# Future Force Modeling and Simulation

## Innovation in wargaming capability development

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***Figure 1. Artist's conception of the MCWAC.*** *(Figure provided by author.)*

As the Marine Corps continues to prepare for the future fight in a time when technology is influencing tactics at all levels of war more so now than previously argued, investments into *Force Design 2030* and further will be critical to sustaining the edge on the battlefield. Likewise, so too has the ingest of data into algorithms that maximize the performance of artificial intelligence and machine learning software that refine the probability of potential outcomes or solutions; amplifying the often generalized *superforecasting* in the likely movement from competition to conflict and returning to the desired state of competition. Program Manager Wargaming Capability at Marine Corps Systems Command was established as an acquisition command in August 2017 and chartered to lead the procurement of the Marine Corps Wargaming and Analysis Center (MCWAC) to house cross-domain network infrastructure to include state of the art modeling and simulation (M&S) capabilities built upon authoritative data sources and feeding cutting-edge realtime analytics to inform and defend big-ticket decisions inherent in the Corps' *Force Design 2030* initiative. Since its inception, the program management office has pursued a three-phase crawl-walk-run approach to identifying, assessing, competing, and then acquiring and integrating the best-in-breed software, hardware, and cloud approaches to meet the current need and simultaneously establish a modular open systems architecture in which individual components can be improved or replaced with the latest technology for years to come, ensuring a modern relevant capability for the life of the system.

In order to meet the demanding analytic requirements of the *Force Design 2030* initiative, the wargaming system would have to span a number of capability axes. First, the envisioned series of games will be at the strategic, operational, and tactical levels of war. Second, all warfighting domains will be involved, to include land, air, sea (and undersea), space, cyber, and information. Third, across these domains and levels of war, the system would be required to include each game's focus on one or more of the warfighting functions (maneuver, fires, intel, force protection, command and control, logistics, as well as information). Fourth, the games would be in

support of three primary use cases: capability development, concept development, and operational plan assessment. Fifth, the system would be required to support every level of simulation integration with the game—from strictly seminar-style games in which the system may support only modest game management, collaboration, and visualization functions up to state-of-the-art artificial intelligence-enabled modeling and simulation of multi-sided capabilities and tactics—deeply integrated into and supporting many different game cells within the overall event.

An end-to-end integrated prototype is currently under development employing a number of innovative solutions to this challenging problem space. The design employs a robust cloud architecture, which provides a reliable capability to scale up compute resources as needed to address complex high entity-count strategic and operational simulations as well as immersive graphically intensive three-dimensional tactical simulations. The system is capable of automatically ingesting and organizing massive amounts of structured and unstructured data from myriad authoritative sources via multiple DOD and intelligence community networks. The system then orchestrates the distribution of these central data elements to each component simulation for proper and consistent model configuration and initialization. In game design, the system streamlines the process of selecting and modifying richly populated world terrain to meet game objectives. During game execution, high-fidelity models are synchronized across time, entity state, and environmental characteristics to ensure each specialized component contributes to the integrated Common Operating Picture, providing both ground-truth as well as side-based perceived views. Simulation outputs are then exhaustively captured and logged for realtime dashboarding and post-game in-depth analysis.

## A Framework of Simulations

Designing a wargaming system of the future is much more than just selecting an appropriate simulation tool. To be sure, many excellent simulation tools exist already, each with its own specialty and focus areas. Just take a trip to Orlando for the annual Interservice/Industry Training, Simulation, and Education Conference, and you will be overwhelmed by the latest commercial and government offerings and capabilities. While much of the focus of these offerings are in support of training requirements, many have immediate applicability to wargaming needs as well. Each tool comes with its own strengths and history of usage across the training enterprise, lending credibility to results. Some of these simulations excel at land operations, some at air and naval operations, some at a tactical level, and others at an aggregated operational level. *None* excel in all the domains, levels of war, and warfighting functions, from concept development through to operational plan assessment. Instead, a framework of simulations is required so that the weaknesses of one tool are augmented by the strengths of another. An initial collection of tools has been selected for the initial prototype, but these are merely a starting point. The framework is designed with a level of flexibility that supports adding or removing tools as technologies evolve.

This framework orchestrates the data movement from point of ingestion through game preparation and distribution to the component simulations. Simulation time is synchronized, and massive entity-count state data is orchestrated amongst the component simulations via a technology incubated in the Army's Synthetic Training Environment program.

The framework continuously collects and logs the voluminous data each component simulation produces during game execution. For example, an air simulation may produce metrics on fuel consumed or sorties executed per day. A land simulation may produce metrics on combat deadlined vehicles and consumption of MREs, water, and ammunition. The framework collects these output metrics and routes them to the unified analytics engine. The analytics engine produces dashboards of relevant information during gameplay for participants' reference, as well as provides operations researchers a mechanism to data-mine the game results of not just one but an entire series of games, or many repetitions of such games, after the fact.

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The framework furthermore eliminates the need for experts in the operation of each underlying simulation. Instead, wargame planners and analysts learn a single system, which translates wargamer scenario, order of battle, terrain, courses of action, and hypothetical assumptions into the specific configuration specifications of each underlying simulation. Training on the system then remains relevant, even when simulations change.

## Conceptual Model Approach

Conceptual models (CMs) are the abstract mathematical, algorithmic relationships between input and output variables, which are the underpinnings of every simulation system. Formal validation, and thus defensibility, of analytic findings comes down to an assessment of the underlying conceptual models together with the data that feeds them. The difference between well-understood and researched CMs, and vague un-documented CMs is the difference between defensibility and "smoke and mirrors." As the Marine Corps' M&S enterprise moves toward a common library of validated conceptual models underlying the breadth of simulations in use across analysis, acquisition, training, and experimentation, the approach with wargaming is likewise first to codify the required CMs

and then develop and integrate them, informed by both the priority of need and the technical complexity for each.

Third parties will be able to contribute CM expertise via a model-based systems engineering process. In this scheme, a system designer or independent research organization develops their CM in SysML and delivers them to the SysML repository, which is maintained by an independent government lab. This human-readable library facilitates validation by subject-matter experts as well as eventual implementation in the wargaming system. As systems development increasingly incorporates the principles of Model-Based Systems Engineering, the integration of accurate representations of these emerging systems is eased by this approach.

## Data Management

With such an emphasis on defensibility, identifying authoritative data sources sufficient to feed the immense appetite of this library of conceptual models is key. Depending on the nature of the need, these data sources come in two varieties: well-maintained databases with codified interface control documents and data held in pockets of expertise where the associated modeling efforts are nascent. Either way, the wargaming system brings in both types of data in a highly efficient manner, regardless of the classification level at which that data exists. During preparation, a planner may then modify that data to meet some type of hypothesis of the wargame under development. As these modifications are made, there is a danger of losing configuration control and the pedigree of the data. (Where did it come from originally, how was it changed, by whom, and under what rationale?) The wargaming system both facilitates these purposeful changes in data, but at the same time reliably records all such changes to maintain data traceability.

In order to orchestrate the data distribution to all component simulations reliably and efficiently, a unified data model has been developed for the system. This data model then forms the basis for simulation entity state information to pass back and forth between sims on the framework backbone. The consistency of representation across the system, combined with the configuration management of any and all changes from the data source, are among the core components necessary for the verification and validation of the system of simulations.

In wargaming, the need arises for certain higher-classification components of a contemplated scenario to be both rigorously modeled and understood at the required classification level and then to inform the broader lower classification game with certain lower classification effects. The requirements and resulting design for a transfer cross-domain solution are being planned in order that the system can handle this common use case securely, efficiently, and accurately.

***... the system design facilitates continuous improvement and validation ...***

## Live and Continuous Verification, Validation, and Accreditation (VV&A)

In order to meet the external scrutiny expected once wargaming simulation results are used to justify big-ticket decisions, M&S VV&A must be addressed. Critics will point out there is not enough time to conduct VV&A and keep faithful to the intent for the system, namely *timely* insight and analysis for senior leaders. This is a valid concern, given traditional VV&A processes, which typically involve years of effort before a formal accreditation is granted for a specific simulation use case.

What is needed therefore is a kind of live and continuous VV&A approach. In this approach, the system begins on day one with a set of simulations that already come with a degree of credibility. Then the system design facilitates continuous improvement and validation, capitalizing on the very nature of wargaming. With each game executed, a plethora of subject-matter experts across all areas of expertise are continually brought into the center. As these players witness the synthetic environment unfold during a scenario, they will see up-close exactly what the simulations are claiming happens next. These participants naturally will question what is purported as reality. When this happens, the system facilitates an immediate investigation. When a player asks, "What data is that behavior based on?" the system can immediately surface the rationale, doctrine, algorithm, or whatever appropriate artifact addresses the question. The participant then has the opportunity to allay the concern or just as valuably recommend a change to better reflect that player's understanding of reality, whether recommending an alternative database, an alternative behavior, or an additional constraint—whatever the key is to reflect that participant's sphere of expertise. The system takes in this recommendation and makes it available to planners and developers to address in future games. In this way, the system is always being improved while amassing an ever-growing body of evidence that the system results can be relied upon for consequential decisions. If for any reason a more traditional VV&A process is required for some specific purpose, the system's ability to surface the configuration-controlled key data, algorithms, constraints, and models again facilitates such a process.

## Outlook

The Marine Corps' focus on *Force Design 2030* and the tools, people, and processes needed to get there drove the development of this approach. Each of the pieces outlined here is essential to achieve the desired outcome. As this system comes online in the new MCWAC and continues to mature in years to come, the bold vision to provide senior leaders with timely, defensible, data-driven insight into the Corps' complex operating environment will become reality.

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