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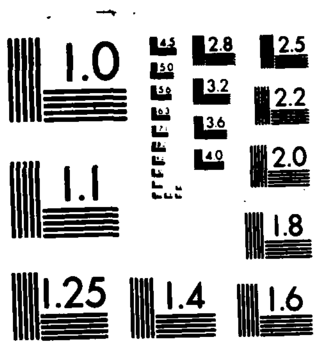

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COMPUTERS IN THE ARMY: APPLICATIONS AND IMPLICATIONS IN THE YEAR 2000

by

Joseph D. Britton

30 April 1983

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ABSTRACT

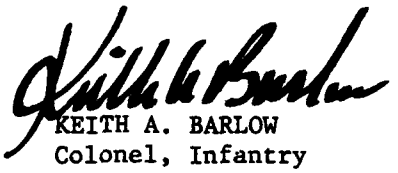
This report examines developments and trends in the fields of computerization and automation in support of a premise that computers and automation can make major contributions to the effectiveness of future US Army forces. The trends and developments are correlated with anticipated needs of the Army at the turn of the century. Decisions to exploit increasingly current and anticipated technological advances are required now if we are to maintain a qualitative advantage over potential adversaries as well as compensate for a quantitative disadvantage in men and materiel. Requirements with respect to manning, equipping, training, fighting, and managing the force are considered in determining applications and defining implications for the Army in the year 2000.

A primary conclusion of the report is that potential applications for computer technology toward meeting the Army's needs will be limited only by our imagination; however, realization of this promise requires the satisfaction of several conditions. Toward that end the report recommends: involving Army leadership to a much greater degree in the evolutionary process and developing greater decisionmaker understanding and expertise; developing a corporate capability in the Army to conduct essential planning for future implementing the Army's development and acquisition strategies to take advantage of the reliability and economy available through incorporation of computers; continuing and expanding the Military Computer Family concept; and configuring personnel management structures to incorporate a distinct career field for qualified personnel in the fields of computerization and automation.

FOREWORD

This futures report projects the state of the art in microelectronics and its application in the US Army to the turn of the century. The author views future data-base management; networking and interactive systems; and programmable robotic equipment, which may be adopted by the Army, as being beneficial to Army combat operations as well as being increasingly cost-effective in terms of dollars and manpower. To help envision a future environment, the author drew on recent Army futuristic studies, futurist literature, and projections of advanced microelectronics found in technical journals.

This report was prepared as a contribution to the field of national security research and study. As such, it does not reflect the official views of the US Army War College, the Department of the Army, or the Department of Defense.



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COMPUTERS IN THE ARMY:
APPLICATIONS AND IMPLICATIONS IN THE YEAR 2000

Introduction. The Army's future structure is uncertain. The dynamics of economic, political, demographic, and technological conditions will significently affect the Army's appearance in the years ahead. Indicators and projections portend a future Army which will be constrained in size and equipment. The Army will face potential adversaries who will maintain their present quantitative advantage and display an increased technological capability to threaten the qualitative advantages the United States and its allies are likely to hold. Compensating for the quantitative edge and maintaining the qualitative edge require decisions now to exploit current and anticipated technological advances. The premise of this report is that computers and automatons offer great potential for assisting the Army in building a technologically superior force which would be capable of offsetting deficiencies in numbers of men and equipment. Basic to that premise are assumptions that the technological advances in the fields of computerization and automation will continue unabated and that the Army will make the commitments necessary to take advantage of the capabilities presented.

Our ability to determine practical uses for computers has been outstripped by recent advances in microelectronics.[1] Positively stated, this means that the capabilities afforded by these and future advances will only be limited by our ability to recognize those capabilities and our imagination in applying them. To support the premise of the report, developments and trends were examined to determine their correlation with some of the specific needs of the Army which may arise toward the year 2000. The US Army Training and

Doctrine Command's concept Airland Battle 2000 (September 1981)[2] and a futures report, A Concept of a Future Force (November 1981),[3] by Mr. Charles W. Taylor of the US Army Strategic Studies Institute, were used as the basis for outlining those needs.

In brief, Airland Battle 2000 is an important step in moving the Army toward concept-driven design; weapons and equipment will be designed to accommodate the mission and force structure rather than the reverse. A basic tenet is that time on the battlefield will be affected by accelerated information processing, real-time acquisition and priority selection of targets, nearly instantaneous decisionmaking, rapid dissemination of orders, and quick execution of tasks;[4] all matters susceptible to computer enhancement. Mr. Taylor, using a likely force design of a 1990's modernized US Army, conceptualizes a force for the early years of the 21st century. This Army is few in numbers of personnel, but technologically superior when compared to traditional 20th century forces.[5]

Backgrounds and Trends in Microtechnology. Over the past several decades, the United States has been in the midst of an information revolution. The increase in access to and dissemination of information has made the United States information rich. One of the new technologies that has made this possible is microelectronics. Microelectronics technology dramatically increases our ability to cope with a changing society and, particularly, to deal with a burgeoning information industry.

The introduction of microelectronics into every aspect of US society has changed significantly the way Americans live, work, and use their leisure time. With no compromise in size or cost, microcomputers can enhance the operation of

any device which would benefit from a capability to retain information, perform calculations, or control functions.[6] Microcomputers are now used in automobiles, home appliances, entertainment devices, security systems, weapons, scientific instrumentation, prosthetic devices--a seemingly endless list of personal and business "machines." Potential applications to enhance military capabilities would appear limitless.

The first electronic digital computer was developed in 1946; a big, slow, and clumsy machine by today's standards. Smaller and faster computers became available with the development of the transistor. The first minicomputer became available around 1962. The microprocessor was developed in 1971 and the first microcomputer was sold in 1975. [The term microcomputer can be taken to mean either a silicon chip (a "microprocessor") capable of doing what a "normal" computer does (control/process, memory, input-output) or a small computer system with such a chip, or chips included in its structure.]

Silicon chips, one quarter inch in size, have replaced the vacuum tubes and transistors of earlier computers, with huge savings in cost and size. Computer circuitry which cost $1 million 15 to 20 years ago is available today for a fraction of that cost. Continuing cost decreases of the same magnitude have been forecast,[7] as have decreases in the size of computational chips. A chip to contain a quarter of a million circuits is being developed.[8] The US military has asked industry to develop an IBM 370/158 (a recent-vintage, main-frame, computer) on a single chip. There is a strong possibility that it will be available in the late 1980's.[9]

The "nanoprocessor," one thousand times more powerful than the micro, probably will be available within a decade. The next step leads to the

"picoprocessor," possibly available by the end of the century. Picoprocessors are based on molecule-sized circuits and are a million times more powerful than the microprocessor.[10]

Software (the descriptive models and programs) will continue to be the most limiting factor in the use of computers since its development and maintenance are labor-intensive, time consuming, and, consequently, expensive. Reducing the software barrier will depend, in part, on development of systems which will allow the user to devise and use his own applications suited to his needs. Much wider use of nonprocedural, or nontechnical, approaches, which would be possible through the formulation of much higher level computer languages than now exist and which would permit straightforward, natural-language communication with computers, could place immense computing power directly in the hands of the user.[11] The ultimate system will be a self-programming computer that can be commanded rather than programmed.[12] Eventually, most computers will respond to speech and, although doubtful by the beginning of the 21st century, even thought. Despite the convenience at the user level, the software to support such "user friendly" systems will be extremely expensive in money, time, and effort. With hardware (equipment) costs decreasing, the cost of software is likely to become at least 90 percent of total system cost.

The functions of data processing and communications are expected to be combined into one dual purpose system.[13] By the year 2000, it can be anticipated that every new television set will include a computer terminal and that even pocket terminals will be readily available.[14] Users will be able to tie-in through common-use communications systems to gain access to information to conduct business, to entertain themselves, and to "telecommunicate" as a normal

part of daily life. Worldwide communication will be an everyday occurrence as the full potential of satellites is realized.

Developments in microelectronics and user-oriented softward, along with the coming merger of data processing and communications, imply that future systems will tend to be highly interactive and network oriented. Large computers still will be needed, but the advantage of being able to follow, or model, an organizational structure with distributed processing, using microcomputers, increasingly will emphasize networking and interactive systems. Future technological developments in hardware will support this tendency through continued decreasing cost factors; increasing ruggedness and reliability; and designs which realize and enhance telecommunications capabilities.

Improvements in data-base structures and management systems finally will make it possible to realize the potential previously predicted for the data-base function. Data will become an organizational resource to be managed rather than something just processed,[15] leading to Management Information Systems which can do what they originally were intended to do--support the decisionmaking process. Whether these are called Decision Support Systems or Command and Control Systems, the requirement is the same--help to make decisions better.

In the field of automation, the trends also are significant and exciting, particularly with respect to robotics.[16] A robot is anything which does a job previously done by a human, operates itself, and has some electronic logic, usually performed by a microcomputer.[17] Robots are reprogrammable and are especially valuable for performing boring, repetitive tasks and jobs dangerous for humans. They are in relatively common use today and continual improvements are being made in their sophistication, especially in logic systems. Probably before the year 2000, robots will be able to make limited decisions.

They will respond to speech and will exercise other sensory capabilities to support the decisionmaking logic. Sensory systems will not be limited to those of humans and will include, for example, infrared and ultraviolet sensors and magnetic and radiation detectors.

Computers and automation have changed our society and that of the world. As we begin to understand the significance of these changes, their effects will be magnified. In the military, the proper use of tools available to assist in making the best strategic, operational and tactical decisions; conserving scarce resources; and doing hard, dangerous jobs an easier way is imperative. Computers are among those tools and the potential for their use throughout the Army of the future is great.

Applications and Implications for the Army in 2000. Computers and automation will affect every aspect of Army operations in the coming years. What follows is a correlation of the previously discussed trends with the needs of the Army at the turn of the century.

- Manning the Force. Demographic projections indicate that the available population for military service will be smaller, requiring adjustments toward operations with smaller but more lethal forces. Improved methods for attracting and retaining the population segment needed for service will be required.

Based on projections of highly visible current trends, the US economy will continue its shift from a base of manufacturing and industry to one of information and communications. Today's basic industry and manufacturing will remain, however, as an important part of the economy with computer-assisted design and computer-aided manufacture providing for greater efficiency and productivity. The need for human labor will be reduced, causing a situation

which should enhance the competitive stance of the military in the labor market. Concurrently, however, the requirement for technically-qualified people to meet the requirements of the changed economy will be reflected in the needs of the Army as well, and in this area competition will be especially stiff. The Army will be affected in the same general manner as the society at large--computers and automation will reduce the number of people but should yield a better qualified force and heighten the requirements for well-trained technicians. Innovative programs designed to attract and retain the people needed and to provide a competitive edge over civilian pursuits will be especially important to the Army at the turn of the century.

- Equipping the Force. Technological opportunities available at the turn of the century will compound the present day problem of choosing among multiple options in meeting computer requirements. The incorporation of computers in equipment, of computer systems in general, and of the use of computers in the procurement of other equipment for the Army will be significantly greater. Procurement actions (comprising design, development, evaluation, fielding, operation, and sustainment) are susceptible to substantial economies through the use of computers and automated activities. The incorporation of computers in equipment and systems will prove more economical than other solutions for achieving effectiveness, reliability and operational readiness.

Advanced abilities to simulate the performance of an item of equipment or system will provide major assistance in designing against requirements during research and development activities. Firm concepts of the final product will be available earlier and accurate predictability prior to field testing will be possible through computer-assisted design of prototypes and further refinement of system simulation. Sophisticated extrapolation of field testing from laboratory modeling will contribute to economies. More intensive and extensive evaluation with greater accuracy will be possible through automated testing and measurement.

Improved efficiency and productivity in basic industries resulting from use of computers and automation will benefit the military in its efforts to provide the best equipment for its forces in the field. Computer-aided design of manufacturing processes and computer-assisted manufacture will produce better quality material at relatively low costs. They will include computer-controlled production lines, robotics, and automated quality control and will contribute to substantial savings. The fielding phase of procurement can be improved through better analysis and control to assure a truly integrated, system-support package. Operational performance will be improved because of embedded processors and computers, while maintenance will be facilitated through self-diagnostic and limited self-repair capabilities. The sustainment system's effectiveness from CONUS to the units in the field will be enhanced.

Embedded computers as integral parts of systems and microprocessors in equipment will prove most economical in assuring design requirements and increasing reliability. Weapons systems can use computers to monitor every aspect of their performance and employment to the point of decision to fire or launch. Self-diagnostic and self-repair capabilities will improve reliability to a greater degree. Computer-enhanced communications for audio-video conferencing will be available in compact, light-weight packages. Individual weapons and vehicles will use processors to monitor performance and guide users in their employment. A vehicle which will not "release" its operator until all performance requirements are met, for example, illustrates how robotic and computerized equipment could save resources and improve operational readiness. An extension of such a capability would be to integrate physically and electronically such a vehicle into an automated

maintenance system for recording of performance data, diagnostics, servicing requirements, and requisitioning or provisioning of parts. Logistical support for forces in the field could be computerized effectively using distributed processing.

Robotics will prove to be a significant force multiplier by the year 2000. Hazardous and repetitious duties are logical candidates for performance by reprogrammable robots. Detection and clearance of mine fields; CBR detection, warning, and decontamination; uploading of ammunition; inventory and supply; equipment maintenance and clerical work; wire laying; and scouting and sensory duties are a few examples of tasks from which humans could be relieved for other more sensitive or less hazardous work in peacetime or combat.

- o Training the Force. Decisions now to exploit current and anticipated training-technology advances will assist the Army in fielding a force for the 21st century with the capability to offset any mismatches in the number of people and amount of equipment. Technological abilities and capabilities can provide a degree of mobility, survivability, and lethality exceeding that of any potential adversary. The battlefield of the future will be increasingly complex and so will the equipment. Unprecedented speed of action, lethality, variety of the threat, and sheer numbers of opposing weapons, systems, and men make such complexity inevitable. Computer and robotic technology, as well as training-technology, will help to make operation of such equipment less complex, but the fact remains that people will be required to maintain and sustain skills to a degree not required previously. Over the next two decades, recruits increasingly will have been raised in a technologically-oriented society which will prepare them psychologically to adapt readily to such equipment and requirements.

Training a force at the turn of the century could well be heavily dependent on computer assistance. Not to be confused with present day self-paced

instruction, interactive systems will provide for one-on-one, tutorial, student-teacher relationships. The small size and low cost of microprocessors will make it possible for each trainee to have his own portable extension of the classroom situation. Team training for fighters and "fixers" will be facilitated through computer-assisted simulators.

Simulation can approach realism through a full range of audio and visual capabilities and robotics, but its primary advantage will be realized in a capability to challenge individuals, crews, and leaders with dynamic situations. Interaction with training and educational devices will be featured from the level of the individual soldier to the highest echelons. Computerized logic games and wargaming can present various rational situations in every environment on any scale needed, easily and rapidly repeated, and with simultaneous participation by players worldwide. Improved readiness and training will be achieved at a small cost due to time and travel savings associated with the widespread use of these new techniques.

- Fighting the Force. The key to fighting the force in the 21st century will be a command and control system capable of dealing with situations requiring nearly instantaneous decisionmaking and communication of orders. A commander will need to operate on a real-time basis. Nodal, interactive, data-sharing and distributed processing and telecommunications will assist in providing the basis for decisions and the means for translating them into action.

Nodes, which might employ a configuration of the Military Computer Family,[19] will be the focal point of hardened, highly mobile command posts at every level of command. Each will be capable of interfacing laterally and vertically. Lateral redundancy of data will provide system survivability should an element be lost and distributive communications will provide real-time information to those who need it. Human considerations of the situation will be available

to the commander through direct teleconferencing. Remote capabilities will allow access to data when the commander is in his command vehicle. Computer graphics will be available for display of the area of operations and will support modeling for decisionmaking.

The following could be an accurate portrayal of a situation facing a commander on a battlefield at the turn of the century:

The commander receives warning of enemy activity through robot sensors, remotely-piloted reconnaissance vehicles, satellite imagery, and human resources; all feed information into an all-source center in his command post by direct data-links or remote-entry devices using extremely short, burst-type digital transmissions. He reviews up-to-date data on the status of forces, views the area of concern through the "eyes" of an airborne robotic-scout vehicle, and teleconferences with subordinate commanders, portraying the area graphically for them and depicting the general course of action. His orders are routed immediately through distributive communications. Should he leave his command post for a position in the area, the commander continues to receive the latest information through remote facilities in his command vehicle. Logistical expenditures, changes in personnel status, losses of equipment, and changes in operational readiness update the data base and initiate replenishment actions. Position-locating devices automatically cause current locations to be portrayed on the graphic displays and quick-reaction gaming capabilities support analysis of courses of action as the situation develops. The commander's capability for making the rapid decisions necessary to gain and maintain the upper hand will be enhanced significantly by the real-time, or near real-time, availability of vital information provided by such a system.

- Managing the Force. The process of managing the total Army at the turn of the century will benefit from many of the same applications described for command and control systems for management of combat. Decision support systems will provide the background for management decisionmaking. They will be modeled on the Army system through distributed processing and communication, will take advantage of worldwide teleconferencing capabilities, and will interface with systems of the Army in the field. Commanders and leaders will find that computerization will allow them more time to spend in troop-leading, training, and personal supervision of the operations of their organizations and units.

Managing the force will require a system compatible throughout the Army which is responsive to the structure and decisionmaking mechanisms of the 21st century force. Such a system will take the form of distributed processing using shared data bases and executed on state of the art processors. Standardization and compatibility will occur at data transition, or interface, levels in both tactical organizations (e.g., battalion to brigade and brigade to division) and base operations (e.g., directorate to installation to Major Army Command) and, similarly, between the sustaining base and the forces in the field. Inexpensive processors and mass memories will be coupled with commensurate improvements in communication capabilities to make this possible. The improvements in communication, which support distributed processing, will themselves be enhanced by the application of computer microtechnology, resulting in fully-automated, distributed telecommunications. Redundancy in equipment will be the key to sustained effective operation of the system and will be the most economic approach to maintaining a reliable system. Within the various levels of operation, use of small computers will be encouraged as a means of increasing management efficiency.

Some of the less direct effects must be considered. Technological advances will continue and procedures for procuring and managing computers will have

to be modified if the Army is to stay abreast. Personnel management procedures for controlling the greater numbers of people required to operate equipment and manage computer resources also will have to be adjusted. Commanders and managers will have to develop computer and communications expertise and understanding considerably exceeding the levels of today.

Procurement actions can be streamlined to take advantage of the rapid growth in capabilities. Off-the-shelf equipment will be suitable for use in many applications including tactical requirements. Leasing of equipment is an approach for both controlling costs and avoiding major investments in equipment quickly made obsolescent. Protocol and translation software and hardware will solve compatibility and commonality problems.

The Military Computer Family approach can provide the vehicle for computerizing the tactical Army in the field. This course could have application in nontactical operations as well, but would not be as efficient as off-the-shelf leasing. Continuous planning will be essential for retaining currency and avoiding time lags and huge costs associated with developing systems decades behind state of the art. Expanded use of small, personal computer systems will be encouraged with authorized procurement on the local level. Exchange of applications information will be formalized as a service throughout the Army, but standardization will only be enforced and managed formally at interface levels. Reliability for all systems will be based on redundancy of equipment and data.

Competition for qualified technicians, programmers, and operators will be stiff between the Army and civilian employers. The Army will have to train in these skills to assure it has an adequate force. It will have to present

significant benefit packages in conjunction with effective career patterns to induce and retain qualified personnel recruited from the society at large as well as to keep those trained by the services.

Enlisted and officer personnel will have to be collected under specific military-occupational specialties (MOS) umbrellas relating to operation, programming, data transmission, and management of automation and computerization. The merging of data processing and communications makes the Signal branch a logical agency for management of such a career field, providing a progressive career pattern for those capable of handling the increased responsibilities of succeeding levels. Officer specialties would incorporate and expand those duties and responsibilities currently associated with Specialty Code 53 (Automated Date Systems Mangement: Specialty Skill Identifier (SSI) 53A--Applications Software Analysis Design; SSI 53B--Automated Information Systems Management)[18] with those qualified who are serving as commanders and staff officers at all levels in every organization where authorized (as Signal officers do today).

As noted earlier, commanders and managers will require increased degrees of expertise and understanding. The expanded use of computers, processors, robots, and computerized communications will require the assistance of personnel specifically qualified as advisors, operators, managers, and subordinate commanders in those areas. This scheme will elevate those best qualified to high levels of decisionmaking in the Army and the Department of Defense and will provide the basis for managing the specific capabilities and the Army's total efforts effectively. The extensive proliferation of computers and ancillary applications today, as well as in the future, increasingly will demand more intensive and coordinated management efforts than is now evident.

Conclusions and Recommendations. The potential applications for computer technology, particularly microtechnology, are limited only by our imagination. The future holds great promise for enhancing the capabilities of a resource-constrained 21st century Army using tools of computerization and automation. Several conditions must be met to do this effectively and efficiently.

- o Leaders, managers, commanders, and decisionmakers must become involved in the evolutionary computer development process and develop greater understanding and expertise in computer technology to assure the system provides them what they need. The product is too important and its use too critical to leave the execution to data processors alone. Data, as the basis for decisionmaking, must become the tool of those directing the course of an organization.
- o The Army must strengthen its corporate capability to conduct the advanced planning essential for successful implementation of successive stages of technological progress.
- o Procurement procedures needed to stay abreast of rapidly advancing technology must be adopted. The Army will become significantly less effective if it continues to use systems based on cardreader/cardpunch capabilities in a time of interactive, user-oriented, near-real-time, distributed processing systems.
- o Continuing advancements in technological capabilities along with decreasing equipment cost and size will, in many cases, make the inclusion of computers/processors in systems and equipment, the development of automated processes, and the use of robots the most

economical ways to meet the needs of the force. Redundancy in equipment and data as well as within systems will prove to be an inexpensive means to assure reliability. The Army's development and acquisition strategies must be adjusted to incorporate these factors in design and procurement activities.

- The Military Computer Family concept should be continued and expanded in its scope. It offers a genuine possibility for staying current with the state of the art and for promoting healthly competition within civilian industry.
- The Army must structure its personnel management policies to permit development of a body of skilled leaders, managers, advisors, technicians, operators and maintainers as members of a distinct career field. This must apply to civilian as well as military personnel. Such policies will help to assure the retention of qualified personnel who can make the applications of computers most effective as well as beneficial for the Army.

ENDNOTES

1. Alan P. Hald, "Toward the Information Rich Society," The Futurist, Vol. 15, No. 4, August 1981, p. 20.

2. US Army Training and Doctrine Command, Airland Battle 2000, Fort Monroe: 1981.

3. Charles W. Taylor, A Concept of a Future Force, (Futures/Long-Range Planning Group Report), 1981.

4. Jim Tice, "Army Plans for Year 2000 Battles," Army Times, March 1982, pp. 1 and 28.

5. Taylor, p. iii.

6. Robert D. Hamrin, "The Information Economy," The Futurist, Vol. 15, No. 4, August 1981, pp. 25 and 26.

7. Blake M. Cornish, "The Smart Machines of Tomorrow: Implications for Society," The Futurist, Vol. 15, No. 4, August 1981, p. 7.

8. Cornish, pp. 6 and 7.

9. "Interview: At Home with James Martin," Computerworld, Vol. 14, No. 38, September 17, 1980, p. 119.

10. Cornish, p. 9.

11. Daniel D. McCracken, "Software in the 80s: Perils and Promises," Computerworld, Vol. 14, No. 38, September 17, 1980, p. 9.

12. Cornish, p. 8.

13. Hamrin, p. 26.

14. "Interview: At Home with James Martin," p. 23.

15. Stephen L. Robinson, "Data Base: The Next Five Years and Beyond," Computerworld, Vol. 14, No. 38, September 17, 1980, p. 12.

16. See Dennis V. Crumley, Concepts for Army Use of Robotic-Artificial Intelligence in the 21st Century, (Futures/Long-Range Planning Group Report), 1982, for a more detailed examination.

17. Cornish, p. 10.

18. US Army Military Personnel Center, DA Pamphlet 600-3; Officer Professional Development and Utilization, Washington: Headquarters, Department of the Army, 1977, pp. 53-1.

19. The Military Computer Family is a Department of Defense program. (See MIL-SID-1862B, Nebula Instruction Set Architecture, January 3, 1983.) It is designed to standardize computer processor architecture where computer software compatibility is maintained for a broad range of new processors and other hardware.

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This report examines developments and trends in the fields of computerization and automation in support of a premise that computers and automation can make major contributions to the effectiveness of future US Army forces. The trends and developments are correlated with anticipated needs of the Army at the turn of the century. Decisions to exploit increasingly current and anticipated technological advances are required now if we are to maintain a qualitative advantage over potential adversaries as well as compensate for a quantitative disadvantage in men and materiel. Requirements with respect

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to manning, equipping, training, fighting, and managing the force are considered in determining applications and defining implications for the Army in the year 2000.

A primary conclusion of the report is that potential applications for computer technology toward meeting the Army's needs will be limited only by our imagination; however, realization of this promise requires the satisfaction of several conditions. Toward that end the report recommends: involving Army leadership to a much greater degree in the evolutionary process and developing greater decisionmaker understanding and expertise; developing a corporate capability in the Army to conduct essential planning for future implementing the Army's development and acquisition strategies to take advantage of the reliability and economy available through incorporation of computers; continuing and expanding the Military Computer Family concept; and configuring personnel management structures to incorporate a distinct career field for qualified personnel in the fields of computerization and automation.


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