Resource Implications of the Difference between Models and Simulations

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ABSTRACT

The purpose of this paper is to argue that given the constrained fiscal environment that the Department of Defense (DoD) is facing, mid-level policymakers must consider whether training or experimentation objectives can be met with low fidelity models rather than high fidelity simulations. In order to do this, they must understand perhaps the most basic lesson of modeling and simulation (M&S)—the difference between a model and a simulation. The paper will begin with a discussion of the difference between the terms and show they are often (incorrectly) used interchangeably. It will then transition to a case study where the Maneuver Battle Lab (MBL) and the Combat Developments Division (CDD) of the U.S. Army's Maneuver Center of Excellence (MCoE) conducted a short suspense wargame for which a specific simulation was requested (out of a lack of knowledge of other available tools) but the desired endstate was achieved through the use of a low fidelity model. The conclusion is, for some training and experimentation cases, the DoD save significant resources through the use of low fidelity models while still achieving their objectives to standard. On the surface, a simple discussion (tutorial) of the differences between models and simulations would not be worthy of discussion, but under fiscal constraints it is imperative that M&S professionals ensure that policymakers understand the differences and how differentiating between the two may result in a significant savings of resources. The paper will also emphasize the point that selection of the proper tool, be it a model or a simulation, should be based on the experiment or training objectives rather than selecting the tool and then determining which objectives can be achieved. The paper will end with areas for continued research.

ABOUT THE AUTHOR

Tom Yanoschik is a graduate of the United States Military Academy and holds a Masters Degree from the University of Texas at Austin. He is retired from the United States Army where he served as a Field Artillery officer. His assignments included service in cannon artillery and multiple launched rocket system units, and as a fire support officer in the 3rd Ranger Battalion. Tom currently serves as the SAIC Site Manager for the Experimentation Environments Branch (EEB) of the MBL, Fort Benning, Georgia. He has participated in virtual and constructive experimentation both locally at the MBL and also distributed through the Battle Lab Simulation Collaborative Environment (BLSCE). Tom is a certified Modeling and Simulation Professional (CMSP).

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INTRODUCTION

The purpose of this paper is to argue that given the constrained fiscal environment that the Department of Defense (DoD) is facing, mid-level policymakers must consider whether training or experimentation objectives can be met with low fidelity models rather than high fidelity simulations. In order to do this, they must understand perhaps the most basic lesson of modeling and simulation (M&S)—the difference between a model and a simulation. The paper will begin with a discussion of the difference between the terms and show they are often (incorrectly) used interchangeably. It will then transition to a case study where the Maneuver Battle Lab (MBL) and the Combat Developments Division (CDD) of the U.S. Army's Maneuver Center of Excellence (MCoE) conducted a short suspense wargame for which a specific simulation was requested (out of a lack of knowledge of other available tools) but the desired endstate was achieved through the use of a low fidelity model. The conclusion is, for some training and experimentation cases, the DoD can save significant resources through the use of low fidelity models while still achieving their objectives to standard. On the surface, a simple discussion (tutorial) of the differences between models and simulations would not be worthy of discussion, but under fiscal constraints it is imperative that M&S professionals ensure that policymakers understand the differences and how differentiating between the two may result in a significant savings of resources. The paper will also emphasize the point that selection of the proper tool, be it a model or a simulation, should be based on the experiment or training objectives rather than selecting the tool and then determining which objectives can be achieved. The paper will end with areas for continued research.

MODELING AND SIMULATION- BASIC DEFINITIONS AND THEIR APPLICATION

As U.S. armed forces are experiencing budget drawdowns due to the conclusion of the Iraq and Afghanistan wars, there has been frequent discussion for the need to increase the use of modeling and simulation (M&S) to save not only money, but also time and manpower. The concept of "blended training" encourages the integrated use of live, virtual and constructive systems to improve the training or learning experience. In some cases this refers to devices that serve as surrogates for ships, vehicles, or aircraft; in others it refers to training devices that support classroom training. Most DoD leaders agree that the use of M&S is beneficial and where opportunities present themselves for obtaining more funding, they will fight for it. Most of the time, taglines such as "we are leveraging M&S to improve the quality of training" or "through the use of M&S we have created a learning environment superior to anything available in the past" are used with little thought to the specific components of the abbreviation M&S. The DoD M&S Glossary (DoD 5000.59-M) defines them as:

Model – A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process

Simulation – A method for implementing a model over time

If the DoD M&S Glossary definitions do not seem correct or acceptable, one would think that the only venue that prepares individuals for credentialing within the M&S community (The Modeling and Simulation Certified Professional [CMSP]) would serve as the authoritative source for the definitions that are included in its title. Every year on the Friday of the I/ITSEC, a half- to full-day tutorial is presented that prepares candidates for the CMSP Examination. The session begins with the basics—the definitions of modeling and simulation. The actual slides from the 2013 session presented by Dr. Mikel Petty of the University of Alabama-Huntsville included the following (Figure 1):

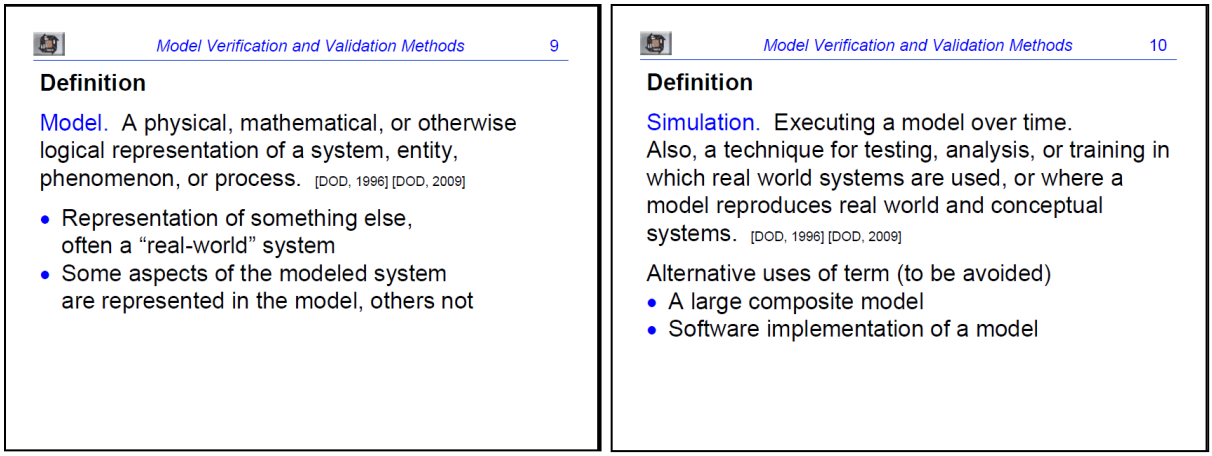


Figure 1. Definitions

Bob Gravitz, CMSP, in his 2012 presentation for the same Friday I/ITSEC tutorial, made the important point that "The terms Model and Simulation are often used interchangeably. The subtle but very important difference is that generally, a simulation is a model implemented over time."[i]

If either of the two terms is singled out it is almost always simulation or an associated word such as simulator. Frequent examples include "as part of our qualification standards, we require pilots to log X hours in the *simulator*" or "success during our recent deployment can be attributed to training received in the Y vehicle *simulator* which allowed the Soldiers while still stateside to practice in the terrain in which we operated." Rarely will you hear someone boast of an outstanding model. They will either use the term "M&S" or reference "simulation." Why is that? Does the DoD or Defense Industry not use any models of value? Are models too simple to have any credibility in areas of such seriousness as combat or training for combat? The answer is no. In this author's opinion, models are of value and are as credible as simulations; unfortunately, the M&S community has done a poor job in its use of the terms and has not done its part in educating non-M&S policymakers in the use of the definitions. This paper will present one example of the successful application of a model achieving relevant and credible outcomes at the U.S. Army's MCoE at Fort Benning, Georgia.

CASE STUDY – THE RECONNAISSANCE & SECURITY BRIGADE COMBAT TEAM (R&S BCT) HOW TO FIGHT (HTF) SEMINAR

The Requirements

In October 2012, the United States Army corps and division commanders, participating in the reconnaissance and security brigade leader workshop, unanimously concluded that the lack of a dedicated, organized, and trained reconnaissance and security force, for echelons above brigade (EAB), represented a significant capability gap. The senior leaders concluded that neither the Battlefield Surveillance Brigade (BfSB), nor its projected force design update, could fill that gap. Based on the feedback received from the workshop, the Chief of Staff of the Army (CSA) directed the Combined Arms Center (CAC) to conduct a series of HTF seminars in order to examine force design and force structure decisions to inform implementation of the R&S BCT concept within six months.

CAC tasked the MCoE—the proponent for the BfSB formation—to be the lead for the study and the CDD became the proponent within the MCoE. The CDD regularly worked with the MBL during its large, distributed force-on-force simulations conducted with the other Training and Doctrine Command (TRADOC) Centers of Excellence (CoEs). The CDD thought that using the same methodology—a large distributed simulation similar to the experiments in which they had taken part—would provide an excellent venue to provide insights to the CSA. When the CDD initially met with the MBL, they laid out the requirements: they wanted to conduct a force-on-force One Semi-Automated Forces (OneSAF) based experiment conducted with the other TRADOC CoEs. They would have approximately 90 days to plan, prepare, and execute the experiment, as well as conduct post-event analysis and report the findings in a Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities-

Policy (DOTMLPF-P) based assessment on three different, alternative solutions to the BfSB. Additionally, there was no supplementary funding that came with the requirement.

In short, they required a venue that would allow senior leaders to identify the advantages and disadvantages of each proposed formation against a credible, dynamic enemy. Given more time to ensure a validated scenario and task organization (both friendly and enemy), several simulations in the Army's inventory could provide the proper environment to achieve the analytical requirements. TRADOC annually conducts larger, distributed experiments over the Battle Lab Collaborative Simulation Environment (BLCSE), a network with Secret classification. For these experiments, the Community of Practice requires three to six months of integration work to validate and integrate the simulations and the mission command systems. Given only 90 days to prepare, execute, and develop findings, the traditional large BLCSE distribution simulation could not be executed.

The Solution

Since a large distributed simulation-based experiment was not possible, the MBL and CDD began to explore viable alternatives. The CDD considered conducting a traditional wargame conducted by subject matter experts on a tabletop map; however, this would not facilitate the large number of participants (30 plus). Additionally, due to the lack of funds, the MCoE could not afford to bring all participants to Fort Benning to conduct the event. Given the specific objectives that the CDD was looking to achieve, the MBL offered that short of a full force-on-force, real-time simulation which they desired, the next best alternative would be the use of Mission Command Systems, such as the Command Post of the Future (CPOF). This alternative could provide high-resolution maps and satellite imagery and the ability to depict unit icons movement across the battlespace. The CDD and MBL developed a methodology that allowed for a distributed wargame in a classified environment across the U.S. modeled in CPOF.

The CDD decided to conduct a hybrid wargame combining a seminar, workshop, and wargame. They would include the following agencies and CoEs (Figure 2): TRADOC G-2, Training Intelligence Support Activity (TRISA), Aviation, Intelligence, Fires, Maneuver Support and Protection, Sustainment, Mission Command, and Signal. There were also representatives from Space and Cyber, Special Operations, and the National Guard community. The purpose of this hybrid-type wargame was to gather initial insights that would assist in the design of the future R&S BCT formation.

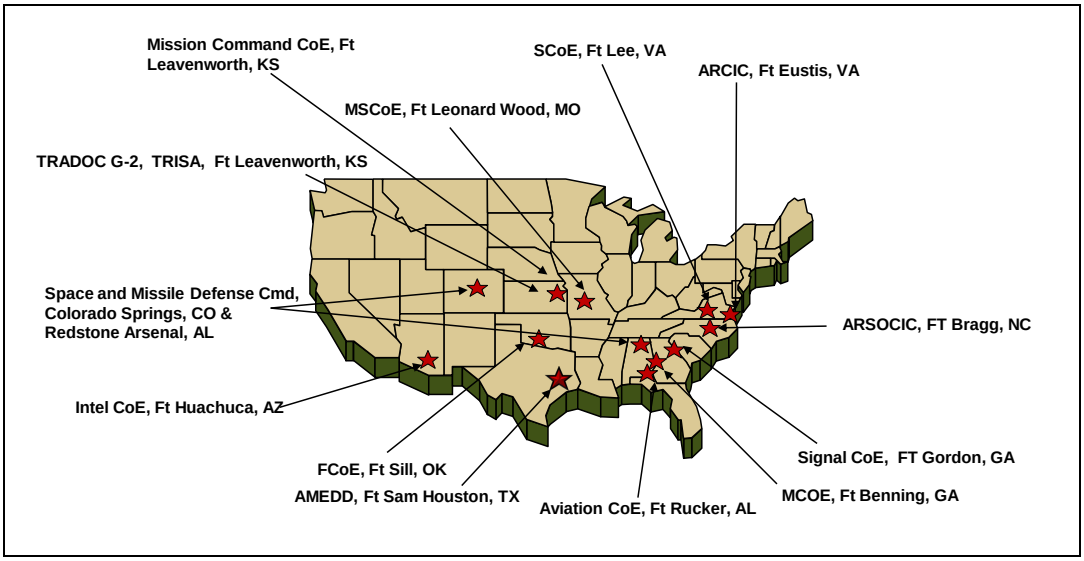


Figure 2. How to Fight Wargame Participants

Since most of the participants were not physically present, the MCoE needed a technique to distribute a digital view of the operational environment. Using CPOF, the MCoE was able to provide a digitally distributed Common Operational Picture (COP) to all participants. When integrated with BLCSE and Adobe Connect, the CPOF COP

provided comprehensive situational awareness and situational understanding for the seminar participants across organizational and functional boundaries in real-time. In order to use CPOF as a wargaming tool, the MCoE employed a CPOF subject matter expert who was able to depict the imagery necessary to conduct the wargame throughout the seminar. This included giving the participants the ability to build and move unit icons. For example, this enabled the Aviation CoE participants to move their unit icons on CPOF while located at Fort Rucker, Alabama; thus, simultaneously allowing other participants throughout the U.S. to see the unit icons moving on the digital map. The wargame followed an action-reaction-counteraction cycle. Actions were those events initiated by the side with the initiative. Reactions were the opposing side's actions in response. Counteractions were the first side's responses to reactions. For all Courses of Action (COA), the friendly forces were the side responsible for the actions and counteractions; the enemy forces provided the reaction. Tom Desrossier, the CDD lead for the wargame, developed the methodology and Figure 3 graphically depicts this cycle and the outputs.

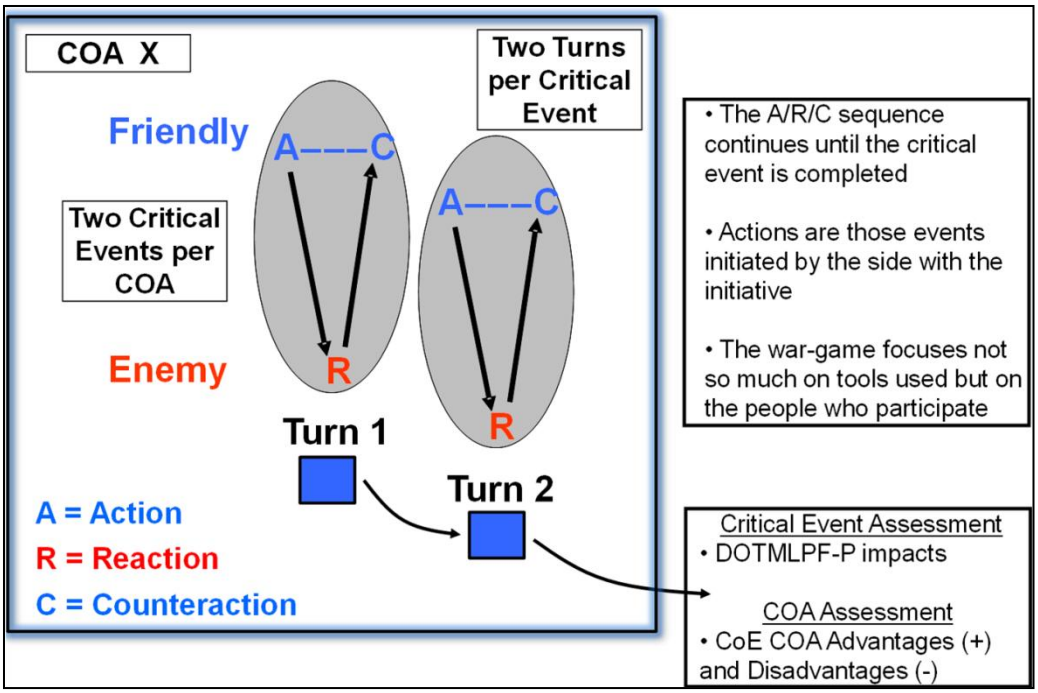


Figure 3. Wargame Methodology

CPOF as a Wargame Driver: Model or Simulation?

One of the first assumptions for alternate solutions was that the use of Mission Command Systems, such as CPOF, which could provide high-resolution maps and satellite imagery and the ability to depict unit icons movement across the battlespace. Based on the description of the wargame methodology and its dynamic nature of actions, reactions and counteractions, it is logical to ask when CPOF become a simulation rather than a model? Given the definitions presented earlier:

Model – A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process

Simulation – A method for implementing a model over time

CPOF is being used as a model. It can be argued that humans moving the icons and providing context for the conditions of the battle depicted on the screen makes the overall wargame a simulation (a method for implementing a model over time); however, CPOF is simply providing the logic representation of units and their place in space. How then was any credible, quantifiable data gathered from the actions of the participants?

Analytical Tools Given a Non-Scientific Model

To capture comments and discussions, three data collection instruments developed by Tony Carbone, an MBL Operations Research Analyst, were used. Participant discussions were collected using a collaborative discussion tool called Facilitate Pro and categorized within the Warfighting Functions (WfF), allowing for quick trend analysis. A mission success tool was used to capture formation effectiveness focusing on subjectively evaluating how successful each COA accomplished the key tasks and endstate specified in the commander's intent statement. Finally to determine the ability of each R&S BCT COA to perform baseline BCT missions, all participating members took a seven-question FACPRO Baseline BCT survey. The survey was structured with six questions focused on subjectively rating each formation COA in the context of performing baseline (Armor or Stryker BCT as appropriate) Mission Essential Task List tasks (Conduct Mission Command, Conduct Defensive Operations, Conduct Offensive Operations, Conduct Security Operations, Conduct Stability Operations, and Provide Fire Support). The seventh question required the Community of Practice to provide general comments in reference to the formation's ability to perform those basic BCT missions.

CPOF-Based Wargame Performance

The HTF Seminar Wargame results allowed the Commanding General, MCoE, to endorse a series of recommended immediate actions that will be sent to the Commanding General, Training and Doctrine and the Department of the Army Staff. Below is the list of recommended actions from the HTF Wargame Report:

(1) Direct three BCTs (two ABCT and one SBCT) to adopt a reconnaissance and security Mission Essential Task List (i.e., guard, cover, screen, zone reconnaissance, area reconnaissance, and area security), align each BCT with a corps, and begin training and leader development to conduct reconnaissance and security missions for a corps or Joint Task Force. Align necessary enablers with the brigades for training. Brigades would still be available for any mission as part of the Army Force Generation cycle.

(2) Schedule Combat Training Center rotations for these brigades in early calendar year 2015.

(3) Conduct further R&S BCT HTF Seminars with division and corps participation.

(4) Revise and update EAB R&S doctrine to drive training plan development (FM 3-94).

(5) Train R&S BCT leaders at reconnaissance courses (i.e., Cavalry Leaders Course, Army Reconnaissance Course, and the Reconnaissance and Surveillance Leaders Course).

(6) Revise reconnaissance courses, Noncommissioned Officer Education System courses—Maneuver Senior Leaders Course, and officer education courses—Captains Career Course, Intermediate Leaders Course, and the United States Army War College programs of instruction to include EAB reconnaissance and security planning, security force assistance, combat advisory, and foreign internal defense (the MCoE is doing this).

Findings from the R&S BCT Wargame

At the end of the R&S BCT Wargame, the CDD and MBL conducted an After Action Review both internally and with the wargame participants. The results exceeded the objectives set forth by the MCoE's Commanding General and include the following:

(1) It was on time, under budget, and has been used for similar projects within TRADOC.

(2) Wargaming may not give you all the answers to a particular capabilities development problem, but it can certainly provide the initial framework for future studies.

(3) The hybrid wargame provides a firm foundation for informing a subsequent and more rigorous, detailed simulation effort.

(4) Using the hybrid concept allows the Community of Practice multiple levels of interaction that include seminar, workshop, and wargame characteristics.

(5) Conducted properly, a hybrid-type wargame is an excellent tool for analyzing organizational force design alternatives.

(6) When enabled by the [BLCSE] network and driven by approved standard defense scenarios, it is a cost-effective way to include both the large community of design stakeholders, and the subject matter experts, to address the force design alternatives and DOTMLPF-P solutions for identified gaps.

(7) The consensus among participants is that the hybrid approach not only combines the strengths of each component aspect—the seminar, workshop, and wargame—but its result is synergistic. Given the current constraints on travel and conferences (this was 2013 when the DoD travel restrictions were in place), conducting hybrid-type wargames is the best practice for developing unit designs.

The important point to note is that with the CPOF-based model, outcomes were reported with sufficient analytical backing to report through the Commander of TRADOC to the CSA. It was conducted with minimal cost and in a short time. Given that success, how did it compare to the outcomes of the previously mentioned large, distributed simulation-driven experiments?

Comparison of the R&S BCT Wargame with Previous Simulation-Driven Experiments

The use of CPOF to model actions for a wargame is quite simple in application, so one might wonder how it compared in size, scope, required resources, and analytical results to similar events that used simulation-based environments. The following chart (Figure 4) compares the R&S BCT Wargame with three similar large simulation-based distributed experiments in which the MBL participated.

Comparison of HTF Wargame and Similar Simulation-Based Distributed Experiments

	HTF Wargame 2013	GAMOA 2012	Joint Fires Experiment 2012	FIATT 2013
Number of Participants at Fort Benning	28	155	41	227
Number of Total Participants	45	239	215	508
Days of Integration	10	90	42	80

Figure 4. Comparison between the Model-Based Wargame and Distributed Experiments

One can consider how the model-based wargame performed compared to simulation-based distributed experiments by examining the outcomes achieved at comparable echelons. In the case of the R&S BCT Wargame, experiment outcomes were focused at the brigade echelon and EAB. Below are recommendations from similar experiments conducted with distributed simulations by the MBL. Each of the events was approximately the same duration as the R&S BCT Wargame. Each involved similar participation across the different TRADOC CoEs. The actions of the maneuver BCTs in the experiments were simulated using OneSAF. The experiments were all conducted over the same BLCSE network as the R&S BCT Wargame. The following are experiment outcomes that came directly from the executive summaries from the MCoE experiments held previous to and immediately following the R&S BCT Wargame:

(1) From the Gain and Maintain Operational Access (GAMOA) Experiment 20-29 June 2012:

-The R&S Brigade (sic.; former name for the R&S BCT) requires additional capability to conduct operations across a corps-sized Area of Operations. Lacking that augmentation, BCTs must be prepared to assume responsibility for area and zone reconnaissance, surveillance, and screening missions.

-Provide the R&S Brigade the personnel and training required to access Army and Joint fires.

-Augment the R&S Brigade staff by adding a Space Operations officer, Cyber Operations officer, Engineer officer, and MP officer to the R&S Brigade Staff.

(2) From the Joint Fires Experiment 6-30 August 2012:

-Provide the BCT with organic capability to detect and defeat the proliferation of threat unmanned aerial systems (UAS) through the use of developing capabilities such as Indirect Fire Protection Capability (IFPC).

-BCTs require organic capabilities to identify, track, and destroy threat UASs through materiel solutions, training, and improved tactics, techniques and procedures.

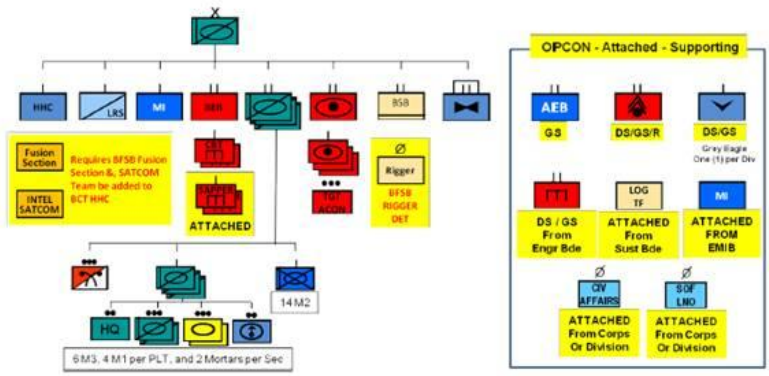
-Equip the 2020 Fires Brigades with Cannon/HIMARS/MLRS mix.

(3) From the Functional Integration of Army 2020 Experiment 22 July-2 August 2013:

-Maintain organizational concept with augmentation for the R&S BCT staff and provide the R&S BCT with specific training to facilitate coordination and synchronization of collection activities from requesting National Technical Means collection down to integrating squad collected data to produce an integrated intelligence product for dissemination.

-Training and leadership development for future BCT commanders and staff needs to include full understanding of the implications of the communications network to understand impact and trade-offs to prioritize the network for communications and data as well as properly leveraging available assets.

Note the similarity between the HTF Wargame recommendations and the recommendations shown above. For investigations or experiments at the brigade level, the CPOF-based model methodology proved sufficient analytically. The primary focus of the wargame was to identify possible design options for the R&S BCT. In order to brief the MCoE Commander, TRADOC Commander, and CSA, the MCoE CDD prepared alternative organizations based on findings from the HTF Wargame. To review, the purpose of the HTF Wargame was to gather initial insights that would assist in the design of the future R&S BCT formation. An example of one of the COAs is shown in Figure 5 (next page).



h. COA 1. This COA depicts a purpose built ABCT-based R&S BCT. The formation has three reconnaissance squadrons instead of three CABs. It has organic LRS and Aviation capability. It is augmented with additional Intel, Space, SOF, CA, FA, and UAS from Corps or Division.

(1) The large amount of mobile protected firepower in this formation provides the ability to develop the situation through action in close contact with the enemy and civilian populations. The organic relationship with support and enabler forces allows for cohesive organizations that possess a common understanding of how to conduct complex reconnaissance and security missions developed through regular training and leadership development. This formation requires more sustainment support due to the increased number of combat systems.

(2) Further analysis is required to determine the correct rules of allocation and dependencies for the baseline maneuver support and protection capabilities the R&S BCT needs. The fiscal, human, and organizational constraints make this force redesign problematic, particularly for the ARNG.

Figure 5. Sample Force Design Outcome of the R&S BCT Wargame

Clearly, the CPOF modeling that supported the R&S BCT Wargame provided sufficient model fidelity and context to allow insights to drive initial formation decisions at the highest levels of the MCoE, TRADOC, and the Army. Granted, it would not provide the required fidelity or proper modeling to be used to obtain insights at lower echelons or to the entity level. The other events which used OneSAF to simulate forces with a much greater fidelity (individual entities [Soldiers] simulated through the SAF, with human-in-the-loop Simulation Interactors controlling in some cases two platoons [80 Soldiers]) were able to get at much higher resolution learning demands at the lower echelons. Wargames or experiments requiring detailed ammunition or fuel usage data certainly could not use the CPOF-based environment to achieve associated Learning Demands (without weeks of follow-on calculations). However, for similar studies requiring insights at the echelon of brigade and higher, the use of models to drive Subject Matter Expert-focused discussion on areas such as force design or force structure is certainly an alternative. In terms of the ability to achieve the experimental or wargame outcomes, the insights/outcomes were comparable to large distributed experiments conducted by TRADOC in previous years. The model-based venue, based on the HTF Wargame case study, will almost certainly be less expensive to execute, as well as have a quicker preparation time than a similar simulation-based environment.

Savings / Return on Investment of the HTF Wargame

The cost to conduct the HTF Wargame was not free, but its cost was considerably less than the comparable distributed experiments mentioned above. The MBL is a mixed organization made of active duty military, Army civilians, and contractors. The EEB conducted the computer-based virtual and constructive experimentation and created the hardware, software, and network in support of both the HTF Wargame and other distributed experiments.

The funding for the majority of the contract work force of the EEB comes from Capacity Funding from the Army Capabilities Integration Center (ARCIC) for the purpose of providing a core contracted workforce with the capacity to maintain the required software, hardware, and Secret network [BLCSE] environment for conducting experimentation. In addition to the Capacity Funding and fixed infrastructure costs, the only expenditure for execution of the HTF Wargame were travel costs (travel plus per diem) for some of the participants which totaled approximately $10,000.

In comparison, for larger experiments, the workforce can surge by over 100 contractors serving as simulation interactors and role players commanding low fidelity notional units. For the large distributed simulation-based experiments listed above, the cost for the surge contract personnel at the MBL alone cost more than $750,000 per experiment. The overall cost to TRADOC, when funding for all of the different CoEs is included, comes to more than $5 million. This cost does not include the man-hours involved in the setup and six-month integration of simulations and mission command systems (mostly Capacity Funding, but at twice the duration of the HTF Wargame).

Implications of the CPOF-Based Model Approach and Areas for Continued Research

One of the most important lessons from the HTF Wargame case study is the need to ensure that the M&S community educates nontechnical customers, peers and leadership on the terminology of M&S. A detailed understanding of coding, architecture, or interoperability standards is not required to properly maximize all that M&S can provide to them or their organization. What is required is a basic understanding of the terminology of the field so that M&S professionals can provide the proper tool, at the best price, and in the quickest time practical. Just as doctrinal terms and symbols are important, so is the lexicon of the M&S profession. Although one would think that inside or outside the M&S community, arguing over the difference between what is a model and what is a simulation is trivial, adherence to a consistent, specific lexicon serves the same utility that use of proper doctrinal terms does for the Soldier.

Besides knowing and understanding technical terminology, it is also important that non-M&S managers follow proper training and experimentation processes when determining what model or simulation best supports their needs. First, they must identify the experimentation or training objectives and *then* determine the manner in which models or simulations will best achieve those objectives. It has been clearly demonstrated that the use of M&S can save resources and improve both training and experimentation, but blindly requesting or directing the use of a certain model or simulation because of a successful experience in the past, or because it was impressive during a demonstration, does not make sense. Although the R&S HTF Wargame's experiment design came about as the result of a constrained resource environment, its success lends itself to be used even when resources are unconstrained.

Another important outcome of the use of the CPOF-based model to answer force development and force design issues at the brigade echelon is that its methodology has already been transferred to other TRADOC experiments. The ARCIC Community of Practice has implemented a similar approach for a series of game-based experiments (GAMEXs) looking at Phases 0-2 (0- Shape the Environment, 1- Deter the Enemy, 2- Seize the Initiative) of the DoD Joint Planning Model. These GAMEXs are focused primarily at the division and brigade echelons. Clearly ARCIC has enough confidence in the outcomes of the HTF Wargame and CPOF-based events to use the technique to achieve findings and insights that are driving doctrine, force development, and force structure decisions for the year 2020 and beyond.

An area for continued research could be to conduct a CPOF-based wargame, followed by a simulation driven event with the same participants under the same conditions to compare the outcomes and insights. Another area for consideration would be to examine whether the same success would be held at lower echelons such as battalion or company to answer force development and force design issues and whether CPOF is an appropriate model or whether there would be one more suitable.

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