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SIMNET: AN INSIDER'S PERSPECTIVE

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L. Neale Cosby

March 1995

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Contract DASW01 94 C 0054

ARPA Assignment A-132

CONTENTS

FIGURES

I. INTRODUCTION

Numerous histories have been written about the Simulator Networking (SIMNET) program of the Advanced Research Projects Agency (ARPA) (Ref. 1). This author does not intend to repeat these works; rather, he hopes that an insider's perspective will interest future developers of innovative technology.

Dr. Victor Reis, the former Director of the Defense Advanced Research Projects Agency (DARPA),[1] used to say that the job of DARPA "is to do what cannot be done" (Ref. 2). In the early 1980's, most people in the defense community accepted the notion that building an affordable, large-scale, free-play, force-on-force, worldwide networked warfighting system was impossible. Fortunately, however, some innovative thinkers also were inspired by Reis' challenge to explore unknown territory.

SIMNET comes as close to a revolution as any ARPA technology in recent memory. It changed the way the military does business, it also changed the simulation industry. Throughout the course of SIMNET's development, hard lessons were learned and relearned. In the end, courageous decision-makers won the day.

This document attempts to substantiate what was done, to show how simulation technology has influenced the future, and to recognize the people who made this revolution possible.

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1 DARPA was renamed ARPA in March 1993.

II. THE PROGRAM

A. A VISION

On September 15, 1978, Captain Jack A. Thorpe, a young scientist with the Air Force Office of Scientific Research (AFOSR) at Bolling Air Force Base in Washington, DC, wrote a paper entitled *Future Views: Aircrew Training 1980–2000* (Ref. 3). Thorpe hypothesized that "advances which are seen on the horizon are not simple improvements in teaching techniques or higher fidelity simulators, but rather bold concepts which tightly align training systems with real combat readiness and make them indistinguishable." The four figures that follow, commissioned by the Department of Defense (DoD) in 1978, depict Thorpe's original concept.

Figure 1 shows a real-time overhead source collecting information about simulations worldwide and communicating these data to distributed simulation planning centers.

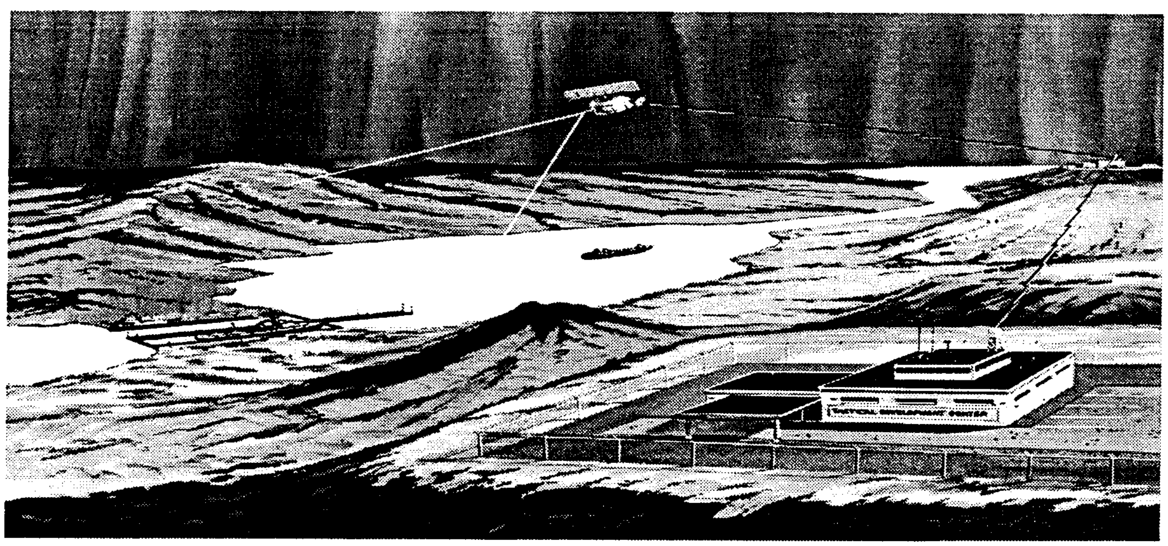

Figure 1. Collecting the Data

Figure 2 shows planners analyzing the situation, using a three-dimensional (3–D) holographic rendering of the denied area, and planning a future operation. The electronic sand table allowed planners to study the terrain and develop options.

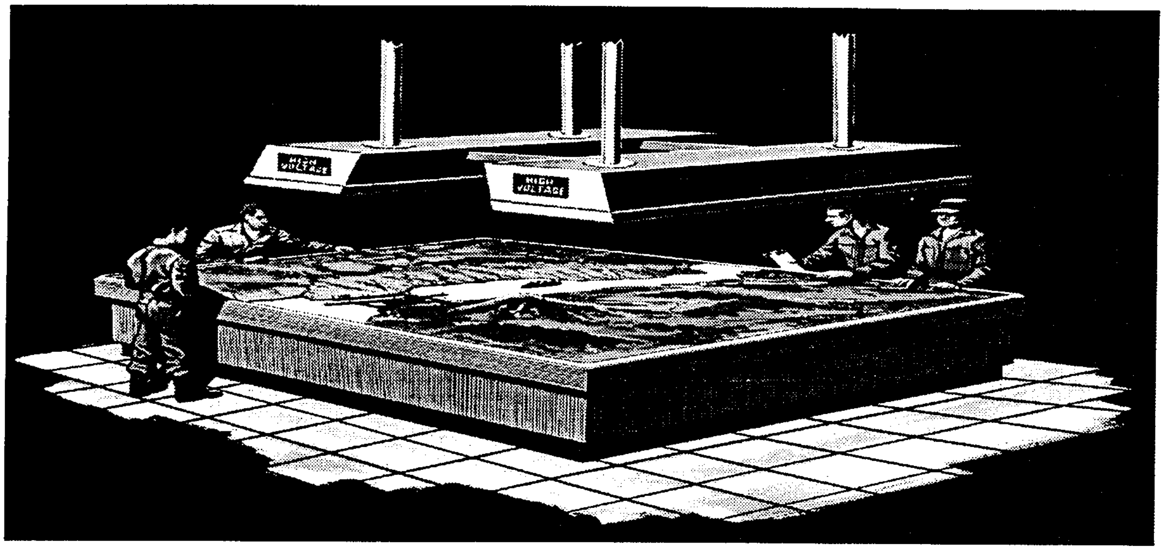

Figure 2. Analyzing the Collected Data

Figure 3 shows four aircraft simulators, with crews flying in the virtual environment and attempting to execute the plan. Coordination, timing, reaction to defenses, and mission effectiveness are assessed.

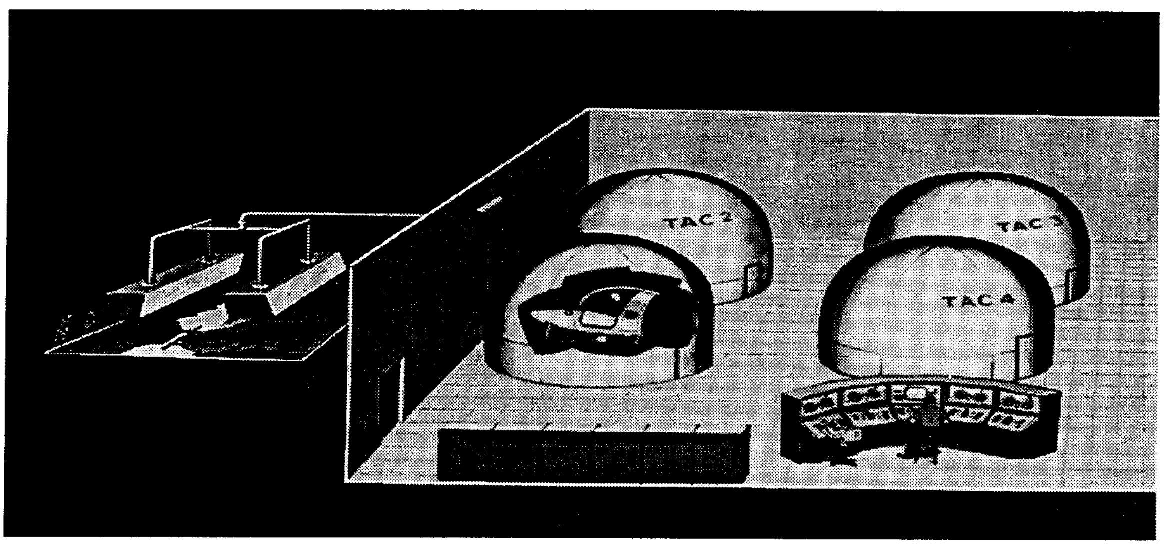

Figure 3. Executing the Plan in a Virtual Mode

Figure 4 shows the chain of command observing the real-time dress rehearsal, assessing the overall plan, and determining whether the plan should be recommended to the command authority.

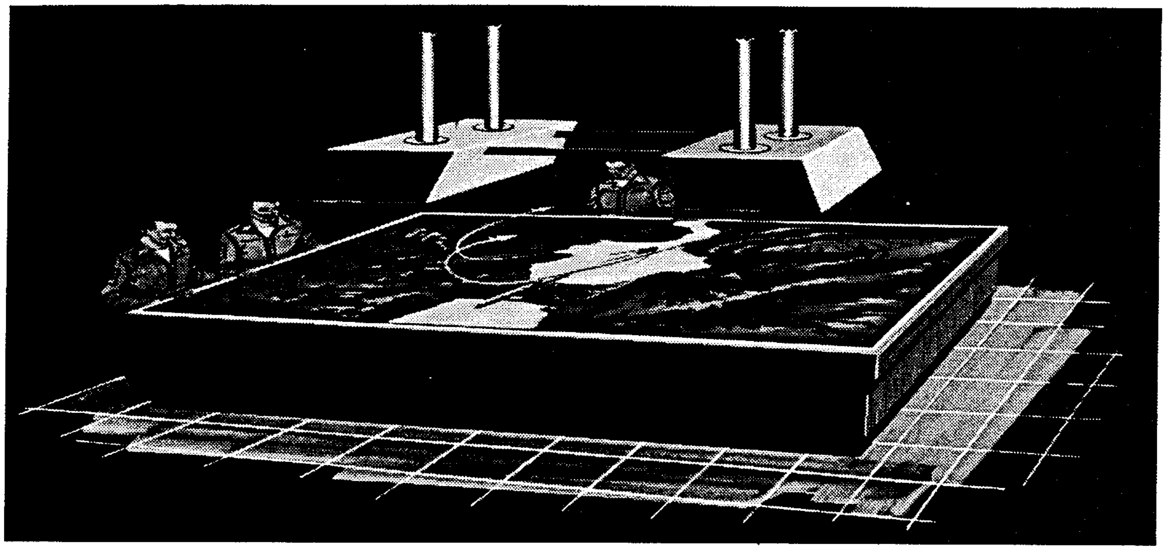

Figure 4. Assessing the Plan for Real-Time Execution

The concepts depicted in Figures 1 through 4, in addition to being used to plan a mission, could be used to monitor the actual mission and to support mission analysis during post-mission debriefings.

B. A BRIEF SUMMARY

In 1981, Captain Thorpe was assigned to DARPA. In 1983, with the help of Dr. Craig Fields, Thorpe began to work on developing this futuristic (SIMNET) technology. Their goal was to develop a new generation of high-tech, realistic, networkable, microprocessor-based simulators that would cost 100 times less than existing simulators. Later, DARPA teamed with the Army to demonstrate this objective in a combined arms environment of 260 networked simulators at 11 sites in the United States and Europe. This demonstration was an immense success and spurred further interest in this revolutionary technology. In 1990, the SIMNET program was transferred to the Army. Under the leadership of Colonel James Shiflett, Program Manager of Combined Arms Tactical Training (CATT) System, the Army began procurement in 1992.

Over a 10-year period, DARPA and the Army invested approximately $300 million to develop and prove simulation technology; field a comprehensive testbed, which remains in full operation today; and conduct training, analysis, test and evaluation (T&E), and advanced concept exercises. Presently, the Army is in the early stages of committing roughly $1 billion to acquire a global, large-scale network of virtual simulators for collective training and combat development in the 21st Century.

III. THE IDEA

SIMNET is not a person, place, thing, or system. It is an idea that is constantly and rapidly changing. In the late 1980's, SIMNET meant high risk to most military researchers and was perceived as a financial threat by the standard simulation makers. In the early 1990's, it became synonymous with an opportunity to become part of the revolution and, perhaps, to increase the bottom line. Today, SIMNET means what it has meant since its inception—a new technology that can be applied to many challenges.

SIMNET has always meant excitement, but the genius of SIMNET is in the unexpected. Simulation technology is still finding new applications in the military and civilian marketplace. From the beginning, the technology for SIMNET was oriented toward training and readiness challenges—fighting the present—because these challenges were the prime concerns of the Army leadership. Later, it expanded into the acquisition business—fighting the future—by giving those who procured weapon systems some insight into battlefield performance. The Pentagon decision-makers were interested in more effective and more economical ways of developing doctrine, material, tactics, and weapons systems, including analysis and testing. Thus, DARPA's initial plan included a developmental testbed that newtworked the military, industry, and academia. Figure 5 is diagram that shows the vision for a SIMNET testbed that was conceived in 1985 (Ref. 4).

The Army now has a network of battlefield development laboratories located at the proponent schools and the material development laboratories. In October 1992, the Army Chief of Staff demonstrated for the Army's four-star generals the use of simulation technology to influence acquisition decisions, systems development, doctrinal development, and organization (Ref. 5). The idea behind this demonstration was to introduce the power of networked simulation in preparing for war.

A. TWO LEARNING ENTREPRENEURS

Without a doubt, Captain Jack Thorpe was the dominant force behind SIMNET's success. He spent 12 years at DARPA, during which time he advanced networked simulation from concept to reality. He had technical expertise, a tolerance for high risk, high

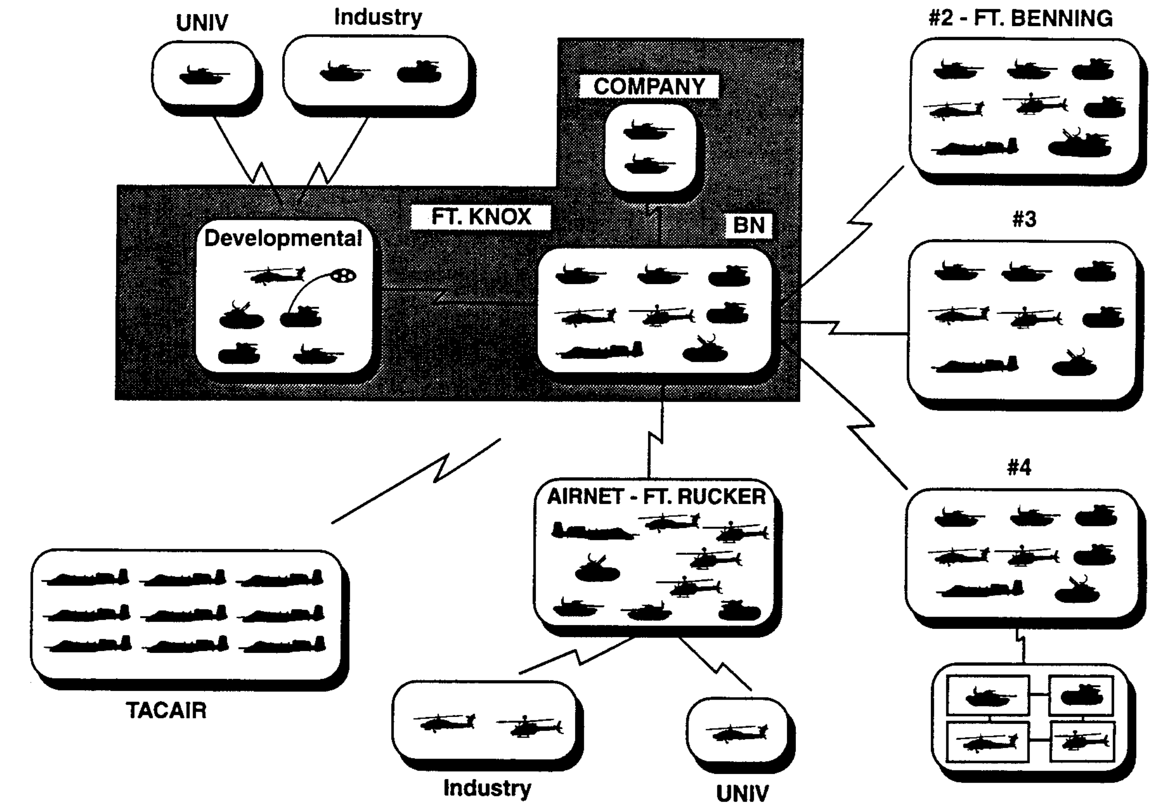

Figure 5. The SIMNET Testbed

personal energy, and a keen awareness of the long-term goal. Ironically, at the same time Thorpe was developing his concept, another visionary was working along the same lines. General Paul F. Gorman, while assigned to the Training and Doctrine Command (TRADOC), envisioned a worldwide, networked training system that would connect field forces with the Army schools (Ref. 6). His idea would create a distributed learning system using subject-matter experts as tutors for operators deployed around the world.

In 1983, Thorpe and Gorman, two of the military's most creative and prolific training minds, met for the first time to discuss potential uses of an innovative, DARPA-sponsored low-cost computer image generator (CIG) under development at Boeing Aircraft. Beginning in 1985, Thorpe and Gorman collaborated on the development of SIMNET and its successor applications.

During their illustrious careers, these two uniformed officers conceived and delivered profound learning systems for the military. Independently, and later together, they worked to advance three of the most powerful, overarching models in warfare:

- The first model (Ref. 7) says that commanders must prepare joint forces (Read: Units) for war by focusing at the point of the arrow (see Figure 6). The preparation must occur with the tactical, operational, and strategic commanders actively participating in an experimental learning environment. In the 1970's, Gorman developed the Multiple Integrated Laser Engagement System (MILES) for this purpose. In the 1980's, Thorpe did the same with SIMNET. In the 1990's, they advocated tying MILES (Live) and SIMNET (Virtual), along with war games (Constructive), in what was called the Synthetic Theater of War (STOW).

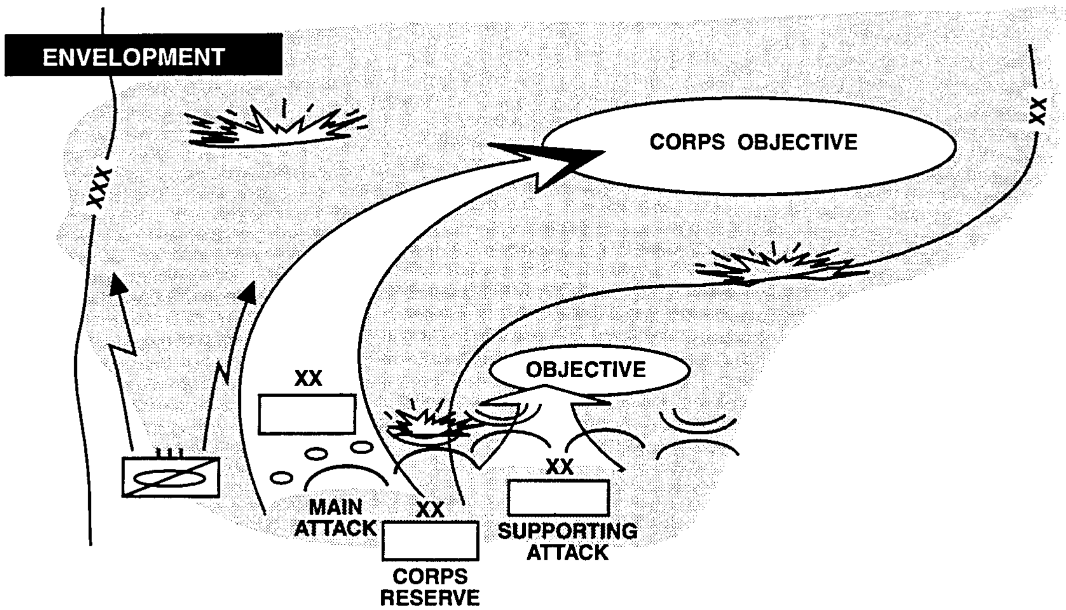

Figure 6. Focus on the Point of the Arrow

- The second model (Ref. 8) says that if we must fight, we must fight with firepower, not manpower. This concept has been the trend since the Civil War. Figure 7 shows the number of people per kilometer of battlefront over the past 200 years. The challenge is to expose even fewer people to the hazards of war but to arm each person with greater amounts of firepower. The most important element of this challenge is to prepare (Read: Train) each person at all echelons to apply the greater firepower adroitly.

- The third model (Ref. 9) says that joint warfare is essential to victory. All members of the team must be structured, practiced, and evaluated (Read: Trained) as a unit before they are sent into combat. All team members must believe that they are a part of a joint team that fights together to win. Figure 8 is an 11 November 1991 memorandum about joint warfare from General Colin

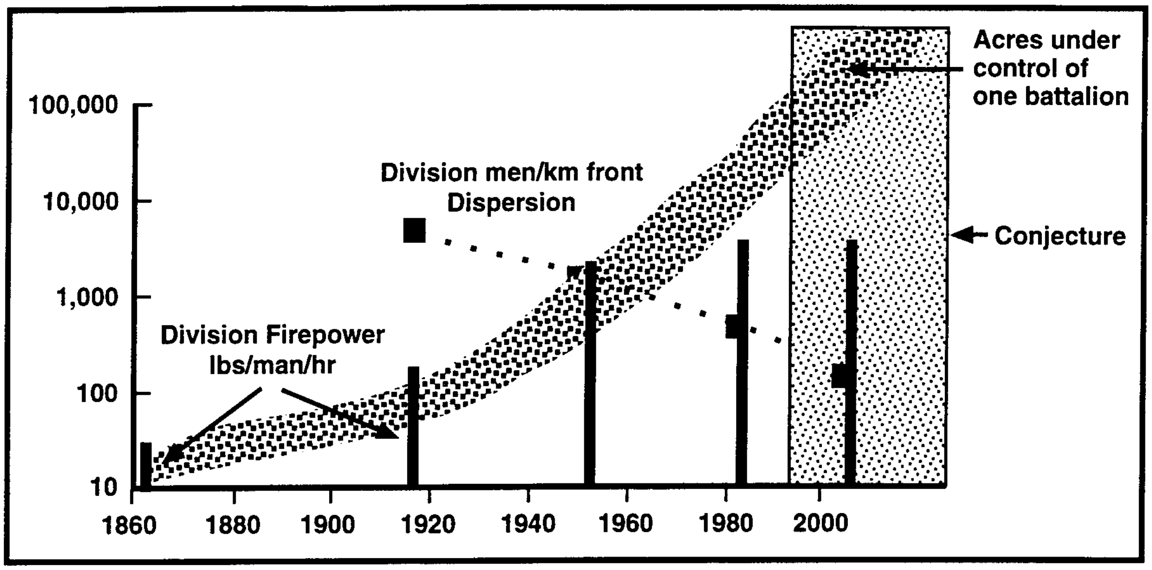

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Figure 7. Trends in Land Warfare

Powell, who was then Chairman, Joint Chiefs of Staff (JCS). The Vice Chairman, JCS and the Defense Director of Research and Engineering (DDR&E) recognized the joint warfare concept in 1992 when they signed a Memorandum of Understanding (MOU) to pursue Advanced Distributed Simulation (ADS) to improve joint warfighting capabilities (Ref. 10).

B. CONVERGING TRENDS

Early on, Captain Thorpe recognized three dominant trends that could be merged to accomplish his goal of developing a networked combat training system:

1. The needs of the warrior
2. Advanced technology
3. Disciplined training requirements.

The Air Force's visionary warfighters were demanding a greater capacity to develop the skills that were essential for surviving and winning in combat. The first trend focused on the need for a capability to practice critical combat skills that could not be practiced in actual aircraft. SIMNET was designed to fill this training shortfall through in-flight training with flight simulators. The analysis of the required level of proficiency versus the capability for training at all echelons showed the disparity of command at the unit level (see Figure 9).

THE CHAIRMAN, JOINT CHIEFS OF STAFF
WASHINGTON, DC 20318

11 November 1991

MESSAGE FROM THE CHAIRMAN

Joint Warfare is Team Warfare

When a team takes to the field, individual specialists come together to achieve a team win. All players try to do their very best because every other player, the team, and the home town are counting on them to win.

So it is when the Armed Forces of the United States go to war. We must win every time.

Every soldier must take the battlefield believing his or her unit is the best in the world.

Every pilot must take off believing there is no one better in the sky.

Every sailor standing watch must believe there is no better ship at sea.

Every Marine must hit the beach believing that there are no better infantrymen in the world.

But they all must also believe that they are part of a team, a joint team, that fights together to win.

This is our history, this is our tradition, this is our future.

COLIN L. POWELL
Chairman
Joint Chiefs of Staff

Figure 8. General Powell's Thoughts About Joint Warfare

During the early stages of SIMNET's development, rapid advances in the computer, communication, and display technology fields were occurring. The second trend facilitated Thorpe's idea of networking large numbers of low-cost simulators together, thus making his goal technically possible and affordable. Dr. Craig Fields and Thorpe

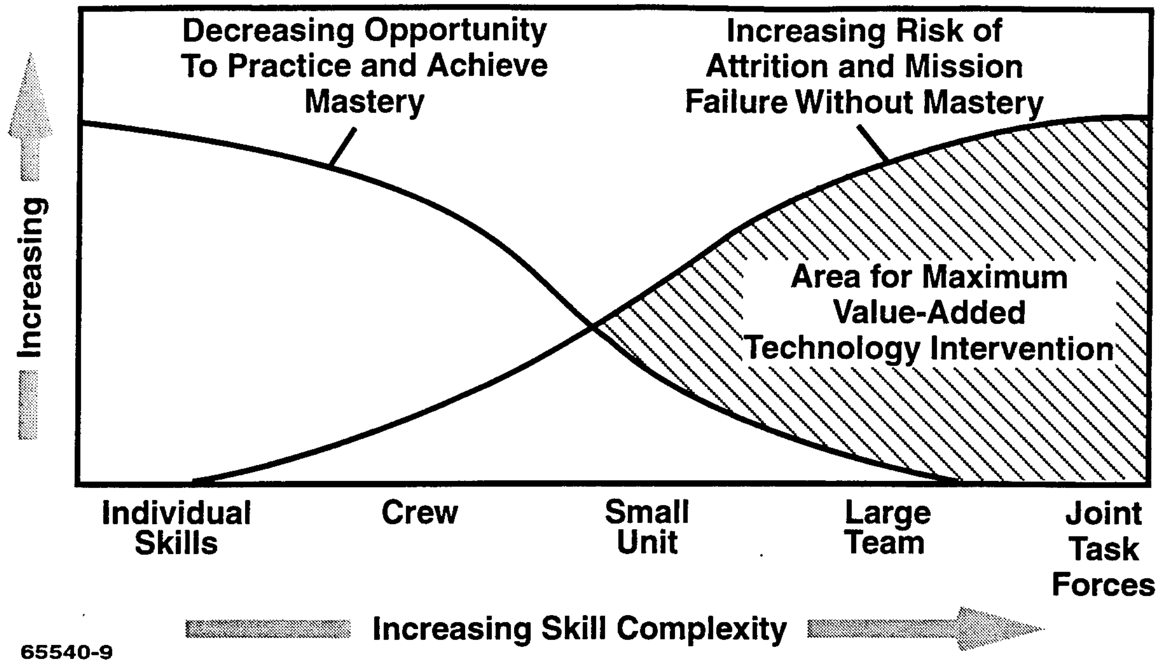

Figure 9. Requirements vs. Capabilities

subscribed to Moore's Law[2] (see Figure 10). This law states that semiconductor technology doubles in speed every 18 months. The same law of exponential increases also applies to communications transmissions capacity—bandwidth.

Fields often encouraged Thorpe to assume that all soldiers would have CRAY-capacity computers in their pockets and that they would have instant personal communications worldwide. The developer's challenge was then and is now to provide the most cost-effective system interface with the human being (Ref. 11).

A behavioral discipline that structured collective training skills from realistic, measurable training requirements supported the third trend. Before the 1970's, training analysis had been applied predominantly to individual tasks, duties, and jobs. However, in the late 1970's, the military Services agreed to apply the techniques of Instructional Systems Design (ISD) to their training management (Ref. 12). ISD techniques allowed commanders and training managers to focus task analysis on collective skill deficiencies that were caused by the inability to practice. ISD techniques also assisted system developers in designing

2 Moore's Law was postulated by Intel cofounder Gordon Moore in the early 1970's.

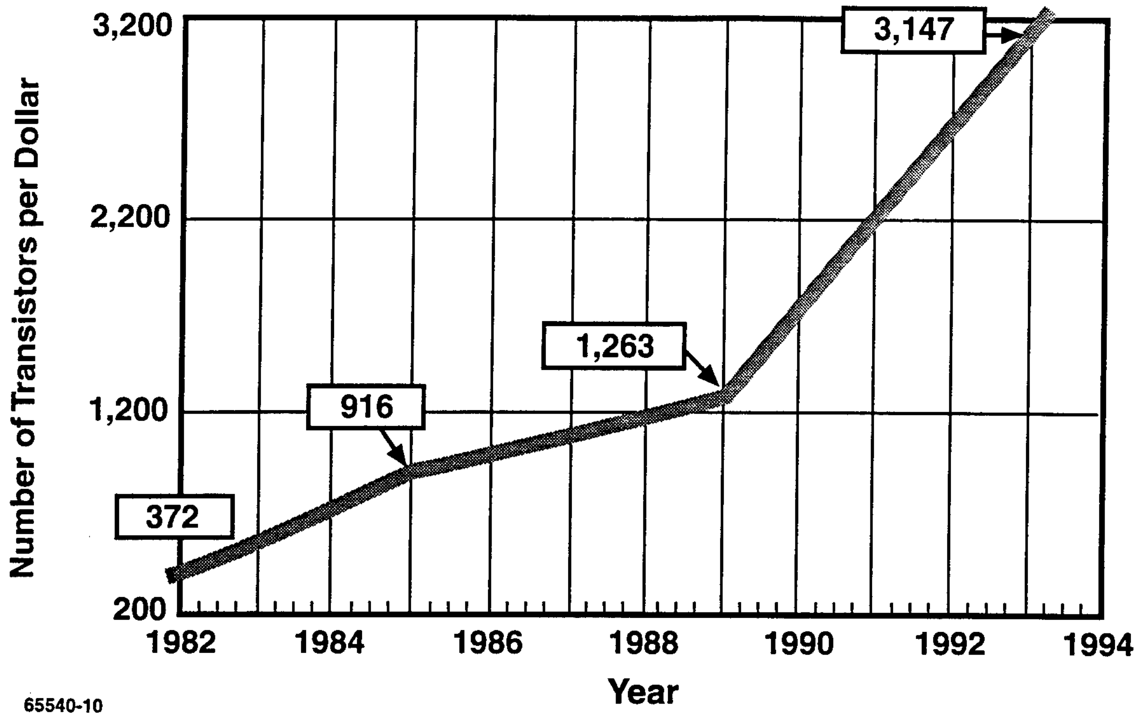

Figure 10. Moore's Law

the functional fidelity of the simulators to save resources by not producing superfluous knobs, dials, controls, and displays. This approach enabled the production of simulators that could be afforded in large numbers.

C. COURAGEOUS DECISIONS

Clearly, the SIMNET program benefited from plucky decisions by leaders with strategic visions. However, one may ask how such a high-risk program could survive in the hostile, ruthlessly competitive business environment of the 1980's. The short but straightforward answer is courage: courageous leaders who listened to their consciences and made courageous decisions for future warfighters. These visionary leaders understood the need for a better technology to enhance collective training, and they were confident that DARPA could deliver this technology. As future generations of warriors review the fast-paced history of SIMNET, they will surely realize that the leadership—at many key milestones during program development—could have taken the easy route and scuttled the entire program. Instead, the leadership persevered, and their decisions have left a lasting imprint.

Figure 11 reflects the long-range vision of the SIMNET decision-makers in what Dr. Elliott Jaques cites in his book, *Executive Leadership*, as the requisite time span for top-level leaders in managing third order categories of complexity (Ref. 13).

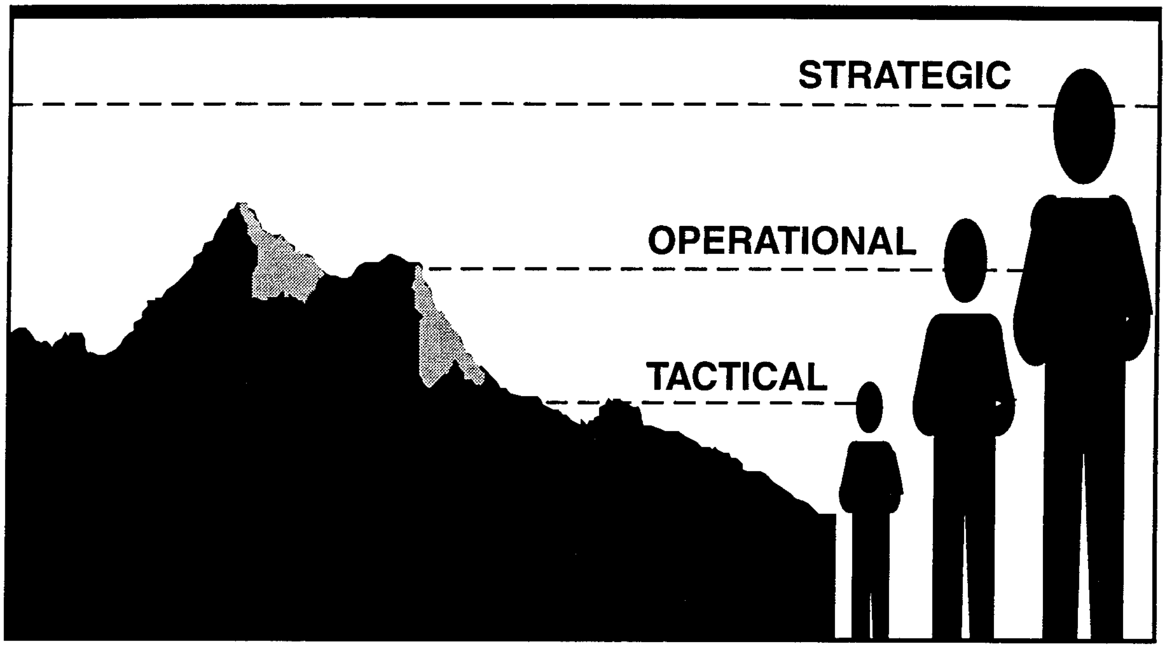

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Figure 11. Leadership Time Span

In addition to General Gorman, Captain Thorpe was aided by the late retired Colonel Gary W. Bloedorn from 1982 to 1992. Bloedorn introduced Thorpe to the Army leadership that would eventually provide the bulk of the research funds. Bloedorn also introduced Thorpe to retired Lieutenant General Frederic J. Brown, who was then the Commander of Fort Knox. Brown became a driving force in the full development that assured SIMNET's acceptance in the Army. In January 1985, General Maxwell R. Thurman, Vice Chief of Staff, made the fateful decision to commit the Army to support the SIMNET program. Later, Chief of Staff General Carl E. Vuono assured warfighters future prowess by continuing to make the tough decisions that were necessary for SIMNET's survival. Early on, Colonel Bob Reddy executed the Army decisions in the Pentagon, and today he continues to apply simulation technology in ARPA. Colonel James Shiflett, who replaced Thorpe at DARPA, completed the research program and transferred it to the Army. Today, he is leveraging the Army research and development (R&D) investment with the procurement of the CATT system.

All of these resourceful, dedicated people were vital links in the chain of events that led to SIMNET's development. Unfortunately, however, while millions of men and women in the Services will enjoy the benefits of SIMNET's success, these sagacious leaders have never been given the proper credit for their courageous decisions.

IV. THE TECHNOLOGY

A. THE EVOLUTION OF A NAME

In 1978, Captain Thorpe used the term "tactics development network/center" to introduce the future technology. In 1983, the name SIMNET became an acronym for simulator networking. When DARPA transferred the program to the Army in 1990, the Simulation, Training, and Instrumentation Command (STRICOM) changed the name to Distributed Interactive Simulation (DIS). The 1992 Defense Science Board (DSB) symposium on Simulation, Readiness, and Prototyping coined the term Virtual Simulation. Later, General Gorman framed the model of Live-Virtual-Constructive Simulation. ARPA's Colonel Robert Reddy fashioned the current moniker, STOW (Synthetic Theater of War). In commercial applications by the education and entertainment industry, names like Virtual Reality, Virtual Environment, 3–D graphics, realistic simulations, and so forth abound.

B. THE BASIC NETWORK ARCHITECTURE

Regardless of the name, this technology allows many different ways to develop new military or civilian business approaches. The core simulation technology is a large "synthetic environment" that can be entered in real time from stations worldwide. Figure 12 shows the basic network architecture for the individual simulator. This architecture emphasizes the desire for flexibility in graphic systems, host computers, programming languages, and operating systems.

Networks allow widely dispersed participants to be brought together on a virtual piece of the Earth without anyone leaving home. Figure 13 is a useful depiction of the flexibility and speed in visiting any spot on the globe, including denied locations.

C. A THREAT TO THE ESTABLISHED INDUSTRY

Initially, the stand-alone simulator industry perceived SIMNET's technology as a threat. In the spring of 1986, when this technology was being expanded from networks of tank simulators to networks that included helicopter simulators, the DARPA program came

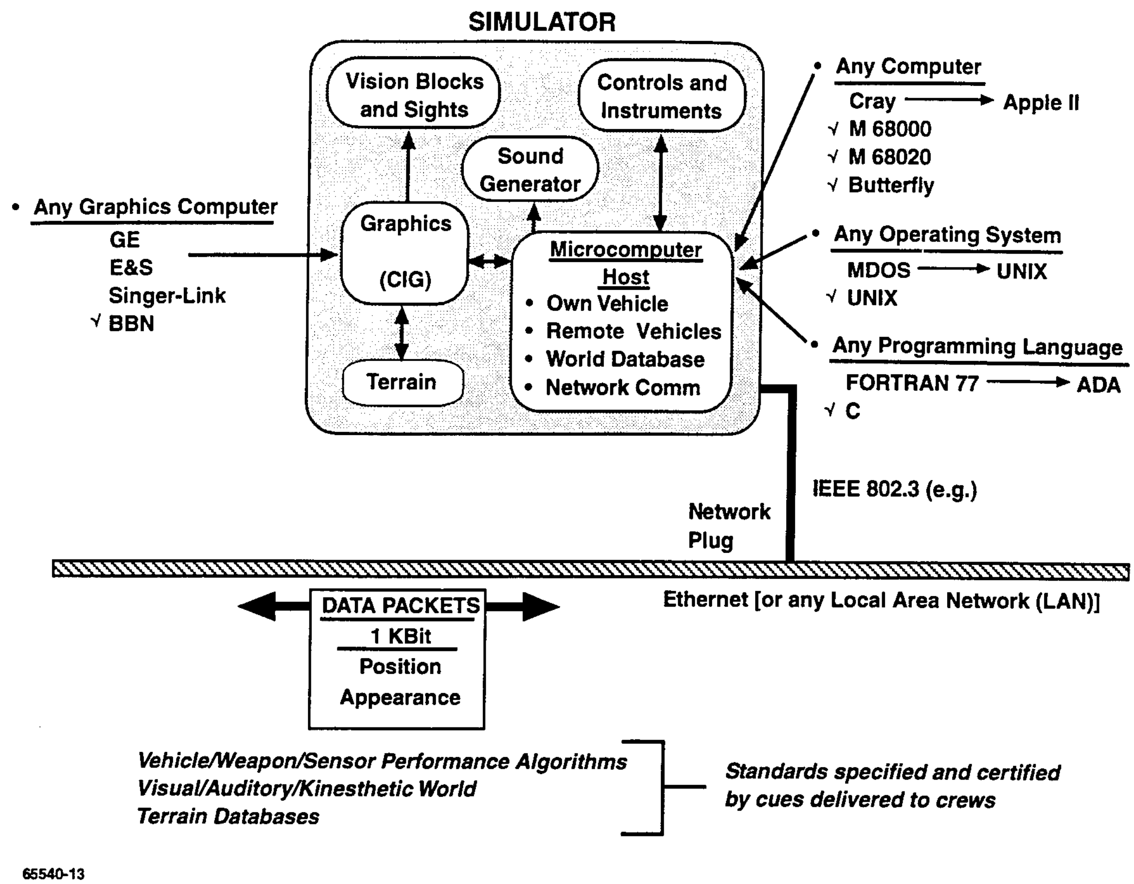

Figure 12. The Basic Network Architecture

under attack by selected lobbyists from the large manufacturers of flight and conduct-of-fire simulators. At that time, CIGs—the systems that paint the environmental scenes (e.g., the pilot's view through the canopy or the armor crewman's view through the vision block of the tank)—cost millions of dollars each. SIMNET's technology enabled the design and production of an affordable CIG that was 30 to 50 times less costly. These low-cost CIGs threatened the established market of the big defense contractors, and their well-placed lobbyists vehemently fought this up-start research effort. Consequently, the DARPA program manager spent many unnecessary hours participating in Congressional inquiries and General Accounting Office (GAO) and Inspector General (IG) investigations.

Industry accolades are reserved for the modest and small businesses that pioneered the innovative simulation technology (Bolt, Beranek and Newman, Inc. and Perceptronics, Inc., with Delta Graphics, Inc.) To be honest, big industry was a hindrance. However, many of the former "critics" now pose as self-appointed discoverers who want more than anything to say that they saw the next wave coming before anyone else.

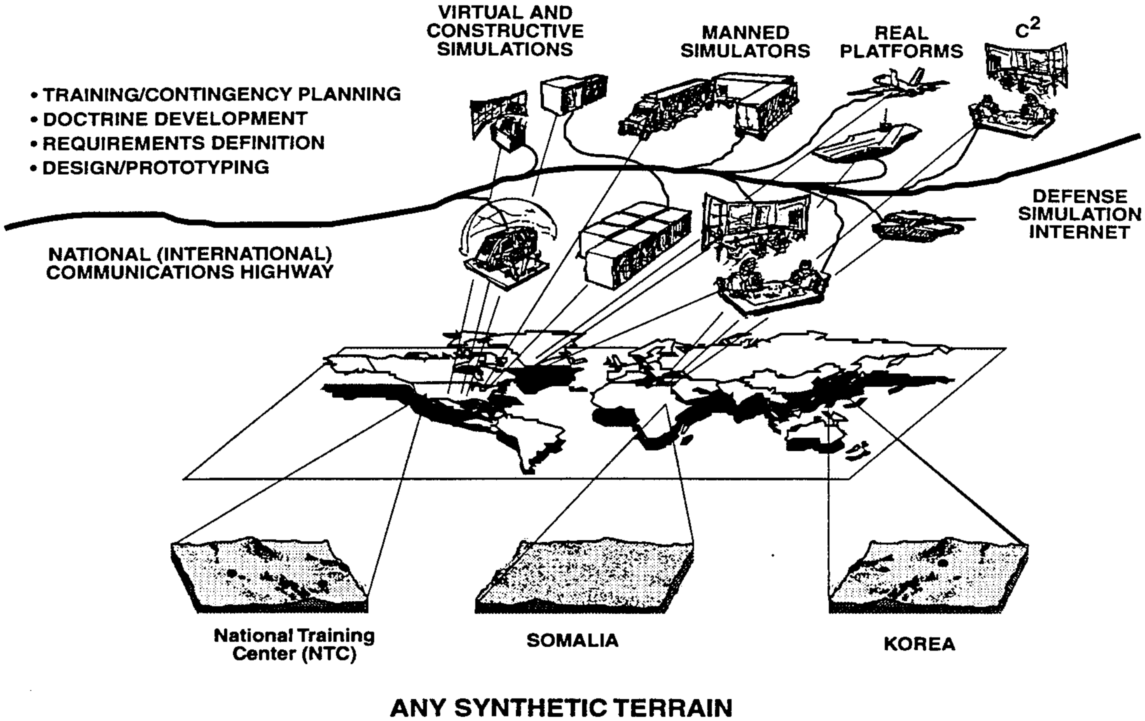

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Figure 13. Around the World in Eighty Seconds

The undeniable fact is that SIMNET's technology has changed the industry. For instance, the 1985 Industry/Interservice Training Systems and Education Conference (I/ITSEC) permitted only one SIMNET paper to be presented and allowed only one SIMNET technology exhibit to be displayed. By contrast, at the 1994 I/ITSEC, DIS was referenced in almost every individual paper and company display (Ref. 14). Meanwhile, during this short period of less than 10 years, CIGs have become faster, smaller, more reliable, and less costly. Today, the market is teeming with high quality, high-powered CIGs in the low hundred-thousand-dollar range, and the good news is that these CIGs continue to get better and less costly. Competition is a great driver.

V. THE FUTURE: WHAT IS NEXT?

A. LOOKING BACK

Before pondering the future, one should search for critical factors that ensured program success. Clearly, young high-tech program managers must comprehend the military need and understand the present and future value of technology. Most importantly, however, they must appreciate the need for people with good instincts or "gut feelings."

People were the decisive factor in developing SIMNET. The right people create the successful chemistry between military subject matter experts and industry technology experts. This chemistry results in a push-pull team effort—technology people pushing and military requirements pulling. One without the other is a prescription for failure.

SIMNET enjoyed a successful push-pull effort. SIMNET is another instance of a lesson learned by ARPA many times over: *good people are the most important ingredient for success in the business of doing "what cannot be done."*

B. LOOKING AHEAD

For cost and safety reasons, the military Services of all countries have developed simulations of fighting systems like tanks, airplanes, and helicopters. The idea is to build actual weapon system replicas that are used as substitutes for practicing the art of warfare. The immediate challenge facing ARPA's ADS team is to converge live field exercises (with actual equipment), SIMNET-like virtual simulation, and constructive war games into a seamless joint forces exercise. Figure 14 demonstrates this challenge (Ref. 15).

SIMNET, together with CATT, will attack the collective training challenge of mechanized forces. However, today's military also is faced with different challenges. The United States' increasing deployments of light dismounted U. S. forces are being made to areas such as Haiti, Somalia, and Cuba in pursuit of Operations Other Than War (OOTW). i.e., peacekeeping. This practice poses another challenge for simulation technology: how to simulate the individual in a SIMNET-like training system. ARPA is developing an R&D program to investigate this new challenge. In support of ARPA's new R&D efforts,

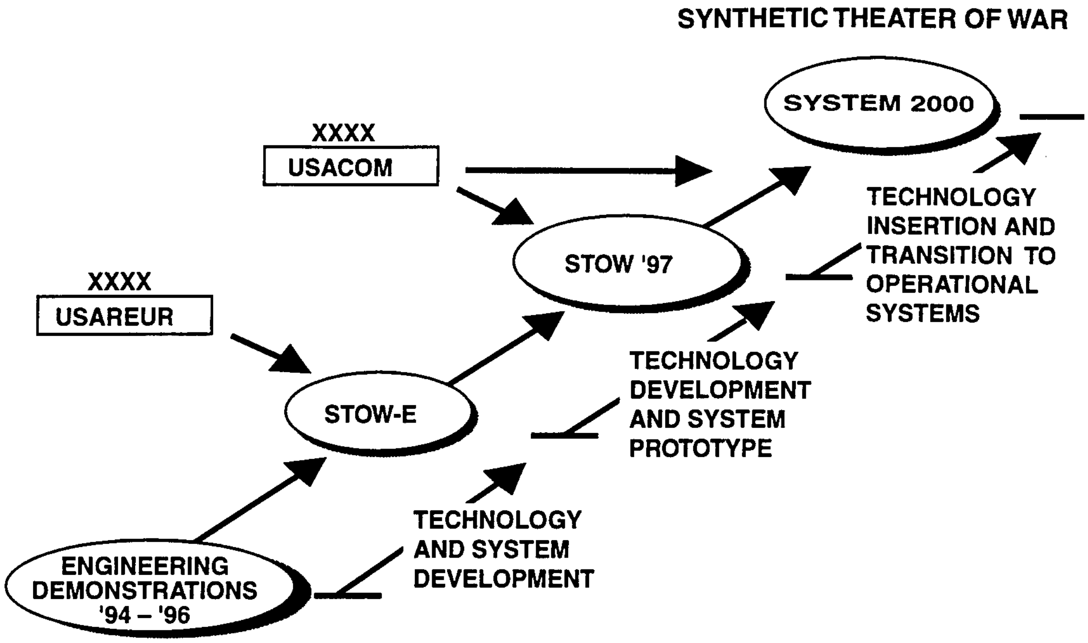

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Figure 14. Concept of Operations

Figure 15 describes the 1994 DSB Task Force on Military Operations in Built-up Areas (MOBA), which emphasizes the functional connectivity for individual combatants to existing and future simulation.

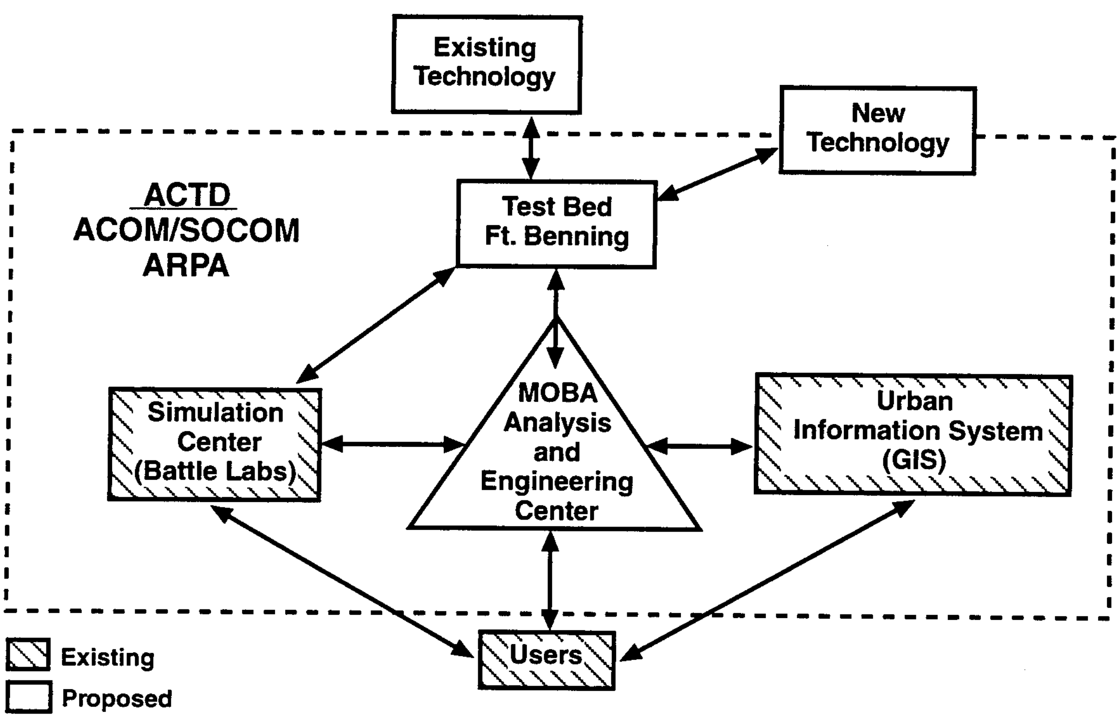

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Figure 15. Functional Connectivities

V. CONCLUSION

By every measure, simulation technology has been a huge success. It turned the simulation industry around, and it has revolutionized military training and readiness for war. However, trying to describe SIMNET's full impact is like an astronaut 225 miles above the Earth's surface trying to do justice to the beauty of Space for the command center in Houston—your appreciation depends on where you are standing.

Analysts used to say that users of realistic simulation have a choice of two of the three characteristics of this simulation—fast, good, or less costly—but not all three. ARPA's simulation technology has changed the "rules." The marketplace is teeming with quality, inexpensive programs that can be run on fast, inexpensive hardware to produce realistic graphics. Although programming used to be very time consuming, today's users can purchase commercial off-the-shelf (COTS) programs—all for a few thousand dollars—that reduce from months to days the time needed to prepare the basic code for 3–D simulations. For a few hundred thousand dollars, users can buy 256 MB of memory and 5 GB of storage hardware. In a few years, almost everybody in training, education, business, and the arts will be able to afford and program his/her own virtual simulation scenarios with outstanding results. In short, the future will provide users with mind-bending tools for authoring and delivering ideas.

In short, ARPA has accomplished what it set out to do—change simulation technology. It changed the industry from a high-priced wholesale monopoly to a low-cost consumer retail business. Simulation technology has provided exponential growth for the electronics industry in the areas of education, training, and entertainment. At the same time, military training has leaped ahead in unimagined ways in a progression of changes that gathers speed and breadth as it goes forward. Undoubtedly, the civilian education, training, and entertainment industries will capitalize on this technology as they ride the "information highway" into schools, workplaces, and homes. Meanwhile, thanks to a young officer with an idea, the military will also ride into the 21st Century better equipped and better trained to meet future challenges.

GLOSSARY

3-D	three dimensional
ADS	Advanced Distributed Simulation
AFOSR	Air Force Office of Scientific Research
ARPA	Advanced Research Projects Agency
CATT	Combined Arms Tactical Training
CIG	computer image generator
COTS	commercial off-the-shelf
DARPA	Defense Advanced Research Projects Agency
DDR&E	Defense Director of Research and Engineering
DIS	distributed interactive simulation
DoD	Department of Defense
DSB	Defense Science Board
GAO	General Accounting Office
I/ITSEC	Industry/Interservice Training Systems and Education Conference
IDA	Institute for Defense Analyses
IG	Inspector General
ISD	Instructional Systems Design
JCS	Joint Chief of Staff
MILES	Multiple Integrated Laser Engagement System
MOBA	Military Operations in Built-up Areas
MOU	Memorandum of Understanding
NTC	National Training Center
OOTW	Operations Other Than War
R&D	research and development
SIMNET	Simulation Networking
STOW	Synthetic Theater of War
STRICOM	Simulation, Training, and Instrumentation Command
T&E	test and evaluation
TRADOC	Training and Doctrine Command
U.S.	United States

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6. AUTHOR(S)

L. Neale Cosby

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Institute for Defense Analyses
1801 N. Beauregard St.
Alexandria, VA 22311-1772

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13. ABSTRACT *(Maximum 180 words)*

Simulator Networking (SIMNET) began as an advanced research project aimed at developing a core technology for networking hundreds of affordable simulators worldwide in real time to practice joint collective warfighting skills and to develop better acquisition practices. A young Air Force scientist, Col. Jack A. Thorpe, originally brought the concept of a synthesis of combat training and advanced technology to the Advanced Research Project Agency (ARPA). There he and others worked to develop a microprocessor-based network of simulators for combat training. Today SIMNET is an established technology that can be applied to many challenges. This document provides an insider's view of the program's history and records events that will be of interest to future developers of innovative technology. The document substantiates what was done to create SIMNET, discusses how simulation technology will influence the future, and recognizes the people who made the program possible.

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SIMNET, simulator, network, computer, advanced technology

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