

CAB D0013009.A3/1Rev

December 2024

Originally published

September 2005

Gaming the GIG: A Brief Manifesto

Peter P. Perla • Ciro M. Lopez •
Arius V. Kaufmann • Michael C. Markowitz



Approved for distribution:

September 2005
Reprinted December 2024

A handwritten signature in black ink that reads "Maureen Wigge". The signature is written in a cursive, slightly slanted style.

Ms. Maureen A. Wigge
Director, Operational Policy Team
Operations Evaluation Group

This document represents the best opinion of CNA at the time of issue.
It does not necessarily represent the opinion of the Department of the Navy.

This document was originally published in 2005; it was reprinted in 2024.

Approval for Public Release; Distribution Unlimited. Specific authority: N00014-00-D-0700.

Copyright 2005, 2024 The CNA Corporation

Contents

Origins	2
Shaping the discussion	6
How wargames, analysis, and exercises fit together	7
What wargames can contribute to M&S and the GIG	16
Training and education	18
Planning and assessment.	24
Research and experimentation	30
Game-based experimentation	36
<i>SCUDHunt</i>	37
Goals of experimentation	47
Classes of games.	48
Games and experimentation	52
Wargames and DMSO vision	56
Future directions	57
References	65



Gaming the GIG

A Brief Manifesto

Peter P. Perla

30 September 2005

Origins

- 2004 request by Dr. Sue K. Numrich, Deputy Director at DMSO
- Teach community about wargaming and its application to the GIG
- Correct misperceptions and misunderstandings

This paper originated in 2004 with an idea by Dr. Sue K. Numrich, then a deputy director in the Defense Modeling and Simulation Office (DMSO). Dr. Numrich suggested that senior officials associated with DMSO and the Global Information Grid (GIG) did not understand wargaming the way she had come to understand it through her contacts with the wargaming community. Dr. Numrich and DMSO became interested in using gaming to help members of the modeling and simulation (M&S) community understand the implications of the Global Information Grid for future military operations and for the M&S community's ability to model and support those operations more effectively. Gaming is a potentially promising technique for exploring such issues. The nature of gaming, its strengths and weaknesses, and its relationship to operations and systems analysis is not widely understood within the M&S and the GIG communities.

Original goals

- Improve understanding through practical example
- Convene periodic workshops with Institute for Defense Analysis (IDA)
- Interactively develop a conceptual design to “game the GIG”

The goal of this limited research effort was to help correct that deficiency. Dr. Numrich’s plan was for the wargaming experts at the Center for Naval Analyses (CNA) to work with the Institute for Defense Analysis (IDA) and a group of government scientists and officials with an interest in gaming the GIG. Dr. Numrich would select and invite the members of the group. CNA would demonstrate the processes of designing a wargame to meet specific objectives by conducting a series of interactive game-design workshops with the group. Our intent was to use the workshops to develop the design concept for a simple boardgame to explore the use of the GIG. In effect, the workshops were to develop a conceptual design for such a game over a series of meetings. Between meetings CNA would work with the sponsor and with IDA to flesh out ideas and identify critical design decisions, and to produce real or virtual prototypes of game concepts, materials, and mechanics.

The project transforms

- Dr. Numrich accepts position at IDA and leaves the project
- Project is redirected in early 2005
- CNA agrees to write a paper defining use of wargaming in support of GIG M&S COI

Unfortunately, before the work got underway Dr. Numrich left the government without being able to assemble the panel of experts she wanted us to interact with. As a result, the project went into limbo until early 2005, when we discussed with DMSO how best to proceed. In conversations with DMSO representatives, we concluded that the best way to use the limited funding still available would be to prepare a briefing paper on how wargaming could be used to link three key communities involved in the development and operational use of the GIG—the military commanders, or operators; the modelers and simulators, or analysts; and the developers of the GIG.

This is that paper. In it we elaborate on our understanding of wargaming and its uses in this context, and present some ideas that we hope will stimulate discussion among the M&S community of interest (COI) for the GIG about how to integrate wargaming into their vision for the future—both as a tool for research about the GIG and as a service to be provided through the GIG.

Gaming is the glue

- Gaming links operators and their decisions to modelers and their tools
- Gaming can empower M&S support for the operators across a wide spectrum of functions

Gaming is good at such linking tasks because its very nature involves creating an interface between operators, who become the players of the game, and modelers, who provide essential representational and assessment tools to the game designers.

This paper explains how and why that is so. It will also explain how and why DMSO and the GIG's M&S community of interest can use wargaming to enable M&S support through the GIG, not only for the operators but also for other COIs across a wide spectrum of functions, ranging from research and experimentation, to training and education, and ultimately to operational planning and assessment.

Shaping the discussion

- **How wargames, analysis, and exercises fit together**
- **What wargames can contribute to M&S and the GIG**
- **Future directions**

To do that, we will start with a brief tutorial about the nature of games—wargames, to be more precise—and how they fit into the world of defense research and analysis. The bulk of the paper describes how gaming can contribute to the modeling and simulation community in general and the M&S issues associated with the GIG in particular. We will conclude by proposing a set of recommendations about what DMSO and other agencies should do in response to the issues the paper raises.

Shaping the discussion

- How wargames, analysis, and exercises fit together
 - **What wargames can contribute to M&S and the GIG**
 - **Future directions**

At one time, games were an element of an analytical trinity referred to as **MS&G** (models, simulations, and games). No longer. DMSO has no “G” in its acronym. This is unfortunate, and it is time to fix it. We will argue that fixing it requires a recognition of both the unique aspects of gaming and the ways in which it binds together the elements of analysis, exercises, and real-world operations.

Wargame defined

- **The usual, vague, definition**
 - Any type of warfare modeling
 - Simulation, campaign and systems analysis, exercises
- **Definition from *The Art of Wargaming***

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

The term “wargame” suffers from being both overused and poorly understood. Look it up in a dictionary and you are as likely as not to find it spelled as two words—war game. Those dictionary definitions range from things like “a simulated battle or campaign to test military concepts. Conducted in conferences by officers acting as the opposing staffs” to “a two-sided umpired training maneuver with actual elements of the armed forces participating.” In common usage, it is applied to virtually anything that represents war but isn’t. A more restricted, and more useful, technical definition is shown above. [1]

(Much of the discussion in this section of the brief is adapted from [1], particularly pages 273–290.)

The key words

- **Wargaming is**

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

- **Key words**

- **Players**
- **Decisions**

The key words in this definition are *players* and *decisions*. Wargames are experiences in human behavior and interaction. Without human players, preferably competing with one another, you can't really have a wargame. (Let's not get sidetracked by arguments about one-sided or solitaire games. Even in such games the human players are competing against another human intelligence, even if only that of the designer of the solitaire system.) In a wargame, the human players find themselves operating in an artificial universe created by the game designers. Their decisions must take that universe into account, and the outcomes and interactions of their decisions alter fundamentally that universe and the situations they will encounter next. These changes usually take effect through the application of some sort of model, which reduces to manageable dimensions the universe and the ability of the players to affect it.

Analysis defined

- **Analysis is**

A scientific method of providing decision makers with a quantitative basis for decisions

- **Key words**

- **Scientific**

- **Quantitative**

Analysis (or operations research, or whatever other term you wish to use to describe what defense analysts do when they build and use models and simulations) is a subtly different beast. As defined by two of its pioneers, Morse and Kimball, it is “a scientific method of providing [decision makers] with a quantitative basis for decisions” [2]. The obvious key words here are *scientific* and *quantitative*. Despite the fact that the field of defense analysis has broadened to encompass operations analysis, systems analysis, engineering, policy assessment, and all sorts of arcane disciplines, its essentially scientific and quantitative core remains.

Exercises defined

- **An exercise is**

An activity involving the operation of actual military forces in a simulated environment

- **Key words**

- **Actual forces**

- **Simulated environment**

When we think about military exercises, we tend to envision forces in the field. Here the key words include an inherent tension. Actual forces (of some sort, even if primarily a headquarters staff) do real things (even if primarily moving electrons back and forth across a network), but they do those things in a simulated environment—at least, some important aspects of the environment, especially those related to combat, are simulated rather than real. When the Navy conducts an exercise at sea, the water and the sky are real enough, but the geopolitical and military environment on which the actions of the forces must be based are simulated.

Comparison



Analysis

Wargames

Exercises

Physical parameters and processes	Human decisions	Execution of decisions
Model, measure, and manipulate data	Qualitative assessments of why things happen	Training evolutions and evaluations of performance
Discard the irreproducible and unpredictable	Numbers are inputs, not outputs	Artificialities and restrictions

Wargames, analysis, and exercises are distinct, if related, approaches to studying military operations. The physical sciences are the paradigm of analysis. Most of the modeling and simulation done in support of such analyses focus on representing the physical parameters and processes of reality. Analysts approximate those real processes with mathematical models, take measurements to quantify the parameters of those models, and manipulate the models and the parameters to “solve” the problems posed by the real world. Unfortunately, the truth is that the supposedly strict objectivity emphasized in such a physics-based approach to understanding reality sometimes conceals the inherently subjective judgments involved in choices of models and parameters. Translating learning about the mathematics into learning about reality is the tricky part of analysis. To make things easier or “cleaner,” analysts frequently simplify or discard much that is not reproducible and predictable as they refine their methods and models. Very often, human behavior is one of the first things analysts discard or “factor out.”

Comparison



Analysis Wargames Exercises

Physical parameters and processes	Human decisions	Execution of decisions
Model, measure, and manipulate data	Qualitative assessments of why things happen	Training evolutions and evaluations of performance
Discard the irreproducible and unpredictable	Numbers are inputs, not outputs	Artificialities and restrictions

Wargames focus precisely on the human behavior that so many analysts find too messy to include in their mathematical models. As a result, wargames are not always good at producing quantitative outputs. One-off wargames are a single realization of a complex stochastic process and so provide limited quantitative data, particularly about overall outcomes. Usually the main value of a wargame lies in a qualitative assessment of why players make decisions. Physics must give way to history as the paradigm for exploiting the power of wargames. People and decisions are paramount, not physics and events. That is not to say that wargames do not use mathematical models and simulations. Indeed, as I said earlier, the universe that the game's players populate and change with their decisions is usually defined to some extent by the same sorts of mathematical models and systems as those used in traditional analysis. The fundamental difference lies in how the wargames use the models. Models and their outcomes are inputs to wargames, not outputs. The stochastic "roll of the dice" translates a player's decisions into altered states of the universe. These assessments and updates then form the new state of nature that the players encounter and in which they must continue to make decisions.

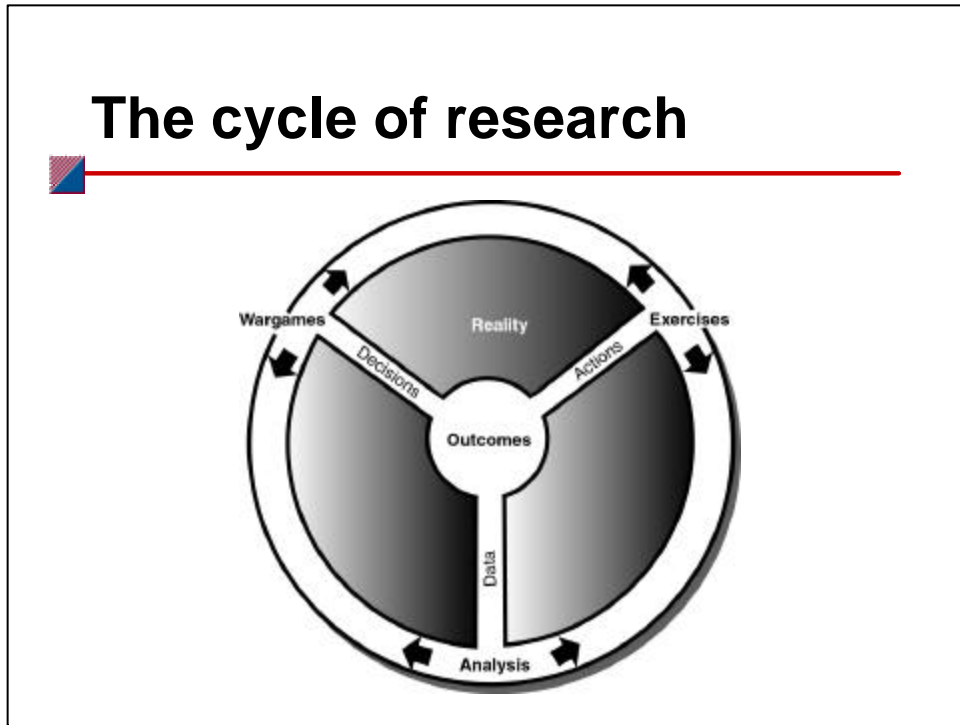
Comparison



Analysis	Wargames	Exercises
Physical parameters and processes	Human decisions	Execution of decisions
Model, measure, and manipulate data	Qualitative assessments of why things happen	Training evolutions and evaluations of performance
Discard the irreproducible and unpredictable	Numbers are inputs, not outputs	Artificialities and restrictions

Exercises focus on people and systems actually doing something. Commanders make decisions, to be sure, but often those decisions are constrained to meet requirements to test systems performance and train people in necessary skills. Even free-play exercises may be less “free” when safety requirements and geographic restrictions get in the way. There clearly can be much about the course of an exercise that can produce reliable information about real performance under physical conditions close to those in the real world of wartime operations. Indeed, using data derived from exercises to help refine and calibrate the models that are used in analysis and wargames is a valuable technique that can be employed to good effect—probably more often than it is. Yet it is also true that the artificialities and restrictions of exercises affect the interpretation of lessons in ways analogous to the familiar caveats about wargames and analyses. In order to focus on enabling the maximum training in executing orders and carrying out physical tasks, exercises must often restrict the range of physical parameters and processes they can allow and limit the potential decisions their participants can make. (An example is the “hard deck” limitations on maneuvering altitudes in Top Gun air-to-air combat exercises.) And of course, as is the case with wargames and analyses of all types, the actual outcomes of exercise combat actions must be approximated by some sort of artificial assessment process.

The cycle of research



Our comparison of analysis, wargames, and exercises highlights what each of these tools and techniques does best. Analysis deals with data and the integration of data to help build artificial representations of reality. Wargames focus on decisions that human beings make when confronted with choices about how to react and reshape their reality. Exercises give real forces and systems an opportunity to take real action to carry out real decisions in real ways. We use all of these tools and techniques to get a better understanding of what outcomes can result when postulated situations and actions occur in the real world. When taken together and combined with evidence pieced together from historical research and analysis or analytical reconstructions of events, these tools and techniques offers us the best route to increasing the depth and breadth of our understanding of the past and the accuracy and applicability of our speculations about the future. Woven together in a continuous *cycle of research*, analysis, wargames, and exercises each can contribute what it does best to our understanding of those realities. It is up to the communities of researchers, engineers, and operators to integrate and interpret the separate results in order to form a combined picture that all can share. It is time for the M&S community to welcome the “G” back into the analytical trinity. And it is time for the developers and builders of the GIG to reconsider the possible ways that wargames can contribute to an understanding of the GIG’s potentialities and to the GIG’s ability to provide valuable services to its users.

Shaping the discussion

- How wargames, analysis, and exercises fit together
- What wargames can contribute to M&S and the GIG
- **Future directions**

Ah, you say, but just what are those contributions? We'll answer this question in the next section of the paper.

Contributions of wargames

- Training and education
- Planning and assessment
- Research and experimentation—
game-based experimentation

Wargames have been used worldwide for thousands of years. The range of uses is wide, as you might expect from such a long history. These are the three primary classes of wargame use that apply specifically to DoD and to the GIG environment. I'll talk about each of these in turn. Together they can lay the foundation for expanding gaming into the M&S and GIG communities, and for connecting those communities to the operators. In particular, I will describe some of CNA's work in a field we call *game-based experimentation*. This is a term that may be unfamiliar to the DMSO and GIG communities, but the ideas behind it should be of great interest.

Training and education

The art of war is of vital importance to the State.

It is a matter of life and death, a road either to safety or to ruin.

Hence it is a subject of inquiry which can on no account be neglected.

From Sun Tzu, *The Art of War*

Let's start by talking about training and education. Thousands of years ago, even before the development of chess in India, the Chinese used the game of *Go* to introduce fundamental concepts of strategic thinking to the warrior class and nobility. In Sun Tzu's classic, *The Art of War*, the master points out certain critical facts about war. [3]

Training and education



Tu Yu quotes Wang Tzu as saying:
"Without constant practice, the officers will be nervous and undecided when mustering for battle; without constant practice, the general will be wavering and irresolute when the crisis is at hand."

From Sun Tzu, *The Art of War*

The critical importance of war to the state clearly demands that those entrusted with waging it on behalf of the state must know their business well. To do so, as master Wang Tzu is quoted as saying, they require constant practice.

Training and education

- “Constant practice” seldom available in real war and very costly when it is!
- Wargames are a cheap and readily available apparatus for training and exercising the mind of a commander
- Practice produces increased probability of victory

Wargaming can provide this kind of mission-critical “constant practice” at very low cost. War is an environment of intense selection pressure. Wargames have endured as part of military culture for all those thousands of years because they work. They enhance the probability of survival and victory because they give military leaders the opportunity to study and polish their skills by playing the games.

Training and education

- Wargaming and training research
 - Enhanced learner motivation
 - Improved retention of lessons
- Key is linking *skills*
- Can't just hand student the game
- Main contributions in *task* and, especially, *mission* proficiency

A few years ago, CNA conducted a study [4] about integrating wargaming into some of the courses at the Navy-Marine Corps Intelligence Training Center (NMITC). Our basic research indicated that there was only a limited amount of literature dealing scientifically with the effectiveness of gaming in training programs. What solid evidence did exist indicated that gaming could enhance learning through two primary mechanisms, increased motivation and improved retention. We studied the skills that the NMITC course's curriculum was designed to teach and compared them to the skills that some commercial computer wargames required their players to employ. We also built what we called a practical application (or PA) to help instructors and students integrate the use of the wargames into the curriculum in a structured manner. Our methodology defined the general process of skill acquisition in a series of levels. At the introductory, *task*, level of proficiency, the focus of training and performance is on developing and using individual skills, such as analyzing the trafficability of terrain. At the intermediate, *mission-proficiency*, level, the focus of attention shifts to developing and using the subset of skills that are critical to the success of the mission, such as conducting an intelligence preparation of the battlefield. At the advanced, *tactical-mastery*, level, the focus shifts to developing the concepts and advanced knowledge structures necessary to employ the full range of mission skills in a tactical environment. Our analysis showed that wargames can potentially contribute to the first two of these levels of performance. In particular, the contribution to the intermediate mission-proficiency level is a significant advantage of incorporating a wargame PA into a training curriculum.

Training and education

- To realize the GIG's promise of C2 advantage, users must develop skills
- Skill development requires practice
- Translating information advantage of GIG technology into operational advantage requires integrating technical and conceptual skills

The GIG holds out the promise of providing “the Warfighter with a new type of information advantage leading to a Command and Control (C2) advantage ...enabled by dramatic improvements in information sharing ... [which produce] dramatically improved shared situational awareness and knowledge” [5]. To realize this promise, the users of the GIG, particularly those operators at the sharp end of the spear, must develop their skills at using it even as its shape is evolving continually. The necessary skills must begin with mastery of the technical aspects of the GIG. But they cannot stop there. The warfighter must translate the information advantages provided by the technical components of the GIG into operational advantages. To do this, the warfighter must also develop conceptual skills at integrating the GIG and its information into the processes of planning, communicating, carrying out, and assessing the progress of military actions.

Training and education

- The 21st century information firehose is beyond past experience
- Wargame-based training provides *synthetic experience*
- The GIG must provide wargame services to develop that experience

Linear, sequential, and hierarchical modes of thought, problem solving, and sense-making were appropriate to the industrial age. All that is so over now. The 21st century warfighter will have to operate comfortably inside the nozzle of an information firehose, learning to monitor multiple data streams, creating knowledge and meaning out of the information flow, continuously switching contexts and perspectives, and communicating both laterally and vertically through the command network. Wargames help players to learn instinctively how to plan-operate-evaluate in a simultaneous rather than sequential mode because the players (who usually have minimal staff support) live in a time-compressed universe. As CNA's research has shown, wargames can play an important part in developing the basic task and mission skills necessary to transform the theoretical advantage of the GIG into a real one. Wargames can provide learners with synthetic experience—the sort of experience most effective at learning and practicing complex tasks. (See [1] for a more detailed discussion of synthetic experience and wargames.) And because the tasks themselves are so bound up with the GIG, the best training and education should be delivered across the GIG itself. This makes it imperative that wargames be included as one of the **MS&G** (not merely M&S) services provided across the GIG.

Planning and assessment

- Prominence after Prussian/German victories in 1860s and 1870s
- World Wars I and II saw explosive growth in the use of wargames for planning and assessing the course of operations

Now let's move on to a discussion of planning and assessment. Over the centuries, wargames developed from devices useful almost exclusively for training and education into devices that could play an important role in operational planning and assessment. After the Prussian General Staff used wargames to help develop the plans that allowed them to defeat with ease the Austrians in 1866 and the French in 1870, wargames became fashionable in all Western nations as a tool to explore the implications of their mobilization and operations plans. (See [1] for a brief history of wargames.) Before World War I the U.S. Naval War College began its long history of integrating wargames into its educational and research processes. Similar practices took place before and during World War II. I won't try to describe these gaming activities in detail here, but I will give you a few extracts from historical works to show the range of wargaming activities involved.

Planning and assessment

In 1902, ... the United States had, thanks to Theodore Roosevelt, more tonnage under construction than any other country except Britain. However, Germany had more warships in commission, especially in the Atlantic, at twelve battleships to eight ... but in November 1902 Germany enjoyed an advantage in aggregate fighting mass of about 50 per cent.

For two years, tacticians at the Naval War College had been trying to combat this advantage in war games played on oceans of floor-sized charts. ... The results were not encouraging. In almost every engagement BLACK prevailed, the sheer range and accuracy of its fire combining to scatter BLUE all over the gaming floor. In Germany, meanwhile, tacticians concluded that their navy could seize key harbors in any Caribbean confrontation.

A MATTER OF EXTREME URGENCY

Theodore Roosevelt, Wilhelm II, and the Venezuela Crisis of 1902

At the dawn of the 20th century, the Western powers were locked in a naval arms race of unprecedented cost and scale. By 1902, the United States Navy, always a stepchild in the American military system, trailed the British, French, and Russian navies in size and strength; however, Theodore Roosevelt's ambitious building program actually placed the USN ahead of Germany when counting battleships on the ways. A diplomatic crisis in the Caribbean turned calculations of comparative naval strength into more than an academic exercise. (See [6] for the full text of the article from which this extract is taken.) Fortunately, the war with the Germans never came. At least not in 1902.

Planning and assessment

[As] the storm clouds of 1914 gathered, the Russian General Staff played a game to test their plans for mobilization against the Germans and the initial attacks into East Prussia.

The Russian plan envisioned an attack by two armies, one moving to the north of the Masurian Lakes and the other to the south. ... The games were played to test this plan and their course revealed a serious weakness in it. Because of the separation between the two armies, forced on the Russians by the geography of the region, the timing of the advance was crucial. Should one army begin its attack too late, the other would be exposed to a concentrated German counterattack. The games indicated that to avoid decisive defeat the Russian Second Army would have to begin its march three days before the advance of [the] First Army. ... This change ... was never made in the plans or their execution.

German games dealing with the same situation identified the same potential problem ... but the Germans took the lesson to heart.

From The Art of Wargaming

By 1914, the general staffs of all the European powers had analyzed and gamed their mobilization plans intently. These games influenced the decision to make fundamental changes to the British policy of involvement on the Continent, and led to the first pre-war integrated planning between the British and French militaries. In the east, the Russian General Staff also used wargames to explore their operational options for striking at Germany. (See [1] for more details.)

Planning and assessment



2 November 1944 wargame at HQ, 5th Panzer Armee

On this occasion the staff ... was supposed to rehearse the defense measures against a possible American attack against the boundary between Fifth and Seventh Armies. ... The map exercise had hardly begun when a report was received that according to all appearances a fairly strong American attack had been launched ... Feldmarschall Model ordered ... [most of the players] to continue the game and use the currently received front reports as additional information for the course of the game.

During the next few hours the situation at the front—and similarly in the map exercise—became so critical that the army group reserve (116th Panzer Division) had to be placed at the disposal of the threatened army. The division commander ... who was present in the room and engaged in the game, received his orders ... and was able to issue actual operational orders to his operations officer.

Rudolf Hoffmann, *WarGames*, OCMH, 1952 [7]

This story is set in the latter days of World War II. It is taken from the translation of a paper prepared for the U.S. Army by German officers following the war. For more on the German attitudes towards and use of wargames in the 1930s and 1940s, see [1].

Planning and assessment

This is not (exactly) the enemy we wargamed against.

Lt Gen William Scott Wallace
Commanding General, V Corps
Operation Iraqi Freedom

War gaming played an integral part in the planning of Operation Iraqi Freedom. Wargames helped coalition forces understand Iraqi plans for delaying their advance by forming irregular units to fight in crossroad town and cities. These wargames then helped the Army develop a counter strategy—maneuvering to the West and bypassing cities. However, their wargames also misled. They had not anticipated that the Iraqis would adapt to coalition maneuvers and attack from the cities. This was the main stimulus for General Wallace's remark. Wargames also depicted the Iraqis as continuing to fight after the fall of Baghdad. Hence, when major combat ended, the deployment pipeline contained heavy combat units, instead of units more useful for an occupation.

Col Matthew B. Caffrey
Red Flag For Joint Campaigns

More recently, the U.S. Army used some sort of wargaming in preparation for Operation Iraqi Freedom. This quotation of Lieutenant General Wallace is taken from an article appearing in the April 2004 edition of the Air Force's online journal, *Air & Space Power Chronicles* [8]. The text is from the article itself.

Planning and assessment

- “Wargaming” is a step in the process to develop a commander’s estimate of the situation (CES)
- Usually this is a bogsat (*bunch of guys sitting around the table*)
- Using the GIG can remove a major impediment to operational games

CNA recently completed a study for the Naval War College’s Wargaming Department dealing with the potential operational use of wargames in the context of the Global War on Terrorism (GWOT) [9]. This study explored a concept for an embedded wargaming capability to allow deployed units to explore effects-based operations for GWOT-related missions in the context of the Commander’s Estimate of the Situation (CES). There is a step in the CES process that explicitly calls for the commander and staff to “wargame” various options to learn the strengths and weaknesses of each. Typically such explorations are relatively informal discussions among the staff; they are seldom supported by formal gaming elements or M&S techniques. One difficulty of implementing a wargaming system onboard ship is the overhead associated with teaching commanders and staffs to use a special-purpose, and infrequently used, system. If, however, the wargame capability were to be embedded into the systems the staff used on a daily basis, it would be far more likely to be useful to the staff, and so to be used by them directly or in conjunction with reachback support. The GIG can enable such an embedded capability—but only if the GIG and its M&S COI include gaming as a distinct service, not merely as an afterthought or a sidelight to more traditional M&S concepts.

Research and experimentation

- Naval War College use of wargaming in the 1920s and 30s
- Wargames evolved into “simulations” after the war
- Recent developments in game-based experimentation and agent-based techniques hold promise

Not only have wargames long contributed training and operations support, but also they have had a long history of use in support of military research of one stripe or another. Returning again to the historical experience of the U.S. Naval War College, wargames played a central role in the evolution of much of the Navy’s doctrine and procedures, particularly between the world wars. As stated in [1], “Based on the insights afforded by strategic gaming, the navy began to explore the requirements for a measured, step-wise offensive campaign to span the Pacific, requirements not just for the navy, but for the entire national political and military apparatus.” The result was a reshaping of the entire planning process for World War II in the Pacific.

After the war, the practical military men who had dominated the use of wargames as tools for research and planning gave way to civilian theoreticians. These operations researchers, who were predominantly physical scientists, were uncomfortable with the messy representations of human behavior in wargames. As a result, they created increasingly complex computer simulations that purported to represent the “true essence of warfare” —as if that essence were to be found in machines and not men.

Recent developments in agent-based techniques and game-based experimentation offer the promise of restoring a better balance among the modeling paradigms. As in the previous section, a few stories will give you a sense of these developments.

Research and experimentation

Advocates of a revolution in naval warfare required ways to determine whether the rapid advances in aviation would enable them to realize their vision. They also needed a means for developing the ... resources necessary to sustain future operational concepts. The answer to this challenge was found in the interrelationship between the Naval War College, the newly created Bureau of Aeronautics and fleet exercises —the “Naval Trinity.”

Wargaming undertaken at the Naval War College represented the first critical element in the trinity. In 1919, Sims, now the college’s president, established procedures designed to facilitate a systematic and rigorous examination of how air power might influence war at sea, providing important insights for theorists, planners and practitioners. The games and simulations exerted strong influence on Navy decisions. Most important, they inspired efforts to enhance naval air power by maximizing the number of aircraft on carriers and compressing the cycle for launching and recovering planes.

Andrew Krepinevich
*Transforming to Victory: The U.S. Navy, Carrier
Aviation, and Preparing for War in the Pacific*

The Naval War College played a central role in the Navy’s research on the use and effects of aircraft carriers. As early as 1919, Admiral Sims, hero of World War I and then-president of the Naval War College, used the resources in Newport to drive the Navy toward an increased and broadened appreciation of the revolutionary role that naval aviation would play in the future. Indeed, the wargames addressed the applicability of one of the very first models of military operations analysis, the Lanchester Laws. Indeed, footnote 14 to Krepinevich’s paper quoted above [10], points this out clearly:

The wargames also demonstrated that Lanchester’s “n squared” law — which sought to replicate the attrition that occurs when two enemy battle lines are engaged — did not apply to carrier air strikes, which are delivered as a “pulse” of combat power, as opposed to a “stream.”

Research and experimentation



We call it the Naval War College, but in reality this institution is more of a laboratory than a college. Here we study only enough to learn the sound principles on which successful warfare is based, the greater part of the time being devoted to actual operations and experiments carried out in chart maneuvers or on the game board. It is through such war games, conducted in miniature, that we can see the whole picture, that the student learns how to apply to actual war situations the principles he has learned through this study.

Rear Admiral Harris Laning
Address to the staff and classes of the Naval War College, 1931

In the early 1930s, Admiral Harris Laning became the president of the Naval War College and increased the quantitative emphasis of the research that used wargames. Admiral Laning “created a department for statistical studies to compile and summarize the available data on weapon effectiveness and the operations of different types of ships as well as aircraft and submarines. ... The end result of such fascination with purportedly hard data was an extremely detailed system of damage assessment” [1]. In his address to the staff and students in 1931 Admiral Laning described the NWC as laboratory, one in which the Navy learned about war at sea and the students learned how to fight it. (This information is taken from [11], as quoted in [12].)

Research and experimentation



[Wargames] conducted at the Naval War College in the early 1920s indicated the importance of maximizing the aircraft complements and sortie rates of carriers. It was not, however, until a prototype, the USS Langley (CV 1), was available that the Navy could determine precisely how this goal was to be achieved.

In 1930 the Navy's Bureau of Aeronautics proposed the construction of eight ten-thousand-ton flying-deck cruisers. The ships-half cruiser and half flight deck-were subjected to war game experiments at the Naval War College and to some experiments with surrogates in the fleet. The results painted a distinctly unfavorable picture of the hybrid ship, and it sank beneath the Navy's programmatic waves, never to be heard from again.

Andrew Krepinevich

MILITARY EXPERIMENTATION: Time to Get Serious

Throughout the 1920s and 1930s, the Navy conducted a series of Fleet Problems, massive at-sea exercises usually involving the majority of the fleet's major units. These Fleet Problems were, in some ways, real-life extensions of the Newport wargames. They helped the Navy's leadership assess whether the insights gained from the Newport games had practical real-world application. According to [13]:

Following Fleet Problem IX [in 1929] Admiral Pratt observed, 'I believe that when we learn more of the possibilities of the carrier we will come to an acceptance of Admiral Reeves' plan which provides for a very powerful and mobile force . . . the nucleus of which is the carrier.' The following year, upon becoming Chief of Naval Operations, Pratt directed that carriers be placed in offensive roles in war games and fleet exercises.

The resulting experiments, such as those described above, altered fundamentally the way the Navy thought about war at sea.

Research and experimentation



The process of rationalization and dehumanization reached its apogee with the arrival of Robert McNamara as secretary of defense at the beginning of the Kennedy administration. McNamara brought to Washington a new breed of civilian “whiz kids,” who preached the doctrine of operations research, systems analysis, and cost-benefits tradeoffs. This new theology buried wargaming beneath a deluge of mathematical analyses and computer simulations. For the systems analysts, buying the right systems required a detailed understanding of the technical nuances of physics and economics, and exploiting new technology, especially to save money, became more important than understanding the nature of war.

The Art of Wargaming

After the war, the heavily physics-based and mathematically driven techniques of operations research and systems analysis gradually overshadowed the “old-fashioned” techniques of wargames. (See [1].) This was a disaster for wargaming, and for the process of using wargaming to understand the nature of war, precisely because the computer (a magical black box, attended by a “priesthood” of programmers and engineers) replaced the open game table (or gaming floor) where all the models and assumptions were explicit and visible—and as a result easy to challenge and change.

Research and experimentation

Complexity theory recognizes that reducing or tearing apart a nonlinear system into its component parts to enable analysis will not work, for the very act of separating the system into lesser elements causes the overall system to lose coherence and meaning. A nonlinear system is not a sum of its parts, but truly more than that sum. Therefore, it must be examined holistically. Clausewitz understood this when he wrote that “in war more than in any other subject we must begin by looking at the nature of the whole, for here more than elsewhere the part and the whole must always be thought of together.” War is not subject to the methods of systems analyses, yet these and other tools of Newtonian physics were the only ones available until Dr. Ilachinski gave us the means to study war as Clausewitz urged.

Paul K. Van Riper, LtGen, USMC (Ret.)
In his Foreword to *Artificial War*, by Andrew Ilachinski

For the past 45 years, those techniques have dominated the formalisms of military analysis and modeling and simulation in the United States and elsewhere. Only recently has a new wave of thinking begun in the broader community of analysts and operators. One leader in applying the techniques of complexity theory to studying war as a nonlinear system is Dr. Andrew Ilachinski. His research, some of which is documented in [14 and 15], was supported early on by now-retired Marine Corps Lieutenant General Paul Van Riper.

Game-based experimentation

- **Classes of experimentation**
- **Classes of games**
- **Linking games and experiments**

But first . . .

- **The *SCUDHunt* example**

Nearly coincident with Ilachinski's development of his techniques for applying nonlinear systems to the study of warfare, CNA was also beginning to articulate the basics of what we came to call *game-based experimentation*. The terminology may be newly coined, but the concept is an old one. Game-based experimentation is the same technique that proved so valuable to the Navy prior to WWII. Recall that games in general, and wargames in particular, focus on the decisionmaking processes of human players, even though they can also provide insights on other matters (as we saw with the Navy games described earlier). Games can be tailor-made to explore specific kinds of decisions under specific sets of assumptions. As such, games can be laboratories or, at the very least, laboratory equipment—test tubes and beakers, as it were—for conducting experiments designed to study human decision processes. Pursuing this line of discussion, I will describe briefly the way we think about different classes of experimentation. I will then describe a taxonomy of games that is useful to consider in discussing game-based experimentation.

Before launching into theoretical discussions, however, I want to set the stage by describing a tangible example of what I mean: the game of *SCUDHunt*, which CNA designed and which ThoughtLink, Inc., a small contractor, programmed into a web-based system. I will also describe a set of experiments we conducted using that game. I will focus on a specific experiment that CNA and ThoughtLink conducted in partnership with the Naval War College. The synergy involved in this effort is the germ of an idea I will propose at the end of this paper.

SCUDHunt

- Distillation game of C2 and teamwork
- Players control ISR assets
- Collaborate and share information to find SCUDs



We designed *SCUDHunt* to help us study shared awareness, command and control, and teamwork. In our experiments, teams of four play the game over the Internet in a synchronous but usually distributed mode. *SCUDHunt* is similar to the classic game *Battleship*. Rather than two players hiding and searching for their opponent's ships, however, *SCUDHunt* players comprise a single team. Working cooperatively, they have a specified number of moves to determine where three SCUD launchers are hidden on a 5 X 5 grid. The game conceals the launchers randomly on the grid at the start of each game, and the launchers stay where they are throughout game play. (See [16] for an overview of the game and its uses.)

The game's operational back-story casts the players in the role of a joint or combined force whose objective is to locate the SCUD launchers, hidden in the hostile country of Korona, represented by the grid of squares. Each player controls one or more information, surveillance, and reconnaissance (ISR) asset, with different capabilities and different SCUD-detection probabilities. These probabilities are described in a general way to players in briefings they receive before the game begins. During play, players must collaborate and share information to build a picture of where the SCUD launchers may be hidden. The mode of communication, the type of visualization tools for displaying information, and the detection probabilities (and false-alarm probabilities) of the ISR assets may vary with the experimental conditions.

***SCUD*Hunt player positions**

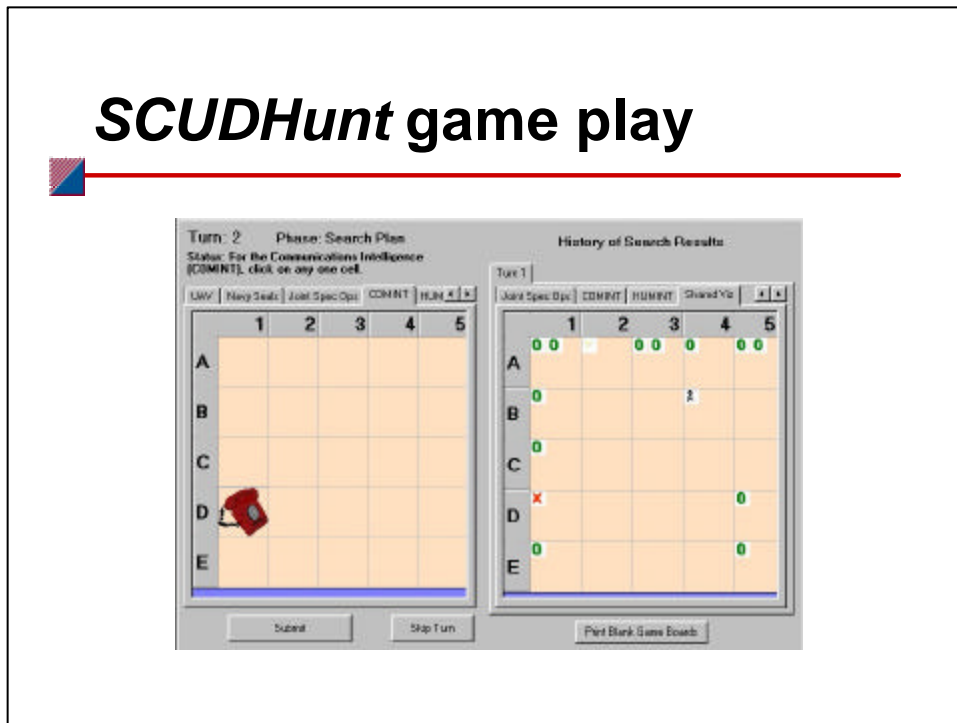
- Space Asset Manager
- Intelligence Manager
- Air Asset Manager
- SpecOps Manager

The player positions and the assets they control are as follows:

- Space Asset Manager: controls a reconnaissance satellite
- Intelligence Manager: controls communications intelligence (COMINT) and human intelligence (HUMINT)
- Air Asset Manager: controls a manned aircraft and an unmanned air vehicle (UAV)
- SpecOps Manager: controls special operations forces (a Navy SEAL team and a Joint Special Operations team).

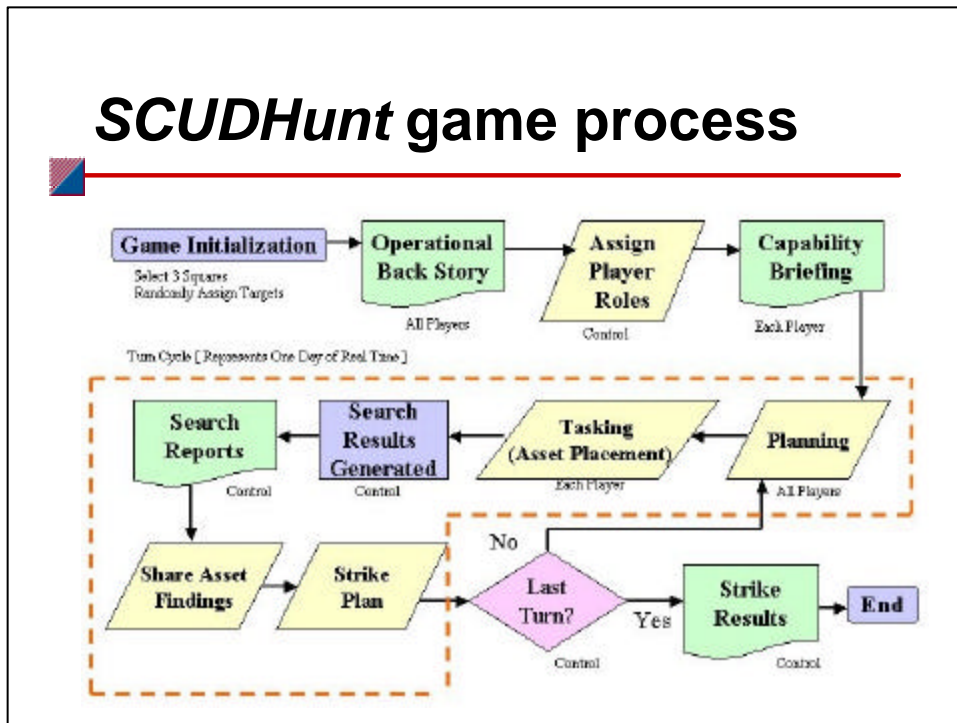
Each of the ISR assets searches different sizes and shapes of regions on the grid during each move. For example, the reconnaissance satellite can search every square in any one column, while the unmanned aircraft can search only one of the four outside edges (two columns and two rows) of the grid.

SCUDHunt game play



To play the game, each player must position his available assets to search particular grid squares. Here, on the left-hand side of the display, we see the COMINT asset placed to search square D1. After all players have placed their assets for the move, the game returns the results for each individual asset. Results are only available directly to the owner of the asset. The results take the form of symbols representing no evidence of a SCUD in the square, possible evidence, or strong evidence. There is also a possibility that some of the search assets (such as the UAV or the SEAL team) may be detected and destroyed by the Koronan defense forces. These results are shown on the right-hand side of the display. In addition, as shown in this image, all the players may receive a shared visualization of all the results. This shared visualization may take different forms. As they attempt to build a shared picture of where the SCUDs are, the players can use various forms of communications and shared visualization tools to share their findings and their interpretations of the results. The essence of the game is that the players receive incomplete, inconsistent, and partly unreliable information about the “ground truth” situation. They must construct an operational “plan” on the basis of their interpretation of this “all-source” intelligence, using pattern recognition, hypothesis building, or other techniques.

SCUDHunt game process



Most of the *SCUDHunt* games we have run incorporate some form of communication among the players, allowing them to share the results of their searches (although we have conducted games in which such communication was prohibited). Different *SCUDHunt* experiments have used Internet-enabled text chat, group teleconferences, and shared visualization tools.

After team members have compiled their own mental model, or picture, of the situation, we require them to report individually their best guess of where the SCUD launchers are located, nominating a minimum of three squares. We set no upper limit on the number of squares they are allowed to nominate, but we ask them to identify the fewest number of squares that would still represent their beliefs about the locations of the SCUDs. We use these “individual strike recommendations” to compute a shared situational awareness score for the team in order to measure the overlap in their perceptions. We also compute the accuracy of their estimates of the SCUD locations. The typical game has lasted for five turns (although this has varied from experiment to experiment).

***SCUD*Hunt and C2 research**

- Created for DARPA SSA project
- Also used by/for
 - George Mason University for Army Research Institute
 - Joint C4ISR Decision Support Center
 - University of Arizona
 - Naval War College

We originally designed *SCUD*Hunt as an experimental test bed for research on shared situational awareness (SSA). (See [17].) We designed the game to minimize any effects of game-playing skill not associated with the ability of the individual players and the team as a whole to develop an accurate shared picture of the information contained on the gameboard. The sponsor for the initial research was the Defense Advanced Research Projects Agency under the program entitled Wargaming the Asymmetric Environment. Our original experiment used a Latin square design to see how different modes of communication and visualization affect a distributed team's SSA. In addition to producing data amenable to statistical analysis and some interesting statistically significant results, the experiment saved time and money when compared to traditional analytical approaches that involve repeated measures using many simulations and experimental subjects. Since that original work in 2000, CNA, ThoughtLink, and other organizations listed above have conducted a number of further experiments to explore distinct concepts of information superiority, training, and leadership. One of those additional experiments involved CNA, ThoughtLink, and the Naval War College.

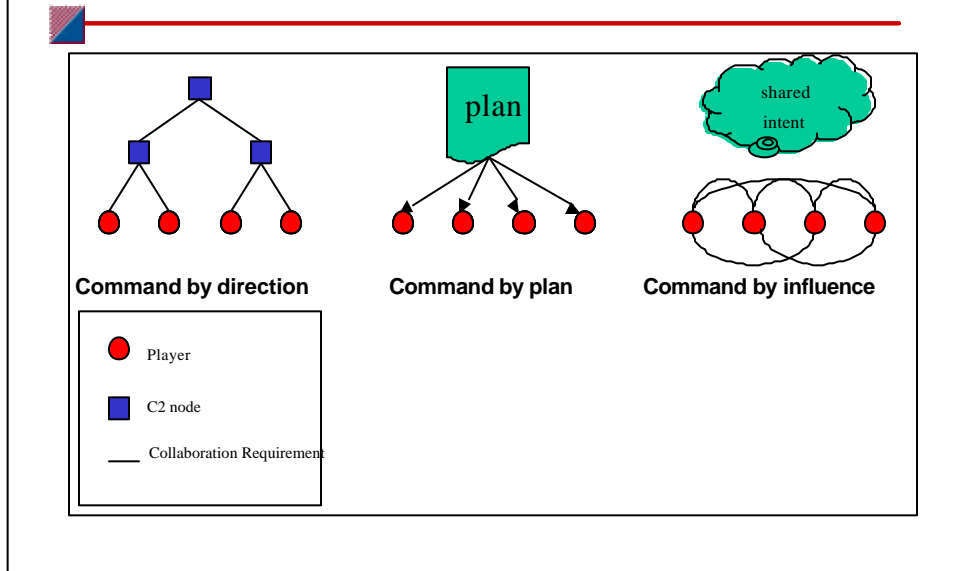
NWC *SCUD*Hunt experiment

- Players from NWC, Naval Academy, Air Force Academy
- Focus on command and visualization
- Six-treatment Latin Square experimental design

In the Spring of 2002, the Naval War College conducted a *SCUD*Hunt experiment with analytical support from CNA and technical support from ThoughtLink. Players for the game came from the student bodies (with some staff augmentation) of the Naval War College, the U.S. Naval Academy, and the U.S. Air Force Academy. (For details, see [18].)

This experiment concerned effects of command method and visualization type on developing a team's SSA and accuracy scores. We investigated three styles of command method: command by direction, command by influence, and command by plan. We also considered two types of visualization techniques: a "shared visualization" in which players simply placed their raw information on a shared display for others to see; and what the War College called "post-visualization," in which players evaluated the quality of their beliefs based on the raw information they had received, and shared those evaluations. We paired each visualization technique with each command structure to define six experimental conditions, or treatments. Once again we employed a Latin Square experimental design, with six four-person teams who played the game under each of the six experimental conditions.

NWC SCUDHunt experiment



Using command by direction, a fifth player, a commander, gave specific orders to each of the four sensor players, directing them where to place their assets each turn. This approach was an example of how an overall commander might attempt to *prioritize uncertainty*.

Using command by plan, the control group, acting as a higher command authority, promulgated an overall plan with branches and options for how the sensor players were to conduct their searches, but left the players with some flexibility in how they would implement the plan. This approach was an example of how an overall commander might attempt to *centralize uncertainty*.

Using command by influence, the control group defined the overall mission—in simplest terms, to find the SCUD launchers—and the players were free to coordinate among themselves about how best to carry out that mission. This command style was essentially the same basic free-play approach used in the DARPA experiment. This approach was an example of how an overall commander might attempt to *distribute uncertainty*. [18 and 19]

For access to [19] and related information, we suggest that you contact the Wargaming Department of the U.S. Naval War College at:

<http://wgd.nwc.navy.mil/>

Some quantitative results

- There is evidence that command-by-direction was superior ($p=.06$ for SSA, $.006$ for accuracy)
- Evidence of training effects ($p=.018$)
- No conclusions concerning visualization

Analysis of the data from the experiment indicated a statistically significant improvement in both SSA and accuracy scores of teams employing a command-by-direction style when compared to the same teams playing under command-by-influence or command-by-plan styles. At the same time, there was some indication that end-game SSA scores were correlated to the number of games played ($p = 0.018$). In this experiment, the average scores for the first three games of a team's set of six—no matter what other variables were altered—were statistically lower than those for their last three games. Because of some problems with the execution of the experiment, we were unable to conduct valid comparisons of visualization techniques. (The experiment and its results are documented in [18, 19, and 20].)

Some qualitative results

- Players tended to prefer their own sensors and ignored information (even confirmations) from others
- Players tended to recreate raw sensor data rather than their interpretations in the push-viz
- False negatives more difficult to interpret than false positives

On a qualitative level, our observations of the play of the experiment's games showed that players tended to rely on the information provided by their own sensors and downplayed the value of those sensors controlled by other players. This was the case even when those other sensors confirmed results that a player's own sensor had already obtained. We also noticed that players had some problems adapting to the idea of posting information based on their interpretation of sensor inputs. Rather than providing the rest of the team with their overall assessments of the likelihood that a square contained a SCUD, players tended simply to post their actual sensor reports. Finally, our observations indicated that when sensor reports were in error, false negative reports (reports that there was no evidence of a SCUD in the square when in fact one was present) proved much more difficult for players to identify and correct for than false positives (reports of a likely SCUD when none was actually present) [20]. All of these results have some interesting implications for the design of various elements and processes of the GIG.

Some collaboration results

- Military Academies can provide a pool of human subjects for research in the effects of human factors on C2 and other topics
- Government (NWC), FFRDC (CNA), industry (ThoughtLink) collaborate to improve wargaming experimentation

From an organizational perspective, this project was an object lesson in collaboration. The experiment required six teams of four players each, for a total of 24 players. It is not easy to find two dozen persons with appropriate backgrounds who are both willing and able to participate in multiple scheduled game sessions, even when each session is no more than an hour or two long. To obtain the requisite number of players, the NWC opened discussions with the research faculty at the military academies to develop areas for shared research. The result was a high degree of cooperation and the successful recruitment of the number of players we needed to run the experiment. Also, by involving the academies and their faculty, the experiment was able to engage the broader military educational community through supporting their requirements for joint professional military education.

This project was also an example of a successful collaboration between the government, a federally funded research and development center (FFRDC), and private industry, all focused on advancing the state of the art for using wargames as a basis for experimentation.

Goals of experimentation

- Explore new ideas or phenomena
- Test hypotheses
- Demonstrate new concepts and their feasibility

Indeed, one result of our work on the project with the NWC and ThoughtLink was a better articulation of the basic ideas of the concept we call *game-based experimentation*. I don't want to launch into a long discourse on the philosophy of science and experimentation; we will only briefly discuss this notion of experimentation so we can explain our thoughts about the role and value of gaming in that context.

There are lots of ways of thinking about experimentation and experiments. The way I find most useful for our purposes distinguishes three goals of experimentation as listed above. As described in [18]

The range of complexity and scope of coverage available through the use of games provide a wealth of flexibility for exploring, testing, and demonstrating a host of variables and issues associated with decisionmaking. Traditionally, gaming—wargaming in particular—has been associated with historical approaches to analysis more than with scientific ones. Traditional wargames helped to explore new ideas or demonstrate new concepts. A single iteration of a complex, multiplayer, large-scale operational wargame is expensive in time and money to produce, and virtually impossible to replicate. Such games seemed poorly adapted as vehicles for scientific experimentation, for hypothesis testing and “scientific proof.”

Our *SCUDHunt* game and experiments have demonstrated the potential for using a somewhat different sort of gaming environment to formulate and test hypotheses using rigorous scientific and statistical techniques.

Classes of games

- Abstractions
- Distillations
- Simulations

SCUDHunt may be a wargame—but certainly not in the same sense that the Navy’s Global War Games of the 1980s and 1990s are wargames. *SCUDHunt* and Global lie along a spectrum of game types or classes. For our purposes, we will identify three primary breakpoints along that spectrum, as listed above.

Classes of games

- Abstractions: *Chess, Go, Stratego*
- Distillations
- Simulations

We characterize abstractions as pure strategy or decision games. They are usually based on geometrical and conceptual environments or on highly stylized representations of the real world. The decisions the players make are also usually highly abstracted when compared to real-world decisions. The usual examples of abstract games include the classic games of chess and *Go*. A more representational sort of game, one that moves a little way along the continuum from the realm of abstraction to that of distillation, is a popular commercial game, Hasbro's *Stratego*.

Classes of games

- Abstractions: *Chess, Go, Stratego*
- Distillations: *SCUDHunt, Axis and Allies*
- Simulations

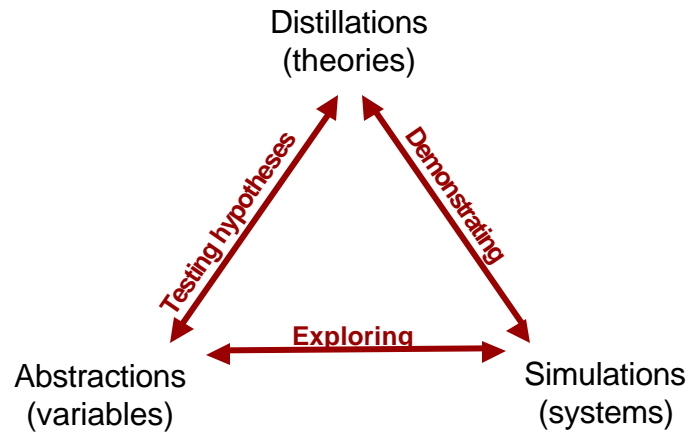
When we talk about games as distillations, we are using terminology sometimes associated with agent-based approaches to studying combat, such as *ISAAC* and *EINSTEIN* [14 and 15]. When we classify games as distillations, we mean games that reduce real-world problems and entities into simplified representations that focus on only a few prominent elements of that real-world environment. (Of course, all wargames do that, so the concept is admittedly squishy.) You can distinguish a distillation from an abstraction because a distillation uses real-world language and concepts to describe situations, actions, and outcomes in the game. *SCUDHunt* is a good example of a distillation game. The actions of the players, the scenario, the available systems, and the results are all easily expressed and understood, as if the game were the real world. Many commercial games have military themes and target a mass market. Such games must have relatively simple rules (to be playable by a diverse audience), and so they can be classed as distillations. One good example of such a commercial distillation game is the Hasbro/Avalon Hill Company's boardgame *Axis and Allies*.

Classes of games

- Abstractions: *Chess, Go, Stratego*
- Distillations: *SCUDHunt, Axis and Allies*
- Simulations: *JANUS, OneSAF*

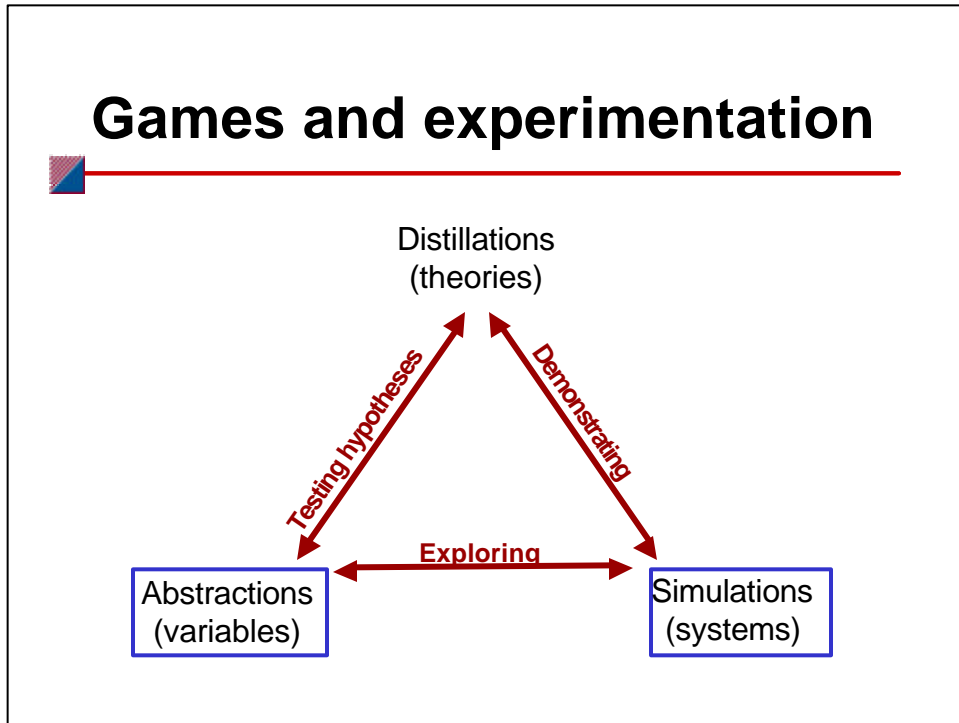
It is much harder to draw a clean line between distillations and simulations, where the difference is more of degree. Simulations are at the upper end of the game spectrum. Like distillations, they are reductions of the real world; however, they reduce reality to a much more detailed model. Simulations endow their models with far more, and more richly represented, characteristics of their real-world counterparts than do distillations. Simulations also tend to represent more intangible elements of actual operations, such as information flow, command-and-control restrictions, operational decision-making, and logistical constraints and effects. They tend to be more quantitatively based and mathematically modeled than other forms of games. Traditional DoD systems such as *JANUS* and *OneSAF* are at the upper level of simulations. Commercial and crossover board wargames and computer wargames such as Avalon Hill/Multiman Publishing's *Advanced Squad Leader*, Panther Games/Matrix Games' *Highway to the Reich*, and BreakAway Games Ltd.'s *NetStrike* are readily regarded as simulations when compared to simpler games, but their degree and extent of detail are at least an order of magnitude less than that of the huge DoD simulations.

Games and experimentation



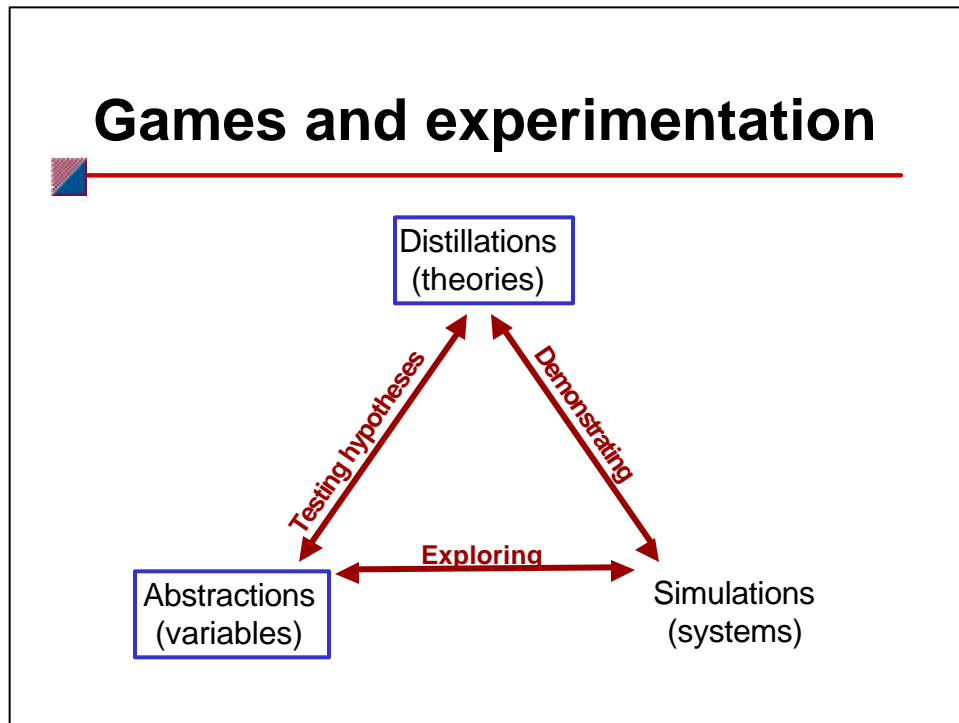
As is the case with any attempt to quantize a continuum, classifying games as abstractions, distillations, or simulations glosses over the fact that most games share elements of at least two of these classes. Our three classes clearly flow into one another. As a result, though each class may be more useful than the others for specific types of experimentation, there are some strong overlaps, particularly if you look at the adjacent pairs of types in the display shown here.

Games and experimentation



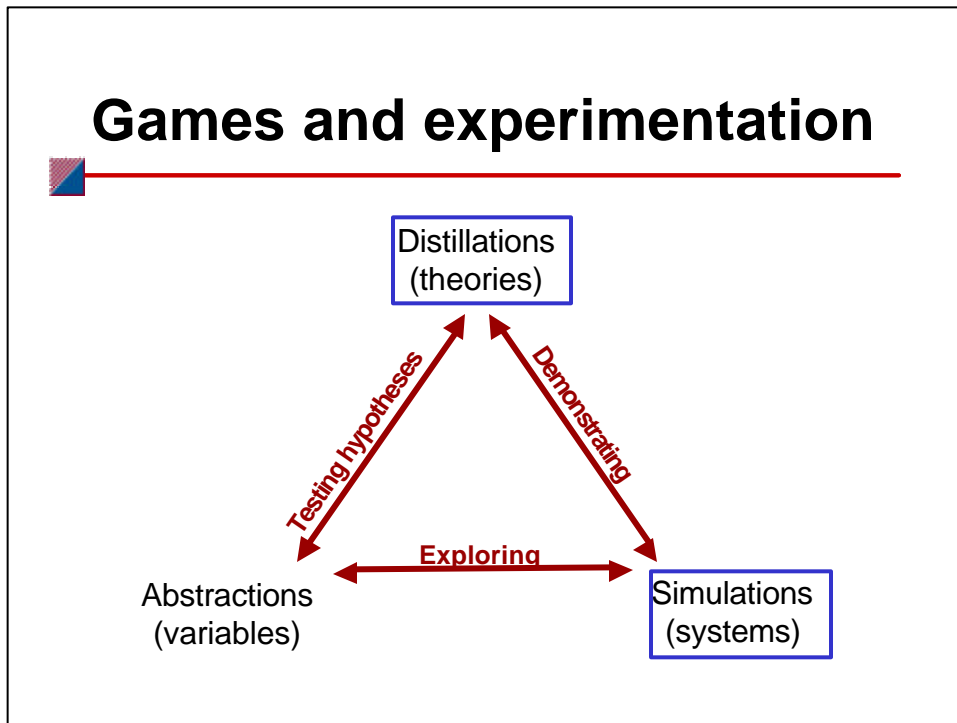
Despite being at opposite extremes of the gaming continuum, abstractions and simulations are both useful for “exploring” type of experiments. Abstractions can help you explore the existence and relative importance of fundamental variables and their relationships as you begin to articulate basic principles. Simulations can help you explore how well physical systems or other practical implementations of theory may actually work in the real world, and can lead you to develop new ideas to explore. We have already seen how the wargames played at the Naval War College during the 1920s and 1930s grew into detailed simulations that helped the Navy explore many of the operational and support concepts that proved critical during World War II.

Games and experimentation



Abstractions and distillations are useful for testing hypotheses. Abstractions work best to test hypotheses about fundamental variables. Distillations, on the other hand, can be applied usefully to test theories about *relationships* among those fundamental variables. Recall that CNA's experiment with *SCUDHunt* for the Naval War College studied how the ability of teams to create shared situational awareness (SSA) can be affected by variables such as their C2 structures, their modes of communication, and their techniques for sharing their visualization of the operating environment [18]. This experiment—and other research using *SCUDHunt* and related test beds—both explored variables and tested theories.

Games and experimentation



Finally, distillations and simulations can be very useful for demonstrating relationships and concepts derived from theory or invented from whole cloth. In the military environment, simulations in the form of wargames or field exercises have played a major role in such demonstrations for decades. (We saw this earlier, in the case of the fleet battle problems carried out by the U.S. Navy during the period between World Wars I and II.) The use of the SIMNET system to “recreate” the actions at 73 Easting during Operation Desert Storm is a more recent example [21]. CNA’s project for NMITC, which I described earlier in this paper, demonstrated how instructors can use a commercial computer wargame to demonstrate the effects and relationships between intelligence preparation of the battlefield and subsequent tactical operations over that battlefield. Such a wargame provides a useful practicum to supplement standard classroom lectures and case studies [4].

Wargames and DMSO vision

Defense modeling and simulation will provide readily available, operationally valid environments for use by DoD components:

- To train jointly, develop doctrine and tactics, formulate operational plans, and assess war fighting situations
- To support technology assessment, system upgrade, prototype and full scale development, and force structuring

From <https://www.dms0.mil/public/vision>

In the preceding discussion, I argued that wargames can play an important and varied role in support of the GIG and its M&S community of interest, as well as the larger M&S community. Historically wargaming has contributed greatly in the areas of military training and education, operational planning and assessment, and military research and experimentation. Compare these success stories to the statement above of the M&S vision for DMSO. It is clearly time for the community to get over whatever prejudices and misunderstandings it may have harbored about games and gaming in the last few decades (“This is serious business; we aren’t playing games here!”) and, in many ways, to return to the very origins of the discipline of military analysis itself in the wargames of the Prussian General Staff and *Jane’s Fighting Ships*. (See [1] once again for a discussion of Fred T. Jane’s wargame, which served as the impetus and marketing tool for the long series of *Fighting Ships* books.)

What I plan to discuss

- Wargaming, analysis, exercises
- Game-based experimentation
- **Future directions**

And so, building on that history, I would like to propose some recommendations for future programs of research and development that DMSO, the M&S community, and the GIG might want to consider in order to integrate wargames and wargaming into their transformation plans.

Recommended directions

- Web-enabled training via the GIG
- Wargames to support operations
- Game-based experimentation
- Consortium of government, FFRDCs, academia, and industry

I recommend that DMSO, in conjunction with DARPA, the Office of Force Transformation, and other DoD agencies, explore all the areas we have discussed in this paper, particularly those listed above. I will discuss each of these in more detail.

Next steps: training

- Conduct a skills-based analysis of conceptual requirements for operational use of the GIG
- Research available data on efficacy of gaming in training
- Define a skills-based training program using web-enabled games

The DoD training community, with DARWARS as a major player, is sailing full speed ahead into applying gaming—much of it based on commercial ideas and standards— to training and education programs in the department. We believe that to exploit the potential offered by the GIG, the department needs to develop a more comprehensive understanding of the fundamental technical and, especially, conceptual skill sets required to operate within the GIG environment. A DMSO effort to take a skills-based analytical approach to defining requirements for training in the use of MS&G across the GIG architecture can provide a start and a model for developing this understanding. As an adjunct to such a study, it would be beneficial to collect and analyze all the relevant data available concerning the application of MS&G to training and education in DoD. Based on the results of these research and analysis efforts it should be possible to develop web-enabled training and education games as a core service of the GIG, in the context of an overall skills-based training program.

Next steps: supporting ops

- Assess utility of gaming disciplines and metaphors for supporting operational planning/assessment
- Define concept for using GIG-based games to provide support
- Develop pilot project with PME organizations and operators

The processes involved in creating games have much to teach the GIG community. The art and science of game design focus largely on the interface between human decisionmakers and the simulation of their environment and activities. Games use a wide range of techniques to extract decisions from their players in a way that feels like a natural part of the player's thinking yet, at the same time, provides the game engine with what it needs to implement the player's decisions and to evaluate and assess the course and outcomes of events that flow from those decisions. These techniques are immediately relevant to the design of GIG interfaces—particularly those related to providing MS&G support for operational planning and assessment. DMSO should sponsor a study to recommend practical concepts for the use of GIG-based games to provide such support. A natural starting point is to explore the potential for expanding training and education games, which may already be familiar to operational commanders and staffs, into GIG-enabled games that can support their operational planning and assessment. Forming connections with members of the community of professional military education—such as the various war colleges, service academies, and postgraduate schools—could be most beneficial in this effort. We recommend that DMSO develop a pilot project to explore the potential. The intellectual leadership and ongoing research underway at the Naval War College argues for an initial attempt to be made there. (Of course, this statement may not seem like a big surprise, coming from the Navy's FFRDC. Nevertheless, we believe the case stands up to objective scrutiny.)

Next steps: experimentation

- Document the principles and experiences of game-based experimentation in C4ISR
- Build a prototype of a game-based research “virtual laboratory”
- Conduct targeted research on basic concepts, like “power to the edge”

Good games can also provide good testbeds for exploring concepts and conducting rigorously designed experiments to test those concepts. How can DMSO and the MSG community build on the foundations already laid in game-based experimentation? There seem to be a couple of opportunities worth pursuing immediately.

First, DMSO should fund a research effort to document the principles and practical experiences that CNA, IDA, the Naval War College, the academic community, and private industry have gained from existing game-based experiments. The outcome of this effort should be a publication that provides guidelines, based on hard-won experience, to help other researchers apply this technique.

Second, DMSO should fund an effort to build a prototype of a game-based research laboratory. This laboratory would be less a specific facility than an assemblage of critical components and expertise: the games to serve as experimental test beds; the game designers to create the games; and the analysts and scientists to formulate problems, design experiments, and analyze data.

Third, DMSO and the GIG should seek partners (such as the Command and Control Research Program) to fund the design and implementation of inexpensive and repeatable tests of core concepts, such as “power to the edge” [22], that define the nature of GIG requirements for structures, processes, and services to support the warfighters in a combat environment.

Next steps: consortium

- Analyze landscape of gaming community in government, FFRDCs, academia, industry
- Develop options for collaboration
- Sponsor a symposium, possibly including a strategic-planning game, to explore options

Which leads us to our final set of recommendations. Building a virtual laboratory for game-based experimentation is a step toward building a broader base of collaboration among agencies of the government, FFRDCs, academia, and industry. A consortium of such groups could advance the state of the art of using MS&G in and through the GIG to support warfighters. To build such a consortium, we must first understand just what the landscape of this currently amorphous potential community looks like. DMSO should take the lead in surveying this landscape and developing options for increasing the collaboration possible among its constituent elements. After a basic analysis of who is who and who is doing what, DMSO should sponsor a symposium to bring together the leaders of the community. Such a symposium might even make productive use of a strategic-planning game to explore options.

Conclusion

- It's time to reincorporate gaming into the M&S community
- Gaming can support development and use of the GIG
- The GIG can enable effective gaming for training, operational support, and experimentation

Ultimately, the goal of this consortium-building enterprise would be to facilitate a joint effort to characterize and advance the state of the art of gaming and the potentialities of web-enabled gaming in the context of both the unclassified Internet and the GIG itself, in order to redefine and reintegrate gaming with modeling and simulation as a renewed analytical trinity for the 21st century. Gaming can support the ongoing development of the GIG, and can provide the means of teaching operators how better to integrate the GIG and its services into their life-and-death environment. In turn, the GIG can provide those operators ready access to effective gaming for training, for supporting operational planning and assessment, and for conducting experimentation to explore and evaluate both old concepts and new. Gaming and the GIG is a partnership waiting to happen.



References

- [1] Peter P. Perla. *The Art of Wargaming*. Annapolis: Naval Institute Press, 1990
- [2] Philip M. Morse and George E. Kimball. *Methods of Operations Research*. New York: John Wiley & Sons, Inc., 1951
- [3] Sun Tzu, *On The Art of War, The Oldest Military Treatise in the World, Translated from the Chinese with Introduction and Critical Notes by Lionel Giles, M.A.* First published in 1910. Online text at: <http://www.kimsoft.com/polwar.htm>
- [4] William D. Brobst et al. *Integrating Wargaming into the NMITC Curriculum: Summary and Recommendations*, December 2000 (CNA Research Memorandum D0002817.A2/FINAL)
- [5] S.K. Numrich, Michael Hieb, and Andreas Tolk. "M&S in the GIG Environment: An Expanded View of Distributing Simulation." In *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC)*, Tutorial Paper, Orlando, Florida, December 2004
- [6] Edmund Morris. "A Matter Of Extreme Urgency: Theodore Roosevelt, Wilhelm II, and the Venezuela Crisis of 1902." *Naval War College Review*, Spring 2002
- [7] Rudolf Hoffmann. *WarGames*. Draft translation by P. Luetzkendorf. Washington, DC: U.S. Department of the Army, Office of the Chief of Military History, MS P-094, 1952
- [8] Col Matthew B. Caffrey, Jr., USAFR. "Red Flag For Joint Campaigns: Building a more effective Air and Joint Force through better operation and strategic wargaming." *Air & Space Power Chronicles—Chronicles Online Journal*, 21 April 2004, available at

<http://www.airpower.maxwell.af.mil/airchronicles/cc/Caffrey1.html>

- [9] Peter P. Perla et al. *Wargaming ESG Operations in Support of the Global War on Terrorism*, September 2005 (CNA Research Memorandum CRM D0012912.A1/Final)
- [10] Andrew Krepinevich. *Transforming to Victory: The U.S. Navy, Carrier Aviation, and Preparing for War in the Pacific*. CSBA Online, the Olin Institute http://www.csbaonline.org/4Publications/Archive/A.20000000.Transforming_to_Vi/A.20000000.Transforming_to_Vi.htm#fn14
- [11] Harris Laning, Admiral, United States Navy, Retired. *An Admiral's Yarn*. Newport, RI: Naval War College Press, 1999. Appendix I, *Opening Address Delivered before the Naval War College staff and classes of 1931, by Rear Admiral Harris Laning, 2 July 1930*.
- [12] Trent Hone. "Building a Doctrine: U. S. Naval Tactics and Battle Plans in the Interwar Period." *International Journal of Naval History Online*, Volume 1, Number 2, October 2002. Available online at http://www.ijnhonline.org/volume1_number2_Oct02/articles/article_hone1_doctrine.doc.htm
- [13] Andrew F. Krepinevich, Jr. "Military Experimentation: Time to Get Serious." *Naval War College Review*, Winter 2001. Available online at <http://www.nwc.navy.mil/press/Review/2001/Winter/Art5-w01.htm>
- [14] Andrew Ilachinski. *Irreducible Semi-Autonomous Adaptive Combat (ISAAC): An Artificial-Life Approach to Land Combat*, August 1997 (CNA Research Memorandum 97-61.10.) Andrew Ilachinski's ISAAC and EINSTEIN applications are extensively documented at <http://www.cna.org/isaac/>
- [15] Andrew Ilachinski. *Artificial War: Multiagent-Based Simulation of Combat*. Singapore: World Scientific Publishing Company Private Ltd., 2004

- [16] Julia A. Loughran and Peter P. Perla. "Using Gaming and Agent Technology to Explore C2." In *8th International Command and Control Research and Technology Symposium*, Command and Control Research Program, 2003
- [17] Peter P. Perla et al. *Gaming and Shared Situation Awareness*, November 2000 (CNA Research Memorandum CRM D0002722.A2/Final)
- [18] Peter P. Perla et al. *Game-Based Experimentation for Research in Command and Control and Shared Situational Awareness*, May 2002 (CNA Research Memorandum D0006277.A1/Final)
- [19] Stephen Downes-Martin. *Shared Situational Awareness Command and Control (SSA C2) Experiment 2002-1, Briefing for the Information Superiority Working Group (ISWG)*, June 5, 2002, Naval War College
- [20] Marcy Stahl. *Analysis and Observations of the Naval War College Shared Situational Awareness Experiment, Final Report*, ThoughtLink, Inc., May 2002
- [21] Jesse Orlansky and Colonel Jack Thorpe, eds. *73 Easting: Lessons Learned from Desert Storm via Advanced Distributed Simulation Technology*, IDA D-1110. Alexandria, VA: Institute for Defense Analyses, 1992
- [22] David S. Alberts and Richard E. Hayes. *Power to the Edge*. Washington DC: Command and Control Research Program, 2003



This document may contain materials protected by the Fair Use guidelines of Section 107 of the Copyright Act, for research purposes only. Any such content is copyrighted and not owned by CNA. All rights and credits go directly to content's rightful owner.

Any copyright in this work is subject to the Government's Unlimited Rights license as defined in DFARS 252.227-7013 and/or DFARS 252.227-7014. The reproduction of this work for commercial purposes is strictly prohibited. Nongovernmental users may copy and distribute this document noncommercially, in any medium, provided that the copyright notice is reproduced in all copies. Nongovernmental users may not use technical measures to obstruct or control the reading or further copying of the copies they make or distribute. Nongovernmental users may not accept compensation of any manner in exchange for copies.

All other rights reserved. The provision of this data and/or source code is without warranties or guarantees to the Recipient Party by the Supplying Party with respect to the intended use of the supplied information. Nor shall the Supplying Party be liable to the Recipient Party for any errors or omissions in the supplied information.

This report may contain hyperlinks to websites and servers maintained by third parties. CNA does not control, evaluate, endorse, or guarantee content found in those sites. We do not assume any responsibility or liability for the actions, products, services, and content of those sites or the parties that operate them.



Dedicated to the Safety and Security of the Nation

CNA is a not-for-profit research organization that serves the public interest by providing in-depth analysis and result-oriented solutions to help government leaders choose the best course of action in setting policy and managing operations.