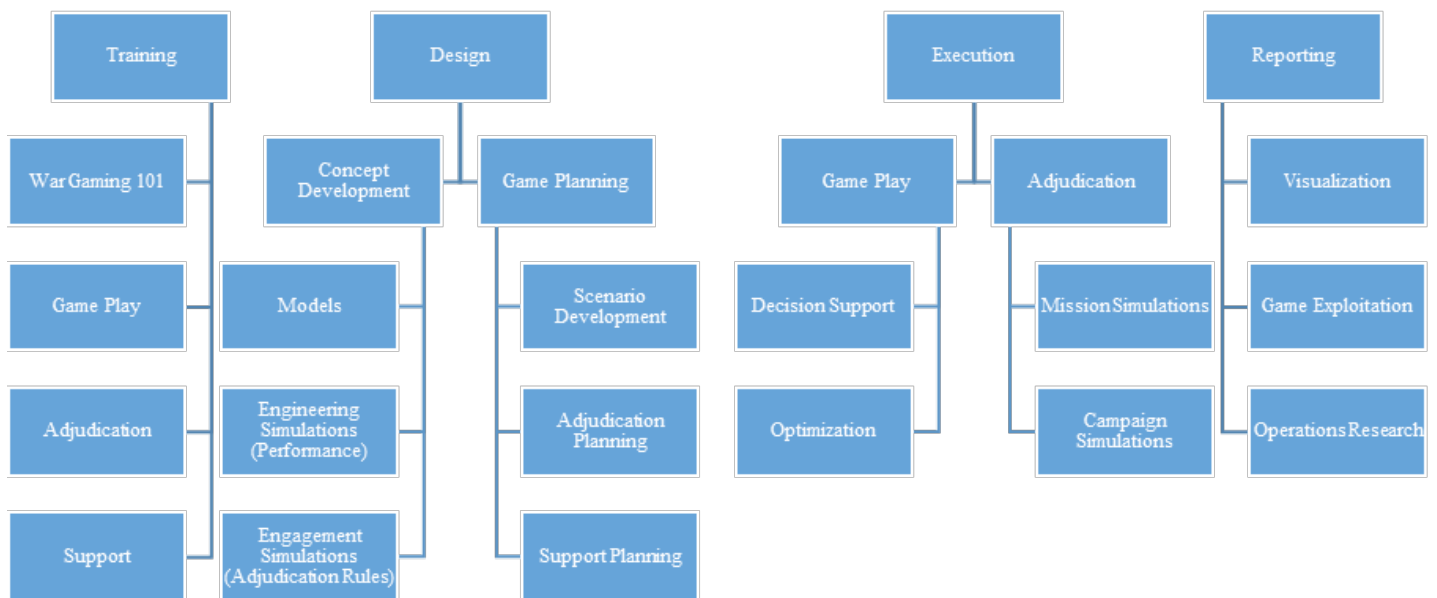


Figure 1. AFRL – Analytical Wargaming Framework

adjudication environment. These simulations rely on notional concepts of operations (CONOPS) that can be challenged and improved through wargaming.

When operating within the structure established by the Deputy Secretary of Defense in February 2015, most advanced technologies developed in AFRL should be explored in long-term wargames (i.e., beyond 15 years). Game planning should be carried out in close collaboration with stakeholders and independent of concept developers to avoid game plans that provide unfair advantages to blue technologies. Nonetheless, game planning efforts should consider available M&S capabilities and products. The scenario development effort should take into consideration the technologies that both blue and red forces will have available in the epoch of interest and examine support requirements as best they can. Models of existing technologies provide a baseline populating the scenario environment on both sides for game play³. Adjudication planning must take into account available results from past engagement simulations and, time permitting, may require additional analyses to minimize subjective decisions during the wargame. Game support planning focuses on capabilities that will facilitate game execution and should consider the availability of mission and campaign simulations and the time it takes to produce results for analytical adjudication.

Game execution consists of two distinct efforts that can be significantly improved with M&S, i.e., game play and adjudication. During game play, players are usually pressed for time and can be overwhelmed with data on advanced technologies they may

not be closely familiar with. In order to augment player cognitive abilities, decision-support systems and optimization tools can be further developed and integrated into the wargame. These tools can harvest M&S data and provide support to players with valuable information packaged for easy reference for their planned courses of action. Throughout adjudication, available mission and campaign simulation outputs should be used to minimize subjective judgements and to augment the capacity of adjudicators to assess game outcomes effectively and on schedule.

Finally, after the game execution phase is concluded, adjudicators, planners, and analysts must parse through newly created game data and produce a comprehensive assessment report of the event. M&S again plays a critical role during and after this reporting phase with visualization capabilities and game exploitation tools to conduct analysis on plays that were executed in the game. M&S allows analysts to conduct operations research on the event, and helps record analytical decisions from the initial game design phases.

Capabilities for Enterprise Wargaming

The AFRL has been an active user and developer of M&S tools in support of its technological innovation mission. Some of these tools, spanning the levels of M&S in the widely-known military pyramid, have supported past wargames (see Figure 2). In addition, the Air Force Office of Scientific Research (AFOSR) is conducting basic research for the AFRL in optimization, game theory, artificial intelligence, and data analytics research with the potential to impact the execution of future wargames.

³ The Threat Modeling and Analysis Program (TMAP) offers authoritative (Intelligence Community) threat models derived from all-source intelligence; models are built in the MATLAB/Simulink environment

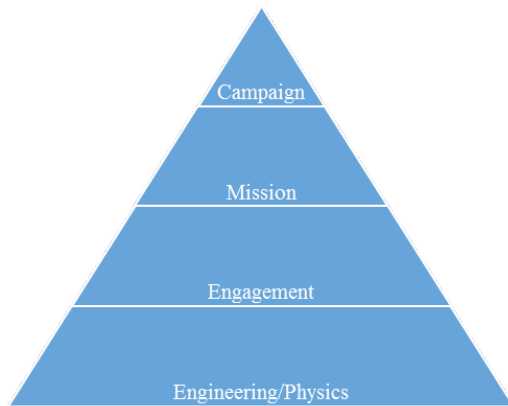


Figure 2. Military M&S pyramid

Simulations used by the AFRL at the **engineering level** are numerous and mainly applied for technology development (e.g., computer-aided engineering, finite element analysis). Of these, there is one M&S capability that should be exploited to advance wargame quality. The Threat Modeling and Analysis Program (TMAP) is an initiative that offers authoritative threat models, predicting system characteristics and performance capabilities. This capability can improve game design by providing analytical support to scenario development, adjudication planning, and red system descriptions. The projected addition of artificial intelligence to the M&S environment will also improve simulation utility as models “self-learn” during an engagement and optimize established courses of action accordingly.

At the **engagement level** there have been several AFRL opportunities to evaluate the integration of M&S into future wargames. The Munitions Directorate has used the Endgame Framework environment to quantify the effects of munition blasts and fragments against the fault-tree of system components in target models to provide probability of kill (P_k). Endgame Framework modules coupled with the Integrated Environment for Weapons Analysis (IWEA) are used to quantify kinetic (blast and fragmentation) and directed energy munition effectiveness against ground targets. Finally, the Munitions Directorate uses a six-degree-of-freedom (6 DOF) MATLAB/Simulink architecture titled Engagement-Level Visually Intuitive Simulation (ELVIS) to visualize engagements using an assembly of modules.

The 711th Human Performance Wing has used various simulations for assessing directed energy bio-effects during wargames. The High Energy Laser Scatter from Targets (HELCAT) simulation

has been used during concept development to provide “danger close” biological effects estimates through the application of standards and dose-response models at common high-energy laser wavelengths. The Directed Energy Weapon Decision Support Tool (DEW-DST) has also been used during concept development to simulate skin damage and repel behavior in millimeter-wave engagements. Finally, the Laser Hazard Assessment Software (LHAZ) and the Radio Frequency Hazard Assessment Software (RFHAZ) have provided analysis tools during concept development for basic laser/radio frequency quantification, protection requirements, and hazard classification.

The Directed Energy Directorate conducts engagement simulations during the game design phase. The Dynamic Aim-point Laser Engagement (DALE) provides the optimal aim-point selection for a laser weapon and a target response to incident laser irradiance, aim-point vulnerability, and selection of aim-point for the shortest time to kill. The Directed Energy Directorate uses a tool to determine the infrared (IR) characteristics of targets by providing signatures in three bands in a 360-degree bubble around the system at varying settings (e.g., throttle, altitude). The Directorate has also used a tool in adjudication planning to assess directed energy bio-effects. A version of this tool has been modified to support concept development and integrated into the Endgame Framework environment and IWEA to evaluate combined directed energy and kinetic engagements. This tool has also been used for real-time directed

energy collateral hazard analysis, providing the laser shooter an estimate of effects on entities surrounding a target. The Joint Radio-frequency Effect Model (JREM) has been used to build lethality tables for High Power Electromagnetic (HPEM) weapons, supporting adjudication planning, and to conduct sensitivity analyses to determine key target elements to engage. Finally, the Directed Energy Directorate has used a collection of scaling laws and assorted support routines, Scaling for High Energy Laser and Relay Engagement (SHaRE), to calculate laser beam metrics and irradiance distributions for engagements.

While M&S options as we move higher in the pyramid begin to consolidate, AFRL has explored multiple opportunities at the **mission level**. The Sensors Directorate has

used its Global Positioning System (GPS) Interference and Navigation Tool (GIANT) to determine the effectiveness of navigation systems in challenging A2AD environments. GIANT simulates GPS control, space and user segments for a broad range of GPS user-equipment within a mission scenario environment in order to examine “system-of-systems” performance. This tool, coupled with optimization and decision-support technologies,

***“Improve
simulation utility
as models “self-
learn” during
an engagement
and optimize
established
courses
of action”***

offers an opportunity for players to plan their courses of action effectively and for adjudicators to provide objective assessments of navigation system performance in contested environments.

The Aerospace Vehicles Directorate is a key contributor to AFRL modeling, simulation and analysis capability. RQ leads the development and maturation of the Advanced Framework for Simulation Integration and Modeling (AFSIM). AFSIM is the M&S framework mandated by the AFRL commander for integrated technology/multi domain mission level modeling and simulation. AFSIM allows rapid scenario composability from engineering to mission level simulations and can be used for both constructive and virtual simulations. The AFSIM framework provides a flexible agent modeling architecture supporting subsurface to space warfighting domains. AFSIM provides a realistic, perception-based representation of systems with tracking, correlation and fusion algorithms which can be linked to other simulations via distributed interactive simulations (DIS) or high-level architectures (HLA). The framework employs an integrated development environment and visualization tool that can be exploited to support multi-domain wargame scenarios. The Air Force Studies, Analyses and Assessments Directorate (AF/A9) and the Air Force Life Cycle Management Center Simulation and Analysis Facility (AFLCMC/SIMAF) are active stakeholders of the AFSIM framework, supporting compatibility and extending the capability to the campaign level. The Munitions Directorate also uses AFSIM for weapon fly-out and survivability estimates in mission-level simulations.

The Directed Energy Directorate has used the Reconfigurable Tactical Operations Simulator (RTOS), a modular, high-fidelity, soldier-in-the-loop, real-time distributed interactive simulation and high-level architecture compliant computer simulation, to support analyses of tactical data link interfaces during game play. The Air Warfare Simulation (AWSIM), the approved Air Force model for full spectrum air warfare operations training and experimentation, has been used to support the definition and laydown of friendly, hostile, and neutral assets in a synthetic warzone where players can then control their forces. Big Tac, a flexible, high-fidelity threat environment capable of presenting a combination of air threats and ground based air defense threats, has been used to enhance immersion of players in a synthetic combat environment. The Directorate uses a stand-alone virtual (man-in-the-loop) simulation station designed to operate as an airborne asset, simulating either an E-3 Airborne Warning and Control System (AWACS) or E-8 Joint Surveillance and Target Attack Radar System (JSTARS) or both. This tool can be potentially integrated into future wargames involving these platforms. The Extended Air Defense Simulation (EADSIM) is a many-on-many simulation of combined air, missile and space warfare. It is uniquely capable of modeling platforms at a high level of detail and simulating the interaction among

multiple platforms. The Modern Air Combat Environment (MACE), a physics-based, many-on-many simulation and threat environment with a large order of battle, is ideally suited for both standalone mission rehearsal and distributed mission simulation. The Next Generation Threat System (NGTS) has been used to model enemy and friendly aircraft, ground units, ships and submarines, associated weapons, sensors, and subsystems. The Space Simulation Generator (SSG) has provided space orders of battle for exercises and training events. Finally, the Directed Energy Directorate has used the eXpert Common Immersive Theater Environment (XCITE), a virtual battlespace software tool, combining high-fidelity Electronic Attack/Electronic Warfare (EA/EW), energy-based aerodynamics, physics-based radar modeling, threat, and theater force models with robust command and control capability.

Though much of the M&S required for technology research, development, test and evaluation occurs at the physics, engineering and engagement levels, the AFRL must also assess military utility at the **campaign level**. The Munitions Directorate uses the Synthetic Theater Operations Research Model (STORM) to study the effects of a given set of munitions on the length and cost of a military campaign. The Aerospace Vehicles Directorate uses the Analysis of Mobility Platform (AMP), a United States Transportation Command (USTRANSCOM) model, to represent end-to-end deployments and quantify operational energy requirements. This last federation of tools consists of a Model for Inter-theater Deployment by Air & Sea (MIDAS), the Enhanced Logistics Intra-theater Support Tool (ELIST), the Capability Analysis and Modeling for Energy Logistics (CAMEL) and the AMP Port Analysis (AMP – PAT). Finally, the Aerospace Vehicles Directorate also uses the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Space and Missile Operations Simulator (COSMOS), a flexible system-of-systems model suite representing space, air, ground, surface, subsurface systems with ISR, weapons, communications, cyber, survivability functions.

The integration of analytical capabilities (see Figures 1 and 3) into future wargames enables AFRL to probe the military utility of emerging technologies and offers an opportunity to evaluate their impact on the battlespace and how they can augment the total force to improve its effectiveness. To facilitate integration, the AFRL wargaming staff is also exploring the use of commercial off-the-shelf (COTS) tools that offer large-scale flexibility ranging from detailed models to advanced, near real-time, mission and campaign simulations. The exploration focuses on tools with readily-available databases that address the capabilities and limitations of a variety of war fighting assets within the full range of military operations. Once an overarching tool has been identified as the foundation for AFRL war-gaming, a common data format will be established for

the exchange of information with other models and simulations. This approach will avoid unnecessary duplication of effort, allowing existing M&S tools to continue supporting their primary missions, while adding analytical rigor to advanced technology wargames. These analytical wargames will inform future Air Force and AFRL investment decisions.

Engineering	Engagement	Mission	Campaign
<ul style="list-style-type: none"> • TMAP • AFSIM 	<ul style="list-style-type: none"> • LHAZ/RFHAZ • HELCAT • DEW-DST • DALE • JREM • SHaRE • EF • ELVIS • IWEA • AFSIM 	<ul style="list-style-type: none"> • GIANT • AFSIM • AMDC2/RTOS • AWSIM • Big Tac • EADSIM • MACE • NGTS • SSG • XCITE 	<ul style="list-style-type: none"> • STORM • AMP • COSMOS

Figure 3. AFRL – M&S Capabilities in Support of Wargaming

Conclusions

Analytical wargaming will help establish a foundation for investment decisions at appropriate levels of risk. Our national defense relies heavily on the success of our most advanced technologies in combat. Innovation is a key element of surprise in our strategic planning efforts. The Department of Defense continuously encourages innovative thinking and informed risk management. The Air Force and its scientific and technical innovation Enterprise are working toward a reinvigorated analytical wargaming capability. To support this objective, the AFRL is working to leverage its M&S used for technology development and apply it to augment wargame rigor. Analytical wargames will help bridge the traditional gaps between the operational and the scientific and technical communities when exploring the realm of the possible using advanced technology concepts. Air Force leadership and AFRL strategic development planners will have increased confidence when making investment decisions in this fiscally constrained and increasingly complex geopolitical environment.

DISCLAIMER: The opinions expressed herein are those of the author and are not necessarily representative of those of the United States Air Force or the Department of Defense.

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Mr. Bestard graduated from the University of Florida in 2006 with a Master of Science degree in Mechanical Engineering, beginning his civilian career with the Air Force as a survivability engineer and managing numerous research, development, test and evaluation projects to ensure aerospace systems can persevere in combat. To accomplish his mission he led initiatives with international partners to develop and standardize vulnerability analysis tools under the auspices of The Technical Cooperation Program (TTCP). Mr. Bestard was also a participant in the Engineer and Scientist Exchange Program (ESEP) from 2013 to 2015 embedded in the Italian General Secretariat of Defence and National Armaments Directorate. In this role, Mr. Bestard participated in policy development, as exemplified by the preparation of a Strategic Research Agenda geared toward emerging technologies to address operational capability gaps and by the shaping of the Italian position on research and development to support the European Common Security and Defence Policy (CSDP). He also conducted a study on robotics and nanotechnology for the Italian Military Centre for Strategic Studies (CeMiSS) commissioned by the Financial Planning Department of the Italian Army General Staff. Mr. Bestard has completed Air Command and Staff College (ACSC) and is Level III Engineering certified in the Acquisition Professional Development Program (APDP).

Wargaming at the Naval Postgraduate School

**By: Jeff Appleget,
Fred Cameron,
Rob E. Burks,
and Jeff Kline**

INTRODUCTION: *The United States Department of Defense (DoD) and the military services have employed wargaming for well over a century to prepare for war and other operations. The Naval War College first employed naval wargames in the late 19th century at the tactical and strategic levels. During the period between world wars, Plan Orange wargaming at the Naval War College was a key contributor to the strategic plan that led to the defeat of the Japanese Empire in 1945. Since that conflict, wargaming techniques have become widespread within U.S. organizations and throughout the world.*

After a recent period of quiescence, there is a resurgence of interest in wargaming by DoD. The Naval Postgraduate School has a long history of teaching wargaming, starting with a partnership to share course materials and naval simulations with the Naval War College in the mid-1980s. NPS education and research wargaming activities on campus have resulted in the execution of over 50 wargames in the past five years. These wargames are conducted as part of resident wargaming courses and other on-campus workshops and events in direct support of DON, DoD, major command sponsors and allies and other international partners, as well as separate wargames to support technical research. Today, wargaming activities of all types can be found in many of the NPS curricula and outreach activities around the globe.

In 2014, a need to bring higher visibility and synergy to the myriad of wargaming activities at NPS resulted in the formation of the Wargaming Activity Hub. The Hub's mission is to leverage wargaming to conduct high quality education, analysis, and research in support of the Naval Postgraduate School's mission, to prepare future leaders, and help shape and form key decisions on the future of the Department of Defense (DoD). The Wargaming Activity Hub's purpose is to support and contribute to the Naval Postgraduate School's educational and research mission and provide a wargaming and simulation environment to assist DoD leaders in their mission to develop new strategies and concepts across all levels of warfare to counter emerging adversary capabilities and complement ongoing field experimentation activities for the rapid testing and fielding of new technologies.

While it would be impossible to detail all NPS wargaming activities, there are several that provide support to DoD and defense partner organizations by leveraging educational opportunities for NPS students and faculty and provide a flavor of the range of wargaming support at NPS.

NPS On-Campus Wargaming Activities

Warfare Innovation Workshops

Originally sponsored by the Navy Warfare Development Command and the Consortium for Robots and Unmanned Systems Education and Research (CRUSER), the Warfare Innovation Workshops have kicked off the NPS Warfare Innovation Continuum since 2010.

The NPS Warfare Innovation Workshop uses seminar wargaming techniques and design thinking for NPS officers and system command engineers to consider how they would design and/or employ new capabilities in hostile environments. How players employ forces and view risk are assessed with a programmed force and again with a force with new technologies included. Innovative employment of new technologies from the synergy between early- to mid-career officers and early career engineers have been the basis for Navy system design and concept development like the Advanced Undersea Warfare Systems (AUWS), undersea docking stations, air UAV swarms, and distributed fleet. The ideas generated from the Warfare Innovation Workshops are further developed in the year-long Warfare Innovation Continuum, a NPS federation of classes, capstone projects, theses, and research work usually involving 400 faculty, students and sponsors.

Global ECCO

Global ECCO's (Education Community Collaboration Online) mission is to build and strengthen the Combating Terrorism Fellowship Program's (CTFP) global alumni network of Combating Terrorism experts and practitioners through innovative and engaging technologies and techniques that both enable and encourage collaborative partnership between individuals, nations, organizations, and cultures. At NPS, Global ECCO has utilized computer and web-based technologies to develop engaging strategic games to educate players about counter-terrorism tactics. The strategic games teach the methods and mindsets of terrorist tactics as well as how to contend with them as opponents face off against each other in a virtual online environment. This strategic gaming environment facilitates thinking about terrorism and combating terrorism issues and provides an effective framework for discussing related concepts. Global

ECCO has developed multiple strategic games including concepts focused on Asymmetric Warfare, Terrorism Finance, Social Network Analysis, Cyber, Counter Insurgency, and Countering Terrorist Ideologies.

MMOWGLI

The MMOWGLI project was originally sponsored by the Office of Naval Research (ONR) for the United States Navy. The goal of the project is to explore the potential of a Massively Multiplayer Online War Game Leveraging the Internet (MMOWGLI), with a variety of themes, to expand engagement in military and non-military strategy development for complex geopolitical problems. The platform is designed to support large numbers of distributed global players working together on idea generation and action planning, with an eye towards surfacing innovative outlier strategies. Several dozen games, workshops and courses have used the MMOWGLI platform.

Red Teaming and Red Celling

The Assistant Secretary of the Navy for Research and Development, Department of Energy, the Commander Naval Surface Forces, and the State of California are four past sponsors of red teaming and red celling activities at the Naval

Postgraduate School. Leveraging the operational experience and technical education of NPS students, these classified efforts focus on technical red teaming future systems and or red celling emerging blue concept of operations. These activities employ wargaming techniques to frame the students' perspective of defeating blue systems and result in recommendations to increase blue system resiliency or modifications to Blue concepts.

"Facilitates thinking about terrorism and combating terrorism issues and provides an effective framework for discussing related concepts"



Warfare Innovation Workshop participants discuss technological solutions for employment.

Resident courses

For students taking degree programs at NPS, there are several wargaming courses to choose from. Within the Operations Research Department, there is a basic course on applications of wargaming as well as a follow-on advanced course. Within the Defense Analysis Department, there are courses that provide students with a deeper understanding of the analytical value of wargaming and historical wargaming. These NPS courses

stress the contribution of wargaming to decision making and problem solving. Students learn how wargames must be developed and analyzed to provide high quality material for evidence-based decision making, whether in dealing with current operations, in exploring and evaluating options for acquisition projects, or for developing new concepts and doctrine. Beyond the courses specifically on wargaming, there are numerous NPS courses on tools related to analytical wargaming, for example computer-based simulation, data collection and analysis, and statistics.

Wargaming Applications

The Naval Postgraduate School has taught the Wargaming Applications course in the Operations Research Department for well over three decades. This 11-week course for NPS resident students focuses on analytic wargaming, which is a wargame designed to collect and analyze information from wargame play, with results that either feed directly into a decision, or are used to develop other analytic products. The course is a mixture of lecture and hands-on practical exercises designed to develop student wargaming knowledge and skills. Since 2009, the course has integrated external DoD or defense partner organizations into the fabric of the course. By the third week of the course, the students have been introduced to their sponsor, and they partner with the sponsor to begin the design process of the wargame that the students will produce for the sponsor. After the completion of formal instruction and the Wargaming Apprentice Certification Exam during the sixth week, the student teams focus solely on designing, developing, executing, and analyzing their sponsor's wargame. This capstone wargaming project, conducted for the sponsor during NPS "Wargaming Week," serves as the students' final exam. While most of the wargaming sponsors have come from DoD organizations, several sponsors have been from allied or partner nations. Additionally, defense industry partners have also sponsored NPS wargames. The course is offered in the fall and spring quarters, and three to four sponsored wargames are designed, developed, executed and analyzed per student section, one section in the fall, two in spring.

Recent sponsors include the U.S. Navy's N-96 examining the Distributed Lethality concept, U.S. Special Operations Command J-3 (International) exploring the implications of a Russian hybrid threat in the Arctic, and U.S. Central Command seeking a better understanding of the implications of Shia Militia Groups employed against ISIS in Iraq.



Fred Cameron facilitates the Zefra seminar wargame with NPS resident students as part of the Wargaming Applications course.



The Russian Hybrid Threat wargaming players contemplate the first scenario in the Arctic during NPS "Wargaming Week"

Advanced Wargaming Applications

The Advanced Wargaming Applications course student teams create a military modeling application for an external Defense sponsor and/or an NPS Faculty advisor that will examine sponsor/advisor approved issues with more focus and depth than the initial Wargaming Applications course permitted. While that wargame was a complete, playable wargame, the time restrictions of the course didn't allow for the design

and development of advanced adjudication, data collection, or analysis tools and techniques, or the analysis of their output. The concept of this course is to start with a Wargaming Applications wargame or a suitable capstone project or thesis proposal that provides a functioning framework where these modeling techniques can be designed, developed, integrated and then used to generate output to be analyzed and documented for the sponsor/advisor as the final course project deliverables. For our defense sponsors, this provides an opportunity for student teams to continue to work on their wargame for a second, consecutive quarter.

This course was offered for the first time in the fall quarter of 2016 and has two student team successes including Remote Advise and Assist and High-Arctic thesis projects for the Defense Analysis curriculum.



Indonesian Navy students tackle a difficult South China Sea scenario in the Basic Analytic Wargaming MTT course

Mobile Training Team Courses

Since 2011, NPS faculty have gone on the road to deliver wargaming education. This is provided to organizations that want to establish an organic wargaming capability or that are expanding their existing wargaming capacity.

Basic Analytic Wargaming Mobile Training Team (MTT) Course

NPS offers a five-day Basic Analytic Wargaming Course to defense partners at their home station. The course provides hands-on experience with designing, developing, executing, and analyzing a wargame. This course is a compressed version of the 11-week resident course described above. The sponsoring organization provides the wargaming topic that will be the focus for the students. The course is then oriented on mentoring the students' development of a wargame that is then executed by the students themselves on the last day of the course. Like the resident course, this course is a mixture of lectures and practical exercises, with even more emphasis on practice. The course was first conducted for the Canadian Forces Aerospace Warfare Centre, and was followed by courses for U.S. Strategic Command, Indonesian Navy, U.S. Central Command, and the Australian government's Defence Science and Technology Group.

Non-standard MTT Courses and Workshops

A custom-designed course is created when a sponsor has a unique wargaming requirement. In 2011, a five day Peacegaming course was designed and conducted for the Kazakhstan Army in order to assess the Kazakh Army students' knowledge of U.N. Peacekeeping



Playing Risk spurs a lively debate on tactics among Counter-Terrorism students in Dushanbe, Tajikistan

Operations using the Peace Support Operations Model (PSOM) developed by the United Kingdom's Defence Science and Technology Laboratory. A wargaming research and development workshop was provided to Lockheed Martin Space Systems through a Cooperative Research and Development Agreement (CRADA) in 2012. A five day Wargaming and Combat Modeling for Counter-terrorism course was designed and delivered in 2014 for Tajikistan government and military students.

Way Ahead

The NPS resident Wargaming Applications course is currently working on four sponsored wargames this fall. Global SOF Force

Structure (SOCOM J-3I), Countering Transnational Organizations (SOCCENT), Iranian Threat Network (SOCCENT) and Theater Anti-Submarine Warfare (U.S. Navy) wargames are currently in development and will be completed and played for their sponsors in December 2016.

NPS is currently developing a classified wargaming workshop to support CENTCOM's newly formed Wargaming Cell with a delivery date in the winter of 2017. CENTCOM is currently pursuing a long-term relationship with NPS that will include recurring Basic Analytic Wargaming MTT courses, periodic Advanced Analytic Wargaming courses, and consulting on CENTCOM wargames as needed.

Several Basic Analytic Wargaming MTT courses may be delivered in 2017. Potential sponsors include NAVAIR (China Lake), Joint Experimentation (Australian Defence Force), U.S. European Command, and NATO. The New Zealand Defence Force is considering a course in the FY 18-19 timeframe.

Some sponsors of the NPS Basic Analytic Wargaming course have asked for a two or three-day course that focuses on advanced analytic techniques. NPS is developing a proposal for such a course in response to Australia's DST-Group's request.

Under an OSD Wargaming Education Initiative, NPS will develop an automated education and assessment system that will permit a lower-cost, time-saving delivery of wargaming skills to DoD, allied and partner organizations. The vision is to take the existing NPS Basic Analytic Wargaming MTT course and develop a two-phased wargaming course (Basic Analytic Wargaming Fundamentals (BAWF) Phases I and II) that will be less resource intensive yet still provide a high-quality wargaming course for DoD, allied and partner organizations. Basic Analytic Wargaming Fundamentals (BAWF) Phase I will provide the means to acquire and assess basic analytic wargaming fundamentals education that students learn on their own without live instruction through a web-based asynchronous education and assessment website. BAWF Phase II will be a three-day, hands-on, instructor-led practical exercise-based MTT course

for a group of 12-16 students who have demonstrated proficiency in the basic analytic wargaming fundamentals as assessed by BAWF Phase I. A prototype of the BAWF I system will be completed by September 2017.

Under sponsorship of CRUSER, the Warfare Innovation Workshops will continue to kick off the Warfare Innovation Continuum each September. The value to NPS students are an emersion in design thinking, conflict assessment, and being exposed to potential thesis research topics. CRUSER will continue to mine this activity to seed research funds into unmanned systems.

Global ECCO is currently working on updating several of its previously developed strategic games to better support specific sponsor requirements. In addition, future strategic games include efforts addressing the issues of boarder security and countering weapons of mass destruction proliferation.

The NPS MMOWGLI team is currently developing a game in support of the NPS Littoral Operations Center to better understand the dynamic interactions of the U.S. Navy with allies and partners in the South China Sea.

Conclusion

NPS continues to provide analytical wargaming education to its students and to DoD and defense partner organizations around the world. Wargaming sponsors continue to benefit from wargames created and analysis conducted by NPS student wargaming teams, and NPS continues to enhance its students' professional development by providing opportunities to work with joint and service sponsors on operational warfighter requirements and analyses worldwide. Our joint, service, and international defense partners benefit from NPS educational expertise and engagement through our MTT outreach, building stronger defense partnerships in a dynamic security environment. NPS stands ready to support DoD, its allies, and its partners through our operationally-experienced multiservice and multinational student body and our world-class faculty.

ABOUT THE AUTHORS

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Mr. Fred Cameron joined the Canadian Department of National Defence in 1974 upon graduation in mathematics from Dalhousie University in Halifax, Nova Scotia. He recently retired after more than 35 years as an operational research analyst. He has since been appointed a scientist emeritus by the Centre for Operational Research and Analysis in Ottawa. During his career, Mr. Cameron provided operational research for all three Canadian military services. From 1976 to 1978 he supported NORAD in its North American air defence mission. He then spent three years in the Netherlands with NATO, with a focus on air operations in the European theatre. From 1983 to 1988 he led the OR team in Victoria, British Columbia supporting Canada's west-coast navy, and had close collaboration with analysts at US Third Fleet on naval operations in the northern Pacific. His introduction to army problems came in 1988 with assignment to the Directorate of Land Operational Research in Ottawa. From 1998 he led an OR team in Kingston, Ontario dealing with future concepts for the Canadian Army. Mr. Cameron deployed to Macedonia and Kosovo in 1999 to provide OR support to the Commander of the Canadian Contingent in KFOR. Mr. Cameron has been an advisory director of the Military Operations Research Society since 2009.

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CAPT Jeff Kline, USN (ret) is a retired naval officer with 26 years of service, two ship commands, and time as a naval analyst in the Office of the Secretary of Defense. Jeff is currently a Professor of Practice in the Operations Research department and holds the Naval Postgraduate School's Chair of Systems Engineering Analysis. He teaches Joint Campaign Analysis, executive risk assessment and coordinates maritime security education programs offered at NPS. Jeff supports applied analytical research in maritime operations and security, theater ballistic missile defense, and future force composition studies. He has served on several U.S. Naval Study Board Committees. His NPS faculty awards include the Superior Civilian Service Medal, 2011 Institute for Operations Research and Management Science (INFORMS) Award for Teaching of OR Practice, 2009 American Institute of Aeronautics and Astronautics Homeland Security Award, 2007 Hamming Award for interdisciplinary research, 2007 Wayne E. Meyers Award for Excellence in Systems Engineering Research, and the 2005 Northrop Grumman Award for Excellence in Systems Engineering. He is a member of the Military Operations Research Society and the Institute for Operations Research and Management Science.

Computer Assisted Military Wargaming: The SWIFT Wargame Tool

By: William Ellerbe,
Karl Selke,
and Michael Ottenberg

“A dynamic representation of conflict or competition in a synthetic environment, in which people make decisions and respond to the consequences of those decisions.”

The Standard Wargame Integration Facilitation Toolkit (SWIFT), an Office of the Secretary of Defense, Cost Assessment and Program Evaluation (OSD CAPE) product, provides a computer environment that supports Department of Defense (DoD) wargaming. SWIFT complements, but does not substitute for good wargaming practices. Deputy Secretary of Defense Robert Work has called for the reinvigoration of wargaming in the Department of Defense.¹ Wargames require careful attention in their application and execution to maximize their utility. As in all walks of life, computer assistance in the areas of wargame design, visualization, adjudication, and analysis would be useful to facilitate DoD wargaming. Several tools are available to support commercial games, but are inadequate to support the full range of professional wargames within the DoD.

What is a wargame? Peter Perla defines wargaming “as a dynamic representation of conflict or competition in a synthetic environment, in which people make decisions and respond to the consequences of those decisions.”² Wargames explore the decision process of the players and provide an immersive environment to think about the issues in question. Wargames results are often what the players take with them when they leave. In other cases, wargames are used to support a larger analytic process where the burden on data capture is more significant. The scale of wargames takes the form of small numbers of participants examining political-military issues in a seminar setting with limited adjudication. Other wargames include a large number of participants examining detailed military issues involving rigid, complex adjudication of combat results. The purpose of the game is akin to the learning objectives, such as new insights into a problem, further testing of a concept or hypothesis, or even for socialization of ideas and issues.

As with any method of inquiry, wargames have a number of inherent limitations. Wargames are rarely repeatable, may be resource intensive, and are difficult to design. Wargames with complicated rule sets or system games are often time-consuming to execute and record. Similarly, seminar games with human adjudication face both dynamic visualization and player move recordation challenges as these processes struggle to keep pace with the social interactions. Moreover, as the resolution and scale of the wargames increase, they are hard to record and even harder to analyze. Computer aids should assist in reducing these burdens in DoD games through providing benefits in visualization, recordation, adjudication, sharing, and collaboration.

¹ Work, Robert. (DepSecDef Memo Feb 9, 2015) Wargaming and Innovation
² <http://www.mors.org/Events/Special-Meetings/Wargaming>



Figure 1. Development Engines

What does it take to accomplish this? Thankfully, the private sector has been vanquishing the foe of computer inaccessibility. We need look no further than Android that allows incredible customization on our phones and tablets. In software and analytic domains, development environments have flourished providing order of magnitude advances in productivity for analysts and programmers. Cross-platform gaming engines are the norm in the commercial world shifting the burden from technology implementation to artistic expression. Even the much smaller commercial wargaming domain has led to several gaming engines used for playing games online or through email by providing a customizable digital game board and pieces (Figure 1). The OSD CAPE solution to this design inaccessibility problem is the Standard Wargame Integration Facilitation Toolkit (SWIFT). SWIFT is a software environment used to build, play, and analyze turn-based wargames conducted primarily for analytic purposes.³ SWIFT provides a toolkit to enable integration of visualization, wargame rules, human and computer-based adjudicators into a multi-player turn-based wargame to facilitate testing, execution, and analysis.

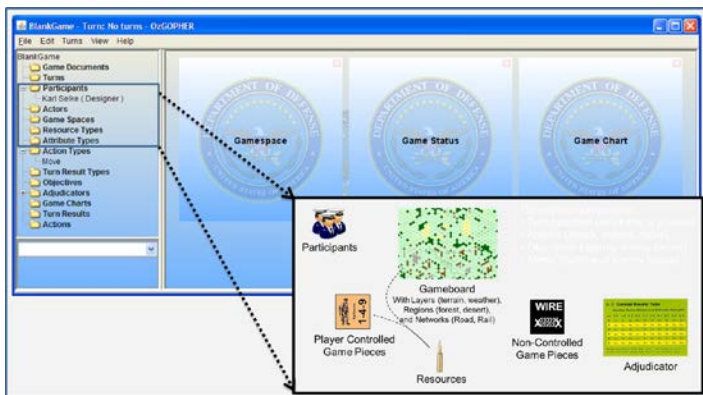


Figure 2. SWIFT Meta-Components as a Common Language

³ Turn-based games are typically games where players play in a sequential order or simultaneously plan their moves with actual execution occurring during the end of turn adjudication phase.

SWIFT supports professional turn-based games from several perspectives: sponsor, developer, player, adjudicator, and analyst. For the game sponsor, SWIFT offers resource efficiency by shifting software development dollars from the “medium” to the actual design or particular game-specific features. Additionally, the wargame is preserved for re-use, modification, presentation, and sharing (think SWIFT as Microsoft Excel for wargamers).

For the game designer and developer, SWIFT not only provides a computer medium for wargaming but it, like most computer environments, enforces a design clarity and common language that is always desired on gaming projects. Games are described and designed in terms of their meta-components: participants, actors, resources, actions, game spaces, turns, and adjudicators (See Figure 2 for complete list). All game meta-components have attributes that can be manipulated to suit the requirements of the game design. The time required to instantiate a game in SWIFT depends upon the game design. It takes days, not weeks to build a manual game that utilizes SWIFT’s visualization and recording capabilities. Days to weeks are required to instantiate semi-automated/fully-automated games depending upon level of complexity.



Figure 3. SWIFT Visualization

For the game player, SWIFT supports visualization and efficient game play. SWIFT is an intuitive, appealing mechanism to learn once and rely on that training to play multiple different types of games shifting the training to the game rules rather than the tool navigation. SWIFT overlays situational awareness, actors, and actions on any map/image resource to include Google Earth’s .kml files (See Figure 3). While players have an enhanced common operating picture (COP) that they can filter in any number of ways, game controllers can implement the fog of war and information hiding by limiting player perception. Although game design can rely upon intermediaries (“pucksters”) between players and the software, we found that players intuitively pick up the point and click interface and have frequently done away with the intermediaries within less than 15 minutes of play. Millennials tend to pick it up with ease.

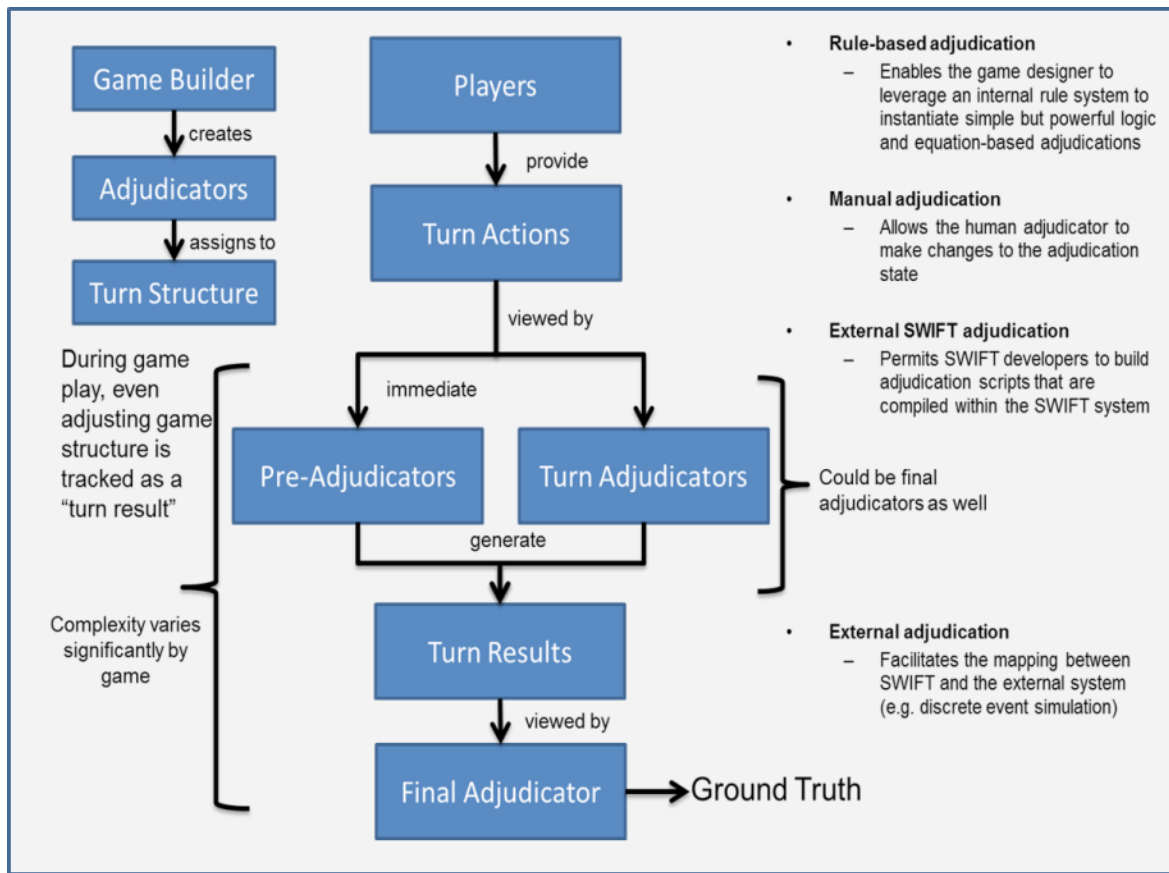


Figure 4. SWIFT Adjudication Approaches

SWIFT's general concept for the adjudication process is shown in Figure 4. For the game adjudicator, SWIFT captures the suggested outcomes of an unconstrained number of adjudicators (human or computer) and presents those outcomes for ground truth selection. SWIFT supports a wide variety of manual and automated adjudication types. It also permits the use of several different adjudicators for the same phenomenology and permits the White Cell to choose the most appropriate or a combination of the adjudicator results for the game turn. SWIFT supports the game analyst by providing a consistent, transparent data structure and a game engine to support stochastic analysis of model-adjudicated games. Its use of structured input/output data facilitates inductive analysis techniques. SWIFT has a playback and other after-action features that support post game analysis. SWIFT can import and export most data to/from Excel for analysis and game development. Ease of use was a key design consideration.

As previously mentioned, SWIFT supports a vast variety of turn-based games from very structured games with significant numbers of game pieces and rules to turn-based seminars where managing temporal, spatial, and behavioral complexity is a key element of game facilitation. Game play can be a series of sequential or simultaneous player moves depending upon game requirements. Multi-level games can

be supported in a single instance of SWIFT as players play in different theaters and/or echelons. SWIFT tracks changes caused by each of the actions and adjudications allowing traceability and understanding during post-wargame reviews and analysis. Additionally, SWIFT games can be played in a local or distributed environment. Using SWIFT in a distributed design creates a dependency on the network supporting the game, but even in local games the quality of the computers, projectors, and room layout are relevant factors. Infrastructure issues should not be underestimated! Regardless, the successful application of the SWIFT environment to a wargame implementation depends upon the wargame design and the specific requirements of the computer medium. SWIFT is not intended to compensate for poor planning and there are many circumstances and designs where it may provide limited to negative value.

We have encountered several questions when discussing SWIFT:

- What are SWIFT's technical characteristics? Is it easily available for use by a DoD organization? SWIFT is GOTS software written in the Java programming language. All data is stored via XML. SWIFT has been used at all levels of classification to support COCOM, Service, and OSD games.
- How long does it take to set-up a game? It depends ... how

complex is the game design? SWIFT can be instantiated to support simple visualization within several days. Games with complicated designs characterized by multiple adjudicators or extensive orders of battle can take weeks. A key question when considering automation is what requires automation and what can be left as manual processes. When the question being examined lends itself to modeling and simulation approaches rather than a wargame, use the technique or tool more suited to the problem. SWIFT was designed to interact with other tools, but not replace them. Wargames are best for examining very complex, wicked problems where the conditions change and the relationships among the elements are unclear. Difficult but highly structured problems are best examined using the appropriate modeling tools.

- How long does it take to run through a game turn? It depends... how complex is the game design? Learning a complicated game tends to far exceed the time it takes to learn how to move actors and make actions in SWIFT.
- How scalable is the tool? This question has a complicated answer. SWIFT can support many game objects (we have instantiated orders of battle up to several thousand units). Note that SWIFT tool has some optimization for speed but it can be a challenge.

SWIFT is a powerful tool for designing, executing, and analyzing wargames, but it is not the entire answer for supporting DoD wargames. SWIFT is a wargame support tool that allows DoD professionals to build aspects of their game into a computing environment without a software developer present. It is not a shrink-wrapped wargame, but an engine for wargaming. It is not a model, simulation or artificial intelligence application even though all three have been considered as sources of adjudication or computer-based opponents. SWIFT requires humans are still required to be in the loop. Secondly, it can't capture data at the speed of thought and there is no voice-to-text. Many so-called wargames involve discussions (many at the same time in the same room). SWIFT or even a handwritten note-taker is not going to have the capacity to record every element of conversation. However, if you have an experienced facilitator, who pauses and emphasizes the key points, you should be able to record the key actions and results in SWIFT.

Third, SWIFT is not a map/GIS application such as Google Earth. SWIFT can import Google Earth data and look just like Google Earth but without the 3D. In fact, it adds the ability to move objects around while capturing their new location and path. It also can capture the player's intent. Many groups are using Google Earth for their COP; however, they have to capture intent and move data in a spreadsheet, then combine everyone's data and create a new COP in Google Earth. SWIFT integrates all these steps. Finally, and most importantly, SWIFT is not a substitute for a good game design. You can create a bad game design in SWIFT, just as you can write a bad book using a word processing application. SWIFT simply provides a tool for you to write the Shakespeare.

ABOUT THE AUTHORS

William Ellerbe, Senior Architect and Software Solution Engineer with AT&T Global Business Solutions, supports the Office of Secretary Defense Cost Assessment and Program Evaluation (OSD CAPE) by designing analytic solutions to support their mission. Mr. Ellerbe has designed, developed and deployed innovative solutions in areas such as modeling and simulation, wargaming and force structures analysis to support the development and evaluation of defense program alternatives. The tools are written in several different languages ranging from JAVA to Microsoft VB, VBA and C#. Solutions are leveraged and agile enabling flexibility and reuse. Mr. Ellerbe is the senior developer supporting the development of OSD CAPE's Standard Wargame integration and Facilitation Tool (SWIFT). Mr. Ellerbe may be reached at William.j.ellerbe.ctr@mail.mil.

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Adjudication in Wargaming for Discovery

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“A warfare model or simulation that does not involve the operations of actual forces”

INTRODUCTION: *Wargaming is currently a very important topic, due to the renewed interest in pursuing the activity within the US Department of Defense (US DoD), for the purposes of discovery and exploration of future courses of action. Wargaming itself is very closely related to simulation, especially simulation for military training and experimentation, however there are some important differences. An understanding of what it means to do wargaming for discovery, and also how adjudication (or evaluation of results) of the plans and events that unfold in such a wargame, is the topic of this article. It begins with an overview of what wargaming for discovery might be, based on definitions from literature and from practice, and continues with an overview of what and how adjudication is currently done within a variety of different systems. Finally, a proposed method that combines some of the strengths of existing adjudication methods with the particular needs for wargaming when it is done for discovery, is presented.*

Wargaming

Wargaming is a particular activity, and although this issue of the *Journal of Cyber Security & Information Systems*, M&S Special Edition, is dedicated to the topic, for the purposes of this article, and a discussion of adjudication, it is worthwhile to begin with some discussion of defining the term. For the purposes of the discussion here, a wargame is an artificial replacement for conflict. It is an event experienced by the players and facilitators, but as such it is guided by rules for its execution, which exist to ensure that the participants make decisions and take actions that would be plausible. It is intended that the player roles will be by opposing human opponents, so that impediments to courses of action and plans are made with the highest degree of challenge. In so doing, the wargame is an excellent tool for exploration and discovery. This is true for new courses of action, new plans, understanding the weakness of existing plans, and other reasons. In order to evaluate the results of matching the plans and actions of each side against the other, the rules for the wargame must include mechanisms for adjudicating results when the players' actions come into conflict with each other. Although this is the understanding of wargaming relied on

for this article, it is by no means a new definition. The description of a wargame as a synthetic replacement for warfare, employing live players on both sides, was described well by Perla, “a warfare model or simulation that does not involve the operations of actual forces, in which the flow of events affects and is affected by decisions made during the course of those events by players representing the opposing sides” [1]. The concept of a wargame for discovery is described well by Wiggins¹ [2]:

There are multiple reasons for the use of war games; discovery, examination of concepts, and even learning. The value of the war game is to create an enabling environment to achieve the desired objective(s). The benefits of a war game are numerous; however, for the most part they provide new ways of conceptualizing the problem, new courses of action, new elements of information needed for decisions, previously unknown relationships between aspects of a problem, understanding of the problem's dynamics.

By this definition we see some commonality with, and some differences from, the body of simulators typically employed by the US DoD in its pursuit of Live-Virtual-Constructive (LVC) simulation. Such simulation is often, but not always, done for the purpose of training. Simulators that exist for the purpose of training work quite well with computer generated forces often (but again, not always) taking the role of red forces, allied forces, and civilian or non-aligned forces. Wargaming for the purposes of this article, works best with live human participants controlling the forces of the opposed sides within the game. LVC simulators also exist, and are used for, staff training where the generation of highly detailed data is a highly valued product of the simulation that results from their use. This data is often specifically for realistic and plausible stimulation of Command and Control (C2) devices that staff members will be training to use, in anticipation of actual operations. In the case of wargaming for discovery, such training is not the main goal. The stimulation of a C2 device is also not the goal. The main goals of wargaming for discovery are the devising, executing, and testing of courses of action against an enemy, in order to explore some military problem or proposed future situation. To that end, knowing whether a course of action is executing successfully, or not, and in which areas it is strong, or weak, is what must be conveyed.

Current users and advocates of computerized combat simulation might be surprised to find that many within the professional wargaming community endorse and continue to promote the

¹ Wiggins also credits the phrase “they provide new ways of conceptualizing the problem, new courses of action, new elements of information needed for decisions, previously unknown relationships between aspects of a problem, understanding of the problem's dynamics” to John Hughes, in a Strategic Studies Group Dissertation, from 1991.

execution of wargames through a strictly manual process. Such wargames take a number of different forms, but the main distinction is between a seminar wargame, and a tabletop wargame. The terms are not precise, and there is often overlap, but to understand (for the purposes of this article) what is meant by the two ideas, the following descriptions are provided.

A seminar wargame is one where a situation, usually of a military nature (but sometimes of an economic, geo-political, or combination of several of these), is presented to an audience, and then courses of action and their results are discussed in an open forum. Often those that are a mixture of military and other domains (usually political) are called Pol/Mil games (political-military). There is a referee staff that prepares and presents information to the participants that describes the background for the situation (which may, for instance, include fictional countries), and also the resources at hand for each of the participating factions. The starting point of the scenario is indicated, and then, through discussion and presentation of ideas, there is a conversation between the participants and the referee staff. Subject matter experts will evaluate the proposed ideas, and either accept them, or have counter ideas (either generated from themselves, or presented by an opposition force group of players). As the tempo of the game picks up, with proposal and counter proposal, the referee staff relies on their own subject matter expertise to evaluate the results of the player actions, and report back to them a description of the unfolding situation. This method for holding a wargame is extremely

“Live human participants controlling the forces of the opposed sides within the game”

flexible, as the timeline can be moved backwards and forwards, and once a proposal is explored and discussed, it can be countered and changed, and then further discussion is made of the alternative. A seminar wargame has a “system” of rules – but they usually define such basic elements including what sides are participating, what the chances are of requesting support from an authority not represented in the game, amount of time allowed to participants to respond to the current situation, and so on. These rules are specifically designed for ease of execution and flexibility, without having to rely on a more formal system for evaluating casualties, or likelihood of success. That is provided through the expert knowledge of the referee staff.

A tabletop wargame is one that is more systematized than a seminar wargame, but perhaps slightly less flexible. It is one where the action of the military and/or political situation is represented on some sort of map, or grid, on a table top. Military units (or other focuses of resource and/or strength) are presented as game pieces (tokens, chits, military models, flags, etc.) that have a place on the tabletop map or grid. Maps and graphics might be employed in a seminar wargame, but typically the movement of forces, and the exertion of power (combat, political, etc.) is controlled by the subject matter experts supporting the referee staff. In a tabletop wargame, a system of rules (similar to those rules that a computerized simulation might employ, although somewhat less complex) is present that declares (for instance) that an armored unit may move so many spaces along

a grid. Likewise, a tabletop wargame system will include rules for determining the results of conflict and/or tasks. This may be the removal or reduction of military forces, the expenditure of results, or the consumption of time to complete tasks. The flexibility in the system results from the fact that by simply counting back a few “turns” in the game, and resetting some of the game pieces, that replaying parts of the conflict with changes to plans or outcomes, is easily handled. A recent case for the continued strength and viability of tabletop wargaming was made by Philip Sabin, in a series of lectures at the German Armed Forces University, at Hamburg [6].

In contrast to both seminar and tabletop wargames, computerized combat simulators have the means to offer highly detailed results from conflict and the execution of tasks by units in the wargame. However, such detailed results come with the price of computerized combat simulators being much more complex to set up and run. Usually the individuals that have the expertise to facilitate, narrate, and execute a wargame are not the same that can operate the computerized systems – requiring additional staff, and frequently a large time and resource investment in ensuring that all the factors and data describing the game must be transformed into data products that the simulator can make use of. In the arenas of weapon systems experimentation (for acquisition, as an example), or for staff training – these investments are worth it, because of the high premium value of detailed results (and also the value of distributed simulators being coordinated and working together). But for wargames of discovery, the community of practice will as often as not find it more convenient to rely on a tabletop or seminar wargame.

Adjudication

For a wargame to fulfill its role as an activity where discovery can take place, the participants must be allowed to try different courses of action within the artificial environment that the wargame presents. Then those courses of action must be evaluated (according to a method, that is part of the game “system”), in order to determine the likelihood of success they might or might not have against an opposing course of action. This is the essential tempo of a wargame – the game presents a situation to the player, the player studies that situation and selects a desired future state to achieve, decides on a course of action that he/she believes will result in that future state, and executes that course of action within the game. The game responds (based on input from other players, the environment, game systems controlling non-player factions, etc.) by adjudicating the opposing actions, and presenting a new situation. The chief task of the game system, whether it is an analog system for a tabletop or seminar wargame, or a computerized system, is the ability to evaluate the results

of the player situations, along with all the other details. This is referred to as adjudication. The similarity of the wargame tempo (observe, orient to a desired outcome, decide on a course of action, execute that course of action) is similar to the operational concept of the OODA loop – observe, orient, decide and act. The OODA loop was devised, originally, by USAF Colonel John Boyd, and an in depth discussion of some of his presentations that explained the idea is in Osinga [18]. It is commented on, in relationship to wargaming, by Perla [4].

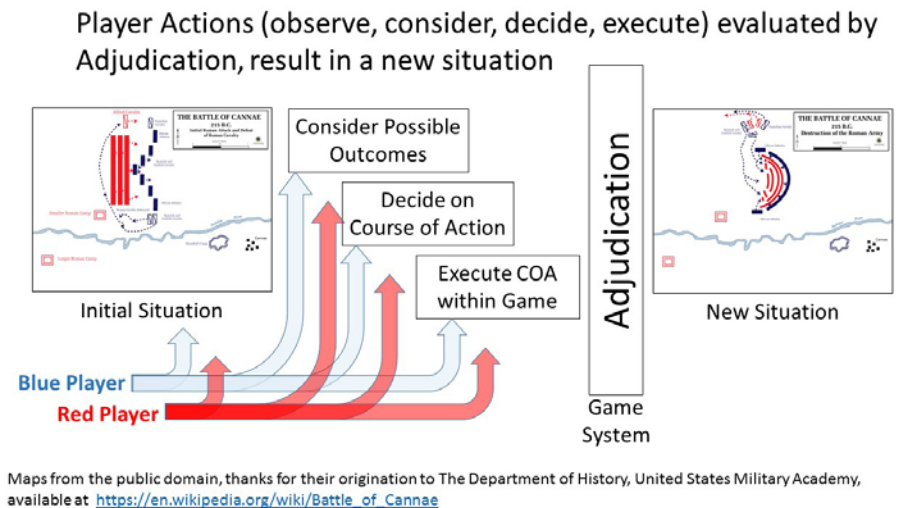


Figure 1-Player action loop in a wargame

Adjudication is the examination of the resources committed, and actions proposed, that result from the decisions (Figure 1) that players in the game make. Those resources and actions are then compared against those of the opponent, with consideration given to space and time in the combat environment, as well as the situation within the environment. Then results are generated. Such results can be a description of whether or not a course of action succeeds, or more commonly, the results for small parts of an overall course of action. These results can be an indication of loss of resources, or attrition, when conflict occurs. Equally, they can be the indication of whether or not a planned for activity succeeds (such as a movement action, or a combat engineering action). An adjudication system will typically not indicate whether or not a particular course of action is succeeding, but it will determine the tangible, knowable effects that result from player decisions. It is then up to the player, or a referee, to interpret those effects, and (as in actual operations) compare them to expected results, to see if a course of action is performing as intended. It is always possible, again as in actual operations, that both sides in a conflict, when given the range of effects that result from their decisions will either both consider their plans to be succeeding, or both failing. In some wargames, a referee will make a pronouncement one way or another, although in discovery wargames there is often value in allowing the players to only react to what they know, and interpret, from the game situation.

Types of Adjudication

There are a number of different ways in which to divide up the many types of adjudication. This article will consider three different ways to categorize or describe an adjudication method. First, adjudication can vary widely based on the amount of input the referee staff has into the process, versus the input from the defined game system. Second, adjudication can vary based on how much a stochastic element can influence the results. Third, adjudication varies widely with the level of focus of a particular wargame. These three different ways of dividing up the various methods and types all begin from the perspective of looking at adjudication of force-on-force warfare (whether it is ground, air, sea, or some combination). Similar divisions could apply to adjudication when it is applicable to other domains within a wargame, based on the principles described here (Table 1).

Adjudication Type	Dimension Applied To
Rigid Adjudication	Formal vs Informal
Semi-Rigid Adjudication	Formal vs Informal
Free Adjudication	Formal vs Informal
Open Adjudication	Formal vs Informal
Deterministic	Stochastic Element
Stochastic	Stochastic Element
Entity Level	Level of Resolution
Aggregated Level	Level of Resolution

Table 1- Adjudication Types, and the division they belong to

The first look at the taxonomy of adjudication is a way to differentiate per the formality of the system (formal vs. informal). That is, between adjudication where the game system is the final word from other cases, where the referee staff has more of a capacity for subjective input into the process. The names for these types come from Wiggins [3].

Rigid Adjudication: An adjudication method where the game system (whether it is a manual process or a computer process) is the final word, can be termed a rigid adjudication method. Many hobby wargames (specifically board games and computer games) employ this method, which allows them to be played without a referee. In such a case, the results of the game system are applied, in all situations. These types of adjudication are (if the system works well) fast, because they work without requiring the analysis and input of the referee staff, but only if they can get input reasonably quickly (given the real-world time constraints of hosting a wargame), and produce output reasonably quickly.

Free Adjudication: The other end of the spectrum from rigid adjudication is that of free adjudication. Here, the referee staff observes the decisions and executed actions of the players, and through analysis and subject matter expertise, are able to determine results, and describe them to the players (in essence, creating the next situation in the wargame, for the players to react to). The strength of free adjudication is that it can cover situations that a game system does not predict (and so, cannot adjudicate), and that the results of

the referee staff are much more meaningful, in terms of describing success or failure, than an attrition report. The weakness of free attrition, compared to rigid attrition, is that it is first a very much time and labor intensive proposition for the referee staff, and second, very much open to opinion and bias on the part of the referees.

Semi-Rigid Adjudication: In the spectrum between fully rigid games, and free games, there is the idea of a semi-rigid adjudication. This attempts to combine the strengths of both previous types, by allowing a formally defined game system to be used by a referee staff, in order to generate unbiased data-driven results, but still allow for the strength that results from having an informed and flexible referee staff that can adapt to situations outside the scope of the game system. The weakness here is that the time constraints of free adjudication still apply to the referee staff, and they introduce even more delays because now the staff must also be concerned about data inputs, and output generation from the system.

Open Adjudication: Open Adjudication is a method for determining the outcome of conflict through a conversation approach, where the participants are able to describe and defend their own actions, and talk through, as a group, the relative strengths and weaknesses of the competing methods. While this might be very useful in certain situations, in order to have the participants discuss and investigate the potentials within the different proposed and executed actions, it takes on the time management weakness of free adjudication that applies to the referee staff, and exacerbates it by applying the same weakness to the entire set of participants. A variation of this is a Matrix game. The matrix game is a concept invented by Chris Engle, and has all conflict adjudication done by the participants constructing verbal arguments why their actions should succeed. The opposition then produces verbal reasons why the arguments are invalid. Once this is done, the referee assigns a probability of success, and after a dice toss, the results are announced. These types of game have been done at the US Army War College and elsewhere [5], and are a way to systematize the Open Adjudication method of relying on discussion and argument to adjudicate actions.

The second axis in the taxonomy of adjudication methods presented here lies in the degree of stochastic methods that are presence in the method. This can range from almost no randomness in the case of a deterministic system, to a situation where there is heavy dependence on stochastic influence to the processes employed in the adjudication method. These may be applied to either the rigid or semi-rigid adjudication methods described above. They do not apply to a loose adjudication method, since no system is relied on in such a case.

Deterministic: In the case of a deterministic technique, what is typically done is that there is some a priori evaluation of the likely events to occur within the game design, and for each, a most likely result is described. These deterministic results are then relied on during adjudication. McHugh refers to a deterministic system as an “expected value” system [7], and it captures the concept of anticipation of the event occurring, and the a priori assigning of an outcome to

that event. An example of this sort of technique could be seen when looking at gunfire tables, for instance. If a naval gun is capable of firing 100 rounds in a certain period of time, and it is determined that a .25 chance of each round might strike the target, then damage could be adjudicated based on 25 of the rounds hitting. There are some more complex permutations of this idea, based on a variety of different situations and the application of different methods from statistics and operations research, but the results are generated without resorting to any sort of random number generation.

Stochastic: The opposite of deterministic is non-deterministic, such as a system where instead of having the outcome of a particular situation being predefined (deterministic), it allows for the introduction of a stochastic factor (a random range of possible results). This is a random factor that is introduced for many good reasons. When introduced, it is usually applied to a likely range of outcomes, which may be part of a formula, or could be in a lookup table. The reasons for the random-ness that a stochastic value introduces can be simplified to the fact that no model, regardless of how complicated or forward thinking, can account for all variables that may exist in actual operations. The introduction of the random factor accounts for the fact that the decision maker (player) equally cannot account for all variability in operations.

The third axis in the taxonomy of adjudication that is given here is the difference resulting from the level of focus, or resolution, of the wargame. The many possible different applications of the term wargame, and wargame system, could apply to different levels of focus, even when we are considering the adjudication of combat actions. It would be possible, in a tactical decision game, for instance, to focus on small units and adjudicate at the level of individual soldiers and vehicles (referred to as entity level, in the LVC simulation community), or to focus on large formations of troops, at the brigade level, or even higher, for a regional or global theater of operations. While the already mentioned differences of the first two axes of the taxonomy of adjudication apply here (they may both be rigid, or free; they may both be deterministic, or stochastic), the interpretation of each of those other differences is also affected by the level of focus. Very coarsely, this axis will look at only two differences, entity level and aggregated level.

Entity Level: Many simulators in the LVC world have sought to introduce greater fidelity into training and analysis by representing combat effects, and adjudicating the results of combat actions, at lower and lower levels (in terms of unit aggregation), which results in higher resolution. In fact, the two factors are typically at odds with each other – great aggregation of units means (necessarily) more abstraction, and lower resolution in the presentation of detail of combat effects and operations. It is beyond the scope of this article to describe the many differences, strengths and weaknesses between low resolution combat models, and high resolution combat models – but both exist, and within appropriate bounds, both could be (and are) used for adjudication, depending on the focus of the game in question. Typically, without resorting to a physics based model that might serve a high resolution first person shooter type

computer game, the lowest aggregation is down to the individual entity, or individual combat platform. Adjudication of combat effects at this point revolve around determining the situation of the entities involved in a combat engagement, and then determining the results of that engagement at the single entity level. Typically, this involves some game system that evaluates each entity's chances of scoring a hit, and then evaluating the results of that hit.

Adjudication at this level of resolution might be useful, especially, for a tactical decision game, but may prove to be too expensive, in terms of compute time and data requirements, for wargames of discovery – unless they are of operations at a very low level. Details on the methods involved, however, are well covered in Strickland [8] and earlier in Youngren [9]. Methods presented there are very well suited for computerized methods of adjudication, because of the number of non-trivial calculations that have to be performed for even a small engagement. It is worth noting that the non-professional domain of wargaming is rife with very good systems for adjudicating small scale, or skirmish, engagements at an entity level that result in plausible results, very useful for discovery wargaming in a tabletop environment when small units are involved in an engagement. The mechanisms are still related to individual determination of chances to hit, and the effects of a hit, to determine the combat results at an entity by entity rate, but they are typically modeled in such a way that they are able to be performed at a reasonable human pace, rather than at a digital, or computer pace. The history of combat modeling, once it took on a life of its own as a pursuit for the non-professional, led (for instance) to the invention and explosion of table top roleplaying games, which feature a wide variety of detailed rules for determining many aspects of encounters between small groups of individuals, vehicles, and weapon systems [10].

Aggregated: The complement to entity level combat modeling for adjudication, although the difference resides along a gradual spectrum, is aggregated level combat modeling. This is adjudication of combat actions, so that a determination can be made as to the value of an operation, at an aggregated level of combatants. Typically, this might correspond to military organizational units (battalions, brigades, task forces), but there are also models that take into account the aggregated strength of all units and forces within a single operation, or line of operations, within a campaign. It is possible, using some of the methods of adjudication described below, to work out a campaign based on the entire strength of one side's military vs the other.

What is lost in aggregated methods, is that the higher the aggregation (i.e. – the larger the group of combat operatives you consider in your evaluation of military operations), the more you have to abstract out details. With reasonably small formations, such as companies or battalions, what gets lost is the idea of the individual. It is not known what each platform or soldier is doing, but that is the point of aggregated combat modeling – you don't have to know. The abstraction takes all those factors into account, and then the results of opposed combat actions are generated by the game system. This might involve a computerized method, or a manual tabletop

method. It might involve calculations involving a stochastic element, or might be based on expected values only, and be deterministic. But the individual action, and to some extent, individual level results, are abstracted out. As the levels of aggregation get larger and larger (for instance, at the level of a brigade, corps, joint task force, or higher) even more detail gets abstracted away. In many respects, this is ideal for wargames of discovery, as the abstracted details may not be needed for the evaluation of courses of action, or determining best case (or novel) responses to particular strategic options. What is important, is to understand the results of the combat action, and the costs (in terms of time, results, and unanticipated consequences).

The means by which aggregated combat is evaluated is done in several ways. By far, for the computerized wargame, one of the more popular methods is the Lanchester Equation, first devised by Lanchester [11] for studying the effects of air warfare during the First World War, but also ably reported on, and described in depth by Taylor [12]. This is a mathematical algorithm that compares the two bodies of combatants involved in an operation, and by applying certain factors, can determine the levels of attrition that each suffer and inflict, over a series of time steps. This (in many ways) is ideal for a wargame, as it presents the cost of operations (in terms of attrition to each side) over time, giving the players a chance to respond and introduce new decisions and actions. The shortcomings of Lanchester are chiefly two. First is that it involves a series of mathematical formulations that, unless computerized, is extremely time consuming, and may slow down the adjudication staff to an unforgivable pace. The second is that the factors mentioned are extremely difficult to get right, and may have many situational variations, which are difficult to predict and prepare ahead of time.

Lanchester; however, is not the only answer to aggregated combat modeling for adjudication. Two other mathematical methods are worth mentioning, that have been developed in response to Lanchester, and they are Epstein [13] and Dupuy [14]. Epstein is very much an attempt by computer modeler Joshua Epstein to address shortcomings in applying Lanchester to extremely mobile warfare (such as a situation with extremely efficient methods of movement and mobilization, as would occur with modern nation states, during the Cold War, when he wrote his book). It is an attempt at introducing fixes to Lanchester, but in doing so increments along with many improvements/changes until it is actually a different system. Dupuy introduces a system whereby different types and qualities of units have a different point value, rather than being based on manpower, such as Lanchester, and then introduces methods for determining attrition and effectiveness based on those point values. Again, it is aggregated combat, and the mathematics involved benefit greatly from computerization, but it allows for rapid assembly of the factors involved, by having data dictionaries with lookup tables for the typical units and unit types that might be encountered in a campaign. Such flexibility is very useful for discovery wargames.

Finally, it should be mentioned that in the non-professional world of wargaming, or hobby wargaming, that there are many different methods for adjudicating aggregated combat using techniques

that are quite suitable for tabletop and seminar wargames. Classic methods, such as the dice driven combat results table, have been around for many decades, and in some forms, go back to the original data driven combat tables from the Von Reisswitz Kriegsspiel [15]. In the case of the original tables for the Kriegsspiel (in several permutations), this was not dice driven, but fell into the category of a deterministic method, using expected values for attrition over a time period (at that time, for instance, the number of casualties resulting from musketry at a certain range, and over a certain period of engagement). The more typical modern version, such as those originally devised by, and promoted by Charles Roberts for the Avalon Hill Game Company. In that form, the combat results table takes into account the difference between two forces, expressed (usually) as a ratio of force, and then a dice roll introduces variation in results (attrition, retreat, disruption of command, etc). More modern examples include many variations and additional introduced factors that reflect a wide variety of different operational engagement possibilities. The strength of such methods for tabletop or seminar wargames is immediately apparent – they can be executed with relative ease, and in games of discovery where ad hoc reconfiguration of an encounter may be needed to explore alternatives on the fly, such methods are easy to recalculate and reapply. With a more detailed, and more nuanced computerized model the results are much finer in detail, and may produce much deeper results other than simply attrition and disruption, but at the price of not being as flexible, and of course, requiring that the digital equipment be supported (including operation, data support, etc.).

Hybrid Adjudication

The three different divisions described, that can be used to divide up adjudication methods, each have a variety of strengths and weaknesses. In each case the different options are suggested by necessity, often, rather than by choice. In cases where there are desirable strengths in the option not adopted, this means that possible benefits are being missed in discovery wargames. An example is in the area of computerized wargame systems, as compared to a wargame system that is designed to support a tabletop event. In a tabletop event, it is more likely that a less rigid adjudication method might be chosen, also that the complexity of the system will be kept manageable, so more likely that a higher level of aggregation will exist in the adjudication method. In a computerized event, it is more likely that the whole event is more rigid (including adjudication) because of the needs of the digital system. This includes data modeling before the event, having a data driven system running on the computer, and supported by technical staff. But it also means that the computer is able to calculate much more detailed result, giving more data to the players (a curse and a blessing) about the adjudication as it unfolds. In looking at these two what-if types of events, there are both limitations and benefits that arise in each.

A design is possible that uses aspects of several different methods combined, to take advantage of different solution sets to the

adjudication problem, providing a maximized set of strengths. Technology alone is likely not to be the answer to an improved system, however it might provide some measure of control over negative aspects that could keep different techniques from combining. For instance, if a system that could combine the flexibility of a tabletop system (simple in-stride execution of attrition/outcomes generation, ease of restructuring operations to allow flexible investigation of alternatives, minimal requirement of technical support during event, etc.), with the values of a computerized system (detailed results, available to any members of the wargaming event that are desired, quickly perform complex calculations, etc.) it is not likely that proponents of either style of adjudication would have cause to complain.

One such example could be a game system that mimicked a tabletop wargame, but was enabled on a large digital, touch monitor. A course of action for military units could be entered, with typical information for a contingency plan (when units arrive, what movement orders they will follow, lines of operation, lines of communication, and so forth), but as the time of the wargame unfolds, a player would be able to interact with the touch screen, either to retrieve information, or to enter alternatives. A referee would be able to, by touch and drag, modify a situation that the game produces. It would allow for a wide variety of different adjudication methods, including being more, or less, rigid. It would allow for executing operations (operational plans, contingency plans, tactical decision games, etc.) such that units could be given a course of action, but interrupting or modifying that course of action could be done directly by a player. Combat modeling could include a method that produces a range of likely results, and then a stochastic determination of which to apply would come into play, or a referee staff in a less rigid, more open style wargame could choose which of a number of different results would apply in a situation. Increased flexibility would be if the referee staff could choose to accept, modify, or ignore results from a combat encounter.

Further, consider a situation where several such tables, each mimicking the interactions with a tabletop wargame, were networked, so that the display on each could have fog of war introduced by the control/networking mechanism – so that information available to one set of players using a table, might not be available to another set of players. It begins to sound like a distributed simulation system used in many different LVC events, but the amount of detail and interaction is purposely kept below a threshold, to ensure ease of use, and maximum flexibility, without requiring technical staff.

Another example could be an actual tabletop system, where military unit markers (game pieces) would have recognizable codes (such as QR codes) that a smart phone or tablet could recognize, and allow a referee to snapshot a situation, draw a boundary around the units to be considered, and the digital adjudication system would calculate the results, and information would be stored, to be retrievable by anyone with a tablet, who

had role-controlled access to information (such that red players could call up information about status of red units, but only limited information about blue units, for instance).

Both of these mentioned designs are in the early development stage at Georgia Tech Research Institute. It is likely, with the renewed interest in wargaming, that there are others in development elsewhere.

Conclusion

Adjudication is at the heart of a wargaming system. If wargaming, as distinct from combat modeling or simulation, is to allow for players applying decisions to control forces engaged in operations against each other, then the ability to judge which set of decisions, and which course of action, results in victory is key to the wargaming event. There are, for many good reasons, a wide variety of different adjudication methods and approaches available, each of which come with different strengths and weaknesses. Several of these different methods have been examined here, especially with regards to evaluating the outcome of combat operations (notably between land systems, but equally applicable for naval and air operations).

The introduction of a hybrid adjudication method is discussed, that takes the approach and basic interaction benefits from using a tabletop system, but applies modern ubiquitous technology platforms to allow the introduction of digital adjudication methods into a flexible tabletop environment. Such a system can leverage technology and lessons learned from the LVC simulation community, from the non-professional hobby wargaming community, and from the existing professional wargaming adjudication community of practice.

Methods of adjudication that were not discussed in this article are those many areas of a conflict that exist, outside direct kinetic combat interaction, but still part of operations. These include the various other domains of the operational environment (political, economic, social, etc.) as well as the acquiring, movement, and expenditure of resources and the impact of effects on both the civilian society and the environment. As those other domains are important to operations, and operational success or failure can involve one or many of those domains, adjudication methods that address them are equally important, but were not discussed (because of space) in this article.

Finally, the one thing that was also not discussed, except touched on very briefly in the description of what adjudication involves, is the fact that adjudication is much more than just counting attrition, and evaluating how long in an encounter a unit is likely to remain combat viable. Attrition involves the whole reason for an operation, or a course of action. A commander in an operation, much as a player in a wargame, is given some sense of what he/she is fighting for. Also, some sense of what the enemy may (or may not) be fighting for. In comparing those two, the commander will (in his assessment of the situation) try to determine what the operational goals, and operational strength of the enemy force are. From this,

the commander will then decide what the defeat mechanism is that will keep the enemy from achieving their goal. A plan (course of action) is then devised that will keep the enemy from achieving their goal, by triggering the defeat mechanism. In his great work on military and national strategy [16], B.H. Liddell Hart expressed this as *The Indirect Approach*. By that, he draws the distinction of a good plan as one which minimizes the enemy's strength, while striking at what will cause the enemy to fail. This is typically not a fight of attrition. In fact, Liddell Hart's eight axioms of how to engage in a campaign against an enemy, would definitely seek to avoid attrition, and emphasis flexibility of thinking, and constant adaptation to unfolding events [17].

- Adjust your end to your means
- Keep your object always in mind
- Choose the line (or course) of least expectation
- Exploit the line of least resistance
- Take a line of operation which offers alternative objectives
- Ensure that both plan and dispositions are flexible – adaptable to circumstances
- Do not throw your weight into a stroke whilst your opponent is on guard
- Do not renew an attack along the same line (or in the same form) after it has once failed

Having an adjudication system that can assess whether or not a player has (correctly) identified a plausible goal for his/her enemy, and a plausible definition of the defeat mechanism that must be attained, in order to keep that enemy from achieving their goals is probably beyond what could be accomplished within a game system. The complexity of such an undertaking is just too high. And if it could be understood, the maxims of achieving that, especially as Liddell Hart and others have described, and has been taught in military thought for decades, is likely to be too complex for a game system to evaluate. So, until that time, whatever systems for adjudication of actions (sensing, moving, fighting, and so forth) might exist, the interpretation of those actions will still require a human adjudication staff. But the tools to help that human staff can, and should, be constantly considered for improvement.

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