7-2017

Models of Models: The Symbiotic Relationship between Models and Wargames

Vikram Mittal
United States Military Academy, vikram.mittal@westpoint.edu

Jeffrey B. Demarest
United States Military Academy, jeffrey.demarest@westpoint.edu

Kennon S. Gilliam
Army War College, kennon.s.gilliam.mil@mail.mil

Robert L. Page
Army War College, Robert.l.page1.mil@mail.mil

Models of Models: The Symbiotic Relationship between Models and Wargames

Vikram Mittal[1], Jeffrey B. Demarest[1], Kennon S. Gilliam[2] and Robert L. Page[2]

[1]*Department of Systems Engineering, United States Military Academy, West Point, NY, U.S.A.*

[2]*Department of Strategic Wargaming, United States Army War College, Carlisle, PA, U.S.A.*

{vikram.mittal, jeffrey.demarest}@usma.edu, {kennon.s.gilliam.mil, robert.l.page1.mil}@mail.mil

Keywords: Wargames, Discrete Event Simulation, Decision Making.

Abstract: Military planning uses wargames to model the processes and decisions of an operation. As these operations become increasingly complex, the wargames similarly become more complex. Complex wargames are difficult to design and execute. As such, computer-based modeling and simulation can aid the wargame development, ensuring smooth execution. In particular, computer-based modeling and simulation can develop and validate the processes, determine initial conditions, evaluate the rules, and aid in validation. In turn, the wargame can provide useful data that can be fed into detailed models that can provide quantitative analysis to decision-makers.

1 INTRODUCTION

Complex problems require advanced problem solving techniques, and the United States military has no shortage of complex problems. Modern warfare requires the analysis of military operations to account for the size of modern militaries, the usage of advanced technology, and the role of socio-political factors. Issues that previously were solved through simple logic now require advanced problem solving and critical thinking to develop solutions. As such, wargames—role played simulations of military movements and processes—are commonly used to evaluate strategies, tactics, and doctrine (Tolk, 2012).

In particular, table-top wargames have become an increasingly useful tool for evaluating military operations. Since table-top wargames are used for aiding in critical military decisions, it is imperative that they account for all the necessary components and the associated interactions. To capture these interactions, table-top wargames are typically built using simple doctrine-based process models, which can be emulated via computer simulations to help inform the game planning and development. These simple computer simulations allow a space for game creators to quickly build, test, and adjust the game.

Though table-top wargames are powerful tools for analysing complex processes, the results are typically qualitative in nature. However, these qualitative results can be used to drive a detailed computer simulation to achieve the quantitative results required by decision-makers. As shown in Figure 1, the wargame and the initial simulation can remain somewhat simplistic; they can then be combined to produce a detailed simulation that captures the necessary complexity of the military operation.

Hence a symbiotic relationship exists between computer-based simulation and table-top wargames. This paper explores this relationship further and details this collaboration and its benefits via a recent case study on the full mobilization of the US Army.

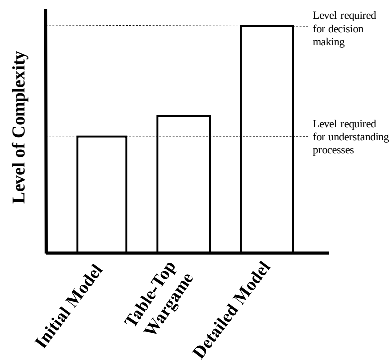

Figure 1: Increased complexity can be captured through the combination of different modeling methods.

Mittal, V., Demarest, J., Gilliam, K. and Page, R.
Models of Models: The Symbiotic Relationship between Models and Wargames.
In *Proceedings of the 7th International Conference on Simulation and Modeling Methodologies, Technologies and Applications (SIMULTECH 2017)*, pages 215-223
ISBN: 978-989-758-265-3

2 WARGAMING IN SUPPORT OF MILITARY PLANNING

2.1 Military Wargames

A wargame is a simulation in which theories of tactics, doctrine, and strategy can be evaluated by means of a disciplined process with a set of rules and steps. Wargames can be used at every level of decision making from tactical through strategic. The wargame process is well-defined in the US Army's *Field Manual (FM) 6-0: Command and Staff Organization and Operations* where it is recommended as a means for a commander to evaluate a course of action for an operation (2016).

A common version of the wargame is a table-top game because this can be created in any austere operational environment. The table-top wargame models the process flow onto a surface, on which game players move markers in accordance with set rules. The game is intended to be a simplified version of a real operation, allowing for insight into the processes. The goal of these wargames is to develop innovative approaches and changes to tactics, doctrine, and strategy (Perla, 2011).

Table-top wargames are a standard practice in the initial phases of planning a tactical scenario, operational maneuver, or strategic campaign. As the scope of the game increases, the design of the game becomes more complicated. If properly designed and developed, a table-top game provides an environment to achieve the wargame's purpose, which could be analytical, experiential, or educational.

2.2 Development of a Table-top Wargame

Figure 2 shows a standard process for developing a table-top wargame. This process is kept at a high level such that it is applicable to a large range of different table-top wargames, whether tactical or strategic.

The table-top wargame is intensive and requires enormous effort to develop and execute (Mood, 1954). Prior to developing the game, a stakeholder analysis must be conducted to identify the purpose, scope, and objectives of the wargame.

Table-top wargames are based on processes which require players to complete well-defined steps within the context of a controlled scenario. As such, the next step in game development is determining the underlying processes. Often, understanding these processes involves consulting with subject-matter experts as well as referring to doctrine.

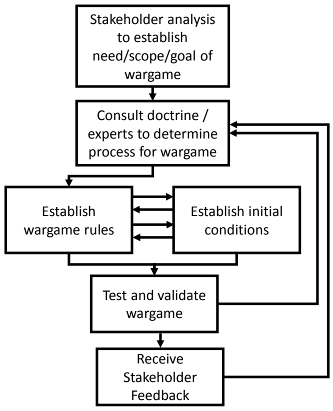

Figure 2: Steps for developing a table-top wargame.

After the processes are determined, the rules for the game can be written. The rules are meant to reflect real-world constraints and requirements, forcing the players to act in a realistic manner. For example, if a table-top wargame replicates an offensive operation, the set of rules would include that tanks cannot go through a minefield, dismounted troops can only move 12 miles per day, and beachheads must be established prior to landing forces.

With the rules in place, the initial conditions must now be determined. The initial conditions are critical in setting the length and complexity of the game. The initial conditions for an offensive operation would include parameters such as the composition and disposition of friendly and enemy forces.

After the initial conditions are determined, the rules need to be re-evaluated. In particular, it is necessary to determine injects for the game. Injects add a variable nature to the game, similar to "chance cards" in Monopoly. An inject for an offensive operation could include changes in weather patterns, changes in political climate, and an enemy ambush.

The table-top wargame then undergoes test and validation. During this phase, a summarized version of the game is executed by subject matter experts to ensure that the processes, rules, and initial conditions reflect reality. Meanwhile, they must also ensure that the game is still simple enough that it can be readily played, as well as confirming it can be executed within time constraints. They also validate that the output of the table-top wargame will answer the stakeholders' needs.

2.3 Execution of a Wargame

After the table-top wargame is developed, the game can be executed. First, the players are selected. Typically, the players have expertise relative to the role that they will be playing. For example, an intelligence officer would play the role of the enemy in traditional force-on-force wargames because they are the most familiar with enemy capabilities.

The game can be played for one or multiple iterations. However, after each time it is played, it is crucial that there be a period of facilitated discussion. The facilitated discussion provides insight into both the wargame and the larger operation.

When the game is played for multiple iterations, changes can be made to the rules to allow for increased variability. These modifications can be based on recommendations by the game players and be used to foster additional discussion.

3 COMPUTER-BASED MODELING IN SUPPORT OF MILITARY OPERATIONAL PLANNING

3.1 Military Computer-based Models Simulations

The military must address problems of both detailed and dynamic complexity (Senge, 1990). Models reduce this complexity for decision-makers and clarify the decision space. A model is an abstract representation of a system, and for very complex military operations, a model simplifies the dynamic interactions between its entities into a sequence of events.

Models are developed throughout the military decision making process. Initial models are developed from doctrine and provide theoretical insight on processes. Later models remove layers of abstraction and add realism to produce quantitative data and practical findings. As these models are developed, they can be implemented through discrete event simulations. A discrete-event simulation is one in which events cause state changes to occur at discrete points in time (Harrell et al., 2004).

The military heavily relies on computer-based discrete-event simulations as a method of testing tactics and strategies without the need for actual hostilities. These simulations range from those aimed at the tactical level such as the Infantry Warrior Simulation, Virtual Battle Space, to the strategic level such as the Conflict Modeling, Planning, and Outcomes Experimentation Program (Tolk, 2012).

These simulations not only have a wide range of scopes, but they also vary significantly in regards to complexity. While simple simulations are excellent for getting a better understanding of a military process, more complex simulations are typically needed for accurate decision making. However, as the simulations get more complex, they require more time and resources to develop.

While the military relies heavily on simulations to support the military decision making process, these simulations are typically separate from the development of table-top wargames. However, the use of a simple high-level model in a conjunction with a wargame allows for a more expedient development of a simulation detailed enough for decision makers.

3.2 Initial High-level Model Development

The first step in analysing a system is to establish the underlying concepts and place them into a simple abstract model. This abstract model can take the form of a simple block diagram model, which shows a sequence of events and the conditions that must be satisfied for an event to occur (Wilson et al., 2013). A standard block model diagram is shown in Figure 3. The overall process can have multiple parallel pathways and recursions. Moreover, each event and condition is tied to actors that influence that event.

The Army Design Methodology promotes the use of these models in military planning and decision making. These models are encouraged because "seeing something drawn may help individuals think through challenging problems, especially when examining abstract concepts" (*FM 6-0*, 2016).

Block diagram models are used throughout modern military doctrine. Standard military planning involves "establishing objectives, devising lines of operations, and lines of efforts" (*FM 6-0*, 2016). The objectives are the events and conditions for a discrete-event model; the lines of operations are the process flow between those entities; and the lines of effort are related to the actors. Typically, objectives are combined in series or parallel, often with feedback, to model complex operations.

After developing the process-flow through a block diagram model, the next step is to identify the high-level characteristics of the military units that will be executing the processes. During this stage of analysis, these units should be defined with enough detail to test and evaluate the processes. However, determining the full details for each unit would entail a significant data collection effort that is not necessary at this level. That is, units should be representative though not necessarily accurate.

These block diagram models with notional units can be readily implemented into a discrete event simulation which models the flow of the units through the designated processes. For example, the simulation of an offensive operation would model the movement of friendly and enemy units on the battlefield. These computer-based simulations typically remain high-level and are useful for studying interactions between processes and identifying constraints.

Though these models can readily be built in Microsoft Excel® or Matlab®, commercial discrete-event packages are useful for the visualization of the simulation. These software packages include ProModel®, AnyLogic®, Simio®, and ExtendSim®. These software packages allow for the definition of entities, whether they are Soldiers or units, and the processes that they must follow. Though the interfaces are different, these packages output a graphical depiction of the entities executing their processes. This graphical output is useful for working in collaboration with a table-top wargame.

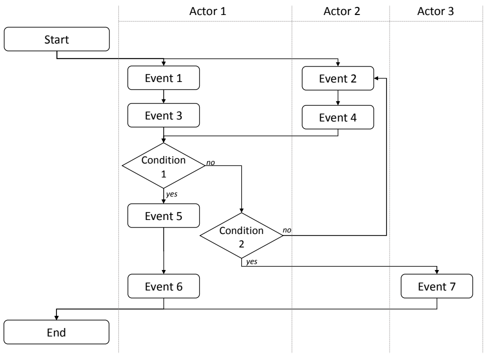

Figure 3: Example of a Block Diagram Model.

3.3 Detailed Model Development

Though the initial models and the associated simulations are useful for understanding the underlying processes, decision-makers need quantitative data to inform their decisions. Therefore, more detailed simulations are built to generate that data. The underlying models require a large effort to collect the necessary information, build the model, and validate the results (Morgan et al., 2017).

These models can be built upon the initial models by removing layers of abstraction. Since military doctrine only provides high-level descriptions of processes, the model designer must translate those processes into the real-world. To do so, the model developer must account for additional constraints and variables that doctrine does not include.

With the processes developed, the next step is to better characterize the units that will be executing these processes. The units must be representative of the real-world units. In particular, the model designer must determine what characteristics of each unit will affect the unit's ability to complete each process. This level of detail can rapidly become very granular; therefore, it is necessary to set the scope to a level that can be achieved with the data that can be collected.

Often the required data is not available, and assumptions must be made. These assumptions increase the overall uncertainty of the results. However, when properly documented, the stakeholders can readily take these assumptions into account when reviewing the results. Additionally, if the assumptions are carefully parameterized, the model can be readily used to perform a comparative analysis between different courses of action.

While the assumptions consist of "known unknowns" it is often useful to include the "unknown unknowns," commonly termed as the "fog of war." Though it is difficult to absolutely quantify these "unknown unknowns," they can be somewhat accounted for through multiple runs and including variability in the input.

As the amount of data increases in the model, the associated simulation requires additional processing power. To this end, the commercial discrete-event simulation packages mentioned in Section 3.2 (e.g. ProModel®) can provide the requisite computational power. It is necessary to ensure that the simulation package offers enough flexibility to fully define the processes and constraints of the model.

4 THE ROLE OF COLLABORATION

As the complexity of the model increases, the role of collaboration between methods becomes increasingly beneficial. In particular, the development of the table-top wargame and the initial models can be done in parallel such that the simulation replicates the game. The simulation can then be used to develop and validate the process, evaluate the rules, and determine the initial conditions. This collaboration can lead to a more expedient development of a detailed model.

4.1 Developing and Validating the Process

The initial model requires that the events, constraints, and actors be clearly laid out, as does the wargame. Therefore, developing these processes in parallel for both the model and the wargame allows for the processes to be more clearly defined.

Additionally, the initial simulations require logic to be entered that mimics the game players. By requiring that the actions of the game players be coded into the model, gaps in the process can be readily identified.

Moreover, the model can reveal that certain processes are unnecessary or inaccurate. For instance, the overall process pulled from doctrine might contain out-dated or tangential elements. Removing these elements not only reduces the complexity but also enhances the fidelity of the wargame.

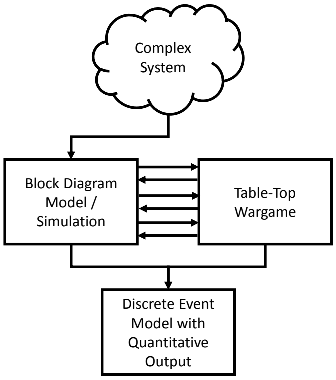

Figure 4: Collaboration between block diagram models, wargames, and discrete event models.

4.2 Determining Initial Conditions

The model aids in determining the initial conditions. Without a computer model, the full implication for many of the initial conditions can only be realized through fully playing the game. The initial conditions for a wargame must be set to avoid bottlenecks while still requiring the game players to make key trade-off decisions. Bottlenecks slow down the game play, frustrating the game players; additionally, bottlenecks force the players into following fixed processes, stifling innovation (Tolk, 2015).

The simulation can be run numerous times to optimize the initial conditions. These design parameters can then be integrated into the table-top wargame. As the wargame evolves, the simulation can be rapidly upgraded and run to ensure that the design parameters are still optimal.

4.3 Evaluate the Rules

The rules for a table-top wargame should be representative of the real-world challenge that the wargame is addressing. Additionally, it should foster conversation, challenge the game players, and avoid frustration. Most importantly, the rules must be clear.

The model builder is an excellent source of feedback on the clarity of the rules. The wargame architect provides the model builder with a copy of the rules that would be provided to the game players. The model builder then uses those rules as the underlying logic for the simulation. The simulation can then be displayed to the wargame architect to validate that the model logic follows his intent.

Additionally, for the wargame to foster innovation, the rules must be logical, allowing the game-players to rapidly process the information and introduce new methods. Similarly, logical rules are necessary for building a model. As such, the model builder provides feedback on the rules to the wargame architect, ensuring that the rules are logical.

4.4 Wargame-simulation Verification and Validation

Following the development of the wargame, it is necessary to get the table-top wargame validated by the stakeholders. The discrete-event simulation provides two opportunities to aid in validation.

First, since the model was developed parallel to the wargame, the process, rules, and initial conditions all have been corroborated by both the wargame and modeling teams. Though both the wargame and modeling teams may not have subject matter expertise, the two sets of teams can determine what information is critical and needed to be confirmed.

Second, the simulation can show the actual flow and operation of the table-top wargame in a media that is conducive to the stakeholder. Stakeholders often have limited time and they may not wish to play the game in its entirety or explore every “what if” scenario. As such, the stakeholder can simply watch the simulation run an automated version of the game to determine if it meets their needs.

Finally, the simulation can also model the gameplay to determine if the game is biased towards a particular outcome or set of outcomes. This gives participants an equal opportunity to “win,” although sometimes a biased outcome accurately replicates the real world system.

4.5 The Role of Feedback

Table-top wargames typically output a summary of findings. While inherently useful, the output can be coupled with the simulation to create richer feedback for the decision-maker. For example, if game players are critical of certain assumptions made for the wargame, these assumptions can be modified in the simulation to perform a rapid sensitivity analysis.

Since the game players are typically subject matter experts, the wargame itself is an excellent source for information for the more detailed model. If wargame information is to be fed into a model, it is necessary to identify what information is essential prior to the execution of the wargame. By doing so, the wargame can be designed to ensure that the wargame generates this information. Additionally, the feedback between subject matter experts and the simulation can be used to arbitrate when simulation parameters based on policy are not realistic.

4.6 Wider Applicability

Use of simulations is not confined to development and refinement of wargames for military applications. Many boxed hobby wargames could benefit from the iterative process laid out here. This could result in a faster delivery to market of hobby games by speeding up the validation and game play rules, especially the concept of fairness and equal chance to win.

5 CASE STUDY: MOBILIZATION OF THE FULL ARMY

The United States Army conducted a study to determine the time required for a full mobilization of the total Army, including the Active Army, Army Reserve, and Army National Guard. A full mobilization involves the simultaneous activation of the Army's reserve soldiers for an indefinite period of time without increasing the total number of soldiers (i.e., a draft is not implemented). The study was commissioned to identify issues associated with a full mobilization, which in turn are analysed to determine opportunities to accelerate the process.

Numerous groups throughout the Army have looked at the mobilization process. However, they typically looked only at specific aspects instead of the whole process. Therefore, the wargame team determined a table-top wargame was most appropriate for three reasons: 1) a lack of system data to support a full simulation; 2) foster conversation and interaction between participants from different organizations; and 3) make the players feel and see the consequences of their decisions.

5.1 The Mobilization Process

Many reserve units were deployed during the Global War on Terror; however, these units underwent a limited, deliberate mobilization, as compared to a full mobilization. A full mobilization involves all units competing for limited resources to achieve a high level of readiness related to personnel, equipment, and training. Not only are the reserve units competing amongst themselves for these resources, they are also competing with active duty units. The underlying doctrine for a full mobilization is covered in *Joint Publication 4-05* (2014).

The reserve component consists of approximately 500,000 soldiers spread out among many units throughout the United States. These units range from small engineer detachments (~30 Soldiers) to large infantry brigade combat teams (~3000 Soldiers). The complications induced by unit dissimilarity are increased by these units being distributed amongst the Army National Guard and Army Reserves, which have different mobilization policies.

When mobilized, reserve units report to home station, their assigned base for training. Active duty units are already at home station, and these bases are spread out across the United States. Each unit has a certain readiness level determined by its personnel, equipment, and training levels. They are given resources to increase their readiness levels in those three categories; however, these resources are somewhat limited, especially at home station.

Units move to other training sites to increase their readiness levels. While small active duty units can increase their training levels at Home Station, large units are required to conduct collective training at the Army's three maneuver Combat Training Centers (CTCs). Each CTC has limited capacity, and units must often wait for their rotation at a CTC.

Reserve units can increase their training levels at a Mobilization Force Generation Installation (MFGI), where they get validated to deploy. Additionally, at the MFGI, they will receive additional personnel and equipment. All reserve units must move through the MFGI during their mobilization process. Additionally, reserve units can also use the CTCs to increase their training levels, though they have a lower priority than active duty units.

Once units are fully manned, trained, and equipped, they move to the Port of Embarkation (POE). At the POE, the units await for transportation to their deployed location.

5.2 Block Diagram Model and Wargame Setup

This set of processes was modelled in ProModel® to create a simple discrete-event simulation. A screenshot of the model is shown in Figure 5. The table-top wargame followed a similar set of processes with the board shown in Figure 6.

Active duty and reserve units are broken up by component; they are further divided into large units

(~brigade) and small units (~battalion). Each unit is given a score between 0 and 3 for their manning, equipment, and training levels. For a unit to deploy, they must have a score of 3 in all the categories. During each turn, manning and equipment points are added to different locations (i.e., home station, MFGI, CTC, POE), such that game players can allocate those points to units at that location. Additionally, units at a training site can receive training points.

The POE requests units to arrive in an order that meets the deployment needs. These requests only state whether they want a large or small unit and whether that unit is active or reserve component. The game players then select the units to fill these needs.

Each turn, there is a point penalty associated with units being idle. Additionally, a penalty is associated for deploying units out of order. The goal of the wargame was to limit the number of turns required while minimizing penalty points.

In November 2016, the table-top wargame was played at the United States Army War College for three different iterations. The first iteration was a baseline game, allowing the wargame participants to familiarize themselves with the rules. The second iteration included additional constraints. The third iteration allowed the participants to implement changes that could speed up the mobilization process.

The goal of the game was to challenge the players and to foster communication such that they discussed innovative real-world strategies that could be implemented to speed up the mobilization process.

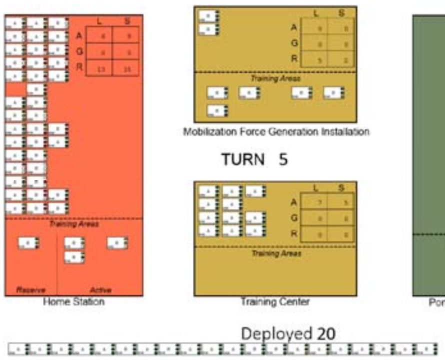

Figure 5: Screenshot of the ProModel® simulation of the basic mobilization process.

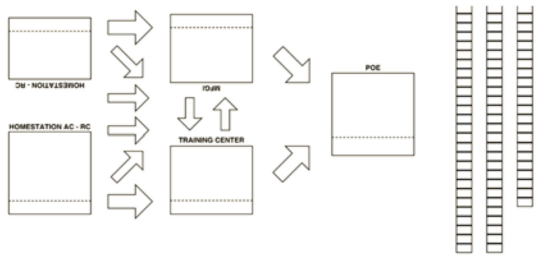

Figure 6: Screenshot of the surface used in the mobilization table-top wargame.

5.3 Relationship between Discrete-event Simulation and Wargame

The table-top wargame and discrete-event simulation were developed in parallel following an initial workshop where a panel of subject matter experts agreed upon a set mobilization process. The simulation informed the table-top wargame and helped set a number of the design parameters.

In particular, the intent was that the wargame would take 18 turns, with each turn taking up to 10 minutes, for a total of 3 hours. The number of turns required to complete the game were dependent on a number of parameters to include the following:

- Starting manning/equipping/training level
- Capacities of different training centers
- Manning and equipment points per turn
- Output capacity of POE

The simulation was run multiple times across the design space in order to fine tune the number of turns to being between 16 and 20.

Figure 7 shows an example of this analysis; the average output of the POE was varied to determine its impact on the total number of turns. When the average POE output was reduced below 6 units per turn, a bottleneck occurs. Therefore, the average output was set to be greater than 6 units per turn.

Additionally, the simulation identified design issues with the wargame prior to execution. For example, early versions of the wargame provided personnel at the POE; however, no unit arriving at the POE could accept additional personnel. If units had below a score of 3 in personnel, they cannot achieve the training score of 3 required to reach the POE.

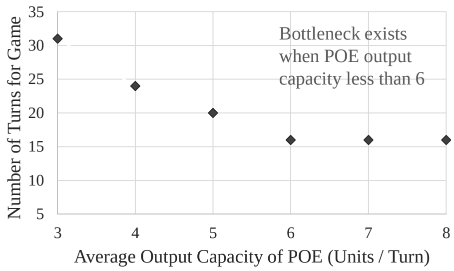

Figure 7: Analysis on the impact of the output capacity of the POE on the total number of turns for the wargame.

The successful replication of the table-top wargame in a computer simulation allowed the game designers to focus on the interaction of players and achieve the purpose of the wargame. Wargame designers were able to adjust inputs, anticipate participant questions, and quickly adjust the rule set because of the cooperation and iteration with simulation developers. Participants also spent very little time "fighting the game" because it was so well fine-tuned.

Moreover, the simulation was run and shown to many of the participants and stakeholders to allow them to see the process being utilized by the wargame. By doing so, they were able to validate the process, rules, and initial conditions.

The scale of this table-top wargame was fairly vast in that it incorporated the full Army, as opposed to just select units. Wargames of this scale typically take six to eight months to plan and fine-tune. Developing the simulation in parallel to the table-top wargame reduced this time to two months.

5.4 Wargame Outputs into a Quantitative Model

The initial model and the table-top wargame created the foundation for a more detailed simulation of the full mobilization process. The updated model does not generalize between units or locations; rather, it models each individual unit, MFGI, CTC, and POE. Additionally, the processes are decomposed to identify opportunities for optimization. By removing these layers of abstraction, the simulation allows decision makers to make informed decisions on how to enhance the mobilization process.

The table-top wargame provided significant refinement into the model. For instance, the feedback from the game players found that several of the processes in the model were unnecessary. Additionally, they identified several additional constraints that play a major role in the mobilization process, including the time to open new MFGIs, back-ups at the POE, and limitations on transportation resources. Beyond its validation value, the table-top wargame itself was an ideal place to make contacts that can provide critical data for the model. Since many of the game players were subject matter experts on an aspect of the mobilization process, they ultimately had access to the raw data that the detailed model needed.

6 CONCLUSIONS

Military planning uses table-top wargames as a technique to model the processes and decisions of an operation. Current and future military operations have high levels of complexity, potentially leading to very complex table-top wargames.

As table-top wargames become increasingly complex, computer-based simulations can aid in wargame development. In particular, they can develop and validate the processes, determine initial conditions, evaluate the rules, and aid in validation. In turn, the wargame can provide useful data that can be fed into detailed models that can provide quantitative analysis to decision-makers. Simply put, the relationship between computer-based simulation and table-top wargames is symbiotic and the outputs of this symbiosis are more efficient analysis, enhanced insights and ultimately, better decisions.

ACKNOWLEDGEMENTS

This research was supported by the United States Army War College's Department of Strategic Wargaming through the Department of the Army G1.

DISCLAIMER

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government.

REFERENCES

Field Manual 6-0 (2016). *Commander and Staff Organization and Operations*. Washington D.C.: Headquarters, Department of the Army.

Harrell, C., Ghosh, B., Bowden, R. (2004). *Simulation Using ProModel.* New York: McGraw-Hill.

Joint Mobilization Planning (2014, February 21). *Joint Mobilization Planning.* Washington D.C.: Joint Chief of Staff.

Mood, A.M. (1954). *War Gaming as a Technique of Analysis.* Santa Monica, CA: The Rand Corporation.

Morgan, J.S., Howick, S., Belton, V. (2017). “A toolkit of designs for mixing Discrete Event Simulation and System Dynamics.” *European Journal of Operational Research.* Vol 257.

Perla, P., McGrady, E.D. (2011). “Why Wargaming Works.” *Naval War College Review*. Vol 65. No. 3.

Senge, P. (1990). *The Fifth Discipline*. New York: Doubleday.

Tolk, A. (2012). *Combat Modeling*. Hoboken, NJ: John Wiley & Sons.

Wilson, P., Manhooth, H.A. (2013). *Model-Based Engineering for Complex Electronic Systems*. Oxford, UK: Newnes.