The long history of gaming in military training

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There is a long history of the dual-use of games in both the military and the entertainment applications. This has taken the form of sand tables, miniatures, board games, and computer games. The current tension between entertainment and military applications of games is just the return of similar concerns that surrounded the gaming tools and technologies of previous generations. Dynamic representations of the physical world are interesting and useful tools in a number of fields, to include the military, city planning, architecture, education, and entertainment. Computer games are tools that allow all of these audiences to accomplish similar goals.

KEYWORDS: *board game, computer game, sand table, wargame*

The military has been using games for training, tactics analysis, and mission preparation for centuries. Each generation has had to wrestle with the personal and public image of a game being used for something as serious as planning warfare in which people's lives are at stake. During the opening years of the 21st century, the industry faced a renewed version of this question with the widespread use of computer games taken directly from the entertainment industry. For example, the Americas Army project is based on the Unreal-2 Engine (Davis et al, 2003 and Zyda et al, 2005) from Epic Games and DARPA's DARWARS Ambush product is derived from Operation Flashpoint by Bohemia Interactive Games. Other agencies have converted Doom and Half-Life, or licensed products like Gambryo or the Havok physics engine to create military training systems. The questions, perceptions, and compromises that these projects face today are not new; they have been experienced by previous generations of engineers who attempted to leverage technologies from other domains. The mathematical models, paper board wargames, and miniatures that were adopted in previous centuries were met with the same types of apprehension that computer games face today. This article paints a broad picture of the history of the use of games by the military, the perceptual issues around that use, and the progress that has been made over many centuries.

Military Gaming Ages

Stone Age

Simulation and gaming as tools of warfare has a long history. At least as far back as the Roman Empire, commanders used sand tables with abstract icons to represent soldiers and units in battle. These allowed leaders to visualize and manipulate a small physical copy of the battlefield. It allowed them to see information in geographic perspective and enabled multiple players to pit their own ideas against one another. Though the visual representation provided the initial value of the practice, creating a playing board upon which multiple options could be compared proved to be even more powerful. These tools allowed leaders and their staff members to compete against each other or against historical records in an attempt to determine which would be the most effective (Perla, 1990).

The sand tables begat miniature gaming as both a military tool and a form of entertainment. Fred Jane, pioneer of the series of reference books on military weapons data, created the "Naval Wargame" in 1903 as a military tool and shortly thereafter H.G. Wells, the famous author of *War of the Worlds*, published the book *Little Wars* in 1913 in which he described the use of miniature tokens and terrain boards for both military training and entertainment. From these roots sprung a century of the use of miniatures in planning military operations.

Paper Age

Strategy board games made of wood or paper emerged in Asia, the Middle East, and Europe. In Japan, there are ancient references to the game of WEI HAI around 3000 BC, a term that meant "encirclement." This game is thought to be the predecessor of the modern game of GO (circa 2300BC). Both of these games used abstract tokens that the player manipulated to gain a territorial advantage over an opponent. CHATURANGA emerged in India in 500BC with a gridded board and pieces that represent the leaders and warriors on a battlefield. It allowed by two-player and four-player games and is the clear predecessor to modern CHESS. It used pieces which explicitly represented the military equipment of the time – the chariot, cavalry, elephant, soldier, and Rajah. In its original form, a die was used to select the piece to be moved. But Indian legal restraints on gambling and games of chance were applied to CHATURANGA, forcing its adherents to eliminate the die and allow the players to develop their own strategies for selecting and moving pieces. By 500AD, this game had moved through the Middle East and Europe, being modified into the game of CHESS that we recognize today. Along the way many cultures cast it as the ultimate test of strategic thinking in a military context. The identification of specific pieces, the movement patterns assigned to each, the size of the playing board, and more advanced rules required centuries of experimentation to arrive at their current balance and to create a game that could challenge players for a lifetime and countries for centuries (Shenk, 2007).

Though GO, CHATURANGA, and CHESS may still be considered games of strategy, they are no longer accepted as training tools for warfare. The continuous evolution of gaming and training had led to more military-specific tools. In 1664, Christopher Weikmann created KOENIGSPIEL which was one of the earliest board games meant primarily for developing and communicating strategies of warfare. He was followed by C.L. Helwig with WAR CHESS in 1780 and Baron von Reisswitz with KREIGSSPIEL in 1811. All of these devices were strictly tools to improve military thinking and to enable military training. During the late 19th century, the United States Naval War College used wargames to plan U.S. defenses against a British invasion of New York harbor. The Germans used wargames to plan to invasion of Poland at the beginning of World War II and the Japanese used this tool to plan the attacks on Pearl Harbor (Perla, 1990).

By the 1950's, two independent inventors introduced the paper board wargame with cardboard military markers and a table of combat results for calculating attrition and movement. The RAND Corporation created a system to present theater-level warfare in a form that would allow more mathematically accurate combat than that found on the sand tables and the board games of earlier centuries. They were charged with integrating the effects of the newly created nuclear arsenal, as well as developing strategies for defending against nuclear attack. Without direct experience with these weapons, wargaming was one of the few ways to explore their potential on the battlefield and in international relations. At the same time, Charles Roberts was

awaiting his commission in the Army and created a tool with which he could hone his own tactical skills. The result was a board game that he named TACTICS and which used many of the same techniques created by RAND. The results of both efforts were the formalization of the playing board with a gridded overlay to manage movement and engagements; the use of a Combat Results Table to formalize the results of the battle; the incorporation of terrain types that influence combat activities; a turn-based play mechanism; and the use of dice to add random outcomes to the battle (Figure 1).

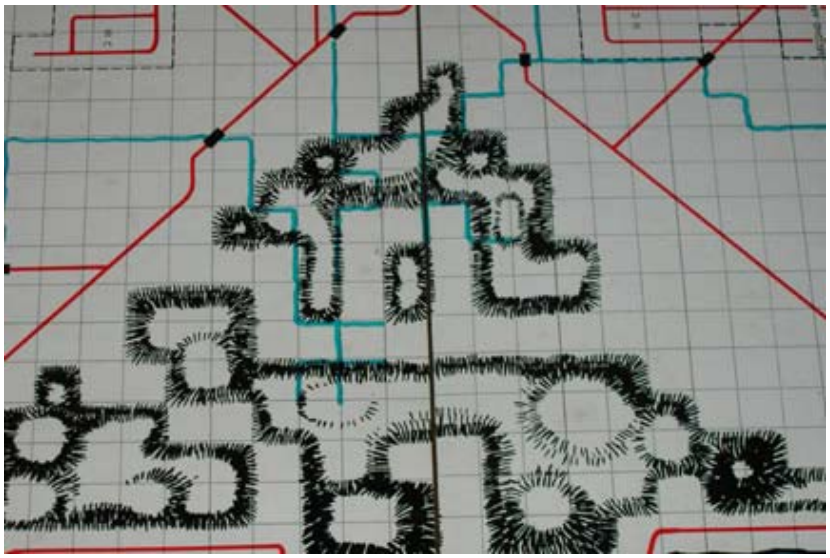

Figure 1. Charles Roberts' TACTICS II board game (circa 1958).
Source: http://www.boardgamegeek.com/game/1574

If these board games had come only from RAND, they may have been considered just a tool for military planning and training. However, Roberts used his creation to create the commercial entertainment company Avalon Hill in 1958 (today part of the Hasbro Company). He popularized wargaming as a hobby and a form of entertainment for those interested in trying their hand as military leaders. These games attracted a significant following of people who were well educated and sometimes experienced as military leaders. They found in this genre the opportunity to express their knowledge and to build small businesses based on their own creations. Hence was reborn the dichotomy between games as serious military tools and games as a form of entertainment. The concern of the appropriateness of playing games for serious purposes has been part of the education of military leaders ever since their popularization in the 1960's (Perla, 1990).

Ghamari-Tabrizi (1995) describes a situation during the Korean War when these board wargaming tools were relatively new tools for teaching strategy and tactics in the U.S military. The military colleges were using them to teach officers the craft of warfare. However, the image of using games as tools to educate military leaders was considered to be something the public was best not aware of. Therefore, the practice was kept secret. However, Milton Caniff, the artist and author of the extremely popular "Steve Canyon" newspaper comic strip had very tight relationships within the Air Force. Steve Canyon was a fictional America hero and a valuable recruiting tool for the military. Caniff learned of the use of wargames in these colleges and did a long series of comic strips in which the hero used them to plan his missions. Thus, the use of

games for military training was exposed to the general public in the "funny papers" (Caniff, 1992).

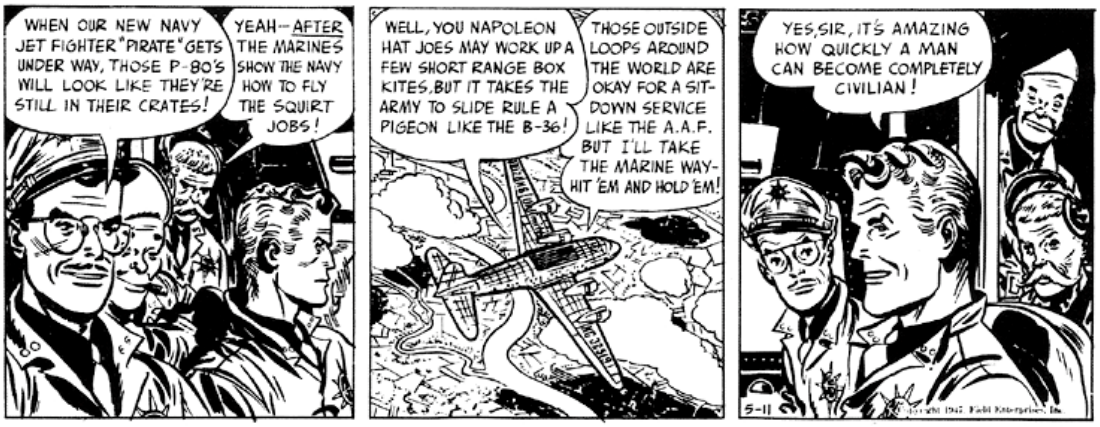

Figure 2. Steve Canyon flying the C-47. Dated May 11, 1945.

Mathematical Age

The military wargames from RAND and Avalon Hill incorporated more mathematics than their predecessors. Players for entertainment sought a game that was easy to use, but military thinkers needed something that was as accurate as possible, even if it were somewhat cumbersome to play. This latter camp adopted computing devices to aid in their calculations. Calculators could be used to generate the results of specific actions and these results could be saved in table form for reference when the situation was encountered again during a game. As computing calculators became more accessible they could be run in real-time to calculate specific combat results during play. This brought more detailed mathematics and logic to games and required no changes to the form of the game itself. Games continued to be played with paper boards, paper pieces, physical die, and miniatures.

During this period, computers could be viewed as an advanced form of calculator that was used by the sophisticated military organizations. However, the cost and rare access to computers widened the gap between the "professional" and the "hobby" users of these games. This split encouraged hobby players to create affordable and easy to use manual mechanisms that could improve the richness and realism of their games without resorting to computers.

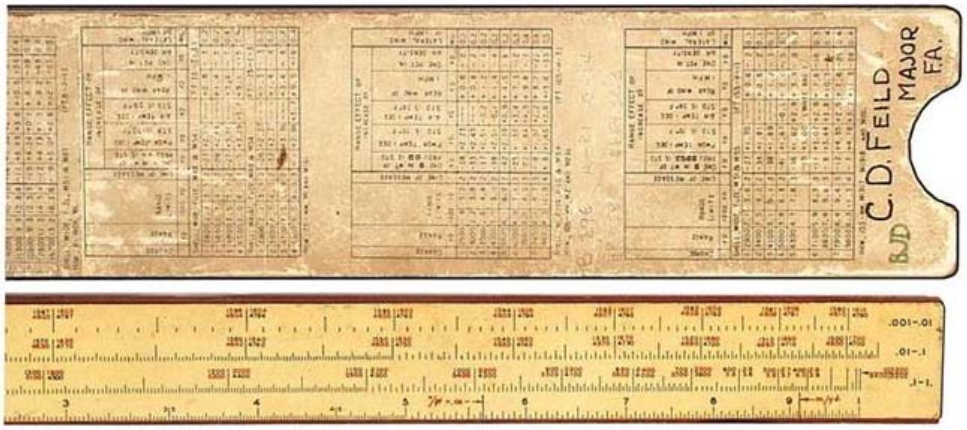

Figure 3. World War II firing table in the form of a sliderule.
Source: http://www.rekeninstrumenten.nl/

In 1948, the Army Operations Research Office at Johns Hopkins University created the AIR DEFENSE SIMULATION and in 1953 the first of a series of models called CARMONETTE. These games lost much of the playability of the board game, but significantly improved the mathematical rigor of the results. These were some of the first truly computerized wargames (Davis, 1995).

Computer Age

Eventually, computers became powerful enough and employed display devices that would allow the entire wargame to be converted into a digital program. This eliminated much of the manual work of moving pieces, rolling die, looking up results in a CRT, and calculating final outcomes. The players could focus on the tactical movements and leave the complexity of manipulation to the computer. This also made it feasible to expand the size of games. The amount of geography, number of icons, and complexity of algorithm no longer had to be limited by the extent of human manipulation. These could be expanded to the capabilities of the computer, which was many orders of magnitude faster than a human player with pencil, paper, and calculator.

Initially, digital wargames were a direct conversion of existing paper wargames. It took some time for the designers and programmers to discover the potential of the new computing machines and to develop more complex logic and algorithms for the computer. They could incorporate mathematic and logical algorithms that were far beyond what could be managed with a human-driven paper game. It also became practical to distribute the game between multiple rooms and to present custom views of the battle for each player (Allen, 1987). Prior to the computer, games with multiple boards and varying views were possible, but required the use of referees who could move between views to build up the views manually. These methods slowed the play of the game. Distributed computer games moved this job into the computers and networks, achieving almost instantaneous synchronization of multiple views of the battle. Allen (1987) describes the emergence of early games like the MCCLINTIC THEATER MODEL at the Army War College and the NAVAL WARGAMING SYSTEM at the Naval War College. The roots of these tools can be seen as early as the 1960s. Both games incorporated the most modern computers, networks, and display devices. They were followed by a long series of computer-

based games developed for both training and analysis by each of the military services, governmental laboratories, and military think tanks.

These simulations improved the mathematical models of warfare, but they also began to bring in attractive graphics for the systems. At the time, the importance of display devices was not completely appreciated. This was one of the first steps toward bringing the military and hobby players of these games back together. In a previous generation, both communities had shared common map boards and pieces. In the convergence that lay ahead they would both be building systems on personal computers and the uncomfortable partnership between the two communities would be revived.

Personal Gaming Age

Today, personal computers and graphics cards have created an affordable platform for supporting games for entertainment, military training, medical education, and global communication. Though the entertainment and military communities had diverged through the 1970's and 1980's they became reacquainted toward the end of the 1990's. Military simulations like Simulator Networking (SIMNET) and Modular Semi-automated Forces (ModSAF) were uniquely military, but beginning to explore the graphic tools emerging from academic research laboratories and commercialized by companies like Silicon Graphics and Evans & Sutherland. On the entertainment side, games like STEEL PANTHERS and CLOSE COMBAT carried a very strong military theme, while SIMEARTH and CASTLE WOLFENSTEIN went off in a uniquely entertainment direction.

The growing power of the personal computer allowed some of the military simulations to migrate from large institutions to individual hobbyists. Traditional military training games like JANUS and parts of SIMNET were recreated in a gaming form and sold for entertainment. The SPEARHEAD game was jointly created by an entertainment company and a defense company comprised of some of the original developers of SIMNET. SIMNET programmers were also hired by Sony Computer Entertainment to create the multiplayer software for online Playstation titles. At the same time, entertainment games and the technologies that are behind them, seeped into the military domain. Epic's UNREAL-2 Game Engine became the foundation for the sensationally popular AMERICAS ARMY game for recruiting. FULL SPECTRUM WARRIOR was created for the X-box console as both a military training system and an entertainment title. OPERATION FLASHPOINT was the basis for the DARWARS AMBUSH game (Chatham, 2007).

Throughout these decades long evolutions people have been concerns about turning entertainment properties into military applications, often referred to as "serious games." There is the concern that games may be adopted because they are visually attractive rather than accurate representations of battlefield activities. These same concerns arise in all industries that adopt technologies that originate from other industries. For example, the medical education field has done numerous studies to determine whether simulations of all types can provide better training than traditional hands-on methods. In most cases they have learned that these new training tools are essential for teaching the more complex skills that are necessary for the latest forms of surgery and the use of advanced equipment (Lane, 2001).

Game Technologies

Entertainment games encapsulate some of the most advanced technologies in computer science. They present compelling and powerful tools that are being adopted by many industries, including military simulation. This section explores the power of these technologies in order to better understand what they offer for military training. Figure 4 shows six technologies that are core to the runtime experience of a game-based training system.

1. The *3D engine* creates the beautiful and accurate visualizations that are used to stimulate players.
2. The *Graphical User Interface* is the menu system and interactive patterns that allow a gamer to immediately begin using a game without ever reading a manual.
3. *Physical Models* create a world in which the effects of movement, engagements, interactions, and sensors are accurate portrayals of the real world.
4. *Artificial Intelligence* provides the brains that are necessary to create in-game opponents that are smart enough to challenge human players. This also creates an adaptive experience that can adjust the game as it runs to insure that the player works through a specific problem of interest.
5. *Networking* allows the virtual environment to be extended to multiple players around the globe. Game companies have created the most flexible and efficient methods for transferring data over a worldwide network.
6. *Persistent Worlds* maintain a virtual world that can grows, changes and remains active over many days, weeks, or years regardless of whether an individual player remains engaged with that world.

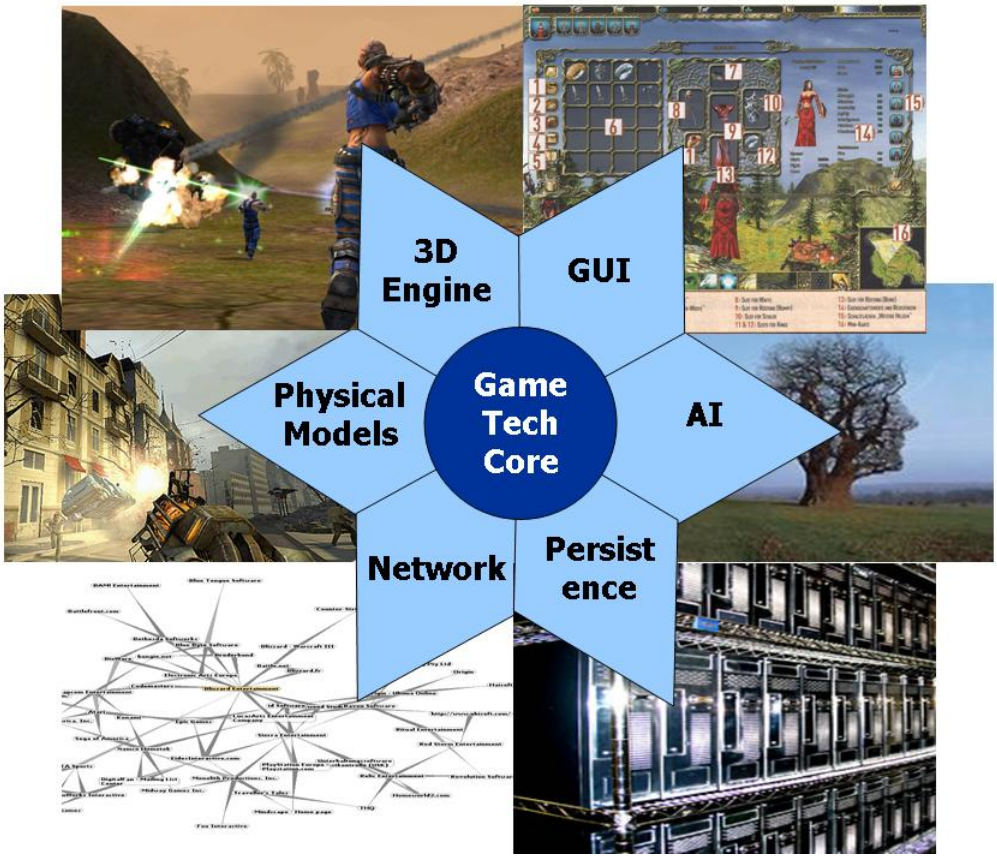

Figure 4. Six core technologies in gaming systems.

But the technologies of in-game play are just one part of what is driving these systems into serious applications. Most serious domains call for a great deal of pre-game data creation and manipulation, as well as post-game data collection and analysis (Figure 5). *World Building Tools* allow the training audience to customize their own scenarios to meet very specific needs. With these a player can create new pieces of terrain, buildings, vehicles, and complex layouts of these to form a game level. *Behavior Scripting Tools* enable the creation of specific actions and motivations for the enemy avatars that are controlled by the computer. Prior to the availability of these types of tools the original designers of the game had to determine how it would be used and create scenarios that could teach those lessons. It was just too complicated for players to modify a world themselves (Chatham, 2007). But the latest generation of games includes tools that allow any user to customize the world and create scenarios that will unfold during a game. Post-game tools collect data on the performance of each player or team and allow a review of that performance with instructor comments on how to improve.

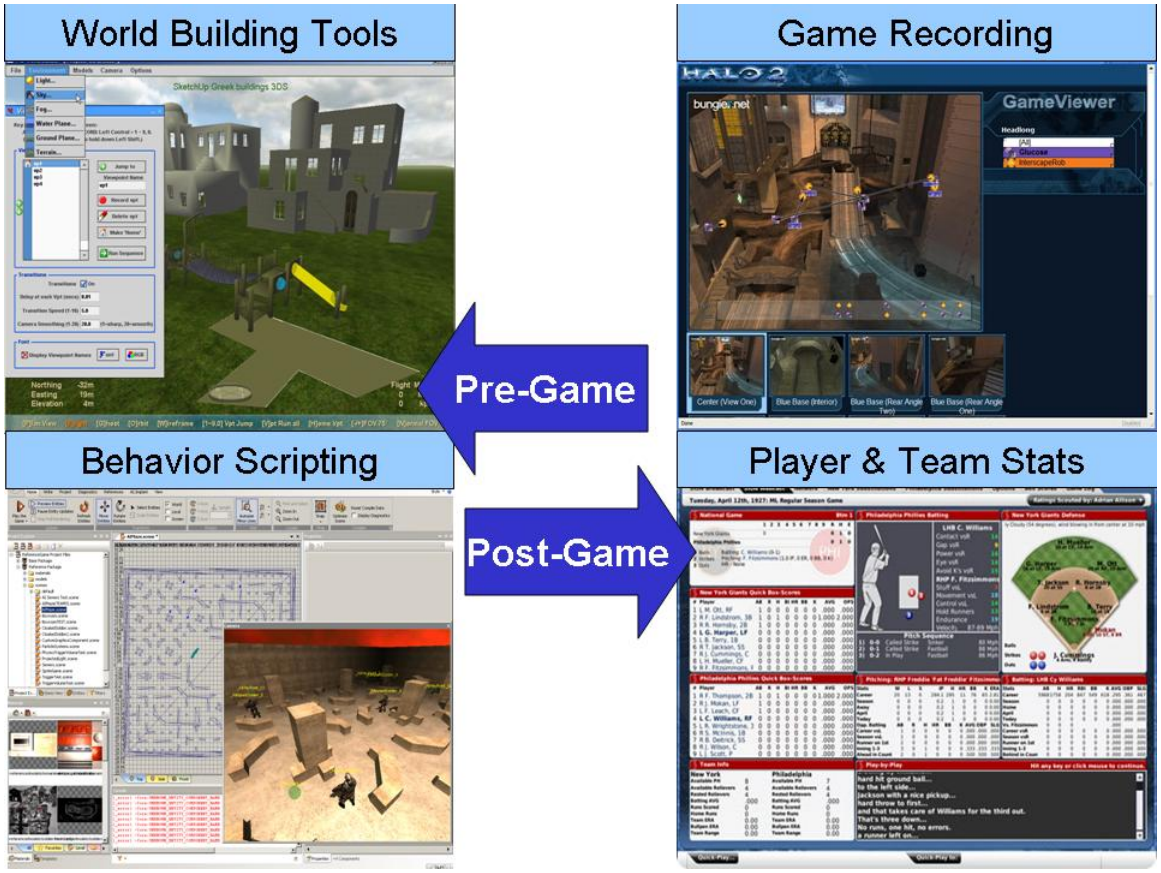

Figure 5. Valuable technologies for pre- and post-Game operations.

As games have become more sophisticated and as the military has come to understand them better, we have been able to identify better means of leveraging these technologies for serious purposes.

Future Technologies

Games of warfare have evolved into multi-processor systems that typically use a client-side application to deliver the user interface and to handle computation that is dedicated to a single player. But they also have a server-side application that can handle more globally useful information and that ties multiple players into a common environment. As the wargame becomes more complex it usually requires additional power on the server side. As we seek to make the system more intuitive to the players, it requires more computation on the client-side. These demands point to new computer and software technologies that may be important in the future.

On the server side, the growth in computational needs is similar to that found in large IT server farms that drive Internet applications like Google Search, Maps, and Earth; but also those that drive massively multiplayer online computer games like WORLD OF WARCRAFT, SECOND LIFE, and EVE ONLINE. The former are well structured for customers who submit independent tasks that do not have to be coordinated in real-time with other customers, such as searches and requests for directions to a specific destination. The latter support a series of small virtaul worlds in which thirty or more players may share the same virtual space and need a server-side computer than can coordinate their actions in real-time. The “massively multiplayer”

part of these games is created by running thousands of these small groups simultaneously and independently. In spite of the large number of players that are reported, relatively small numbers of these work together in a shared space simultaneously. If a military application is going to support hundreds of players who interact with each other, then something more powerful will be required – perhaps, something like an interactive version of a supercomputer (a.k.a. high performance computer). These machines have typically been used to handle computationally intensive jobs that do not require interactivity with the customer. But, the large number of processors, powerful chips, and large memory spaces could also be used to support large interactive exercises if the connections to the players were maintained throughout the job, rather than being terminated as is typical of "batch jobs".

As computers have become ubiquitous across the soldiers, sailors, airmen, and marines that make up the military services, it has become possible to envision an environment in which these customers or players can use their own computers as the clients in a global, server-based training system. Millions of potential trainees or players could connect to servers to run collaborative training on their own schedules. The servers would need to deliver specific content to each player according to his or her role and the skills that they are trying to learn. It would be impossible to manually deliver specific content to each of the millions of servicemen and women around the world. Instead, the servers would have to supply the necessary content and connections on demand. The means of establishing such a system are currently beyond the capabilities of the military networks, servers, and clients that are available. But the shadows of such a future can be seen in the demands for custom training, the shift to constant operations, and the types of innovations that are emerging in the commercial spaces for games and internet-based interactions.

Economics of the Cutting Edge

At the beginning of the 21st century there is concern that commercial and entertainment technologies appear to be outstripping those in military systems. It appears that we have reached a global economic inflection point in which the populations of many countries have significant disposable income and disposable personal time. These people choose to spend this surplus on personal computing equipment and games for entertainment, creating a gaming industry that earns over $18 billion annually. This industry is infused huge amounts of money each year and exists in an environment of extremely aggressive competition. Existing and newly formed companies introduce more advanced hardware and software products every year. This revenue and the environment have resulted in seizing the position of technical leadership from the military and government organizations that held this in past decades. There was a time when the most advanced computing devices could be found in military weapons and vehicles for space exploration. But today, the revenue behind commercial computing hardware and software is much larger than that available from the government. Computer games and similar entertainment products are just one domain within this larger technology shift. The military has become accustomed to using commercial off the shelf (COTS) computer hardware. It must look forward to using COTS software for applications like training and data analysis. Three dimensional image generators used to be cabinet sized machines. Today they are small cards that fit into a personal computer. Maps used to be created on paper by professional cartographers. Today they are embedded in web pages and can be customized by anyone surfing the web (Figure 6).

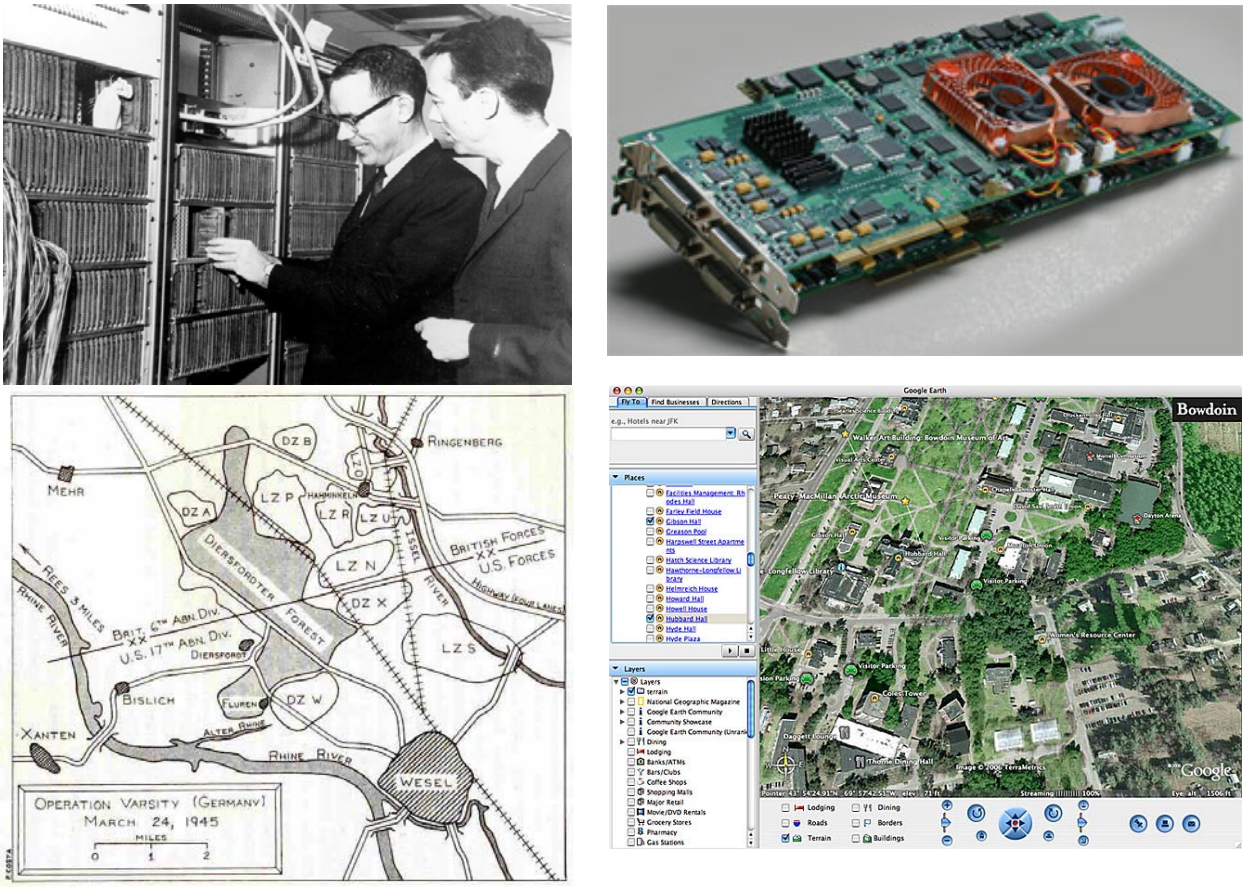

Figure 6. Commercial products can completely displace military-specific hardware and software.

Conclusions

The term "game" refers to an activity pursued for entertainment and enjoyment. But it also denotes a competition between multiple players. This competition reaches its ultimate form in military operations where life, liberty, and global security are at stake. These games are no longer enjoyable, but they incorporate the competition and strategies that emerged from their entertainment roots. Since games can be used to think clearly about a military operations, they have been and always will be a part of this very serious activity.

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