Report

of the

Defense Science Board

Task Force on

Computer Applications to Training and Wargaming

May 1988

Office of the Under Secretary of Defense for Acquisition
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DEFENSE SCIENCE
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OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

MEMORANDUM FOR SECRETARY OF DEFENSE
CHAIRMAN, JOINT CHIEFS OF STAFF
UNDER SECRETARY OF DEFENSE FOR ACQUISITION

SUBJECT: Report of the Defense Science Board Task Force on Computer Applications to Training and Wargaming--INFORMATION MEMORANDUM

The attached final report of the Defense Science Board Task Force on Computer Applications to Training and Wargaming was prepared at the request of the Chairman, Joint Chiefs of Staff (CJCS). This study focused on the training of joint operational commanders, their staffs, and the commanders and staffs who report to them. Necessarily, such training exercises decision making and it involves the actions of senior civilian decision makers. The Task Force considered near and far term technical opportunities which might be effectively applied to joint training.

The Task Force found that computer-based, simulated scenarios offer the only practical and affordable means by which joint commanders and their staffs can exercise their decision skills, test war plans and train to work as a closely coordinated force. Technology is adequate, and further technology improvements lie predictably ahead. The challenge and the opportunity is to apply this technology to the improvement of joint training. Substantive improvement can be affordably attained.

The Task Force made five recommendations. All are addressed to CJCS. Collectively, they provide for evolutionary improvement, better exploitation of current service and joint assets, and JCS coordination of the development and use of simulations for training. Implementation of the recommendations is affordable.

I believe that the implementation of these recommendations will strengthen the ability of the nation to exercise and hone the skills of the joint commanders and their staffs. I recommend that the Chairman, Joint Chiefs of Staff, reviews the Executive Summary and takes the necessary actions to implement these recommendations.

Robert Everett
Chairman

Attachment

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE BOARD

May 6, 1988

Mr. Robert R. Everett
Chairman
Defense Science Board, OUSD(A)
Room 3D1020, The Pentagon
Washington, DC 20301-3140

Dear Bob:

The Defense Science Board Task Force on Computer Applications to Training and Wargaming has completed its study. Our report is enclosed. The findings and recommendations of the study, if implemented, will in my judgment serve to strengthen significantly the ability of this nation to train its most senior joint military commanders and the civilian leaders with whom they must work in time of crisis or war.

It has been a pleasure to work with such expert, diligent individuals on a subject which is vital to this nation's readiness. I and the other members of the Task Force are ready to work with the Office of the Joint Chiefs of Staff to implement these recommendations.

Sincerely,

Anita Jones

Anita K. Jones
Chairman
DSB Task Force on
Computer Applications to
Training and Wargaming

Attachment

COMPUTER APPLICATIONS TO TRAINING AND WARGAMING

Table of Contents

Executive Summary

Computer-based, simulated scenarios offer the *only* practical and affordable means to improve the training of joint operational commanders, their staffs, and the commanders and staffs who report to them. Such decision makers need the opportunity to exercise their decision skills, to test war plans, and to train to work as a closely coordinated force.

Increasingly, joint training cannot be conducted in the anticipated theater of operations. There are political objections to disruption of civil activity. The cost of an actual exercise at this level is great. Battle simulation offers the only opportunity to practice the use of certain weapon systems, sensors, tactics, and techniques against a skilled adversary.

Today, it is possible to make a substantive improvement to computer-assisted joint training and wargaming. The addition of the Vice Chairman to the Joint Chiefs of Staff, with the delegated responsibility to oversee CINC operational planning and to serve as *spokesman for the CINCs*, provides a **management opportunity**. There is also a **technological opportunity**. Driven by the commercial market, computer technology is evolving rapidly and is increasingly cost-effective. For the most part, the computer technologies supporting computer-based training are adequate. The challenge is to take cost-effective, but maximum advantage of these technologies.

This report advises how to exploit these opportunities.

Background

The Chairman of the Joint Chiefs of Staff asked the Defense Science Board to develop a plan to integrate anticipated advances in computer technology to support training and wargaming for joint warfighting. More specifically, the DSB Task Force, formed in response to this request, addressed how to apply computer technology to improve:

(SDW)

- joint operations training,
- the development of joint warfighting doctrine, and
- battlefield wargaming for the operational commander.

Our inquiry considered simulation, gaming, and training to improve the readiness of joint commanders and staffs. We did not address individual and unit training, nor service-specific collective training. This had already been addressed by the 1982 DSB Summer Study on Training Technology. Nor have we examined combined training with allies. Improving joint training is a precursor for improving combined training.

Each service and the JCS build automated simulations for education and training, and for analysis. Each organization develops its simulations independently, without coordination. Redundancy and overlap abound. A particularly costly and difficult-to-build portion of the simulations is the large database encoding the characteristics that provide realism and accurate portrayal, e.g., characteristics of weapon systems, mobile platforms, order of battle, theater maps, and weather. There is insufficient coordination among the many DoD simulation builders. This results in redundant databases with less quality, less data validation, and less ability to maintain accurate data over time than could be achieved.

Typically, a service simulation represents the forces, threats, and other influences relevant to that service's fighting posture very well. The quality of representation of the other services' posture decreases in quality as the "distance" from the concerns of the builder increases. So, for example, an Army simulation may represent ground warfare well, air support less well, and maritime concerns much less well. Civilian, allied, and neutral influences may be missing altogether. As a result, the service simulations lack adequate joint training functionality. This is not a surprise. Joint training of commanders was not a requirement for most service built simulations. However, the services are dependent upon one another in a theater; better representation of each other's warfighting would improve service-particular training as well as joint training.

Often the people being trained must travel to an artificial training site. Yet, computer technology is now capable of supporting distributed training. Personnel can train from their duty stations using warfighting hardware and software interconnected by secure electronic communications, where appropriate.

Recommendations

This Task Force offers five complementary recommendations. Taken together, they constitute a plan to improve substantially the quality of training for senior joint-operations personnel. All recommendations are addressed to the Chairman, Joint Chiefs of Staff. The plan is evolutionary. It exploits current service and joint assets. It is modest in cost. It calls for the JCS and the joint commanders to take a leading role in coordinating the development and use of training simulations. Yet, it does not invite the JCS to usurp the services' responsibility and authority to train and command their respective forces.

1. Make joint simulations interoperable: Internet existing service, college, training center, and joint games and simulations for education and training. Evolve them to be distributed, so that commanders and staffs can train from their duty stations in peace or wartime. Use one standard DoD communication protocol, and use cost-effective communications hardware and software.

To facilitate the sharing of simulation data, create a shared repository, a library of automated, validated data descriptions for simulation use. Make the data descriptions available DoD-wide. To ensure the quality and timeliness of data, each data description should be built and maintained by the organization/service that is most knowledgeable about the data.

2. Promote joint simulation usage: Continue and extend the involvement of the most-senior joint commanders in battle simulations. The CINCs should be supported as they obtain required joint simulation capabilities, particularly on-station capabilities.

3. Establish requirements for future capabilities: Establish long-term joint training simulation requirements. Document them in JCS directives and use these requirements to develop and issue guidance for future system designs, substantive enhancement of current systems, development of technical standards for gaming, training and simulation, and management of a simulation-prototype program. It is intended that these requirements would influence service-built simulations as well as joint simulations. In exploring future capabilities, the Task Force found that, in general, most candidate capabilities applied to military training simulations and were not specific to joint simulation.

4. Establish a prototype program: Establish a continuing program to demonstrate exploratory prototype simulations, followed by rapid acquisition of selected capabilities. The program should monitor technology advances and selectively build experimental prototypes. The joint users should be closely involved. Selected, prototype-proven capabilities should be rapidly fielded.

5. Undertake a major joint training initiative: Institutionalize the management and budget in OJCS to oversee: the immediate internetting of existing assets, enhanced joint simulation use, increased use of joint assets for testing war plans and joint doctrine, creation of the shared data repository, and implementation of the rapid prototype program. CJCS should coordinate spaces, program elements, and budget lines — both joint and in the services — to arrive at more-effective simulation-based training with less development redundancy.

Summary: The strong competition for DoD resources means that the decision to implement these recommendations may preclude some other investment. The Task Force believes that, particularly in an era of shrinking defense funding, an investment in improving the skill of the senior joint decision-makers exerts enormous leverage. Just a few "better" decisions at the senior joint level in time of conflict would save much more than the materiel that could be bought with these same funds.

Introduction

The Chairman of the Joint Chiefs of Staff asked the Defense Science Board to develop a plan to integrate anticipated computer technology advances to support training and wargaming for joint warfighting. More specifically, the DSB Task Force formed in response to this request addressed the application of technology to training joint decision-makers, i.e., the joint commanders, their staffs, and the commanders and staffs who report directly to them. The objective is to improve:

- joint operations training,
- the development of joint warfighting doctrine, and
- battlefield wargaming for the operational commander.

This report offers the requested plan.

The Task Force believes that the **only** practical and affordable means by which to improve the capabilities of these decision makers is to use computer-assisted, simulated scenarios as the basis for training. There are three reasons why simulation-based training is the only alternative:

- Large joint/combined exercises of actual forces cannot be conducted in their anticipated theater of operations. For example, in Europe armored and air force field exercises increasingly evoke political objections to the attendant noise, safety hazards, damage to roads and fields, and disruption of civil activity.

- The cost of an actual exercise escalates. Field exercises employing actual forces as training aids for higher commanders and staffs are expensive. Given artificialities dictated by concerns for maneuver damage, safety, and avoidance of civil disturbance, they are not particularly effective.

- Battle simulation is the only way commanders and staffs can gain experience with using certain weapon systems, sensors, tactics, and techniques against a skilled adversary. Among these, for example, are electronic warfare measures and counter-measures; accessing, integrating, and disseminating national and international intelligence; supporting theater intelligence and counter-intelligence; attacking opposing forces deep beyond the forward line of troops; and large-scale threats to rear-area security.

In addition, other benefits accrue from simulation-based training:

- Digital communication networks, computers, and displays are now in general use throughout U.S. forces as aids to actual operations. Adaptations of similar technology for simulating battle provides realistic training. Moreover, experience with a computer-based simulation that emulates stress and battle damage on the command, control, and communication system is the most-effective way to develop future C^3 system requirements.

- Degraded communications guarantee devastating impacts. Simulations enable commanders (users) to inject likely communication losses and to observe effects on subordinates. Moreover, commanders and subordinates can better learn how to "cope" and what to expect from supporting forces.

- Crisis reaction-time grows shorter for both civilian and military decision makers. The need to gain experience with eliciting decision under stress increases proportionately. Simulations support a variety of scenarios, and can be played and re-played as desired. In many cases training and gaming can occur many times faster than real-time.

- Compared to warfare in decades past, joint command decisions have more leverage. The cost of a command mistake or staff error has increased, but the payoff for adroit synchronization of joint combat power has grown apace.

- Repetition has always been useful in teaching. Using computers, different learners learning on the same scenarios bring forth new approaches. Repetition, as often as needed, can be employed to identify critical "outcome" sensitivities.

So, while field exercises should be performed, commanders and staffs must be trained with simulations as well. The objective of the simulation-based training is to hone the skills and decision-making ability of each commander and staff so that they perform as though mature, war-experienced veterans.

There is much evidence that experience is an effective teacher. Statistics from several wars indicate that the probability of a pilot being killed in action decreased by a factor of three to five after the first few combat engagements.[1] Similarly, when SAMs were first used by the enemy in Viet Nam, the U.S. lost about 1 in 20 sorties to SAM missiles. After getting some experience with the threat and improving counter-measures, losses dropped to 1 in 120.[2] There are substantial data to document the fact that a modest amount of combat experience dramatically increases the ability of an individual or a small group to fight successfully. It is difficult to find similar, documented data for commanders. However, there are indications that some commanders and their staffs are vastly more effective than others. For example, a NATO-sponsored review of the performances of World War II German U-boat commanders found that 33% failed to engage any targets, and another 13% failed to sink any of the targets they found. Thus, nearly half (46%) were ineffective. On the other hand, the most effective 10% accounted for 45% of the sinkings, and one U-boat

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1 Weiss, H. "Systems Analysis of Limited War." *Annals of Reliability and Maintainability*, 1966.

2 Unattributed anecdote.

commander alone was credited with 118 engagements and 39 hits.[3] History credits the submarine commanders involved for this difference. Improvement of a commander's decision skills is a crucial force training component.

The Defense Science Board performed a study in 1982 on "Training and Training Technology". It considered the full range of training at all ranks: mental and manual skills, military procedures, as well as decision-making. In contrast, this Task Force addressed a subset of the issues, namely the training of the highest echelon decision-makers. To the extent that they overlap, our findings and recommendations are consistent with those of the 1982 Study.

Our inquiry excluded combined training, i.e., training in combination with our allies. However, we believe that implementation of our recommendations is a precursor for future actions required to enhance combined simulation/training capabilities.

The Terms of Reference, reproduced in Appendix A, explicitly cites areas of computer technologies and architectures. It became clear to the Task Force — quite early — that technology provides an opportunity, not a problem. *Effective application* of current and predicted technology to gaming, simulation, and training is the challenge. That has a higher immediate payoff than improving some technology. Consequently, the Task Force focused on application, but did not ignore technology issues. The Technology Assessment section of this report surveys the state of, and anticipated advances in, the various computer technologies useful for joint training.

Training, education, exercises, and wargaming cover a broad range of activity. We found that attitudes about these activities, and even the definitions of these and related terms, are different for the services and the JCS. In practice, these activities are accomplished in different ways depending upon context, participants, and objectives. Appendix B provides a glossary of terms as used by the JCS and in this report. In the interest of terse phrasing, in this report the term **simulation** is used to refer generally to the computer-based systems, with an emphasis on the software components, that support automated and simulated scenarios used in training, exercising, education, analysis, and wargaming.

The Task Force membership, listed in Appendix C, includes retired senior military leaders with decades of operational experience as well as a history of concern for force training. It also includes experts in relevant technologies. The Task Force met nine times at a variety of locations, listed in Appendix D, and heard briefings from developers, players, trainers, and technologists. Appendix E lists briefing subjects and briefers. We were very well-supported in our efforts by a variety of individuals and organizations across the Department of Defense. Some of the key individuals are listed in Appendix F. A summary of the results of our questionnaire-survey of the CINCs is given in Appendix G.

The Findings and Recommendations section of this document defines the plan that we were asked to prepare. It is in the form of five recommendations. We believe them to be opportune, affordable, and feasible to implement. We believe that proper sustained execution of the plan will improve joint readiness. The actions required for implementation are listed in Appendix H.

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3 NATO/SAC-Atlantic Memorandum, 16 March 1977.

Technology Assessment

This section assesses the current state and predicted advancement of various technologies, and discusses how well each technology supports simulation. By and large these technologies are:

- advanced enough to support major improvements to our simulation capabilities,
- being driven by a vast civilian market, and
- dropping rapidly in cost.

The Task Force considered only those technologies appropriate for simulation related to joint commander and staff training. We did not consider specialized technologies such as those that support flight simulator displays, eye tracking devices, and vehicle motion simulators.

The past decade has brought improvement in all the technologies listed below, in either capability or performance/price, or both. For many of the technologies, the buyer can choose between enhanced capability at the same cost as an older system, or lower cost for the same capability. This is not typical of other technologies such as those in materials, nuclear, propulsion, or agriculture.

Eleven technologies are discussed:

- processors and memories,
- graphics, images and display,
- communications,
- disks,
- operating systems,
- programming languages,
- databases,
- man-machine interfaces,
- expert systems,
- simulation, and
- packaging.

Those technologies which closely depend upon physical implementation are improving rapidly; those which are predominantly implemented in software have developed less rapidly. It is not appropriate to spend the limited training resources in attempting to mature any of these technologies more rapidly. Such resources are better invested on harnessing the technologies to the training and simulation task.

Processors and Memories

Remarkable improvement has been made. Performance/price ratios double every 2.2 years; i.e., double the computation power can be purchased for the same price every two years.

Mainframe performance of over one million instructions per second (MIPS) is packaged in workstations and personal computers, some with color graphics, priced between $5,000 and $25,000. Rapid strides have been made in the performance of high-end single processors using deeply pipelined designs; they remain expensive. Vector processors, either integrated into the main processor(s), or attached as peripherals, are cost-effectively available. Multiprocessor, shared memory systems are available off-the-shelf. This year, several companies have announced 30-MIP, 50-MFLOP (million floating point operations per second) processors priced under $100,000.

Performance/price ratios for both computer chips and memory chips are expected to continue to double at about the same rate for at least the next decade. Exciting possibilities, such as superconductivity at (close to) room temperatures, could, if realized, result in breakthrough improvements.

In the past decade, support for experimentation with new chip designs has substantially improved. Design techniques and associated tools have emerged. New chip designs can be demonstrably fabricated with several weeks' turnaround at the MOSIS rapid prototype chip facility. The process is cost-effective above 1000 chips.

We note that simulations, particularly those used for analysis purposes, have an appetite for computation resources that sometimes overreach the state-of-the-art, and frequently overreach the state-of-the-affordable. In some cases, wargaming simulations require machine resources beyond what is available. The pragmatic solution is to determine what resources are to be devoted to a simulation task, and then to restrict the simulation size to be one small enough to be computed in an acceptable time on those resources.

Graphics, Images and Display

Current technology is barely adequate. However, it is being driven by industry needs that complement simulation needs. Gaming and simulation involve several distinct display tasks. Each is discussed separately.

Text and Table Display: Typically, small screen displays, viewed by one or several individuals, are used to display text information, such as status of force components. Such display stations are ubiquitous, adequate, and cost-effective. Color is noticeably better than monochrome for communicating complex information patterns because related items can be color coded. Reverse video is frequently used to highlight important information items on monochrome displays. Screen sizes on the standard workstations are quite adequate for one viewer, and barely adequate for groups up to 4-6.

Situation Display: Situation displays typically depict richly detailed, large area, static maps. These maps are overlaid with scores, up to a few hundreds, of movable and changeable icons, each of which may be associated with a few text characters. For this task, the technology is barely adequate, or inadequate. Screens are too small in size and resolution, so that clustered icons and associated text become jumbled and indistinguishable.

Software map displays typically do have the capability to "zoom," so that a smaller (larger) area can be displayed on the same screen. Such redisplays typically occur at an acceptable rate. Icon movement against a static, though very detailed scene or map, is adequately presented and updated at timely intervals.

Arcade video technology includes hardware-assisted "sprites," i.e., separately movable sub-images or icons such as space-ships. This is a natural technology-assist to buy for situation displays.

Image Display: By image we mean essentially photographic depiction, or the equivalent depiction, of uninterpreted raw intelligence. The technology is barely adequate because image resolution is too low. High-definition television, discussed below, offers promise for image improvement. The marginal technology is that for situation displays.

Screen size per se can be enhanced by commercial television projectors, with costs ranging from $2,000 for poor images, to $15,000 for good ones of size 5' x 8', to $40,000 for bright, theater-sized ones. Such projectors are limited to 512 x 512 pixels nominal resolution, and usually display standard NTSC TV signals only.

Screen *resolution* on standard workstations is between 512 x 512 pixels (approximately NTSC television resolution) and 1024 x 1024 pixels. As soon as such images are projected large, the serious resolution limitations become evident. A typical wall map is 5' x 8' with a resolution of better than 400 lines/inch, or 24,000 x 38,400 pixels. Commercial 1000-line resolution video projectors typically cost more than $100,000 each.

The television industry is moving toward an 1100-line high-definition TV (HDTV). This is a new standard that may appear within five years and will be likely within ten years. The system resolution will be approximately that of standard commercial 35 millimeter movies, i.e., much better than today's television.

The simulation community should be prepared to exploit HDTV when it appears, but scarce Department of Defense dollars should not be invested in developing any special high-resolution wall displays for simulation purposes.

Updating a *computer generated image* of even a 512 x 512 display pixel-by-pixel can be slow or fast, e.g., 0.25 - 5 seconds or 60 Hz. Today's systems superimpose static, detailed map data from videodisks with coarser, movable symbols. This approach continues to be attractive in the future. Compact disks and their computer-attached readers promise to be substantially cheaper than videodisks, and quite satisfactory for the purpose.

Communications

Secure and affordable communications are in routine use in both the civilian and military sectors. The on-going acquisition of the DoD Defense Data Network (DDN) will further facilitate secure distributed simulation and training. Local area networks and long-haul networks are both technically adequate to support simulation needs.

Commercial and DoD protocol standardization is proceeding. Standard protocols exist and are increasingly accepted for military use, particularly for command and control use. Off-the-shelf hardware at acceptable cost exists to install and run both local and long-haul networks, secure or insecure, at high speed. Cryptographic hardware is readily available, and its manipulation of data no longer inordinately slows transmission.

As a consequence, the automated support for training and gaming can be routinely distributed, where appropriate. Commanders and staffs can train or exercise at their posts. Standard command and control communications hardware can be used, where appropriate. As a result, training verisimilitude increases.

Disks

Disks continue to be the secondary storage devices of choice for bulk data requiring high-speed access to randomly selected, small blocks. Driven by the vast civilian market, the cost/bit continues to drop. The most dramatic development is in WORMs, the write-once-read-many-times devices. The compact disk offers a read-only memory. It is a cheap, powerful medium for storing read-only bulk data such as maps, weather, and other "canned" data descriptions. Compact disk technology maturation is being driven rapidly by a vast civilian entertainment market. Optical disks provide bulk, WORM storage for images.

It is possible to convert topographical maps to digital terrain descriptions rapidly, i.e., two hours to convert a 20-by-20 kilometer area. Cheap, reliable, and compact disks can carry map data. Paper and fabric maps that previously filled the volume of a C5-A can now travel in a few crates.

Operating Systems

Operating Systems are quite adequate to support the interactive style of use in simulations. Industry forces encourage convergence to a relatively few system standards. No single standard is likely to emerge because several of the most-used operating systems are captive to one vendor or another, such as DEC VMS and IBM VM. There are a handful of widely used commercial operating systems. It is not advisable for simulation systems to stray from using what will eventually be the most frequently used commercial operating systems.

However, the sensitivity of applications, such as simulations, to the influences of an operating system are less than they used to be. Today, an application tends to depend more upon interfaces to programming languages, shared file systems, network protocols, and database systems. In turn, each of these typically runs on multiple operating systems. As a consequence, applications are more easily freed from their tether to a single operating system. It is not appropriate to standardize on a single operating system to host simulations.

It is not even essential that remotely communicating simulation systems have a common operating system. However, software components can be more extensively shared if the simulation systems use a common operating system. This is principally a cost factor, not a determinant of capability.

Programming Languages

Progress in languages continues at a slower pace than with hardware. The Department of Defense standardization on Ada[4] as a production language will substantially help when used to build production simulation software. Use of rapid prototyping languages, such as Lisp, APL, Prolog, Smalltalk, as well as rapid prototyping tools, will accelerate experimentation with new simulation capabilities.

Database Systems

General-purpose, relational-model systems, now available off-the-shelf, provide a database technology of great generality, power, and stability. The technical problem is for the users or controllers to build and enter into the database system the large amount of data that provides simulation richness. This typically remains a hard technical problem and one always solved at considerable costs measured in both funds and elapsed time. Standard schemata and definitions specifically tailored to the simulation application are badly needed across the DoD simulation community. Such standards would enable simulation database sharing. As a result, costs would be saved and the quality of data would be higher across the DoD simulations.

It is especially important, and singularly difficult, to get standard, precise semantic database item definitions. Again, this is not an issue of technology, but of arriving at some standard DoD simulation definitions.

User, or Man-Machine, Interfaces

This is a relatively new technology that is still in a primitive condition. Yet, it offers great promise as a simulation component. Like operating systems, languages, and database systems, it is best driven by the civilian market. Three decades ago, only programmers interacted directly with computers. Today, everyone interacts with them because of the explosion of the personal and office computer market as well as the introduction of "computer clerks" in the form of automated bank tellers, supermarket checkout systems, form fill-out machines, and catalog order clerks. Reduction of the cost of graphics with color, large screens, and bit-mapped displays has accelerated interface improvement.

Much attention has been paid to the interface between the casual, non-programmer user and the machine. Unimaginative interfaces based on the user typing or viewing sequential lines of text have been replaced and augmented by simpler interfaces based on

- adaptable menus tailored to offer only what is sensible to select at each instant,
- pointing devices and associated techniques so that the user points his finger or slides a mouse to drive the screen cursor,
- windows which zoom up and down in size, which can be dragged across the screen, and which overlay one another,

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4 Ada is a registered trademark of the U.S. Government - Ada Joint Program Office.

- color-coded information designators,
- iconic representation of information, and
- spoken input and output provided via speech synthesis chips and speech recognition algorithms.

Expert Systems

Isolated expert systems are just now coming into operational use on real applications. Currently, each system is limited to its own narrow knowledge domain. There are far fewer expert systems in actual operational use than one would believe by reading the public and technical press.

An **expert system** is a knowledge collection combined with an inference engine capable of interpreting queries and chaining together separate items of knowledge to develop new inferences. The knowledge is typically causally represented as a system of rules. In some cases, expert systems can retrace their paths of inference on demand, thus explaining their conclusions and reasoning.

The underlying difference between the expert system software and conventional software is that the expert software is heuristic and conventional software is algorithmic. For that reason, expert systems have proven to be more difficult to build. Successes promised in the 1960's are not yet realized. As a rule of thumb, the probability of building an expert system to perform a task adequately is directly proportional to how narrowly the task is defined and how well human experts understand how they perform the task. An expert system can be expected to be able to diagnose an avionics line-replaceable unit failure. However, do not expect to replace a tank commander with an expert system. Tactical creativity, unpredictability, savvy, and wiliness — all attributes of a good commander — are not attributes of the rule-based expert systems being built today.

Expert-system technology was developed with the objective of enabling such a system to substitute for a human mind in a decision-making system. Today's applications typically reserve action responsibility for human beings, and employ the expert system as an advisor. Used this way, the technology can assist the human being in reaching his full potential. There are several reasons. In the first place, the unforgetting expert can provide an elaborated checklist, reminding the human of things he knows but might skip under the pressure of decision. Second, the disseminated memory of the expert system can hold and make available to the novice the richer experience of a more seasoned expert. Third, the cumulative memory of the expert system can serve as a corporate memory, holding the lessons learned by a whole group of human experts.

Expert systems can participate in a simulation as a friendly player, enemy player or even a controller. Automating a friendly player is the least risky. The limitations of that friendly player might only make the human player's job more difficult. Automating the enemy is more risky. Limitations of the expert system could possibly reduce the difficulty of enemy/friendly exchanges and mislead the friendly player as to the options the enemy might choose to execute. Enemy portrayal via an expert system might be of value where the training objective is limited to staff procedural training, e.g., Blue Flag daily "frag" order preparation. In short, the Task Force has serious qualms about automating the enemy player or cell.

It is possible, and desirable, to automate the detailed bookkeeping tasks that controllers perform. Further, an expert system might monitor an unfolding simulation and tune it based on some set of rules, just as a controller does. Whether to replace the human controller by software depends upon the expert system's quality and the simulation run's objectives. To the extent that actions taken by a human controller can improve the simulation's training effectiveness, automating that controller may have disadvantages. If controller automation affords the opportunity for a small group of players to run an exercise that would not otherwise be performed, automation might be appropriate.

Simulation

Simulation technology is that knowledge for electronically representing and evolving a scenario, perhaps with human interaction influencing the evolution. Over the past two decades military simulation technology has slowly improved. Models are more encompassing and accurate, although rigorous model validation lags. Many simulations can be performed at real-time or many times faster than real-time. Information from both the simulation database and the computed outcomes has been made more readily accessible to players in a timely way. Simulation software has tended to become more modular. Cleaner interfaces separate code modules from one another and from data. This is conducive to incremental enrichment of simulations, as well as to distributing simulation modules across computer networks.

Human controllers have been freed from routine, detailed tasks. The Navy's Center for Wargaming uses half the number of controllers that were needed ten years ago to support a command cell or "player." Similarly, game setup and control team preparation time has been significantly reduced. However, if a substantial amount of new data has to be prepared, setup time for a new war-game scenario is still measured in staff-months, not staff-days. At the same time that controller effort per game has been reduced, the number of games supported has typically increased. The Navy Center for Wargaming reports that in 1978, about 10 games per year were run; in 1987, 50 games were supported. Today, there is no technical barrier to supporting multiple, independent, concurrent simulations on a single computer system.

Increased computing power availability has encouraged more use of engagement-level simulations in which outcomes rely directly on player decisions and individual systems-effectiveness calculations. Campaign/theater simulations that are appropriate for training joint commanders and staffs cannot typically be based on the simulation of events at the engagement level, because game progress would be too slow. Higher levels of aggregation of events, weapons, and forces are based on various analytical principles such as Lanchester theory. However, they have generally not been validated theoretically or empirically.

A number of improvements are desired. For example, the duration of any campaign is long relative to the time available for commander and staff training. Effective techniques for accelerated time-stepping between periods of real-time play have not been developed. Operating a simulation at variable levels of aggregation according to the concerns of the participants and the simulation run objectives has not yet been reduced to practice.

And, of course, a simulated battle is not real. The simulation does not capture conditions such as rough air, shallow water, blowing sand, cold, illness, claustrophobia, lack of sleep, and fear. Technology is not going to capture these influences. However, the effects of operational and environmental degradation on such aspects as attrition, information flow, and information quality need to be accurately portrayed. There are data on these degradations. Although there is no validated, systematic technique for incorporating these effects into simulations, some incorporation is within the state-of-the-art, and deserves incorporation.

Packaging

The commercial market has packaged components embodying the above technologies into cost-effective workstations. These can be networked or stand-alone. Packaged thusly, these workstations, with mainframe computational power, can be inserted almost anywhere, cheaply. Such a station has the spatial footprint of a desk chair. A workstation with at least medium-resolution graphics and a rapid-refresh rate can display mobile, iconic representations of force units arrayed across a battlefield map. Even equipped with very simple simulation software, such displays can be the basis for commander and staff "what if" exercises. The simple moving-icon visuals provide a remarkably effective assist in thinking through complex tactical alternatives.

Packaged and applied to special purposes, the above technologies make dazzling changes. Workstations make it feasible to place small units of computation and even simulation technology into the hands of a joint staff, where computer technology can be incorporated more closely into their daily operations.

Findings and Recommendations

Multiple simulations are built, independently, by the services and the JCS. The Task Force found no unifying idea among the several services on how to develop a single joint simulation. Nor did we find any one joint authority with a notion of how to build joint warfare simulations capable of supporting joint operational training at all echelons of command, encompassing all of the armed services and the unified and specified commands.

We did find some simulations that adroitly use available technology. We did learn about some simulations under development that should produce solid joint training vehicles. The service colleges, including the National Defense University, aggressively incorporate simulations into their programs. The U.S. European Command has an aggressive program at the Warrior Preparation Center. There are numerous joint training efforts that are laudable.

The services have developed warfare simulations tailored to meet their own unique needs. The Navy has invested heavily in comprehensive simulations. They routinely upgrade simulations, while servicing an extensive program of production use. We were particularly impressed with some of the Army simulation prototyping accomplished by ADEA and shown to us at Ft. Lewis. Taken together, the joint and service activities comprise an extensive community. They innovate. There is a modest amount of informal cross-fertilization, despite the lack of any all-encompassing authority or plan. It is appropriate to field a variety of simulations, both joint and service specific. However, there are more simulations than can be justified. The Catalog of Wargaming and Military Simulation Models[5] lists about 90 different simulations and over 500 models. We believe that if the developments made by one service were readily available to another, there would be fewer simulations, less overlap between them, and better overall quality.

Simulations in use are only peripherally related one to another. Currently, each service develops simulation systems almost without reference to the other services, or to the unified or specified commands. Each develops much of the substantial and necessary data descriptions from scratch, resulting in duplication of effort across the services, as well as less than achievable quality.

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5 Guirreri, Joseph A. Catalog of Wargaming and Military Simulation Models, (10th Edition), JCS May 1986, JADAM-270-86 (available from DTIC as ADA169472; from NTIS as #7034874650).

The Task Force found that a service will typically develop a simulation that very well portrays its force structure and weapon systems in what it perceives as typical threat and force employment scenarios. However, its depiction of other forces and influences were of notably poorer quality. The quality of the data describing those forces decreased in direct proportion to the "distance" from the primary service concerns. Predictably, the depiction of the forces, operations, and threats related to other services was more simplistic and of lower quality. Allies — except for NATO in some situations — are rarely portrayed at a high level of detail. Except at one or two unified headquarters, neutrals and diplomatic or civilian influences are rarely depicted.

It should be understood that joint training of commanders has rarely been a Service simulation requirement. Hence, it should be expected that they portray less well what is more germane to other services. Nonetheless, it is appropriate to use service-specific simulations for joint training. In addition, the interdependence of the services fighting in a theater, means that more-accurate portrayals of the concerns of the other services would improve the fidelity of the service-specific simulation.

High-fidelity simulations require a large supporting information base and specialized software to process each of the contributing dimensions. With the exception of a few types of data, typically each simulation system depends upon a unique database. It is very costly in time and funds to develop each data-description component. The Task Force anticipates that the quality of both service and joint simulations would increase, and the total number of simulations would naturally decrease, if authoritative, validated, reusable data descriptions were available.

Informational dialog, among the model and simulation builders, routinely takes place, and software, data, and personnel are exchanged among the services. But this mutual enrichment activity is neither institutionally encouraged nor technologically facilitated. The Task Force noted a few cases in which one training enterprise acquired capability from another, often due to an entrepreneurial individual. We also observed lashups where one simulation component was run stand-alone and the results were then fed manually into the main simulation system. Our recommendations encourage and facilitate more such interchange.

As part of our inquiry, we surveyed the CINCs and asked particularly about the potential for improvement of computer-based joint training. Their replies are summarized in Appendix G. They pointed out that performance could be improved if the several service simulations were compatible and "played together." It is clear that the CINCs have very little automation training support except when they go to the centralized training centers. This problem, too, is addressed by our recommendations.

The remainder of this section presents our five interrelated recommendations, all addressed to the Chairman, Joint Chiefs of Staff. They exploit existing assets, call for increased use of simulation-based training, recommend evolutionary progress, incur modest cost, ask the JCS to take a leadership role for service as well as joint simulation, present an aggressive prototype program, and state that the JCS should be the DoD organization that provides institutionalized management and budget to coordinate joint simulation-based training.

The five following sections each contain one recommendation — in boldface type — preceded by the findings pertinent to that recommendation. In some cases, advice on how to deal with technical issues related to implementing the recommendation follows its statement.

Make Joint Simulations Interoperable

It might be possible for the JCS to establish top priority for development of a new, high-fidelity, advanced-technology joint simulation system. But, the Task Force concluded that this course of action would be costly, time-consuming, and potentially wasteful, in that the services would continue to require the distinctive simulation capabilities they have already acquired. We believe that current technology and communications can support making existing simulations interoperable. Hence, we conclude that any joint or service efforts should devote their funds to netting together the gaming and simulation components now in use.

The advantages of this approach include:

- Availability of authoritative, high-fidelity simulations for each of the service components of the combatant commands.

- Focused efforts upon the interactio. - among the unified and specified commands, and among the componen.s of the unified commands. those "seams" where joint doctrine be rs, and service procedures and techniques ar: most often at issue.

- Redu.ed costs and compressed development time.

We do not intend that there be, necessarily, only one simulation per service. We noted many models and different simulation types gainfully being employed, and believe that this diversity is both necessary and useful. Wargames and simulations are a technique used for training, for analysis, and for education. These different objectives have different measures of success, and incidentally different masters with separate funding. It may be adequate and appropriate for different simulations to be at different levels of deta ith different interactive and display capabilities.

Just as we do not advocate one or just a handful of simulations, we do not advocate the interconnection of all simulations. Whatever is in use should be capable of being interconnected by taking modest, rapid actions. Verisimilitude, let alone the urgency of readiness for joint operations, requires sound portrayal of land, sea, and air forces in most simulations. Interconnection should be invoked as appropriate.

The ability to network simulation assets, permitting players to participate from local, possibly wartime, duty stations obviates, in many cases, the need for construction of a large centralized training site. Consequently, the cost of cement, furniture, and landscaping is saved along with the ongoing site maintenance costs. Travel costs for participants can be saved. Computation costs are reduced to the extent that training and gaming hardware can be the same as the day-to-day operations hardware.

There will still be a need for a core group of controllers and software developers. They will sometimes need to be collocated, and they may or may not need to travel to be eyeball-to-eyeball with players — it depends upon the system and the objectives.

There are formidable internetting obstacles. First, each service has a distinctive culture due to tradition, operating environment, missions, accustomed command techniques, available communications, and a host of other differences. The Task Force concludes that the "cultural differences" will endure and ought to be regarded as strengths to be nurtured, rather than flaws to be eliminated.

However, terminology is disparate, reflecting the service cultures. Cross-service miscommunication is unduly frequent in the training area. Terminology differences need to be reduced to facilitate sharing ideas and interconnected simulations software.

There is a perceived difference between education and training, which is often cited as a reason for preserving uniqueness ("theirs is for training, ours is for education..."). Frequently, this difference is cited as a mandate for bringing participants to a simulations' center for face-to-face interaction, in addition to interface with computers, as opposed to distributing the simulation to participants at their assigned place of duty.

Virtually all models have incompatibilities stemming from, for example, aggregation of detail, time-steps, method of representing terrain, or data reliability. Incompatibilities impair mixing or combining models. The more closely two incompatible models or simulations must interoperate, the more difficult the problem. We do not believe that the insufficiencies of existing models can be traced to, or be ameliorated by technology. Evolutionary movement toward interconnection and interoperation will yield standard interfaces and standard techniques for translating data from a form suitable for one model to a form suitable for another.

Interconnecting computers raises the specter that performance data from one service will be communicated to another or to a joint commander and be used in a detrimental manner. Data that could be used for evaluation of individuals or units are particularly sensitive. Technology permits data, particularly low-level data specific to an individual, to be protected, retained, or selectively destroyed with assurance. Gross characteristics will be transmitted, but it is necessary for the joint commanders and the various services to have an accurate overall picture of one another, even if painful at times.

The Task Force is convinced that the Secretary of Defense and the Chairman of the Joint Chiefs of Staff have a timely opportunity to advance joint readiness through internetted simulations, an opportunity that will:

- Permit the services to continue to use and develop further the games and simulations each needs for force training purposes.

- Exploit both the automation technology, which is available now and readily predictable for the future, and the plentiful communications promised by satellites, DDN, and fiber-optic cables.

- Capitalize on the growing standardization for intercommunication among computers being driven by international commercial competition and by DoD.

Cost-effective computer communications technology permits **internetting** computer hardware and software. Internetting two computer sites or programs requires a computer at both ends to transmit/receive, a communication medium, and a protocol that dictates the packaging of information to be transmitted. Large amounts (megabytes) of information can be transmitted across great distances (thousands of miles) very rapidly (in seconds). Internetting permits data transfer, but it does not imply that the recipient computer system can make use of the transmitted information.

Two software programs, more generally computer systems, **interoperate** if one system can translate information received from another, and then take some meaningful action without manual intervention. Internetting two programs or systems is much simpler to accomplish than their interoperation. The latter depends upon some mutual assumptions, involving such things as units of measurement, grid system definitions — e.g., latitude/longitude versus hexagons, a notion of time, and data item definitions. It is not necessary for the systems involved to have identical, or even similar, assumptions, but it is necessary for cognizance to be taken where there are differences.

Interoperation can be facilitated most rapidly if simulations incorporate the same or similar electronic data representations. We are going to recommend a specific way to cause such data sharing to happen. In this recommendation, we distinguish between an underlying **database system** that can be bought off-the-shelf, and **data descriptions** that are specific to military simulations. The database system is a container in which to store application-dependent data descriptions so that they may be queried and updated. One simulation data description, for example, might consist of Soviet bomber flight characteristics and carrying capacities.

Both the advance of communication technology and DoD adoption of common communication protocols facilitate internetting. Aggressively proceeding with internetting will leverage existing assets and prepare the way for interoperation. The Task Force believes that internetting — at least in the European theater — will naturally set the scene for closer cooperation with Allies for combined training.

Recommendation 1: CJCS should cause the service and joint simulations to interoperate.

- **First, internet service, college, training center, and joint games and simulations.**

- **Second, evolve simulations currently restricted to institutional settings toward distributed configurations capable of training joint commanders and staffs in their wartime command posts, wherever cost-effective and appropriate.**

- **Third, create a shared simulation-data repository to facilitate sharing common data and software components in future games and simulations and in major enhancements of existing assets.**

In the remainder of this section, we outline some technical actions to be taken in implementing this recommendation.

To internet existing simulation assets:

- Standardize on one joint communication protocol. Select an existing, in-use protocol; do not invent a new one. Require that all future simulations and all extant simulations that are enhanced in a major way in DoD be compatible with the joint communication protocol.

- Accelerate installation of Defense Data Network communications among the service colleges, national military colleges, and wargaming centers.

- Buy cost-effective communications products:

  -- use off-the-shelf or DoD-developed items, and

-- use war-fighting hardware and software, where appropriate and possible, particularly for C^3.

To distribute extant simulations:

- Preferentially use distributed simulations for JCS/CINC training.

- Require JCS-funded simulations to evolve toward distribution with access from the field assured.

To create the shared simulation-data repository:

- Define the simulation elements that may be usefully shared. At a minimum these include:

  -- a data dictionary. Select, do not invent, a standard definition of database items. Adopt wholesale an existing definition; avoid haggling. Recognize that the services may have legitimate need for additional, but not overlapping or replacement, items.

  -- data descriptions for information domains needed by many simulations, e.g., threats, maps, weapon system capabilities, mobile platform capabilities, and red order of battle.

- Electronically encode each data description:

  -- Select an agent to define each domain. The agent ought to be the most knowledgeable source about the domain. For example, the Defense Mapping Agency should be the agent for map data and the Army should be the agent for U.S. Army platforms and weapons.

  -- The agent defines, automates, i.e., represents the data description in an electronic form, and maintains his assigned data description, periodically re-releasing it to the repository.

  -- Expect to see some domains with multiple electronic representations, e.g., they might differ in richness of detail, authenticated fidelity, basic data representations used, and service culture.

- Do NOT standardize on

  -- computer hardware,
  -- one operating system,
  -- one underlying database system, or
  -- graphics and image hardware or software.

- Standardize on the Ada programming language for new production simulation software. Do not standardize on a programming language or on rapid prototyping tools for prototype software.

- Buy off-the-shelf, cost-effective products for simulation development and game control.

- Where possible, use the same hardware — computers, graphics, and communications — for simulation as for warfighting.

The existence of a shared repository does not imply a physically centralized site containing a single database software system, computers, data, and librarians. JCS oversight, documentation, and a network of agents and their networked computers are a sufficient, probably desirable, form for the repository.

The Task Force expects that the shared data repository will substantially reduce the number of different simulation components. It should encourage a service to "pick up" portions of its simulations from the shared repository, especially those parts that deal with other services, intelligence, and environment data.

The repository has not been described here as a "standard." This is deliberate. Repository users, particularly those creating service-unique simulations, will have legitimate cause to adapt data descriptions retrieved from the repository. However, users who do adapt data retrieved from the repository should make that adaptation in a way that preserves their ability to retrieve and then adapt future repository releases of the same data description. There is no technical impediment or additional cost to adapt data this way.

If the simulation repository is successful, demands should shortly be placed upon it to define, collect, and maintain software translators, capable of translating one data-description format to another. Translators may perform very simple functions, such as re-packaging the data in units for shipment across a network, or as complex as reading the full data description from one underlying database system and entering it into another. Be prepared to accept programs, beyond translators, into the repository when they have the potential to enhance interoperation. High program quality standards should be applied to any data descriptions or programs entered into the repository.

Promote Joint Simulation Usage

In recent years the Chairman of the Joint Chiefs of Staff has held some of his conferences for the Commanders in Chief of the unified and specified commands at service simulation centers, and has devoted time during the conference for the senior leaders present to participate in a warfighting simulation. We applaud this procedure. It has the benefit of keeping the CINCs informed of recent joint training simulation developments.

The personal participation of the senior officers responsible for joint war-readiness and for the services is an act of leadership, an example that their staffs and subordinate examples are bound to observe, to copy, and to support. JCS/CINC games and exercises facilitate standard interoperation and discovery of doctrinal clarification needs.

It is difficult to involve senior officials, military and civilian, in joint training. But as crisis decision time shrinks and military command decisions remain integrally interdependent upon civilian and diplomatic decisions, it is crucial that the senior officials themselves experience the demands that will be made jointly on them in time of war. It is hoped that as technology makes it possible for an official to participate from his office, more participation will occur.

Experimentation with simulation components that naturally support local command "what if" exercises will provide commanders and staffs with experience in effectively applying automated decision aids. Distribution of the simulation capability into duty stations provides an excellent means for joint commanders to "pull" simulation and decision-aid technology into the command post.

While we encourage increased use of simulations in joint training and joint doctrine determination, we suggest caution in using simulations for the purpose of evaluating future capabilities, particularly weapons and platform capabilities. The number of unknowns is so large as to make results suspect.

Recommendation 2: CJCS should continue and extend the involvement of the most senior joint commanders in battle simulations:

- **Increase utilization of joint simulation exercises in all professional schools.**

- **Extend the networks to permit CINCs to conduct joint training with remote wartime assigned forces.**

- **Support CINC's acquisition of required joint simulation capabilities.**

- **Provide appropriate senior government officials the opportunity to participate in exercises with the JCS and the CINCs.**

Requirements for Future Capabilities

There was no DoD-wide authority responsible for joint training when the study began. The Task Force sees a need for the JCS to set long-term requirements that act as a roadmap to guide joint-simulation development. To the extent that these requirements influence service-developed simulations as well, more gain is possible. While we do not recommend that the JCS usurp the training responsibility and authority of the services, it is the responsibility of the JCS to ensure that the forces can fight jointly. To that end, some of the requirements should be directed at the operational and support "seams" between the services to facilitate joint operational use of service-built simulations.

Recommendation 3: CJCS should establish long-term requirements for joint simulations.

- **Establish long-term requirements and document them clearly in JCS directives.**

- **Using these requirements, develop and issue guidance for:**

  - **-- Design of future systems (with an Initial Operating Capability of more than 5 years hence),**
  - **-- Any substantive enhancement of current systems,**
  - **-- Development of technical standards for gaming, training, and simulation, and**
  - **-- Selection and development of prototypes to explore future capabilities.**

To make this recommendation concrete, the Task Force considered what kinds of capabilities made sense both functionally and from the point of view of what technology will support in the near-term. We found merit in each of the capabilities discussed below. To define actual requirements demands deeper consideration and user input than this Task Force could bring to bear. The intent of the following discussion is to suggest that technology will support substantive enhanced capability in each of the following areas:

- Interoperability
- Scenario flexibility
- Distributed network
- Variable staffing
- Economy
- Simulation-data repository
- Variable timing
- Rapid setup and reconfiguration
- Enhanced verisimilitude
- Effective visuals
- Measurement and evaluation

Interoperability — Interoperability of joint training simulations provides the necessary interface between (enhanced) existing and future service simulations. Interoperability depends upon communication interconnections between simulation components. Where appropriate, communications permit real-time sensor and weapons system input and output to be a component of a larger simulation. Interoperability does not preclude single-service exercises. It permits one service to reap the benefits of simulation developments by other services.

Scenario flexibility — It should be possible for the user to tune a scenario along dimensions such as force component magnitudes; aggregation of simulation events; speed with which play unfolds; weapon and vehicle capabilities for friend and foe; and probabilities — even the algorithms — used for computing attrition and battle damage. A full-force-involvement scenario includes land, sea, air, and space combat, together with diplomatic and civilian influences. Scenario component modularity enables depiction of only those portions applicable to the exercise, analysis, or game envisioned.

High-intensity combat may include transition to full conventional and/or nuclear war, sustained combat, and transition to peace. Medium-intensity combat similarly includes escalation, de-escalation, sustained combat, and transition to peace. Low-intensity situations are characterized by intermittent operations, crisis management, and national diplomatic involvement. Any of these may involve multiple country allies and opponents. Theaters are substantially different; simulations should be adaptable in ways that increase fidelity of representation of the various theaters.

Distributed network — Distributing simulation components has numerous benefits: 1) It enables broader participation by the actual personnel at their assigned duty locations. 2) Local processing can be injected to reduce need for data transmission and to enable stand-alone operation. 3) Other simulation and gaming components can be configured in, where appropriate, from diverse sites including the Joint Wargaming Center, Warrior Preparation Center, service gaming centers, on-line service training exercises such as Red Flag, SDI test and training sites, and service simulators for ships, aircraft, and ground vehicles. 4) Real systems, or embedded training components of real systems, can participate, where useful and permissible. 5) Location of participating hardware and real systems is transparent to the trainees. 6) Some command player stations can have been and will be miniaturized and portable so that individual players or stations can be mobile.

Distribution relies on common communication protocols and technology for secure communications. Both are available for use today.

Variable staffing — Player and controller station staffing may be determined by objectives and available resources. Play may involve a full command staff with few or no "automated player" positions. Alternatively, one or more players may interact with automated players whose actions are software determined. Wisdom is needed to avoid use of automated players whose limitations would be detrimental to the exercise objectives. It is anticipated that advancing computer and information technology, as well as simulation fidelity improvements, will lead to better and more credible rule-based computer decision-making techniques for automated player positions. Technology has to make some breakthroughs before creative surprise will be routinely exhibited by an automated player.

When a controlled progression of training is to be performed, automated players, either friend or foe, are particularly desirable. Automated players have the advantage that they can be designed to behave so that a specific situation can be repeated, either to measure progress across multiple training exercises or to exercise many players in the same situation, for example to explore doctrine issues. Allied forces, so heavily dependent upon international political determinations for their locations and possible use, might well be automated as determined by the CJCS, who is best able to make such politico-military estimates.

Some training objectives dictate that human-versus-human is the preferred mode of operation. Other objectives, particularly command/staff socialization, dictate that the command/staff be collocated. Automation or distribution can be entirely inappropriate.

Economy — The same or better capability can be bought in the future for less cost, if DoD exercises wise acquisition practices. Off-the-shelf commercial equipment and software, where available, will usually offer minimal cost. Availability and reliability of equipment improves continually and maintenance costs correspondingly decrease. Today, techniques to initialize and reset remote components are in routine practice. Man-machine interface techniques slowly improve; as a result, the cost of training a user on some computer equipment decreases.

Simulation-data repository — A shared data repository, as described in a previous recommendation, should contain electronically encoded data and even programs. It can be relied upon to provide data components describing: US, allied, and enemy system capabilities; environment descriptions, including terrain, maps, and weather friend and foe assets; and orders of battle for friendly and enemy forces. Any future definition of a simulation or a simulation component would assume the use of relevant shared and maintained data. This reduces simulation development cost overall, engenders consistency of representation, and assures maximum fidelity of even second order simulation attributes.

Variable timing — Training objectives dictate the ratio of the simulation time to real time. For some training objectives and some analytical applications, simulation time should be many times faster than real time. Faster computing engines as well as more sophisticated simulation techniques will facilitate variable timing with broader limits than those available today. To the extent that aggregation techniques are not developed and validated, there will be a tendency to execute simulations with increasingly larger number of entities taking action at the engagement level. This engenders a heavy computation load. The current limits on simulation speed-up will only gradually be reduced if there is no breakthrough in simulation techniques.

Rapid set-up and reconfiguration — Faster computing engines permit faster set-up. Better software engineering techniques permit stopping play, restarting, reconfiguring, and moving backward or forward in time very rapidly. Restarting or reconfiguring at arbitrary points in play will be difficult for a long time to come, in general. Software techniques can be used to provide for expected, convenient restart and reconfiguration points. Modularity permits components to be removed from or added to play.

Enhanced verisimilitude — Simulations can provide a richer, more realistic portrayal of scenarios as 1) the underlying data descriptions enlarge to include more detail and more accuracy, 2) faster computation of more underlying event sequences means that more events "sit behind" what the player sees happening, 3) better military simulation algorithms determine the next event with more realism, and 4) sharing of data and simulation software components permits each simulation to include more elements than if each simulation were developed from scratch.

Effective visuals — Technology offers increasingly cost-effective visual imagery. Visual display is particularly effective for facilitating human understanding. Training simulations should continue to capitalize on the technology as it emerges.

Measurement and evaluation — Few commanders of any service cheerfully submit to evaluation, and many doubt that joint commanders are capable of adequately evaluating the performance of a component. Hence, joint training simulations have tended to avoid even the suggestion of evaluation. Performance measurement and feedback for learning — regarded as useful in most forms of experimental learning — are often dismissed as infeasible, distracting, dysfunctional, or more appropriate to training than to education.

Measurement can be separated from evaluation. The computer is very good at non-intrusively collecting and storing objective measures of player action, such as time elapsed before recognition of commencement of an enemy attack, ammunition expended, or time elapsed to respond to a movement order from the commander. Such uninterpreted, raw measurements can be used for at least three kinds of evaluation: self-evaluation, training-system evaluation, and performance evaluation.

By self-evaluation, we mean that only the player himself sees the measurements in the form of feedback to contribute to his assay of his own performance. Software technology can assure that data are collected, protected, displayed in controlled circumstances and then destroyed. This use of measurement data is documented to be quite valuable. Immediate and interactive player displays can naturally be extended with such data displays.

By training-system evaluation, we mean the evaluation of the simulation itself in attaining the objectives it serves. Statistical technology permits protected data to be amalgamated so that even under analysis, embarrassing particulars of individual and unit performance are not evident, yet gross characteristics can be seen. Responsible management of training systems requires evaluation of the systems as training vehicles.

Performance evaluation of individuals or units involves judgements by peers and superiors. Even if performance evaluation is not desired, or acceptable, technology now permits measurements to be taken, protected, retained, selectively destroyed with assurance, and statistically amalgamated to mask individual characteristics. Self-evaluation and training-system evaluation can be supported without opening the door to performance evaluation, if that is the policy of the user.

This Task Force believes that valid performance evaluation is a valuable aspect of training at any echelon of command. At a minimum, amalgamated data that have been rendered quite blind to the identity of either individuals or units can be used to develop baseline analyses and comparisons. Without them, neither participants in the simulation nor their joint commander will form sound ideas about proficiency attained, or need for further training.

In summary, these long-term capabilities do not dictate a single simulation architecture. Intended use and possibly service-specific requirements will dictate suitable architecture(s).

Establish a Prototype Program

Establishing a requirement for the best future systems requires maintaining a watchful eye on computer technology advances and incorporating the products, prototypes, and techniques into experimental simulations. The Task Force was briefed on a number of prototype simulations that harnessed technology advances in a timely way. Many of these prototypes were built at low cost and very rapidly. Two examples are:

- SIMNET: a network of tank commander training stations, built by DARPA and the Army. Each tank station costs roughly $250K (half for graphics and half for the "tank"). Physically local and remote tank stations may participate in the same exercise with the behavior of each tank "visible" to the others via the graphic view-port and network. The first two M-1 tank simulator prototypes were operational at Ft. Knox three years after the beginning of the program. Today, there are about fifty simulators — mainly M-1 tanks — but also Bradley vehicles, helicopters, and close air support fighters.

- BASE: a Brigade/Battalion Automated Simulation Exercise was prototyped for ADEA, the Army Development Employment Agency, in 36 months at a cost of about $750K. Four workstations allow detailed command and staff planning and operations for course maneuvers, air, artillery, and admin/logistics in computerized force-on-force situations.

Possible application of a new idea or breakthrough in technology via earlier acquisition of training prototypes is an effective way to explore future capability early. Based on tested training prototypes, the user can write better acquisition requirements, with more assurance that the acquisition could be cost-effective. SIMNET is a success in this dimension. It is a possible contributor to a production system for helicopters and armored personnel carriers, as well as tanks.

Rapid prototyping tools are becoming prevalent and effective. The Task Force was briefed on several. One example permitted the rapid prototyping of map-based interactive displays. The system is equipped with digitized maps and an inventory of icons representing weapons and platforms. The user designs menus and control programs to control the map display and icon movement across map backgrounds. A typical application was said to be prototyped in a month, and delivered in the form of a low-cost workstation. Such tools offer great leverage in maintaining a short prototype-development schedule. In addition, the prototype can be in a form that is somewhat realistic so that the user can better critique it.

Taking full advantage of rapid training prototype technology is not always consistent with the current requirements-development and acquisition processes. Streamlining these processes and introducing the feedback advantages inherent in rapid prototyping can be effective in many acquisition arenas.

Where large numbers of training end items are going to be needed, competition promises rewards. Where large, complex simulations are being bought, special rules apply. It is particularly important for the program office to have a solidly grounded knowledge of what capabilities can be bought and at what price. A prototype program can serve to make the joint training community smart buyers. There are requirements for which modest technology — not the latest, most-expensive, and highest-fidelity technology — is adequate. The prototype program can produce the data and examples that a Program Manager needs to decide and to justify that he is not buying inappropriate technology!

Joint gaming and training needs and interoperation among service systems will be better served if simulation prototypes on the leading edge of DoD training technology frequently have a joint flavor. For this reason. JCS leadership in prototyping would be advantageous.

Recommendation 4: CJCS should establish a continuing program to demonstrate exploratory prototype simulations, followed by rapid acquisition of selected capabilities.

- **Monitor advances in technologies useful in gaming and training, seeking to apply them to validate a substantive improvement in effectiveness.**

- **Selectively, build experimental training prototypes to harness**

  -- **new simulation and training techniques, and**
  -- **substantive increases in processing power, communications, display, and heuristically driven simulation components.**

- **Use a fast-paced executive agent, such as DARPA or ADEA.**

- **Employ rapid prototyping tools and languages, as appropriate.**

- **Ensure close customer involvement.**

- **Measure prototype performance.**

- **Support rapid fielding of advanced, proven joint-simulation capabilities.**

We anticipate a budget for the training prototype program in the range of $10 - $20 million per year.

A question that the Chairman might wish to ask is: What should be done first under such a program? **If the Chairman wants to take immediate action** to initiate this prototype program, the Task Force recommends that the first prototype effort be to establish a networked simulation testbed using existing assets. To be more specific:

- Internet an existing simulation from each of the service colleges.

- Play a game in "month 12" using those assets.

- Joint commanders playing the game participate in designing it.

- Use the Military Education Coordination Committee to facilitate this first prototype.

- Use off-the-shelf or DoD-developed items as needed.

- Use a fast-paced executive agent.

Playing a game in month-12 is the one non-negotiable attribute of this effort. The expected results include a service college simulation network in the near-term and some lessons learned to guide further simulation internetting.

Undertake a Major Joint Training Initiative

Numerous organizations have the mission to develop joint simulations, but there has been no single authority responsible for their coordination. The joint training budget has long been dispersed and difficult to trace. Responsibility and authority have been diffuse. This is likewise true in the services. The authority for training converges only at the level of each Military Department's secretariat or headquarters staff. While the Task Force conducted this study, the U.S. Readiness Command, which had been in the forefront of the Modern Aids to Planning Program (MAPP), passed out of existence. However, its Joint Exercise Support System (JESS), the main simulation for its projected Joint Warfare Center, has been assigned to the OJCS (J-7). This system is based on a two-service simulation that requires internetting with a maritime simulation to be maximally useful for true joint training. Much useful work on joint training has been undertaken by the several senior service colleges, but this has proceeded largely without direction or coordination by any central authority. DoD elements generally have not been effective in promoting readiness through joint training.

The Task Force found that the use made of a facility, center, or simulator at a given time was not always well chosen. Some facilities were only partially used, whereas others were used beyond design limits. Some facilities, run by fixed "faculties" adhering to "school solutions," seemed on occasion to restrict user intuition and innovation. Such facilities must be tailored to meet the variety of customer needs and to resist the attraction to be a showcase for the intellectual brilliance of the resident staff and faculty.

There is competition between facilities offering essentially the same capability to improve the chances of winning a war. This competition is healthy, but encourages the attitude that "more high-tech equipment is better" in cases where that argument cannot be justified. The latest technology is not always needed. For example, in the SIMNET tank simulator, the graphics are about arcade-game quality, but they are quite adequate.

We are encouraged by the emerging role of the JCS Vice Chairman as the central authority for joint training. This central authority has been lacking in the past. We are also encouraged about his designation of the Joint Staff's Director for Operational Plans and Interoperability, the new J-7, as the staff officer responsible to him for progress in joint training and doctrine.

The J-7 has a daunting task, particularly in developing guidelines for internetting existing simulations for training commanders and staffs. **Sustained**, institutionalized management will be needed to convince the services to spend their money and dedicate their people for joint training purposes. Moreover, the J-7 will have to develop a plan for the expeditious and constructive evolution of joint simulations.

Recommendation 5: CJCS should undertake a major joint simulation initiative.

- **Institutionalize management and budget to oversee:**

  - **Immediate internetting of existing assets of the services, joint commands, senior service colleges, and defense agencies.**

  - **Continued use of those networked assets to enhance joint readiness through joint training of commanders and staffs.**

  - **Use of joint assets, particularly the National Defense University, to advance joint doctrine and to explore interoperability issues and procedures.**

  - **Creation of the shared simulation repository.**

  - **Implementation of the rapid prototyping program.**

- **CJCS should coordinate spaces, program elements, and budget lines — both joint and in the services — to arrive at more effective simulation-based training with less development redundancy.**

The Task Force recognizes that, in an era of strong competition for resources, the limited availability of new funding and personnel spaces may inhibit action on our recommendations. But the funding and personnel required to implement these recommendations are modest. Based on our collective experience, and on what we learned during the course of our investigations, we believe that a relatively modest investment needs to be made **now** to develop and use the joint-training simulations as recommended. We predict that an investment to hone the skills of senior joint decision-makers, who will decide how to use the nation's warfighting assets in time of conflict, will provide a substantially larger return in terms of both readiness and warfighting effectiveness than that gained by investing an identical amount to acquire additional war materiel.

Appendix A — Terms of Reference

THE UNDER SECRETARY OF DEFENSE

WASHINGTON D C 20301

RESEARCH AND ENGINEERING

10 SEP 1985

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Defense Science Board Task Force on Computer Applications to Training and Wargaming

You are requested to organize a Defense Science Board Task Force to assess the application of new computer technology to joint operational training, exercises, and battlefield wargaming for operational commanders.

The objective of this study should be to develop a plan of how to integrate anticipated advances in computer technology with our computer simulation efforts, supporting training and wargaming for joint warfighting. Specifically, the Task Force should determine how to best apply advanced computer technologies to improve the development of joint warfighting doctrine, joint operations training, and battlefield wargaming for the operational commander. The Task Force efforts should include a review of:

(a) The results of the JCS Scientific and Technical Advisory (S&TA) Panel's simulation architecture for integrating current military warfare simulation effort.

(b) Advanced and evolving computer technologies; e.g., Artificial Intelligence (AI) Computers, Time Warp Event Modeling, Hyper Cube Processors, Array Processors, Super Computers, Local Area Networking with PC's, Teleconferencing, and Computer Graphics.

Because USREDCOM is responsible for developing joint training of assigned forces and joint tactics, techniques, and procedures for forces assigned, both USREDCOM and the Joint Analysis Directorate (JAD) of the Organization of the Joint Chiefs of Staff (OJCS) will be good initial sources of information.

This Task Force is sponsored by the Chairman of the Joint Chiefs of Staff. Dr. Anita K. Jones has agreed to serve as Chairman. Captain Paul R. Chatelier, USN, OUSDRE/R&AT, has been appointed as the Executive Secretary, and CDR Hugh N. McWilliams will be the DSB Secretariat representative. It is not anticipated that your inquiry will need to go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code.

Donald A. Hicks

Appendix B — Term Definitions

The military training and wargaming arena has not evolved a commonly accepted set of terms and their definitions. The Task Force repeatedly encountered misunderstanding due to variations in definitions. For this report we are using terms as they are defined in the JCS Publications 1 and 2 (United Action Armed Forces, US GPO 1987-170-209, Dec. 1986).

analytical models:	Simulations to improve understanding or help with decisions such as force structure analysis.
embedded training:	Training using operational equipment that involves simulating or stimulating of equipment performance.
exercise:	A simulated wartime operation involving planning and execution carried out for training and evaluation purposes.
gaming:	A technique in which the learner is presented situations involving choice and risk.
individual training:	In the military usually refers to institutional training received in the schoolhouse.
model:	A mathematical or logical representation of warfare; simulated representation of some entity.
simulation:	Carrying out the steps or computations of a model in order to determine what will happen in a given set of circumstances.
training:	Structured process of imparting or acquiring job-related skills or knowledge such as operational procedures. The term is synonymous with education which refers to the imparting/acquiring of information which is more general in nature such as concepts.
training models:	Simulations to improve participants' skill or provide short of combat such as command post exercises.
training system:	Total training program for a system including courseware: training devices/aids; operational equipment and personnel required to support or employ the system.
unit training:	Unit training usually refers to on-the-job training but may include institutional aspects (classroom instruction).
wargame:	A simulation of a military operation involving opposing forces, using information designed to depict actual or real life situations.

Appendix C — Task Force Membership

Dr. Anita K. Jones -- Chairperson
University of Virginia

Professor Frederick P. Brooks, Jr.
University of North Carolina

Captain Paul R. Chatelier
USN (Ret.)

General Paul F. Gorman
USA (Ret.)

Mr. Ervin Kapos
Ervin Kapos Associates

Admiral Issac C. Kidd, Jr.
USN (Ret.)

Lt. General Richard D. Lawrence
USA (Ret.)

General Robert T. Marsh
USAF (Ret.)

Mr. James A. Perkins
McDonnell Douglas

Professor Thomas B. Sheridan
Massachusetts Institute of Technology

Dr. Earl A. Alluisi -- Executive Secretary
OUSD(A)/R&AT

Appendix D — Meeting Locations

23-24 October 86	Institute for Defense Analyses Arlington, Virginia
24 November 86	Pentagon Washington, D.C.
12-13 December 86	Eglin AFB Florida and Hurlburt Field, Florida
12-13 January 87	Institute for Defense Analyses Washington, D.C.
17-19 February 87	Boeing Aerospace Company and Fort Lewis, Washington
17-18 March 87	Naval War College Newport, Rhode Island
23-24 April 87	Institute for Defense Analyses Arlington, Virginia
21-22 May 87	National Defense University and Pentagon, Washington, D.C.
17 July 87	Institute for Defense Analyses Arlington, Virginia

Appendix E — Briefings and Briefers

TOPIC	BRIEFER & ORGANIZATION
23-24 October 1986	
AMIP-Army Model Improvement Program	MAJ Joseph Trien, USA Army Combined Arms Center
Navy Wargaming	Mr. Gary Morton Naval War College
USAF Operational Wargaming	LT COL Daniel D. Cecil, USAF HQ USAF Directorate of Operations
Wargaming Simulations	LTG John Cushman (USA-Ret) PIRP-Harvard
CBI (Computer-based Instruction) Effectiveness	Dr. Jesse Orlansky Institute for Defense Analyses
NTSC Simulation and Training Efforts (NTSC)	Mr. Frank J. Jamison Naval Training Systems Center
Training Device Development	Dr. Ron Hofer PM-TRADE
Modern Aids to Planning Program (MAPP)	Mr. Vincent P. Roske Joint Chiefs of Staff
SIMNET	LT COL Jack Thorpe, USAF DARPA
USREDCOM	COL Richard Hull, USA US Readiness Command
Joint Warfare Center	COL Ronald Spivey, USAF US Readiness Command
AFHRL Programs	COL Dennis Jarvi, USAF Dr. Hendrick Ruck Mr. Bertram Cream Dr. Herbert Bell Air Force Human Resources Laboratory (AFHRL)

TOPIC	BRIEFER & ORGANIZATION
23-24 October 1986 (Continued)	
Reserve Components and Guard	Mr. Gerald H. Turley Deputy Assistant of Defense Reserve Affairs
Manpower and Force Management	COL Joseph L. Higgins, USAF Office, Assistant Secretary of Defense for Manpower for Force Management and Personnel
24 November 1986	
Gaming and Simulations	Mr. Erwin Kapos
Future Combat Roles	Mr. Jim Perkins
ACME	Dr. Earl A. Alluisi Office of the Under Secretary of Defense (Acquisition)
12-13 December 1986	
Tactical Air Warfare Center (TAWC)	BGEN John E. Janquish, USAF Tactical Air Warfare Center
BLUE FLAG	COL Robert H. Boles, USAF Tactical Air Warfare Center
USAF/Air Ground Operations School	COL Paul L. Grimmig, USAF Tactical Air Warfare Center
SecDef--CINC STRUCTURE	Dr. Earl A. Alluisi Office of the Under Secretary of Defense (Acquisition)
1982 DSB Study Follow-Up	Mr. Paul R. Chatelier Perceptronics
BLUE FLAG Automation Support	CAPT Randy Sherwood, USAF Tactical Air Warfare Center

TOPIC	BRIEFER & ORGANIZATION
12-13 January 1987	
Decision Aiding Technology for Tactical Battle Management	Mr. Vernon Miles Air Force Studies Board
DARPA Advanced Technology Research	Dr. Craig Fields DARPA
NATO Distributed Wargaming System	Dr. Robert Lyons Defense Communications Agency
Synthetic Holography	Dr. Stephen Benton MIT
Naval Wargaming System - Past, Present, and Future	Dr. Leonard Birns Computer Science Corporation
Battle Management and Intelligent Simulation	Mr. R. Peter Bonasso MITRE Corporation
Battlefield Decision Aids	Mr. Raymond P. Urtz Rome Air Development Center (RADC)
Application of AI Wargaming	Dr. Nort Fowler Rome Air Development Center (RADC)
Warrior Preparation Center	Mr. Jerry Colyer Warrior Preparation Center (WPC)
Knowledge-Based Intelligence Systems	1/LT Michael McCowan, USAF Rome Air Development Center (RADC)
17-19 February 1987	
Boeing Aerospace Company Overview	Mr. Leroy J. Mason Boeing Aerospace Company (BAC)
C-SAFE War Gaming	Mr. Joseph Russel Boeing Aerospace Company (BAC)

TOPIC	BRIEFER & ORGANIZATION
17-19 February 1987 (Continued)	
Peacekeeper Weapons Control System Trainer	Mr. R. W. Ormsbee Boeing Aerospace Company (BAC)
BAC's System Integration and Modeling Network	Mr. A. W. VanAusdal Boeing Aerospace Company (BAC)
BAC's Rapid Workstation Program	Ms. W. H. Lee Boeing Aerospace Company (BAC)
Advanced Computer Graphics	Mr. M. H. Tonkin Boeing Aerospace Company (BAC)
The Army's Integrated Training Management System	LT COL Robert H. Behncke, USA Army Development and Employment Agency
The Army's Training Information System	Mr. James Maddon BDM Corporation
Army Family of Simulations	COL Benson F. Landrum, USA Combined Arms Training Activity
I Corps Simulations Overview	Mr. Gilbert Conforti, USA Fort Lewis
Joint Exercise Support System (JESS)	Mr. Tom Hayes Jet Propulsion Laboratory
Rand Strategy Assessment System	Mr. Paul K. Davis Rand Corp.
17-18 March 1987	
Wargaming at the Army War College	COL Edward Kielkopf, USA US Army War College
Naval War College Wargaming Department	CAPT J. Hurlburt, USN Naval War College
Air Force Wargaming Center	COL Dean Pappas, USAF USAF Air University

TOPIC	BRIEFER & ORGANIZATION
17-18 March 1987 (Continued)	
NWC Wargaming Micro-Models	CDR Robert Champney, USN Naval War College
Rapid Prototyping	Mr. Ray Urtz USAF Air University
Enhanced Naval Warfare Gaming System (ENWGS)	CDR James Puffer, USN
Joint Wargaming and Interoperability Issue	Mr. Howard Miller Naval War College
Logistics Gaming	COL Ruane Naval War College
Global Exercise	Mr. Bud Hay Naval War College
23-24 April 1987	
Executive Session -- No Formal Briefings	
21-22 May 1987	
Wargaming and Simulation Center Overvie University	COL W. E. Hogan National Defense (NDU)
Joint & Combined Operations	LTC Robert Might, USA National Defense University (NDU)
Current Computer Support to Academic Exercises	Mr. Richard Wright Mr. Keith Thorp National Defense University (NDU)
Future Wargaming Support	Mr. Sasha Taurke National Defense University (NDU)

TOPIC	BRIEFER & ORGANIZATION
21-22 May 1987 (Continued)	
Unified Space Command	Dr. David Finkleman US Space Command
Computer Image Generation for Training	Mr. Robert Schumacher Evans and Sutherland Corp.
Training Performance Data Center (TPDC)	Dr. Tom Sicilia Training Performance Data Center (TPDC)
17 July 1987	
Executive Session -- No Formal Briefings	

Appendix F — Support Personnel

DSB Military Assistant:	Cdr. Hugh H. McWilliams, USN LCdr. George A. Mikolai, USN
Working Group:	BGen. John C. Heldstab, USA Col. Frank Landrum, USA Dr. Franklin Moses, OUSD(A) & USARI Dr. David Payne (Hay Systems)
Government Advisors:	
Army:	Dr. Herbert K. Fallin, Jr. Mr. John A. Riente
Navy:	Mr. Robert H. Hillyer RAdm. Leighton W. Smith, USN
Air Force:	MGen. Michael J. Dugan, USAF MGen. George L. Butler, USAF Mr. Raymond P. Urtz
JCS:	Mr. Vincent P. Roske

Appendix G — Survey of CINCs

The Defense Science Board (DSB) requested the Commanders, Unified and Specified Commands, to complete a questionnaire on computer applications to training and wargaming within their organizations. The CINCs were asked to respond to two major categories of questions: the cost of training/wargaming, and questions pertaining to general topic areas such as suggested improvements and measures of training success. Since most of the CINC's did not provide detailed cost data, this category was not included in our analyses. The following is a narrative summary analysis by topic area of the CINC responses.

Specific Topics

Improving Joint Training

Many of the CINCs believe there should be more realism, more fidelity in the training and less basic data gathering. Some have the opinion that Command Post Exercises (CPXs) and Field Training Exercises (FTXs) lack realism and do not adequately test capabilities to operate under a global war scenario. For example, one CINC stated "...under a global war scenario we would need to operate some 600 plus airlift missions per day for the first ten days (and) present JCS CPXs don't adequately test our capability to do this. Using present ADP, this capability is suspect." Performance could be improved significantly by ensuring that Air Force, Army, Navy-Marine Corps simulations for wargaming are compatible and jointly exercised. For example, USSOUTHCOM relies on both the Navy and Air Force combat air support in its Joint Interoperable Tactical Command and Control System exercises and wargames. The Navy has most of its training and experience using the VAX 8600 and associated programs/models and the Air Force has been using the Honeywell H6000 and World Wide Military Command and Control System (WWMCCS) programs/models. These two systems are not plug-in compatible. Hardware/software standardization and associated training would provide the capability for increased training compatibility and should enhance performance during both exercises and real-world situations.

Additional comments and recommendations from the CINCs included a more active role for higher ranking officers in the exercises/wargames; providing clearly defined and measurable learning and performances objectives; and conducting post-game analyses of lessons learned.

Measure of Success

Although much of the data collected is detailed and readily measurable (e.g., number of bridges or miles of roads built or number of interoperability problems identified and corrected in an exercise), the overall measure of success reported was usually a subjective judgement of the commander regarding how well the objectives were achieved. Recommendations for improving future evaluations included using trained evaluators from outside the command and increased use of automated evaluation techniques.

Automation Requirements

The CINCs noted the following needs in the area of automation requirements:

- Better graphic displays and outputs.

- Faster-operating computer model of battle damage assessment and more sophisticated models to take into account enemy philosophy, doctrine, tactics and capabilities.

- More portable and more powerful computer, i.e., a more rugged computer to be used in various gaming locations.

- More automation of procedures and production of standard reports, messages and instructions.

- Additional recommendations for using automation more effectively included providing automated interfaces among service wargaming centers, and using distributed systems to include commanders at their home site.

Where To Focus Additional Training And Joint Skills

There was agreement on where to focus additional training for joint skills. It can be summarized in two statements:

(1) There is too much military-to-military interaction within single component service lines.

(2) There should be increased emphasis on integrating multi-service capabilities for joint operations. Specific training needs identified include more training for people who operate the airlift system and better displays and training materials translated for the participants who do not speak English.

Type of Joint Training Problems Requiring Regulation And/Or Doctrinal Changes:

There were no problems identified which require changes in regulations or doctrine.

Additional Areas That Should Be Addressed

- Development of a multilevel security system for WWMCCS, because operating at Top Secret hampers support.

- Several CINCs addressed the need for additional Artificial Intelligence support but gave very few details. Examples of comments received were:

  -- "Artificial Intelligence ... and Local Area Networking with PCs are sorely needed."

  -- "Better graphic displays/outputs and the use of Artificial Intelligence methods and expert systems could be employed to greater benefit."

  -- "Other areas of investigation-application of Artificial Intelligence systems to rapid response strategic decision-making."

It is considered imperative that operational commanders be involved and committed to the development of any system.

Main Conclusion

The CINCs believe, in general, that performance could be improved by ensuring that Air Force, Army, and Navy-Marine Corps wargaming simulations are compatible and jointly exercised. In essence, it appears that they are asking for more active "jointness" among the services.

The CINCs unanimously agree that more wargaming automation support is needed, with the nature of this additional support ranging from simple data/report assimilations to more complex requirements such as artificial intelligence applications. This requirement is substantiated by their inputs concerning the amount and types of computer support now being provided for a wide range of wargaming exercises. There appears to be a relatively small amount of computer technology dedicated to supporting wargaming exercises which involve thousands of players at great cost.

Appendix H — Actions Required for Implementation

Recommendation 1: CJCS cause service and joint simulations to interoperate.

- Internet service, college, and joint games and simulations now.
- Establish shared simulation repository to facilitate future interoperability.

Action: CJCS should cause to have prepared, by Q1/89, a plan of action to internet the existing service-college and joint training and simulation centers. The plan should include milestones and funding profiles, as well as provisions for the centers to be coordinated for compatibility with a standard communication system, and for shared-repository data to be available to users in Q1/90.

Recommendation 2: CJCS promote use of simulation-based training for senior officials responsible for joint operations.

- Broaden CINC use of simulation.
- Have CINCs game/train with remote wartime assigned forces.
- Experiment with training equipment on exercises.
- Provide for participation of senior government officials, as appropriate.

Action: CJCS should cause to have prepared, by Q1/89, coordinated and extended simulation-based training programs for the CINCs, to include other personnel responsible for joint operations (e.g., appropriate senior civilian wartime decision makers). The coordination should address CINC and network requirements to train with remote (i.e., distant, anticipated) wartime forces.

Recommendation 3: CJCS develop long-range requirements for future joint simulations.

- Establish and document long-term requirements.
- Requirements guide future systems designs, enhancement of current systems, shared repository content, joint simulation standards, and prototypes.

Action: CJCS should cause to have established and documented, by Q1/89, long-range requirements for future joint training simulations, together with a plan to meet those requirements. The plan should include provisions for annual updating, and for coordination of service, CINC, and Defense agency plans for joint training and training simulation.

Recommendation 4: CJCS establish a continuing prototype program; CJCS and services procure systems based on results.

- Monitor technology advances.
- Develop timely prototypes: harness new technology, and new simulation and training techniques.
- Use DARPA-like rapid-prototyping methods.

- Ensure close customer involvement.
- Streamline acquisition.

Action: CJCS should cause to have prepared, by Q1/89, plans for a five-year advanced technology development program to demonstrate applicability of technology advances, as described in the Task Force report. The plan should include milestones and funding profiles, as well as provision for rapid DARPA-like prototyping capable of an early demonstration no later than the twelfth month after program initiation.

Recommendation 5: CJCS undertake major joint training and simulation initiative.

- Institutionalize management and budget to oversee: immediate internetting of existing assets, promote use for training and doctrine development, shared simulation repository, and rapid prototype program.
- CJCS coordinate spaces, program elements, and budget lines (joint and services).

Action: CJCS should cause to have designated, by Q1/89, an appropriately staffed joint training simulation advocacy office to manage, evaluate, and coordinate the actions taken to implement the previous recommendations. These actions should include management of the advanced technology development program and its funding, as well as plans for joint training and simulation, and the funding for the internetting of service and joint simulation assets, the shared simulation repository, and enhanced CINC use of simulation-based training.