PROGRAMMING THEATRES OF WAR: GAMEMAKERS AS SOLDIERS

(To appear in Robert Latham, ed., *Bytes*, *Bandwidth, and Bullets*, New York: The New Press, 2003.)

Timothy Lenoir
Stanford University

In 2002, on July 4 (the entertainment industry's traditional date for premiering the summer's movie blockbuster), the US military released its new videogame, *America's Army: Operations*. Designed by the Modeling, Simulation, and Virtual Environments Institute (MOVES) of the Naval Postgraduate School in Monterey, California, the game is distributed free on the internet and is intended as a recruiting device. Produced with brilliant graphics and the most advanced commercial game engine available at a cost of around $8 million, the game is a first-person multi-player combat training simulation requiring players to complete several preliminary stages of combat training in an environment that simulates one of the military's own main training grounds—in other words, it is cyber boot camp. The military had to add supplementary servers to handle the demand for the game, a reported 400,000 downloads the first day. As of late August, 2002 the site continued to average 1.2 million hits per second. *Gamespot*, a leading review, not only gave the game a 9.8 rating when it first appeared but also regarded the business model behind the new game as itself deserving an award.[1]

Contrary to initial expectations, the military-industrial complex did not fade away with the end of the Cold War. It has simply reorganized itself—in fact, it is more efficiently organized than ever before. Indeed, a cynic might argue that whereas the military-industrial complex was more or less visible and identifiable during the Cold War, today it is invisibly everywhere, permeating our daily lives. The military-industrial complex has become the military-*entertainment* complex. The entertainment industry is both a major source of innovative ideas and technology, and the training ground for what might be called post-human warfare. How has this change come about?

Distributed Networks: SIMNET

The historical answer to this question begins with the construction of the DARPA-funded SIMNET, the military's distributed SIMulator NETworking project. Simulators developed prior to the 1980s were stand-alone systems designed for specific task-training purposes, such as docking a space capsule or landing a jet on the deck of an aircraft carrier. High-end simulators typically cost twice as much as the systems they were intended to simulate: for example, in the late 1970s an advanced pilot simulator system cost more than $30-$35 million and a tank simulator $18 million, at a time when an advanced individual aircraft was priced around $18 million and a tank considerably less. Air Force Captain Jack A. Thorpe, serving as a research scientist in flight training R&D at Williams Air Force Base east of Phoenix, Arizona, was brought into DARPA to address this situation.[2] In September 1978 Thorpe had presented the radical idea that aircraft simulators should be used to *augment* aircraft, teaching air-combat skills pilots could not learn in peacetime flying but could learn on simulators in large-scale battle-engagement interactions. Thorpe proposed the construction of battle-engagement simulation technology as a 25-year development goal.[3] Concerned about costs for such a system, Thorpe actively pursued technologies developed outside the DOD such as videogame technology from the entertainment industries.[4] In 1982, upon approval for SIMNET from DARPA, Thorpe hired a team joining military personnel with industrial and computer graphics designers to develop a network of tank simulators suitable to collective training.

The main reason that pre-SIMNET simulators were so costly was that they were typically designed to emulate the vehicles they represented as closely as engineering technology permitted—a flight simulator aimed to be "an airplane on a stick." SIMNET's contrasting design goal was *selective functional fidelity* rather than full physical fidelity; it called for learning first what functions were needed to meet the training objectives, and only then specifying the needs for simulator hardware. As a result, many hardware items not regarded as relevant to combat operations were not included or were designated only by drawings or photographs in the simulator. Furthermore, the vehicle simulator was viewed as a tool for the training of crews as a military unit; the major interest was in *collective,* not *individual,* training. The design goal was to make the crews and units, not the device, the center of the simulation.[5] This approach helped make possible the design of a relatively low-cost device.[6]

Combining these concepts with newly available technology for visual displays and less costly networking architecture, SIMNET was constructed of local and long-haul nets of interactive simulators for maneuvering armored vehicle combat elements (MI tanks and M2/3 fighting vehicles), combat-support elements (including artillery effects and close air support with both rotary and fixed-wing aircraft), and all the necessary command-and-control, administrative and logistics elements.[7]

The terrains for battle engagements were simulations of actual places, 50 square kilometers initially, but eventually expandable by an order of magnitude in depth and width. Battles were fought in real time, with each simulated element—vehicle, command post, administrative and logistics center, etc.—operated by its assigned crew members. Scoring was recorded on combat events such as movements, firings, hits, and outcomes, but actions during the simulated battle engagements were completely under the control of the personnel who were fighting the battle. Training occurred as a function of the intrinsic feedback and lessons learned from the relevant battle-engagement experiences. Development proceeded in steps, first to demonstrate platoon-level networking, then on to company and battalion levels, and later on to higher levels.

The prototypes and early experiments with SIMNET elements were carried out from 1987-89, and the system was made operational in January 1990. The Army bought the first several hundred units for the Close Combat Tactical Trainer (CCTT) system: an application of the SIMNET concept, the CCTT was the first building block of a system that would eventually contain several thousand units at a total cost of $850 million.[8]

The Battle of 73 Easting

The value of the SIMNET as a training system for preparing units for battle became apparent almost immediately during the Gulf War. Hailed as the most significant victory of the war, the Battle of 73 Easting took place on February 26, 1991, just three days into the ground war, between the U.S. 2nd Armored Cavalry Regiment and a much larger Iraqi armed force (armed elements of the 50th Brigade of the Iraqi 12th Armored Division). The battle was named for its location: 73 Easting is the north-south grid line on military maps of the Iraqi Desert. The battle lasted from about 3:30 PM until dusk fell at

5:15 PM, and took place in a swirling sandstorm. The U.S. 2nd Calvary consisted of M1A1 Abrams battle tanks and M3 Bradley fighting vehicles. During the action the cavalry troops destroyed 50 T-72/T-62 battle tanks, more than 35 other armored fighting vehicles, and 45 trucks. More than 600 Iraqi soldiers of the 12th Armored Division and Tawakalna Republican Guard Armored Division were killed or wounded and at least that number were captured. After the battle, Gen. Franks, the VII Corps commander, praised the action of the 2nd Cavalry as a classic instance of the cavalry mission to find, fix, and fight the enemy. The 2nd Armored Cavalry had trained intensely before the battle both in the field and on the SIMNET preceding the battle. Immediately, 73 Easting's potential as a simulation for network training on the military SIMNET was appreciated.[9]

A few days after the battle the military decided to capitalize on the SIMNET experience and technologies to record the Battle of 73 Easting for use in future networked training. For the 73 Easting simulation, most of Jack Thorpe's original team, builders of the SIMNET, combined with the staff of the Institute for Defense Analyses Simulation Center (IDA) under the leadership of Lt. Neale Cosby as prime technical contractor. Additional expertise was furnished by the Army's Engineer Topographical Laboratories.

Early military simulations had incorporated rote behaviors and did not capture "soft" characteristics well. IDA's effort to go beyond this limitation resulted in a computer-generated simulation of the Battle of 73 Easting, based on in-depth debriefings of 150 survivors.[10] The goal of the project was to get timeline-based individual experiences in response to the dynamic unfolding of the events—soldiers' fears and emotions as well as actions—and to render the events as a fully 3-D simulated reality which any future cadet could enter and relive. Data gathering for the simulation began one month after the battle itself. The team assembled battle site surveys and interviews with participants. Troopers from the 2nd Cavalry accompanied the DARPA team members to reconstruct the action moment by moment, vehicle by vehicle. They walked over the battlefield amidst the twisted wreckage of Iraqi tanks, recalling the action as best they could. A few soldiers supplied diaries to reconstruct their actions. Some were even able to consult personal tape recordings taken during the chaos. Tracks in the sand gave the simulators precise traces of movement. Every missile shot left a thin wire trail which lay undisturbed in the sand. A black box in each tank, programmed to track three satellites, confirmed its exact position on the ground. Headquarters had a tape recording of radio-voice communications from the field. Sequenced overhead photos from satellite cameras gave the big view. A digital map of the terrain was captured by lasers and radar.[11]

With these data a team at the IDA Simulation Center spent nine months constructing a simulation of the battle. A few months into the project, they had the actual desert troops, then stationed in Germany, review and correct a preliminary version of the recreation by sitting in tank simulators and entering the virtual battle. Nine months after the confrontation the recreated Battle of 73 Easting was demo-ed for high-ranking military in a facility with panoramic views on three 50-inch TV screens at the resolution of a very good videogame.

The Battle of 73 Easting confirmed Jack Thorpe's original vision for the SIMNET: networked simulation technology using history to prepare for the future. The simulation provided both a link with history and at the same time served as a dynamic interactive training vehicle for the future. As a computer simulation with programmable variables, the scenario could be replayed with different endings. The next step after creating this detailed, accurate historical simulation was to couple it with Project Odin, a wargame simulation engine developed in preparation for Desert Storm by Neale Cosby and the IDA staff.

The goal of Project Odin was to create a simulated electronic environment housed in a moving-van sized truck with generator-trailer. Odin was intended for use in the field, its knowledge base supplied by up-to-date intelligence. It would allow officers to see the battlefield in three dimensions and enable them to zoom to any location to review the arrangement of forces. By adopting various perspectives of the opponent one might infer the counterpart's intent and more easily gain mastery of the battlefield.[12] Odin was not designed to destroy targets, but to assist in visualizing the battle about to be entered, or ideally, already joined. SIMNET technology was at the core of Odin. Like other SIMNET simulation units, Odin combined a digital terrain database of any part of the world; intelligence feeds of friendly and enemy orders of battle (through another DARPA program called Fulcrum); an order of battle generator; a wargaming engine with semi-automated forces using AI components; and an extremely flexible visual display (the "flying carpet").

The "flying carpet" was the most innovative aspect of the SIMNET machine, allowing zooming to any part of the battlefield as well as forward or backward jumping in time, from any perspective. The simulated battlefield could be visually displayed from any viewpoint, air or ground, in two or three dimensions, and the overall situation at any moment could be seen on a digitized map. In 3-D mode a popup "billboard" display permitted a commander to click on an aggregate of battalions of armor, for instance, and get a selective representation of different classes of weapons: a useful feature for rapidly inspecting the force layout on the battlefield without all the clutter.

Once the 73 Easting project was completed, Project Odin provided a perfect platform for an interactive, predictive simulation. With the simulation database plugged into Odin, it was possible not only to rerun the historical simulation, but also to change the equipment used by the enemy to test out tactics for other scenarios. For example, it was hypothesized that infrared vision systems enabling navigation in the sandstorm favored the 2nd Cavalry, whereas the Iraqis had only optical sights on their equipment. The simulation allowed the addition of infrared to the Iraqi equipment in order to gauge its effect on the battle's outcome. In addition, multiple Odin simulators could be hooked up to the network, all running the 73 Easting database. Soldiers in the simulators and commanders at workstations could break into the simulation and add new tactics. Once improvements in processors and graphics cards became available, it was imagined that the size of simulation units could be reduced and actually embedded into M1 tank units, attack helicopters, or F-16s themselves, allowing real soldiers to train for an impending mission right up to the hour of the engagement.

From DARPA to Your Local Area Network

In contrast to popular perceptions of the post-Cold War dismantling of the military-industrial complex, the major defense contractors receive more funding today than they ever have. According to William Hartung, as a result of a rash of military-industry mergers encouraged and subsidized by the Clinton administration, the "Big Three" weapons makers—Lockheed Martin, Boeing, and Raytheon—now receive among themselves over $30 billion per year in Pentagon contracts. This represents more than one out of every four dollars that the Defense Department expends on everything from rifles to rockets.[13]

While defense spending has not diminished, and seems destined not to in the immediate future, the relationship between defense contracting and the commercial sector has shifted radically. In the early years of the Cold War, when Eisenhower first called attention to the phenomenon of the military-industrial complex, attempts were made to keep relations between defense contractors and commercial firms either rigidly separate or delicately balanced in a complicated dance. During the late 1980s and early 1990s following the collapse of the Soviet Union and the debates surrounding large government research projects such as the Superconducting Super Collider, policy discussions focused on reorienting defense research spending so that research not only served national defense but also ultimately benefited the commercial sector. The military-entertainment complex is one of the effects of this shift.

In the 1990s, the end of the Cold War brought an emphasis on a fiscally efficient military built on sound business practices, with military procurement interfacing seamlessly with industrial manufacturing processes. The Federal Acquisitions Streamlining Act of 1994 directed a move away from the DOD's historical reliance on contracting with dedicated segments of the US technology and industrial base. In Secretary of Defense William Perry's mandated hierarchy of procurement acquisition, commercially available off-the-shelf alternatives should be considered first, while choice of a service-unique development program has lowest priority. In effect these changes have transformed military contracting units into business organizations. In keeping with this new shift in mentality, "Company" websites now routinely list their "product of the month."

This shift in policy radically transformed the fields of computer simulation and training. Throughout the 30-year history of these fields, developments in computer graphics, networking and artificial intelligence (AI) had always been driven by demands of military and aerospace contractors because of the importance of simulation technology to military training. The perceived importance of simulation to the outcome in the Gulf War provided stimulus for increasing DARPA-supported research and development efforts around SIMNET (see Chart 1). Given the enormous expense of military aircraft and other armed systems, and given both the cost and political difficulties in arranging large scale training maneuvers, an effective campaign was mounted in the name of cost-effectiveness in support of military investment in simulation technology. STRICOM, the Army's Simulation Training and Instrumentation Command, was founded in order to manage and direct the DOD's simulation efforts in the newly streamlined, flexibly managed military of the 90s. In this role STRICOM has played a pivotal role in developments that have led to the current synergism of military simulations and the entertainment industry, the new military-entertainment complex.

The shift in procurement policy led to a loosening—indeed in many ways an erasure—of the boundaries between military contractors and the commercial sector. As a result many important technologies in the area of networking, simulation, virtual reality, and artificial intelligence have moved from behind the walls of military secrecy into the commercial sector; and even more importantly, technology has flowed freely from the commercial sector, particularly the game industry, into the military. Several concrete examples show clearly how this has worked. One of the most instructive early examples is provided by Real3D of Orlando, Florida, a relatively short-lived company formed through merger and spinoff in 1995 and dissolved in 1999.

Chart 1. Large DOD Development Programs in Modeling and Simulation

Project Name	**Description**	**Estimated Program Cost ($millions)**
Close Combat Tactical Trainer	Networked simulation system for training army mechanized infantry and armor units. It is composed of various simulators that replicate combat vehicles, tactical vehicles, and weapons systems interacting in real time with each other and semiautonomous opposing forces.	$ 846
Battle Force Tactical Training	Tactical training system for maintaining and assessing fleet combat proficiency in all warfare areas, including joint operations. It will train at both the single-platform and battle group levels.	165
Warfighter's Simulation 2000	Next-generation battle simulation for training Army commanders and battle staffs at the battalion through theater levels. It has a computer-assisted exercise system that links virtual, live, and constructed environments.	172
Joint Tactical Combat Training System	Joint effort by the Navy and Air Force to create a virtual simulation at the battle group level in which combat participants will interact with live and simulated targets that are detected and displayed by platform sensors.	270
Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration	Program to construct synthetic environments for numerous defense functions. Its primary objective is to integrate virtual simulation (troops in simulators fighting on a synthetic battlefield), constructive simulation (war games), and live maneuvers to provide a training environment for various levels of exercise. The demonstration program will construct a prototype system to allow the U.S. Atlantic Command to quickly create, execute, and assess realistic joint training exercises.	442
Joint Simulation System (core)	A set of common core representations to allow simulation of actions and interactions of platforms, weapons, sensors, units, command, control, communications, computers, and intelligence systems, etc., within a designated area of operations, as influenced by environment, system capability, and human and organizational behavior.	154
Distributed Interactive Simulation	A virtual environment within which humans may interact through simulation at multiple sites that are networked using compliant architecture, modeling, protocols, standards, and databases.	500
TOTAL		**$2,549**

SOURCE: U.S. Department of Defense, Office of the Inspector General. 1997. *Requirements Planning for Development, Test, Evaluation, and Impact on Readiness of Training Simulators and Devices*, a draft proposed audit report, Project No. 5AB-0070.00, January 10, Appendix D.

Developments connected with companies like Real3D are seminal in the historical evolution of the Post-Cold War effort to create a seamless environment in which research work carried out for the high-end military projects can be integrated with systems in the commercial sector. The history of Real3D can be traced back to the first GE Aerospace Visual Docking Simulator for the Apollo lunar landings. In 1991, GE Aerospace began exploring commercial applications of its real-time 3-D graphics technology, which led to a contract with Sega Enterprises Ltd. of Japan, the world's largest manufacturer of arcade systems. Sega was interested in improving its arcade graphics hardware so their games would present more realistic images. GE Aerospace adapted a miniaturized version of their real-time 3D graphics technology for Sega's arcade systems, providing a visual experience far exceeding expectations.[14] By the time Real3D closed its shop in 1999, Sega had shipped more than 200,000 systems that included Real3D technology.

In 1993, GE Aerospace was acquired by Martin Marietta, the largest U.S. military contractor and a leader in the field of visual simulation. Martin Marietta not only advocated expansion of their relationship with Sega, but also encouraged further research and analysis to look at other commercial markets, such as personal computers and graphics workstations. In 1995, Martin Marietta merged with Lockheed Corporation to form the mega-defense contracting firm Lockheed Martin, and shortly thereafter launched Real3D to focus solely on developing and producing 3-D graphics products for commercial markets. Finally, in December 1997, Lockheed Martin established Real3D, Inc. as an independent company and at the same time announced Intel had purchased a 20 percent stake in the firm. While it got off to a roaring start, Real3D went out of business just four years later, with Intel purchasing its numerous (roughly 40) patents and many of its employees returning to contracting with Lockheed Martin.[15]

3-D graphics capabilities were not the only Martin-Marietta "spin-offs" made more widely accessible through the streamlining of military procurement. High level research on distributed simulation environments such as SIMNET and on the use of AI in generating synthetic agents, high priority research problems in both the gaming and film industries, are other examples of federally funded research work that have been more rapidly disseminated through the military's new integrated product teams.

The employment trajectories of individuals who have participated in both the military simulation community and the entertainment industry suggest paths for the dissemination of research ideas across these seemingly different fields. An illustration is provided by the career of Steven Woodcock, Real3D's senior software engineer from January 1995-1999. Woodcock began his career in the development of game simulations for Martin Marietta. From October 1989 to January 1992 Woodcock was senior software engineer and from 1992 to 1995 lead software and technical engineer for Martin Marietta Information Group, National Test Bed, where he was responsible for all weapons code development, testing, integration, and documentation for ARGUS, the Advanced Real-time Gaming Universal Simulation.[16] ARGUS is a real-time, distributed, interactive command and control simulation focusing on missile defense, running on a TCP/IP network consisting of a Cray-2 supercomputer and more than 50 Silicon Graphics workstations. During this time Woodcock added to these responsibilities work developing the Martin Marietta/Sega arcade platform. From March 1995 to March 1997 Woodcock shifted his venue completely from military network simulations to the interactive game industry, where he was lead programmer and oversaw all aspects of game development on the Sega-produced arcade game *Behind Enemy Lines*, featuring a true 3-D environment and use of AI. Woodcock has noted that his previous experience at Martin Marietta in distributed applications, real-time simulations, and artificial intelligence has proven invaluable in designing the real-time, 3-D, multi-player game environments he has worked on since 1995. From January to June 1996 he was AI and game engine developer for a Sony PlayStation project named *Thundering Death*. On this project Woodcock implemented the first goal-based AI on the PlayStation using neural networks to provide an ever-learning opponent. Such techniques are now stock-in-trade of every videogame.

If the career of Steven Woodcock illustrates the ways in which personnel, ideas, and technologies have flowed from military simulation efforts to the entertainment industries, the "careers" of *Doom,* a videogame produced by id Software, and *Falcon 4.0*, one of Spectrum Holobyte's videogames, provide glimpses into how the exchange has also gone in the opposite direction—from the game industry to the military.

The shift in military culture reflected in procurement policies is evident in new military approaches to developing critical thinking. Emblematic of this shift was Marine Corps Commandant Gen. Charles C. Krulak's 1996 directive aimed at implementing improvements in what he termed "Military Thinking and Decision Making Exercises." Gen. Krulak wrote: "It is my intent that we reach the stage where Marines come to work and spend part of each day talking about warfighting: learning to think, making decisions, and being exposed to tactical and operational issues." He identified an important way to exercise these skills:

> The use of technological innovations, such as personal computer (PC)-based wargames, provide great potential for Marines to develop decision making skills, particularly when live training time and opportunities are limited. Policy contained herein authorizes Marines to use Government computers for approved PC-based wargames.[17]

General Krulak directed the Marine Combat Development Command to assume responsibility for the development, exploitation, and approval of PC-based wargames. In addition, the Command was charged with maintaining the *PC-based Wargames Catalog* on the Internet.[18] In response to this directive, a group of Marine simulation experts from the Marine Corps Modeling and Simulation Management Office in the training and education division at Quantico, Virginia tracked down a shareware copy of the commercial game *Doom* produced by id Software and began experimenting with its game engine. *Doom* was a milestone in the history of software distribution—the first level was released as shareware, uploaded to the University of Wisconsin server on December 10, 1993.[19] Gamers attracted by this first level would then purchase the full version from id. So many fans were taking the shareware copies and modifying them in various ways that id decided to release the *Doom* level editor as open source in 1994. General Krulak's marines acquired the shareware version and level editor and adapted the game as a fire team simulation, with some of the input for the Marine version coming from Internet *Doom* gamers employing the same shareware software tools to build new levels.[20] Instead of using fantasy weapons to face down monsters in a labyrinthine castle, realistic images of sites, weapons, and soldier action characters were scanned into WAD files. The game was also modified from its original version to include fighting holes, bunkers, tactical wire, "the fog of war," and friendly fire. *Marine Doom* trainees used Marine-issue assault rifles to shoot it out with enemy combat troops in a variety of terrain and building configurations. The simulation could also be configured for a specific mission immediately prior to engagement. For example, Marines tasked with rescuing a group of Americans held hostage in an overseas embassy could rehearse in a virtual building constructed from the actual floor plans of the structure.

While a number of military simulations and commercial airline flight simulators have been adapted to the commercial game market, Spectrum Holobyte's *Falcon 4.0* was the first off-the-shelf commercial flight simulation videogame to be adapted to military training.[21] *Falcon 4.0* is a network-based game that supports either single player or multi-player modes. The game's 600-page manual suggests the complexity of the game and indicates why the military finds it attractive for its own training purposes. As producer Gilman Louie explains, the *Falcon 4.0* is a detailed simulation recreating the experience of an F-16 pilot operating over a modern battlefield. The simulation has a highly accurate flight model and avionics suite incorporating flight parameters conforming to real-world specifications. *Falcon 4.0* accurately recreates such effects as deep stall (to escape, the player must use the real-world procedure of flipping the Manual Pitch Override switch and "rocking" the aircraft out—the standard game trick of simply lighting the afterburners won't restore normal flight in this simulation). Weapon modeling is equally realistic and, except for omitting a few classified details, provides an amazingly accurate representation of weapons deployment. The simulation is so detailed, in fact, that reviewers of the game report consulting a real-world "Dash 1" manual for the F-16 when playing the game. The realism of *Falcon 4.0* is further enhanced by graphics generated from actual aerial photographs and map data from the Korean peninsula. In its current version, the game only requires a computer with a processor of 400 MHZ or higher.

The extreme realism in this videogame led Peter Bonanni, graduate of the F-16 Fighter Weapons School and pilot instructor of the Virginia Air National Guard, to work with Spectrum Holobyte to modify the *Falcon 4.0* flight simulator game for military training. According to Bonanni, *Falcon 4.0* mimics the look and feel of real military aircraft and allows users to play against computer-generated forces or, in a networked fashion, against other pilots, which facilitates team-training opportunities. Another reason for Bonanni's enthusiasm is the virtual world around the player. Although the product features scripted Tactical Engagement missions as well as an Instant Action mode for newcomers, the heart of the product is the dynamic campaign mode, where the player assumes the role of a pilot in an F-16 squadron during a conflict on the Korean peninsula. The campaign engine runs an entire war, assigning missions to units throughout the theater. A list (displayed either by priority to the war effort or by launch time) shows the missions available to the player's squadron. The player can fly any of these missions, with the freedom to choose air-to-air or air-to-ground sorties. Unlike games with pre-scripted outcomes, the campaign engine allows story lines, missions, and outcomes to be dynamically generated. For instance, if a player is first assigned a mission to destroy a bridge but fails, the next mission may be to provide support to friendly tanks engaged by an enemy that just crossed the bridge. Each play of the game influences the next.

Like Steven Woodcock, Peter Bonanni moves seamlessly between the military and entertainment worlds. Bonanni not only helps adapt the videogame to military training needs but also writes a regular column for the www.falcon4.com website on tactics and has designed several of the 31 pre-built training missions included with the game. He is author of two best-selling books on *Falcon 4.0,* one co-written with colleague James Reiner, also an F-16 instructor pilot and graduate of the F-16 Fighter Weapons School, and like Bonanni a consultant on the game. Beginning with some basics on the game and the various gameplay options, *Falcon 4.0: Prima's Official Strategy Guide* gives readers a guide to instant action missions, multi-player dogfights, and full-fledged campaigns. The book is a serious no-nonsense manual, devoting separate chapters to laser-guided bombs and even the AGM-65 Maverick missile. Bonanni's second book, *Falcon 4.0 Checklist,* was already high on the Amazon.com sales list before it even hit the bookstores.

The scenarios depicted here have mutually benefited both the military simulation effort and the videogame industry through their two-way flow of people and technology. The military profited from id Software's release of *Doom*'s code and level editor for creating the first military first-person shooter training simulation; and at the same time the game industry benefited from people like Woodcock and Bonanni, with their various skills, who added whole new dimensions to commercial games.

Among the numerous similar accounts of spin-off groups who were involved with the design of SIMNET and subsequently left military contract projects to launch commercial simulation and videogame companies, MÄK is one of the most interesting, because it adds a new dimension to the military-entertainment complex; namely, the simultaneous release of a product as a commercial videogame and a training simulation for military purposes. MÄK (pronounced "mock") Technologies (Cambridge, MA) was founded in 1990 by two MIT engineering graduates, Warren Katz and John Morrison. After graduating from MIT both were original members of Bolt Beranek & Newman's SIMNET project team from 1987 to 1990, where they participated in work on network interconnectivity for distributed simulations. MÄK's corporate goal is to provide cutting-edge research and development services to the Department of Defense in the areas of distributed interactive simulation (DIS) and networked virtual reality (VR) systems, and to convert the results of this research into commercial products for the entertainment and industrial markets. MÄK's first commercial product, the VR-Link™ developer's toolkit, is the most widely used commercial DIS interface in the world. It is an application programmer's toolkit that makes possible networking of distributed simulations and VR systems. The toolkit complies with the Defense Department's DIS protocol, enabling multiple participants to interact in real time via low-bandwidth network connections.[22] VR-Link is designed for easy integration with existing and new simulations, VR systems, and games. Thanks to such products, MÄK was ranked 36th in the 1997 New England Technology Fast 50 and 380th in the 1997 National Technology Fast 500 based on revenue growth between 1992 and 1996.

In addition to its work in the defense community, the company's software has been licensed for use by several entertainment firms, such as Total Entertainment Network and Zombie Virtual Reality Entertainment, to serve as the launching pad for real-time, 3-D, multi-user video games. One such game, *Spearhead*, a multi-user tank simulation game released in mid-1998, was written by MÄK and published by Interactive Magic. *Spearhead* can be played over the Internet and incorporates networking technology similar to that used in the military simulations the MÄK cofounders first worked on with SIMNET.

The networking capabilities of distributed simulation technology developed by MÄK and other government suppliers are now enabling entertainment providers to create platforms for 3-D worlds supporting up to 100,000 participants simultaneously. Katz has described his vision provocatively in a chapter for the book *Digital Illusion: Entertaining the Future with High Technology*. The chapter is titled "Networked Synthetic Environments: From DARPA to Your Virtual Neighborhood."[23] In the near future MÄK co-founders Katz and Johnson are betting that Internet-based populations the size of a mid-sized U.S. city will be able to stroll through an electronic shopping mall, explore and colonize a virtual universe, or race for prizes in cyberspace's largest 3-D road rally.

The contract awarded by the U.S. Marine Corps to MÄK in 1997 has assisted this vision of vastly shared virtual reality; it further erodes the distinction between military simulation technology and the technology available to ordinary users. The contract called for a multiplayer, networked game/training simulation *Spearhead II*, developed in cooperation with the U.S. Marine Corps in order to ensure that a high level of realism would be incorporated into the simulation. The special operations unit commander in this game will see a battle engagement from a 3-D tactical view, enabling him to select units, issue orders, and monitor the progress of his forces. Each player will be able to assume a position in the command hierarchy of either US or opposing forces. Additionally, players of platform-level simulations will be able to assume their appropriate positions in the command hierarchy. MÄK will use the same game engine in both its military and civilian versions. The military version will add more accurate details about tactics and weapons, while the civilian game will be less demanding. But both versions will allow multiple players to compete against each other over a local-area network or the Internet.

While many key developments in the area of networked games, artificial intelligence, and graphics during the mid-1990s were spin-offs of the military simulation efforts, the recent development in all of these areas has been more heavily weighted toward contributions from the game industry. Military technology, which once trickled down to civilian use, now often lags behind what is available in games, theme park rides and movie special effects. As STRICOM Chief Scientist and Technical Director Dr. Michael Macedonia wrote in a recent article in *Computer*:

> As Siggraph—the computer-graphics community's showcase—has demonstrated over the past several years, the demands of digital film development are making way for computer games' even more demanding real-time simulation requirements. As a mass market, games now drive the development of graphics and processor hardware. Intel and AMD have added specialized multimedia and graphics instructions to their line of processors in their battle to counter companies such as Nvidia, whose computer graphics chips continue breaking new performance boundaries.…
>
> By aggressively maneuvering to seize and expand their market share, the entertainment industry's biggest players are shaping a 21st century in which consumer demand for entertainment—not grand science projects or military research—will drive computing innovation. Private-sector research-and-development spending, which now accounts for 75 percent of total US R&D, will increase to about $187.2 billion in 2000, up from an estimated $169.3 billion in 1999….[24]

Graphics is not the only area of computing innovation that bears out Macedonia's claim. The same pattern has been repeated in AI research. Artificial intelligence was once synonymous with military research. Since the birth of the videogame market, artificial intelligence had been a standard but minor feature of games. Emphasis was placed instead on other aspects of the game, from tuning 3-D engines to integrating last minute sound effects. Design and coding the computer opponents was often deferred to the final phase of the project. But from the mid-1990s on, AI has been adapted by commercial game developers with striking success. And once mutual exchanges between military, academic AI researchers and videogame design teams began, the successful game applications accelerated the field and created a reverse flow back into large scale military projects.

The Institute for Creative Technology

Until the last two or three years crossovers from military simulations and the entertainment industries have been unplanned and opportunistic. Recently several top officials in the military simulation command have sought more formal collaborative relations with the videogame and entertainment industries. In December of 1996 the National Academy of Sciences, acting on the initiative of Professor Michael Zyda, a computer scientist specializing in artificial intelligence at the Naval Postdoctoral Academy in Monterey, and indeed the same director of the MOVES Institute behind the networked action game *America's Army: Operations* discussed in the opening paragraph of this paper, hosted a workshop on modeling and simulation to investigate the possibility of organized cooperation between the entertainment industries and defense.[25] Zyda was joined in this effort by Warren Katz from MÄK, Gilman Louie from Spectrum Holobyte, and several academic and industry leaders from the fields of computer graphics and virtual reality. Zyda's report and follow-up proposal stimulated the Army in August 1999 to give a $45 million, five-year grant to the University of Southern California to create a research center, the Institute for Creative Technologies (ICT), to support collaboration between the entertainment and defense industries, to apply entertainment-software technology to military simulation, training and operations, and to leverage entertainment software for militarily relevant academic research. The research center has enlisted film studios and videogame designers in the effort, with the promise that any technological advances can also be applied to make more compelling videogames and theme park rides. Although Hollywood and the Pentagon may differ markedly in culture, they now overlap in technology: wargames are big entertainment. In opening the new ICT, Secretary of the Army Louis Caldera said, "We could never hope to get the expertise of a Steven Spielberg … working just on Army projects." But the new institute, Caldera said, will be "a win-win for everyone."[26]

While putting more polygons on the screen for less cost has certainly been one of the military's objectives at the ICT and in similar alliances, other dimensions of simulated worlds are even more important for their agenda. Movies, theme park rides, and increasingly even videogames are driven by stories with plot, feeling, tension, and emotion. Military simulations have always been extremely good at modeling hardware components of military systems. Flight and tank simulators are excellent tools for learning and practicing the use of complex, expensive equipment. However, to train for real world military engagements is not just to train to use the equipment but also to cope with the implementation of strategy in a fearful environment with uncertainties and surprises. As Marine Corps Commandant Gen. Charles C. Krulak emphasized, decisions made in war must frequently be made under physical and emotional duress. His directive states that the PC-based wargame exercises in peacetime should replicate some of the same conditions: “Imaginative combinations of physical and mental activities provide Marines the opportunity to make decisions under conditions of physical stress and fatigue, thereby more closely approximating combat.”[27]

How has the pursuit of this line of development in new settings like the ICT taken shape? Prior to the ICT’s launch the work by several key ICT members focused on constructing semi-automated forces and multiple distributed agents for virtual environments, such as training programs. Others in the ICT worked on building models of emotion for use in synthetic training environments. Still others constructed intelligent agent technology for incorporation into state-of-the-art military simulation systems.
At the opening ceremonies of the ICT, Executive Director Richard Lindheim outlined several projects for the institute. Among them was a construction of what he referred to as “the holodeck”: immersive virtual environments with interactive synthetic agents, *synthespians*, for the staging of simulation- and game-based learning exercises. Some examples of the programs underway at the ICT that partially realize the mission of creating the holodeck are the Advanced Leadership Training Simulation and the Mission Rehearsal Exercise.

One of the Mission Rehearsal Exercise scenarios presents a situation to train soldiers heading for combat, peacekeeping and humanitarian missions. In this interactive scene, you are an American soldier in Boznia-Herzegovnia whose Humvee has accidentally struck a civilian vehicle and injured a child. A soldier stands, awaiting orders to continue with the mission or to call for Medivac assistance. "Sir, we should secure the assembly area," he says—a platoon already in position is expecting your arrival as backup. Along the cobbled streets, a crowd has gathered. A TV crew is now on the scene. A helicopter circles overhead. Tension mounts.

The five-minute scenario is projected onto a 150-degree movie screen, complete with 10.2-channel audio that creates floor-shaking sound effects. To enhance the sense of reality, smells including burned charcoal can be pumped into the room. Participants can gesture and touch objects and elicit responses in the simulator. The machine also uses voice recognition technology and different languages to allow participants to converse with the characters they encounter. The designers of this simulation, led by Jonathan Gratch, have spent considerable time trying to make this artificial intelligence respond in unpredictable ways so the experience is slightly different each time the system is used.

Other simulations are being constructed to train soldiers for circumstances too dangerous for real-life training—for example, a chemical spill. The goal of constructing the holodeck is to create the type of technology that allows teams of soldiers to be embedded in any environment. By 2008, ICT hopes to take the experience off the movie screen and compress it into a helmet, which users can wear to experience virtual reality anytime, anywhere.

Directly related to the game-based mission rehearsal exercises is the ICT games project, which will release two games, Combat System XII and C-Force, by the end of 2002. The games are intended to have the same holding power and repeat value as mainstream entertainment software and will be available commercially as well as for military training. The goal of the ICT games project is to create immersive, interactive, real-time training simulations to help the Army teach decision-making and leadership skills. The first game, Combat System XII, is a PC-based company command simulator scheduled for completion in December 2002. As the commander of a U.S. Army light infantry company, the student must interpret the assigned mission, organize his force, plan strategically, and coordinate the actions of about 120 men under his command. The second game, C-Force, will run on the Microsoft XBox, and places the student in the role of a squad leader. The student is at the tip of the spear, leading and coordinating about a dozen men to complete a series of missions and come home safe. The games are being designed in a collaboration involving STRICOM and commercial game development companies and will include state-of-the-art technologies in artificial intelligence and physics modeling of military equipment as well as an extensive pedagogical evaluation module.

Shareware: Mods Rock the Game Industry

At the same time that developments like the ICT have formalized the mergers and crossovers in the military and the entertainment industry, the previously distinct roles of videogame makers and videogame players have become increasingly complex and co-mingled. Since id Software released the Doom level editor in 1994 a number of videogame companies have released editors allowing users to modify various game-related parameters. (In fact, as noted above, *Marine Doom* was a product of the adapted shareware version of *Doom*.) id Software's John Carmack was simply noticing a phenomenon that had been around since the beginning of computer games, going back to 1983 with Andrew Johnson, Preston Nevins and Rob Romanchuk's parody of Silas Warner's original game *Castle Wolfenstein* –the mod was called *Castle Smurfenstein*—for the Apple II and the Commodore 64.[28] By 1990 players of *Duke Nukem* began to build their own editors to make modifications of games and share them with other players. With the takeoff of the Internet, this phenomenon, called "modding," began to assume massive dimensions. Many game mods were extremely professional and great additions to the game. Realizing the importance of this phenomenon for building a fan base for games as well as the potential value of incorporating such mods into the commercial game itself, Carmack released *Final Doom* in 1996 with a compilation of user-built mods, and he allowed the mod builders to share in the proceeds from sales.[29]

The next phase of the mod movement, and indeed some would maintain its high-water mark, began in 1996 with id Software's release of *Quake*, which was written in Quake-C, a subset of the computer language C designed by Carmack especially for *Quake*. *Quake* was not only the first true 3-D game: Quake-C enabled an unprecedented degree of interactivity in a first-person-shooter videogame. Immediately *Quake*-mods began to spring up and a vibrant internet community devoted to creating mods for all aspects of *Quake*, including its AI components, emerged. Players who were not highly-trained computer programmers were able to acquire guidance not only in how to build their own levels and fill them with monsters, but also to specify how the monsters would act in some situations. If players didn't like the standard-issue game monsters, they could build their own—and they did. Extensive websites, such as www.planetquake.com, www.actionnation.com, www.botspot.com and later the Modsquad's www.planetunreal.com, began to provide interviews with mod creators on how they constructed their patches, open forums and tutorials for would-be game AI builders to create new scripts and modify their games with tools posted on the website and promoted by commercial game makers.

Among the literally millions of mod builders worldwide a number have achieved legendary status for having changed the way games work. One of the most famous mod careers of this generation is that of Ben Morris,[30] who in 1994 as a teenager built the most widely used level editor for *Doom*, called the *Doom Construction Kit.* Morris' utility was celebrated in the modding community as a resource for crafting complete conversions of games to generate an entirely different look and feel from the original. In 1996 when id's fully 3D game Quake came out Morris set to work on building a level editor called Worldcraft. Morris made Worldcraft publicly available as a free download in December 1996. Marc Laidlaw described the wonders of Worldcraft in his regular feature "Street Cred" for *Wired*, as follows:

> So you want to be a god? Nothing to it. If you already have a fairly powerful PC and a registered copy of Quake (id Software's cutting-edge 3-D game), all you need is the powerful level-design shareware Worldcraft. This week, using Worldcraft, I made a brand-new world. Not a huge one—but it's all mine. It has teleporters and magical floating platforms, gold keys, hidden tunnels, secret elevators, vast dark chambers rimmed by molten lava, and, at the center of it all, an inside-out ziggurat full of luminous golden orbs and a lovely blue bridge. … Last week I could hardly draw a line with a straight edge. And clarity is crucial when you're working in three dimensions at once, because the possibilities for confusion skyrocket as your map begins to sprawl. Starting with a handful of simple forms (blocks, wedges, and spikes, with more forms slated for future versions of Worldcraft), you add and subtract shapes to build just about any imaginable structure. Fill your map with secrets, infest it with monsters, and you're ready to upload a finished map to the Worldcraft Web site and invite your friends to share your nightmare…Try your hand making maps for 3-D games, and you may discover a pastime more addictive than the games.[31]

Morris, a Victoria, BC native, was ultimately offered a position at Valve Software to join the team in creating a new game called *Half-Life*.

Valve Software has transformed the active involvement of an extensive mod community into a business model for commercial game development. The first step toward this new business model was *Half-Life*. Valve was founded by two Microsoft engineers, Gabe Newell and Mike Harrington. Their game project was based on a license of the *Quake* game engine from id Software. Newell and Harrington invited Ben Morris to join them in using Worldcraft to create the game. *Half-Life* appeared in 1998 and has been the most successful single person, first-person shooter game to date with more than 50 "Game of the Year" awards from various organizations. In addition to the game content itself, factors contributing to the game's enormous success are its multiplayer component and its streamlined, extremely fast connection directly to a local area network. Valve also followed id's lead in providing the game source and a user mod builder to create stakeholder buy-in for *Half-Life* and subsequent Valve titles.

The next step in the formation of Valve's business model actually happened *outside* the company in the amateur gaming community, and it illustrates how, for the moment at least, the mod community has become both dedicated stakeholder and major generator of both the technology and content driving the industry. Enter Minh "Gooseman" Le, a computer science student at Simon Frasier University near Vancouver. The Gooseman got his start with building a mod for *Quake*, called *Navy Seals*, a project that occupied him during July and August of 1997. Using the software development kit issued by id with *Quake*, Le modeled some exceptional weapons and a stable of characters. He teamed with various other modders, most of whom he met only online, to build levels for *Navy Seals*. With the overwhelming success he enjoyed in the modding community, Minh Le decided to construct a complete mod of a game. He felt he had done everything he wanted to do with the *Quake* engine and decided to work with the new Valve game, *Half-Life*, released in early 1998. Like id, Valve released a software development kit for *Half-Life* a few months after the initial game publication. Minh Le was already poised to build what has become the most spectacular mod of a game ever, *Half-Life: Counter-Strike.* Minh Le, now in his senior year, designed the first version of the game entirely on his own and assembled a team of mappers, modelers, and editors to collaborate in the construction.[32] The *Counter-Strike* team has eventually grown to about 12 persons distributed all around the globe.[33] Most of the team had never met face-to-face before launching the game. *Counter-Strike* transformed *Half-Life's* sci-fi adventure with biotech experiments gone awry into a team-oriented multiplayer military mod that pits a hostage rescue team against terrorists. (In the days following the World Trade Center attack on September 11, 2001, new mods began surfacing with the hunt for Ben Laden as their theme.) The first beta version of *Counter-Strike* went online in June 1999 and by late 1999 had become the most popular online game in history with upwards of 65,000 people logged on at any one time. By 2000 *Counter-Strike* was included as one of the tournament games in the Cyberathlete's Professional League, and the CPL Pentium4 Processor Summer 2002 Event held in Dallas featured *Counter-Strike* as the main tournament game with prizes totaling $100,000.[34]

Early on, Valve recognized the value of the mod community around *Half-Life*, and in 1999 began organizing an annual *Half-Life* mod expo, where mod builders could come to show off their creations.[35] As the popularity of *Counter-Strike* continued to grow, Gabe Newell approached Minh Le to release *Counter-Strike* as a commercial game. By creating a symbiotic relationship with the mod community, Valve extended the life of *Half-Life*. While *Counter-Strike* still goes on as a freely downloadable online game, the retail version comes packaged with *Half-Life*. The retail version came out in the fall of 2000 as *Half-Life: Counter-Strike*, and included the *Counter-Strike* mod as well as several other popular *Half-Life* mods. Valve repeated this same scenario with another extremely popular *Half-Life* mod, *Day of Defeat*, a game that transforms the original biotech nightmare into a battle zone for ultra-realistic squad-based combat set amid the ruins of World War II's European theater. In March 2002 at the annual Game Developers Conference (GDC), Valve announced that it had contracted with the team behind *Day of Defeat* to release a retail version. At this same GDC event Newell announced the formation of a new company, Steam, that aims to recognize the importance of the symbiotic relationship to the user community for commercial game development. Steam is a broadband distribution network that will offer instant updates—many built by modders—to recent Valve games and serve as a distribution point for new mods.[36] Mod teams will be offered a $995 engine license plus royalty to allow them to distribute their mods over Steam. Valve co-founder Newell announced the new broadband distribution enterprise: "Once a mod team has developed an audience they could think about either being aggregated into some other offering or going all the way to publishing their game over Steam."[37]

Just as the military has leveraged the commercial sector for advanced technology, the game industry has pursued the open source community for some of its hottest developments. The examples of id and Valve demonstrate that these developments have already had enormous implications for the industry. Since the mid-1990s the military too has been deploying newly minted best practices of game design and business models to compete in the arena for young highly-trained cyberwarriors. The launch on July 4th of *America's Army* as a free online download and the commercial/training simulation projects at the Institute for Creative Technologies are just some of the most salient examples of how the new military is adapting to the cyber-economy. But to date the military has not announced that it will bite the bullet and release software development packages for its new products analogously to Valve, id, and other fast-moving game companies. In her contribution to the ICT's May 2002 Inside Games Workshop, J.C. Hertz urged that, in terms of practices stimulating innovation the military has been leagues behind the commercial game industry, "because of [the game industry's] development process and cultural infrastructure: extensible applications, constantly modified and improved by the player base, a highly motivated, globally networked, self-organizing population of millions, all striving to out-do one another."[38] Hertz argued that in order to fully transform itself the military will have to adopt two key features of the cultural infrastructure that drives the commercial game industry: continuous, user-driven innovation as a conscious principle of software design; and the social ecology that drives online multiplayer games.[39]

In a sense, whether they like it or not the military is now part of the ecology Hertz describes. To see this, consider the game engine at the core of *America's Army*. It is the Unreal game engine designed by Epic Games, considered by everyone in the industry to be the premier game engine for its amazing artificial intelligence and game physics engine. The engine, originally designed for Epic Games' *Unreal*, released in 1998, has been licensed for all sorts of applications, including many games as well as architectural and historical recreations. While it cost $3mil to produce and licenses for $350,000, this game engine has important roots in mod culture, or more specifically "bot" culture which is devoted to the design of computer opponents in games.[40] One of the principal designers of the AI components of *Unreal* is Steven Polge, who before joining Epic was famous in mod culture as the author of the "Reaper" bot for *Quake* that introduced unprecedented learning capability and precision targeting into a computer opponent.[41]

It is not just the presence of high-level talents on a par with Ben Morris, Steven Polge, and Minh Le out there in mod culture that gives one pause—and perhaps a bit of a chill—in thinking about what it means for the military to be out there too. As the example of Polge reminds us, Epic is one of the new-styled companies exploiting user-driven innovation. Indeed, as might be expected, a vibrant and enthusiastic mod culture has grown up around *Unreal* and its highly acclaimed multi-player *Unreal Tournament*. Exactly parallel to the other games I have discussed, a number of sites provide portals to the extensive Unreal mod community. Gamespy's Planet Unreal, which might be considered the "official" *Unreal* mod site has access to tools, tutorials, discussions, and downloads for modifications, editors, textures, models, and skins, as well as reviews and much more. Given our theme, one of the more interesting recent mods is *Terrorism: Fight for Freedom*. Like the other mods I've discussed, *Fight for Freedom* recruits its team members online from around the world. In the original single-player version of *Unreal* the player is cast as a prisoner aboard a ship en route to a penal colony. The ship crashes on a mysterious planet where the mystical Nali race is victimized by the cruel and technologically advanced Skaarj. As you journey through the many environments on the planet, you must find a means of escape from the planet and help the Nali defeat their oppressors. The game has stunning graphics contrasting medieval Nali architecture and culture with the sci-fi design of the weapons and the Skaarj warriors. The architects of *Terrorism Fight for Freedom* describe their project in an update from August 11, 2002:

> *Terrorism: Fight for Freedom* is a modern-day, small-scale warfare Total Conversion for Unreal Tournament 2003. The mod is based upon wars that are currently occurring in the world.
>
> The armed forces involved are the Special Forces, comprised of soldiers from armies across the world, and the Tangos. T:FfF has many of its maps loosely based on locations around the world where there are conflicts currently occurring. T:FfF, along with these 'Wars Of The World' Campaigns will feature a set of maps called 'Single Black Ops' which are maps that don't have any particular theme but give the player a wide variety of stipulated situations. Single Black Ops can include things such as Hostage Rescue operations to things such as Terrorist weapon dump raids.[42]

The beta version is expected to launch in December 2002 or January 2003.

Given this rich scenario, we might best consider *America's Army: Operations* itself as a highly developed *Unreal* mod. Indeed, it already seems to suffer from some of the issues that fill the forum pages of *Half-Life: Counter-Strike*; namely, cheat codes and hacks. For instance, in one of the features of *America's Army*, to be "authorized" to play the highest levels of the game, you need to train in a cyber boot camp that actually replicates facilities at Fort Benning, Georgia. It only took a few days before a cheat appeared allowing players to bypass the training sessions. More are sure to follow. In a post 9-11 world where distributed collaboration in a military context has come to signify "terrorist cells," the potential mods based on the *Unreal* engine conjure up an all too frightening potential *reality*. No doubt somewhere, either in the game industry itself or among the worldwide community of mod builders, a group is currently developing a cyber-terrorist game based on attacking the computer infrastructure of a country, disabling its power grid, infiltrating its financial networks, and hacking into mainstream news media such as the *New York Times* to confuse the public about what's going on. Will this be a market in which the U.S. military can choose (or afford) not to compete?

Endnotes

---

[1] Among the numerous reviews, see Kyle Ackerman and Rob de los Reyes, "Frictionless Insight's First Annual E3 Awards, March 24, 2002. Online at: http://www.frictionlessinsight.com/Articles/E3_2002/E3_2002Awards.htm. Also see the Best of E3 Gamespy award for "best action game," http://www.gamespy.com/e32002/awards/index15.shtml

Amer Ajami, "America's Army Operations," *Gamespot PC Reviews*, July 7, 2002: http://gamespot.com/gamespot/stories/previews/0,10869,2873293,00.html

[2] Fred Hapgood, "Simnet," in *Wired Magazine*, Vol 5, No. 4, April 1997, online at: http://www.wired.com/wired/archive/5.04/ff_simnet_pr.html

[3] J.A. Thorpe, "Future Views: Aircrew Training 1980-2000," unpublished concept paper at the Air Force Office of Scientific Research, 15 September 1978, discussed in Richard H. Van Atta, Sidney Reed, and Seymour J. Deitchman. *DARPA Technical Accomplishments: An Historical Overview of Selected DARPA Projects, 3 Volumes,* Institute for Defense Analysis, IDA Paper P-2429, 1991: Vol. 2, chapter 16, p. 10. M. Harris, "Entertainment Driven Collaboration," *Computer Graphics*, Vol. 28, No. 2, May 1994, pp. 93-96 argues that SIMNET was inspired by the Atari game Battlezone.

[4] Ibid., note 50. Chapter 16, p 10.

[5] The training concept was to provide a means of cueing individual behavior, with the armored vehicle being part of the cueing. When individuals and crews reacted, they would provide additional cues to which others would react. Thus, the technology was to play a subservient role in the battle-engagement simulations, making no decisions for the crews, but rather simply and faithfully reproducing battlefield cues.

[6] Van Atta, Chapter 16, p. 13.

[7] See J.A. Thorpe, "The New Technology of Large Scale Simulator Networking: Implications for Mastering the Art of Warfighting," in *Proceedings of the 9th Interservice Industry Training Systems Conference, November 30-December 2, 1987,* American Defense Preparedness Association, 1987,492501.

[8] R.J. Lunsford, Jr., *US Army Training Systems Forecast, FY 1990-1994*, Project Manager for Training Devices (US Army Materiel Command), Orlando, Florida, October 1989, p. 14. Cited in Van Atta, Chapter 16, p. 31.

[9] F. Clifton Berry, Jr., "Re-creating History: The Battle of 73 Easting," *National Defense*, Nov. 1991.

[10] Ibid. Also see the discussion of the Battle of 73 Easting in Bruce Sterling, "War Is Virtual Hell," *Wired Magazine*, Vol 1, No. 1, January 1993, online at: http://www.wired.com/wired/archive/1.01/virthell.html?topic=&topic_set= see especially pp. 6-7 of the online article.

[11] Berry, "Re-creating History." Also discussed in Kevin Kelly, "God Games: Memorex Warfare" from *Out of Control*, (New York; Addison Wesley, 1994): http://panushka.absolutvodka.com/kelly/ch13-e.html

[12] Personal communication.

[13] William D. Hartung, "Military Monopoly," *The Nation*, January 13/20, 1997.

[14] See the discussion by Jeffrey Potter of Real3D *in Modeling and Simulation: Linking Entertainment and Defense*, pp. 164-165.

[15] Real3D went out of business in October, 1999. See WAVE Report, Issue 9099, 10/20//99. http://www.wave-report.com/1999%20Wave%20issues/wave9099.html#anchor27942

[16] For Steven Woodcock's bio see: http://www.cris.com/~swoodcoc/stevegameresume.html Also see Steven Woodcock Interview on the future of AI technology and the impact of multi-player network-capable games in *Wall Street Journal Interactive Edition* (May 19, 1997). Also see Donna Coco, "Creating Intelligent Creatures: Game Developers are Turning to AI to Give Their Characters Personalities and to Distinguish Their Titles from the Pack," *Computer Graphics World*, July 1997, Vol. 20, No. 7, pp. 22-28.

http://www.cgw.com/cgw/Archives/1997/07/07story1.html

[17] General Charles C. Krulak, Marine Corps Order 1500.55, "Military Thinking and Decision Making Exercises," online at http://www.tediv.usmc.mil/dlb/milthink/

[18] For the PC-Wargames Catalog, see: http://www.tediv.usmc.mil/dlb/milthink/catalog/title.html

[19] On Doom and the open source movement, see Eric S. Raymond, "The Magic Cauldron," June 1999 online at: http://www.tuxedo.org/~esr/writings/magic-cauldron/magic-cauldron-10.html#ss10.3

[20] For an interesting discussion of Marine Doom, see Rob Riddell, "Doom Goes to War: The Marines are Looking for a Few Good Games," in *Wired Magazine*, Vol 5, No. 4, April 1997. Online at: http://www.wired.com/wired/archive/5.04/ff_doom.html?topic=&topic_set=

[21] Michael Macedonia reports that perhaps the most successful use of commercial games for training has been with *Microsoft Flight Simulator*. The Navy issues a customized version of the software to all student pilots and undergraduates enrolled in Naval Reserve Officer Training Courses at 65 colleges. The office of the Chief of Naval Education and Training has also installed Flight Simulator at the Naval Air Station in Corpus Christi, Texas, and plans to install it at two other bases in Florida. See J.C. Herz and Michael Macedonia, "Computer Games and the Military: Two Views," *Defense Horizons*, No. 11, April 2002, pp. 1-8, especially p 7.

[22] MÄK's products use technologies called Distributed Interactive Simulation (DIS) and High Level Architecture (HLA). Both technologies efficiently connect thousands of 3D simulations together on a computer network. Replacing the DIS standard for net-based simulations, HLA has been designated as the new standard technical architecture for all DoD simulations. All simulations must be HLA-compatible by the end of 1999. The transition to HLA is part of a DoD-wide effort to establish a common technical framework to facilitate the interoperability of all types of models and simulations, as well as to facilitate the reuse of modeling and simulation components. This framework includes HLA, which represents the highest priority effort within the DoD modeling and simulation community. MÄK intends to leverage its technology for both the military and commercial markets by taking advantage of the nearly $500 million a year spent by the US government on optimizing the speed and capabilities of DIS and HLA. State-of-the-art military DIS systems are now capable of running over 10,000 simulations simultaneously, networked together across far-ranging geographies. As low-cost commercial data services (bi-directional cable TV, ADSL, etc.) become more widely available to consumers, industry analysts projected the market for on-line, 3D, multi-user simulations to reach $2 billion in the year 2000.

[23] Warren Katz, "Networked Synthetic Environments: From DARPA to Your Virtual Neighborhood," in Clark Dodsworth, Jr., ed., *Digital Illusion: Entertaining the Future with High Technology*, New York: ACM Press, 1998, pp. 115-128.

[24] Michael Macedonia, "Why Digital Entertainment Drives the Need for Speed," *Computer*, Vol 33, no. 3, 2000: http://www.computer.org/computer/co2000/r3toc.htm

[25] Committee on Modeling and Simulation, *Modeling and Simulation: Linking Entertainment and Defense*. Washington, D.C.: National Academy Press, 1997.
http://www.nap.edu/readingroom/books/modeling/ (main url)

[26] Andrew Pollack, "Trying to Improve Training, Army Turns to Hollywood," *New York Times* August 18, 1999. Online at http://www.isi.edu/nyt_uarc.html.

[27] Loc. Cit. Note 16 above.

[28] For the history and context, see the *Castle Smurfenstein* website: http://evlweb.eecs.uic.edu/aej/smurf.html

[29] On the development of mods and the shareware movement in gaming two invaluable sources are Wagner James Au, "Triumph of the Mod: Player- Player-created additions to computer games aren't a hobby anymore -- they're the lifeblood of the Industry," in *Salon*, April 16, 2002, online at: http://www.salon.com/tech/feature/2002/04/16/modding/ J.C. Herz, "Gaming the System: Social Ecology, Cultural Dynamics, and Networked Innovation in the Computer Game Industry," paper presented in the Institute for Creative Technologies Inside Games Workshop May 22, 2002, available online at: http://www.ict.usc.edu/%7Einsidegames/ J.C. Herz and Michael Macedonia, chief scientist for STRICOM, engaged in an extremely interesting and provocative discussion on user communities, game design and the military in

"Computer Games and the Military: Two Views," *Defense Horizons*, April 2002, pp. 1-8, online at: http://www.ndu.edu/inss/DefHor/DH11/DH11.pdf
Another outstanding discussion of the mod phenomenon is provided in Sue Morris, "Online Gaming Culture: An examination of emerging forms of production and participation in first-person-shooter multiplayer gaming," June 1999 online at Gamegirlz: http://www.gamegirlz.com/articles/gameculture.shtml

[30] Ben Morris's career is discussed on many game websites. One of the most helpful interviews was done by Vangie "Aurora" Beal , "The Past, Present & Future of Worldcraft - An interview with Ben Morris," 1999, online at Gamegirlz: http://www.gamegirlz.com/articles/wc_001.htm

[31] Marc Laidlaw, "My World and Welcome to It," *Wired*, Vol 5, no. 3, March, 1997: online at: http://www.wired.com/wired/archive/5.03/streetcred.html?pg=5 Laidlaw has subsequently joined Valve Software as a writer and game designer.

[32] On Counter Strike creator Minh "Gooseman" Le, see Bruce Rolston, "The Secret Life of Gooseman: Minh Le may be the most influential designer you know nothing about," *The Adrenaline Vault*, December 30, 2000: http://www.avault.com/articles/getarticle.asp?name=gooseman

[33] See the brief bios of the CS Team at the official Counter-Strike site: http://www.counter-strike.net/csteam.html

[34] See the event announcement page of the Cyberathlete's Professional League at: http://www.thecpl.com/index.html?p=sc2002. The Summer Event took place at the Dallas Hyatt Regency and was primarily sponsored by Intel and co-sponsored by Plantronics, Micro Exchange, BAWLS, SoundMax, Xabre and NetFire.com. Merchandise sponsors include: Logitech, Altec Lansing, Belkin, Hercules and Netgear.

[35] See the announcement by James Fudge, "Half-Life Mod Expo July 29", *Computer Games Magazine*, July 28, 1999, online at: http://www.cdmag.com/articles/021/139/hl_mod_expo.html for the mod expo that took place in San Francisco, July 29, 1999; and the Sierra Games (Valve parent company) announcement: http://www.sierra.com/games/half-life/official-releases.html#modexpo

[36] See the press release on the Steam website: http://www.steampowered.com/HTML/Press_Release.html

[37] Quoted in Wagner James Au, "Triumph of the Mod: Player- Player-created additions to computer games aren't a hobby anymore -- they're the lifeblood of the Industry," in *Salon*, April 16, 2002, p. 1, online at: http://www.salon.com/tech/feature/2002/04/16/modding/

[38] J.C. Hertz, Loc. Cit. note 28 above, p. 2.

[39] Ibid. In his response to Hertz's similar argument in *Defense Horizons*, April, 2002, Michael Macedonia acknowledged the importance of the commercial sector as the leading element in contemporary gaming and simulation, a point he has made numerous times as Chief Scientist at STRICOM. He did not, however, take up the interesting challenge about what it would mean for the military to throw itself completely into the globally networked, self-organizing and distributed networks driving game innovation.

[40] Discussed by J.C. Hertz, "For Game Makers, There's Gold in the Code," published by the *New York Times* on December 2, 1999. Archived at http://www.nytimes.com/library/tech/99/12/circuits/articles/02game.html - requires registration but no fee.

[41] The superior AI of the Reaper allowed it to learn the gamer's particular style of play and adapt to take advantages of his or her weaknesses. The Reaper is difficult to kill because it is excellent at avoiding shots, but is then deadly accurate with the placement of its own shots. On Steven Polge's career, see the interview on Planet Quake: http://www.planetquake.com/interviews/steve.shtm Polge worked on network protocols at IBM for seven years before joining the gaming industry full time.

[42] http://www.planetunreal.com/fightforfreedom/introduction.htm