Technical Report 881

The Impact of Advanced Technology on the U.S. Military

Naomi Verdugo and Nehama E. Babin
U.S. Army Research Institute

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This paper focuses on the impact of advanced technology on three areas of the military organization: manpower, training, and human factors. Military technology has undergone rapid changes and the military organization has experienced changes in occupational structure, training technology, and manpower requirements. High technology has generated interest in issues such as the impact of advanced technology on small unit cohesion, de-skilling in the operation or maintenance of high-tech weapon systems, and the development of new training programs for advanced military technology. The changing nature of warfare and how these changes will require a varying range of technological weapons and equipment are also discussed.

Additionally, the authors suggest an approach for empirical investigation of the relationship between technology and the military.

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Manpower, Personnel, and Training

FOREWORD

The Manpower and Personnel Policy Research Group of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs socioeconomic and demographic research on manpower, personnel, and training issues significant to the U.S. Army. Questions about the impact of military technology on these issues have generated continuing interest.

This overview was conducted at the request of the Technical Cooperation Program (TTCP) Subgroup U (Behavioral Sciences) Executive Chairman COL Franklin C. Pinch of the Canadian Forces, Canada. A draft report was provided to subgroup members and panel chiefs for comments in November 1989 at the annual subgroup meeting. Their input will be used to produce a TTCP report with a cross-national focus on military technology issues. The conclusions developed in this report will be used to help identify questions for future research on the impact of technology on the military.

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The authors are grateful to MAJ Douglas McLiverty for providing information on military recruiting and retention and to Dr. Edgar M. Johnson for his guidance and encouragement.

THE IMPACT OF ADVANCED TECHNOLOGY ON THE U.S. MILITARY

EXECUTIVE SUMMARY

Requirement:

The U.S. Army Research Institute for the Behavioral and Social Sciences conducts research on manpower, personnel, and training issues of particular significance and interest to the U.S. Army. This research was conducted for the Technical Cooperation Program (TTCP), Subgroup U (Behavioral Sciences) to encourage further cross-national research in the area of military technology and its impacts. This research focuses on the impact of technology on military manpower, training, and human factors.

Procedure:

The authors used a variety of source materials to assess the impact of technology on the U.S. military. After reviewing what is known about the impact of technology on military recruiting, retention, social processes and unit effectiveness, training, and human factors, suggestions for further research are presented.

Findings:

The results of this study suggest that there have been no definitive answers as to how advances in technology have affected the military. However, certain questions were raised that could be answered by further research. It was also concluded that further constraints in military spending will reduce military end-strength as well as procurement of technology. It is unclear what effect this will have on combat effectiveness, but it is certain that the military will cease to be the leader in technological innovation. The private sector will now drive this area.

Utilization of Findings:

This report has been distributed among TTCP members for input. Their input will serve to produce a report with a cross-national focus. The suggestions for research presented in this paper will be used as a catalyst for original research in this area.

THE IMPACT OF ADVANCED TECHNOLOGY ON THE U.S. MILITARY

CONTENTS

THE IMPACT OF ADVANCED TECHNOLOGY ON THE U.S.

I. INTRODUCTION

This paper reviews the impact of advanced technology on the U.S. military. In particular it focuses on the effects of technology within three main areas: manpower/personnel; training; and human factors. Additionally, we suggest an approach for empirical investigation of the relationship between technology and the military.

When viewed historically, technological change within the military has been a continual process. However, "technological changes between the Civil War and World War II...pale in comparison with developments that have occurred since 1945." Among these technological developments and advances are aeronautics, submarines, nuclear weapons, modern electronics, aerodynamics and propulsion, as well as computer-based command, control, and communications systems (Binkin, 1986, p. 5).

The significance of the study of technology and the military cannot be overestimated. The military, in most Western societies has frequently played the role of leader in technology change and development. In fact, the military is often the testing ground for many new technologies, especially in the U.S. where, for example, medical technology has often seen its first test in battlefield hospitals. The impact of technology is likely to become apparent in the military setting before it is felt throughout society as a whole. Furthermore, the military is one of the few societal institutions where manpower, training, and technology come together in a single forum, and must be well integrated for the organization to accomplish its mission. Therefore, the military provides an excellent arena for learning about the broad array of impacts of advanced technology on military organizations.

Throughout the years, military research has encompassed a variety of theoretical and methodological approaches emphasizing different variables. Technology has been one of those variables and has, of course, played a critical role in human factors research. However, to date, technology has merely been one of a panoply of dimensions characterizing military organizations. Today the significance of technology identifies it as a major catalyst in shaping a nation's military organization and agenda. The body of theory and research on organizations (for example, see the work of Perrow, 1979, Woodward, 1965, and Hage and Aiken, 1969) identifies technology as central in the study of complex and formal organizations. Portions of this literature have identified technology as a major explanatory variable in the development of organizations, their structure, their size, their processes, and the characteristics of their members. In other words, if one wants to understand how an organization is formed, and why it operates as it does, this particular theoretical model makes the assumption that technology is a major causal variable underlying the shape and form of organizations, and even their environments. Drawing from research on complex organizations, this paper argues that technology is not merely a characteristic or outcome of military organizations. Rather, changing technology is a driving force in shaping military organizations, manpower requirements, training, "man-machine" interface, and combat performance.

As technology becomes more sophisticated, it becomes imperative for each military organization to align the skills of its manpower with the requirements of the technology. Militaries must also consider the supply, skills, and abilities of future recruits when designing weapons systems. The implications of this are many. Each nation must insure that there are sufficient numbers of military recruits and that they have the necessary skills. Consequently, the population, employment, and education trends in each country become vital to this goal. Within the military, retention of experience and skills is an important issue, as is the balance of reserve and active forces. With the advancement of technology other issues come to the fore such as whether high levels of technology cause de-skilling or require increased skill levels. Making assumptions about this issue will affect the development of military training programs. Changing technology could impact over time on the military occupational structure. The implications of changing and ever-advancing technology for the military are manifold and in need of research attention.

In the area of human factors, the impact of technology is even more direct. Human factors research owes its existence to technological change and the need to insure that weapons and other machinery are designed with the human operator and maintainer in mind.

Changes in technology have also altered the nature of warfare today. Military conflicts and war no longer follow a limited pattern of tactics and strategies. It is not necessarily true that war will be conducted across a front line with troops organized in traditional formations, with traditional weapon systems and equipment, and conventional command and control configurations. On future battlefields, the shape and form of battle and war will be highly varied, with servicemen and women more widely dispersed throughout the area of combat (Zeidner and Drucker, 1988). Today's potential battlefield ranges from one of high intensity, involving nuclear weapons, high-tech armaments, and the massive movement of troops, to one of low intensity conflict, characterized by a dispersed battlefield and troops, the lack of a front line, and low-tech weapons. In low intensity conflict, servicemen and women bear greater responsibility, relying less on traditional chains-of-command, and sophisticated weapons and supplies. Indeed, today, it is just as likely that servicemen and women will be required to respond to low intensity conflicts as they will to high intensity conflicts. It has been speculated that U.S. military involvement in the Third World is most likely to be low intensity (Gonzalez, 1988). This poses special problems in the area of military preparedness. Many Western societies have developed a reliance on the technological "fix." Van Creveld (1988) warns that low intensity conflicts, such as guerrilla warfare, often result in the triumph of troops with less sophisticated weapons over those with every advanced weapon and device. He cites Vietnam and Afghanistan as just such cases. Hence, training for diverse fighting conditions becomes more important, as does the quality of leadership and motivation which are so critical in low intensity conflict. However, the impact of technology must be kept in perspective since much of combat effectiveness comes down to the human factor.

In view of the diversity, "flexibility," and array of the modern battle and battlefield, and the accompanying technologies, nations must now be prepared for many different situations. It is very important to begin the process of examining and understanding how technology affects manpower, training, and human factors under different crisis situations, and how the changing nature of warfare alters these relationships.

II. THE ISSUES

In this section we outline the issues on the impact of technology in three major areas: manpower/personnel; training; and human factors. These represent three somewhat distinct aspects of the military, thereby providing a broad forum for examining the ways in which technology has affected the military.

A. Manpower

The manpower area has been divided into three subtopics: recruitment; retention; and social processes and unit effectiveness.

1. Recruitment

In today's military, recruitment has become as much a function of technology as it is of demographics and economic conditions and incentives. In fact, in the U.S. changes in technology have served to exacerbate an already difficult recruiting situation.

There is no doubt that changing national population trends critically impact on the ability of military institutions to fulfill manpower requirements. Recruitment is the foundation of the U.S. Armed Forces. While there is currently no difficulty recruiting officers -- the supply of officers is easily met via ROTC (Reserve Officer Training Corps) and OCS (Officer Candidate School) -- in FY90 recruiters for the Regular (active duty) enlisted Army were expected to recruit about 124,000 men and women (this figure has since been reduced to 119,000 and is expected to decline even further). Clearly, recruiting is a critical function, and with various demographic changes converging on the population, an increasingly difficult one. While it is expected that the Army will meet its accession requirement, it may fall short of the assigned number of male high school graduates scoring in the top half of the Armed Forces Qualification Test (AFQT). The 17-21 year old male population, the group from which most recruits come, is projected to decline by 12% between 1985 and 1995. On top of these difficulties there have also been declines in the number of high school graduates, as well as declines in the number and percentage of those scoring in the upper half of the AFQT. Hence, "high quality" youth -- those deemed most desirable by the military -- are declining both in number and as a percentage of all youth. This is the same group most in demand by employers and colleges as well. As the segment of highly qualified youth declines, competition for this group increases. To further add to recruiting difficulties, the youth (16-24 year old) unemployment rate has declined by 20% (from 13.5% to 10.8%) between FY85 and FY89, reflecting the increase in non-military opportunities for youth.

Recruiting incentives such as the Army College Fund (ACF) and enlistment bonuses are designed to attract qualified youth to military service. Unfortunately, the value of these incentives has declined over time. For example, ACF (with the GI Bill) has declined by one-third since 1985 due to inflation and the rising cost of college (in excess of inflation). The current budget before Congress provides for significant increases to ACF and enlistment bonuses. However, with American policy makers concerned about the growing deficit, and increased pressure to reduce military spending, it is unlikely that significant increases in basic pay or enlistment incentives, beyond those currently being considered, will occur soon.

While the acute nature of these recruiting difficulties will be somewhat lessened by cuts in military end-strength (particularly cuts in the number of troops stationed in Europe), technology has become a major force in determining the ability of the U.S. Armed Forces to recruit. As technological advances are implemented in weapons systems, they typically become more complicated to maintain. Consequently, entrance requirements for selected MOS (military occupational specialties) have become more stringent to insure that recruits are suited to the complex training required for these jobs. MOS themselves have become more specialized reflecting the impact of technology on the modern military. As noted by Binkin (1986), the proliferation of MOS and the increased specialization that results occurred beginning in 1815 when the Navy initiated the transition from sail to steam power. Technological change did not affect the Army until World War I. Indeed, as late as 1898 "90 percent of all U.S. soldiers were still assigned to infantry-type duties." However, by the end of World War I "almost 60 percent of all enlisted men were in noncombat jobs" (Binkin, 1986, p. 4).

As a result of the increased specialization and technological requirements, military entrance requirements increased. Consequently, the number and proportion of youth capable of meeting these requirements declined. While enlistment incentives are designed to attract recruits to those MOS which are particularly difficult to fill, the eroding value of these incentives along with the expansion of non-military opportunities (due to employers and colleges vying for the small pool of highly qualified youth) bodes ill for military recruiting. Technological advances also add to the manpower shortage by reducing the number of positions available for youth scoring in the lower half of the AFQT. Further, the proportion of males age 17-21 without high school diplomas and/or who score in the lower half of the AFQT is projected to increase from 56% to 59% between 1980 and 1995 (Verdugo and Nord, 1987). Hence, by 1995 only about 41% of 17-21 year old males will be "high quality."

Both civilian and military policy makers must be aware that recruitment, now and in the future, is a four-pronged phenomenon which is determined by demographics, incentives, civilian employment opportunities, and technology. The interaction of all four must be considered to adequately fulfill force requirements.

2. Retention

In light of recruiting difficulties, retention becomes a key avenue to reduce the annual recruiting mission. If the military increases its retention of personnel, then the number which must be recruited declines. Further, the serviceman or woman that reenlists is more experienced than a new recruit and, though basic pay rises with additional years in the military, training costs are dramatically reduced (Binkin, 1988). Experienced personnel do not require the amount of training needed by new recruits. Not only do reenlistments reduce the direct costs of training, but indirect costs (the amount of time servicemen and women spend in the classroom as opposed to the field) are reduced as well. The retention equation becomes even more complex when one considers the fact that there are many personal factors impinging upon the experienced soldiers' decision to stay in the force. For example, the quality of life for the military family has become a major component in retention decisions. As noted by GEN Myer, "We [the Army] recruit soldiers, but retain families."[2]

Demographics aside, technological advances have affected the costs of retaining the military's most experienced personnel. In the U.S. the military may be on the cutting edge in the adoption of new technology, but most innovations are soon adopted by the civilian sector. Therefore, the skills for which the military trains its most able personnel are increasingly transferable to the civilian sector. This outflow to the civilian sector of skilled servicemen and women represents a tremendous cost with respect to training and experience and increases the costs of incentives such as reenlistment bonuses designed to retain the military's most skilled personnel.

Technological advances have also led to the increase of personnel in noncombat MOS. This serves to decrease the number of combat personnel and raises questions about combat effectiveness. Overall force structure plays a role in all this as well. While the number and proportion of active duty personnel are decreasing, the number of reserve personnel are increasing. Today, 50% of U.S. Army personnel are located in the reserves. We must, therefore, ask whether the active force has the correct mix of MOS to handle a range of combat situations from low intensity to high intensity. For example, 70% of the Army's maintenance capability is located in the reserves. Given this, are the active forces capable of handling the maintenance requirements of combat? Force structure, which is currently weighted toward the reserve forces, also raises the question of imparting high tech training to the reserves. Proportionately fewer active duty separates are enlisting in the reserves. In the past the enlistment of active duty separates in the reserves was the main way in which high-tech skills were imparted to the reserve forces. With this avenue for reserve recruits drying up, there is some concern that reserve forces do not have the requisite amount of training to handle the operation and repair of complex weapons systems in wartime. Consequently, there is some concern that current force structure may have led to reductions in combat effectiveness among both the active and reserve forces.

3. Social Processes and Unit Effectiveness

Cohesion, leadership and motivation are counted among the critical human determinants of effectiveness of the small fighting unit. Social scientists have not yet undertaken the

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[2]From a speech by GEN Edward C. Myer, 11 October 1980, Washington, D.C. to the Army Family Symposium.

task of exploring the impact of changing and advanced technology on these aspects of military organization. However, without a doubt technology will profoundly affect the "social processes" of the small fighting unit, and therefore, ultimately, unit effectiveness and performance.

In the future, military organizations will most likely find that they will need to determine if changing military technology will require changes in military leadership. The U.S. military establishment has spent many years and a great deal of resources trying to improve and train military leaders, as well as identify critical performance and characteristics of leaders. Leadership is recognized by the U.S. military establishment as a major causal variable in determining combat unit effectiveness and combat readiness. Will the military need smarter leaders if military technology becomes more difficult to operate and maintain? For example, signal MOS have become more technologically sophisticated over time. The commander of a signals unit is unlikely to be able to perform the job of each soldier under his command. The complexity and diversity of the field may also hamper the commander's ability to understand what each member of his unit does. Will changing technology mean a changing relationship between a leader and his troops? This is quite likely given that technology has enabled a soldier to be responsible for a larger combat zone. This means that the squad leader commands more dispersed troops (Zeidner and Drucker, 1988, p. 200). A significant consideration in the area of military leadership is that in most Western, allied nations, today's younger leaders have minimal or no combat experience. In 1986 the U.S. Army promoted to 06 (Colonel) its first combat arms commander without combat experience. In 1987 over 50% of 05's in the U.S. Army (Lieutenant Colonel) had no combat experience. Today that percentage is even higher. It is important to explore how the lack of combat experience among military leadership and changing technology interact, and the effect of this interaction on unit effectiveness.

Another significant issue to be faced by military organizations is whether or not technology (i.e., machinery, and especially advanced technology) changes relationships between servicemen. As yet this is an unexplored topic in military sociology and psychology, but an important one. Like leadership, social processes within the small military unit (small group cohesion, satisfaction, motivation, morale and unit and command climate) have been found to be a critical ingredient in soldier and unit effectiveness. Study after study (see for example, Shils and Janowitz, 1948; Stewart, 1988; Van Creveld, 1988) has shown that factors such as cohesion and bonding between soldiers are major forces in motivating soldiers to fight. Motivation also plays an important role. Does technology enhance soldier and unit relations, or does it drive a wedge between soldiers? Does sophisticated technology increase or decrease a soldier's confidence in his/her weapons and equipment? The issues are numerous. A beginning must be made in understanding how technology affects the human dimension and military processes. For example, interviews which were conducted with non-U.S. Army officers have revealed that in countries which have less money budgeted for high-tech military equipment and arms, soldiers have learned to be more resourceful and more flexible. They have learned to rely on their units and on each other.[3] Whatever the case, the impact of technology on social processes and unit effectiveness deserves careful study. In today's high-tech military, technology plays a large role in determining social processes and effectiveness within the unit.

4. Summary

This subsection provided a brief overview of the impact of technology on military manpower, focussing on recruitment, retention, and social processes which influence unit effectiveness (i.e., military leadership, relations between servicemen, and motivation). There is some concern that changes in technology have increased the military's need for high quality youth, just as all demographic and economic indicators suggest such youth are declining in number and as a percentage of all youth. Due to these declines, colleges and recruiters have stepped up their efforts to attract these high quality youth, leading to increased difficulties in military recruiting. With greater percentages of the military located in reserve as opposed to active duty units, there is some concern about whether the distribution of MOS is appropriate, and also whether reserve units have sufficient training to operate and maintain their weapons systems. A number of important research questions were raised regarding the impact of technology on military leadership, relationships between servicemen, and motivation. As noted by Van Creveld (1988), these human dimension issues are critical to combat performance. Simply using ever more sophisticated technology without regard to the motivation, cohesion, and leadership of troops is a tactic likely to fail, particularly in low intensity conflicts.

B. Training

Changing technology in the military organization will have profound implications for the structure and technology of training.

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[3] From interviews on "Determinants of Combat Unit Effectiveness" conducted with Foreign Military Liaison Officers, U.S. Army TRADOC Field Element and U.S. Army Materiel Command, June, 1989.

First and foremost, the nature of war today no longer necessarily follows a traditional scenario of two enemies facing each other across a front-line, using similar traditional and historically-based tactics to attempt to win a war. Today, warfare takes on many forms, from high intensity conflict, involving nuclear war, to low intensity conflict, the lowest of which is guerrilla warfare. Consequently, most military organizations must now train for a variety of combat scenarios, involving a range of technologies with varying degrees of complexity. This means that training for war now requires more planning, more resources, and greater diversification.

Second, in order to facilitate the performance of individuals across MOS, it must be determined whether higher levels of technology will demand greater knowledge and more sophisticated skills than are needed presently. Furthermore, the military will need to discover if additional training requirements will apply only to those who maintain the technology (combat service and combat service support troops), or to those who use the technology (e.g. combat troops) as well. Then, the organization must develop the appropriate training approach as well as the level of training, while taking into consideration the abilities of those being trained.

A third outcome of changing technology concerns types of training. The proportion of school-house (book or computer) training to on-the-job, field training will have to be aligned with the level of sophistication of the hardware. If the future for military organizations is high-tech, it is most likely that more and more training will be necessary. While the development of software training programs means that training need not be located in the school-house, it will, nonetheless, increase the amount of time spent in training and thereby reduce the amount of time spent in field exercises. Additionally, unit, or on-the-job, training is being increasingly infiltrated by computerization. According to Gorman (1988), "miniaturized... robotic tutors are now becoming available for individual training in units and will be commonplace in decades" (p. 6). Gorman indicates that the same will be true for unit collective training. Such events could well result in even greater distancing of the soldier from his buddy as well as the actual experience of combat field training. This has important ramifications for social processes within units, general unit effectiveness, transferability of skills, and basic combat skills. At this point the U.S. Army has more hours devoted to school-house training than do military organizations of other countries.[4]

Advanced technology may also affect the balance of individual to collective training in the field. Compared to other nations, the U.S. has a greater proportion of field time devoted to collective training at the higher unit level. Other countries spend more time on the small unit field training exercises and on individual training. Interviews conducted with foreign liaison officers who are assigned to the U.S. Army for a tour of duty have indicated that the extra time spent on individual and small unit training in the field has paid off in high levels of soldier motivation, unit cohesion, soldier skills, and soldier-leader relations. Of interest is whether or not the ratio of collective training to individual training is a consequence of the level of technology in a military unit.

A fourth consideration regards requirements for military trainers and educators. It is probable that the complexity of technology and warfare will be at such a level that programs to train the trainers will need to be revamped and reorganized to meet the needs of a state-of-the-art military technology. The military will also have to concern itself with the adequacy of the supply of trainers. The incorporation of increasingly complex technology may demand an ever growing supply of trainers for the military. Military establishments may find that they will be required to rely on the civilian sector for trainers. Should this be the case, the military will find it necessary to match civilian salaries in order to attract trainers with appropriate skills and knowledge levels.

Finally, the changes in technology and training mean that it will cost more for a military to train its members. In an era of shrinking defense budgets this is a critical consideration. In fact, money may ultimately be the deciding factor in just how far a nation's military organization can go technologically. The technology only has utility and value if used properly and appropriately. We may be able to buy the hardware, but if no one can use it or fix it, it is of no use to anyone. Therefore, a fundamental issue is the availability of resources to fund a military training program to match not only the technology but also the manpower.

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[4] From interviews on "Determinants of Combat Unit Effectiveness" with Foreign Military Liaison Officers posted in U.S. Army TRADOC Field Unit Element and U.S. Army Materiel Command, June 1989.

In summary, changing military technology will rely on changing the technology and structure of training. A technologically advanced military has implications for the diversification of combat and therefore the diversification of training, the methods of training, the computerization of training, skills and availability of trainers, and training budgets. According to Gorman (1988), traditionally, development and modification of training programs have followed advances in technology, often resulting in malfunctions and poor utilization of technology. In the future, if the technology is to have value, training must go hand-in-hand with the technology. The two must be synchronized. Ultimately, this means that policy makers will be required to make difficult budget decisions.

C. Human Factors

> ...[T]he next generation of U.S. weapons is sure to represent a major improvement in military capability. But whether the armed forces can achieve the full performance designed into their systems is an open question, whose answer depends largely on the extent to which military personnel will be up to the task of operating and maintaining the new weaponry (Binkin, 1986, p. 34).

"Human factors" refers to efforts to match man and machine. In light of the tremendous cost and complexity of modern military weapons, it is critical to insure that weapons systems are designed incorporating the skills of those service men and women who will be operating and repairing them. Without taking the projected demographics and educational qualifications of youth into account, weapons systems will not be fully utilized by operators, and may not be repaired quickly. Ultimately, this means combat effectiveness will suffer.

The lag time from inception to production of weapons systems is typically five to ten years. It is very important to include human factors considerations into the design phase. In an effort to reduce this production lag, new acquisition strategies such as the Non-Development Item (NDI) have speeded the production phase, but at the expense of human factors considerations. Engineers must be cognizant of the characteristics of servicemen and women available to operate and repair the weapons systems of the future. Among the characteristics to be considered are intelligence levels required, as well as "...manual dexterity, reaction times, stress tolerance, or the amount of training of the final users" (Van Gelder, 1972, p. 23). Other factors to be considered early in the design phase include: how and under what conditions the equipment will be used; the variability of skill levels of operations and maintenance personnel; and whether specific skills are required for operation and repair.

Demographic projections through 1995 suggest that the available pool of recruits will decline not only in number, but also in quality. Fewer high school graduates are projected to score in the upper AFQT test score categories. The AFQT is considered to be a measure of trainability, suggesting that military recruits will be less able to operate and repair increasingly complex weapons systems in the years ahead.

Two obvious solutions to the manpower shortage are for engineers to design equipment that requires fewer people to operate and repair, and that skill requirements be reduced. With respect to reductions in the number of personnel required, we know of no instance in which automation has led to reductions in the number of military personnel. While the Howitzer Improvement Program is pointed to as a human factors success since it reduced the number of gun crew staff from five to four, the resulting support staff increased from four to five. Hence the total staff size remains at nine, though the distribution of staff by MOS was altered. This seems to be a common result of advances in weapons systems.

With respect to personnel quality required for new weapons systems, the answer is mixed. A conversation with staff of the U.S. Army's MANPRINT (Manpower and Personnel Integration) program indicated that weapons systems are becoming simpler to operate due to technological advances combined with efforts to design equipment that matches the skills of its operators. Indeed, forthcoming advances in navigational systems are expected to significantly reduce entrance requirements and training for selected MOS. However, at the same time, skill requirements for maintenance functions are increasing and the number of personnel required in maintenance are also increasing. GEN DePuy comes to similar conclusions in his research. He notes that while combat operator jobs "...will not be much more difficult, and sometimes will be easier" as a result of technological advances, electronic maintenance will increase in difficulty (DePuy, 1986, p. 130). He further notes that "[b]y internalizing operator functions in electronic processors, complexity at the maintenance level has increased. The required number of maintainers and their required skill levels have increased well beyond the quantity and quality inventory" (DePuy, 1986, p. 135).

Do technological advances <u>necessarily</u> make new equipment more difficult to repair, if not operate? This is a central debate in the human factors area, with some arguing that personnel requirements will decline with "de-skilling," while others argue that higher level skills will continue to be required. Proponents of the de-skilling view believe manpower quality requirements can decline within the armed forces, as has occurred in some civilian occupations such as mining (Talley, 1989) and printing (Wallace and Kalleberg, 1982). They use civilian sector evidence to support the notion that de-skilling is a common result of technological advance. Witness the smart cash register that enables people who can't add, subtract, or calculate change to work as cashiers (Binkin, 1986, p. 37). Certainly the public has benefitted by the simplified operations of the ordinary 35mm camera. Relatively inexpensive models are now available that advance the film, automatically focus, adjust for light, set the flash, and rewind the film. However, most of those writing in this area believe that technological advances in the area of weapons have served to increase the complexity of weapons systems maintenance, though operations have sometimes become simpler.

In an effort to reduce the difficulty of maintaining high tech equipment, "black box" technology has proliferated. It enables those without high-tech skills or training to make simple substitutions of one box (e.g., a circuit board) for another, and therefore "repair" the system. The black boxes themselves, however, must still be repaired. Without skilled repairmen in the military services these boxes must be repaired via contract with the private sector and this means shipping them back to CONUS. Certainly this adds to logistical problems in wartime, not to mention cost. In anticipation of a shortage of highly trainable youth capable of mastering high-tech operations and repairs, the Army is ordering more weapons systems which contain this black box technology. However, these weapons are more expensive to procure and repair.

If it is the case that technological advances imply "de-skilling," then military entrance requirements can be eased, thereby reducing the acute problems foreseen in military recruiting. However, past history, as well as "the weight of the evidence," suggests that technological advances have not led to de-skilling to any significant degree (Binkin, 1986, p. 69). In fact, it is now the case that entry level requirements for various Army MOS have been increasing (DePuy, 1986, p. 123). Indeed, the current Director of the Army's Programs, Analysis, and Evaluation Directorate, MG Reno, noted that as the sophistication of equipment increases, the military will require a higher order of skills than those now required.[5]

III. PROPOSED RESEARCH APPROACH

In order to gain a better understanding of the impact of technology on the military, a research approach is proposed which consists of the building of a cross-national data base and the analyses of research questions regarding the relationship between advanced technology and the military organization.

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[5]From a speech by MG William H. Reno, 6 September 1989, Washington, DC, to the Second Federal Forecasters Conference.

The development of a cross-national data base would include information about technological, manpower, and training characteristics of each nation's military organization. The purpose for developing the database is two-fold: to provide descriptive statistics permitting cross-national comparisons and analyses of issues, and to aid in developing a definition of technology and a scale by which it can be measured.

Selected critical indicators can be used to build the cross-national data base and to develop national descriptive profiles. For example, data on MOS structures and distributions, can be used to describe the degree of differentiation of MOS within each military organization. Longitudinal and cross-sectional analysis of these data would help us to understand the extent to which technology has affected military occupational structures. Simple calculations of manpower distributions by MOS would yield the ratio of combat occupations to service and service support occupations. A description of the socio-demographic characteristics of service members, as well as military skill and ability test scores, can be employed to draw a picture of the nature of the military "workforce" across nations. Similarly, a description of the characteristics of the available "recruitable" pool of civilians would provide an indication of the level of skills and abilities available for military service. Descriptive analyses could examine the extent to which the military and civilian groups match, and the extent to which the MOS requirements match the characteristics of those in service and those available for recruitment. Among other variables which can be included in the data base are: the nature of initial enlistment (volunteer or conscript); characteristics of the reserve forces; propensity to reenlist (and the degree to which a military is a "career" or "citizen soldier" force); attrition rates; the size of military organizations; and the proportion of national budgets devoted to the armed forces. Data of this sort are useful in placing the issues under study into a national context and in controlling for differences in national characteristics.

The cross-national data base would also be a tool in helping to define technology and develop a method of measurement of technology. This is a complicated task with two major difficulties: 1) deciding upon ways to operationalize and measure technology; and 2) identifying and locating appropriate data to measure technology. Simply counting numbers and types of weapons in each country's military will not even begin to enlighten us on the multi-faceted subject of high technology. Technology could simply refer to machinery or sophisticated devices. Yet it could also be defined as tasks or techniques which affect the transformation of desired objects. Others, such as Hage and Aiken (1969), define technology as levels and types of knowledge. Perrow (1979) identifies dimensions of technology as the degree of variability, repetitiveness and predictability within the transformation process. He argues that the greater the level of variability and uncertainty in the transformation, the more complex the technology. Binkin (1986) uses concepts such as complexity, reliability, maintainability and availability to gauge the level of sophistication of military hardware. In some fashion, researchers will have to come to terms with the phenomenon of technology and make decisions regarding its definition and measurement.

The second portion of the research would go beyond simple descriptive profiles and would tackle complex research questions about technology and the military organization using the previously developed measures and scales of technology. We have identified the following as research questions:

1) First, the increased sophistication of weapons systems has exacerbated the recruiting problem by increasing the entry requirements for many MOS. An obvious solution to this problem is to reduce the military's demand for manpower, perhaps by cutting end-strength. The U.S. military will be making cuts, and some analysts forecast even steeper reductions in military manpower in the coming years. However, it is not clear that such cuts actually reduce the demand for high quality recruits (that segment of the youth population which is most difficult to recruit and retain). This question could be answered by examining the impact of recent end-strength reductions on the demand for skilled manpower. Using extant data, it would be significant for military decision makers to know if reductions in manpower have occurred in MOS with more stringent entry requirements equal to those MOS with less stringent requirements.

2) With force structure in the U.S. military increasingly weighted toward the reserve forces, it is important to assess the distribution of personnel by MOS in the active duty and reserve forces. There are some concerns that reserve forces may be lacking in maintenance capability with 70% of such personnel located in the reserves. An analysis of force structure, using readily available data, could address the adequacy of MOS distribution between active and reserve forces.

3) Due to budget constraints, active forces are declining in number while reserve forces are increasing. With fewer active duty separates entering the reserves, there are some doubts about the warfighting ability of the reserves, particularly their ability to operate and maintain high tech equipment. This issue is critical since reserve forces are increasingly likely to be called upon in time of war due to reductions in the size of the active duty forces. Using existing data on the reserve forces, this issue can be addressed by assessing the degree to which MOS with more stringent entrance and training requirements are filled by active duty separates versus recruits with no active duty experience.

4) It is likely that, in the event of war, conflict may well be of the low intensity type. We must consider whether our troops are getting sufficient training and field exercise in responding to low intensity conflict. One approach to this research question is to assess the percentage of training and field exercise involving small units as compared to training involving larger units.

5) There is a need to resolve the debate within the human factors area concerning de-skilling. As technological advances are made, are military occupations becoming simpler to perform, thereby requiring less training? This question can be answered by examining the amount of training required across a variety of MOS, both in the operations and maintenance fields. Also, interviews with those in these MOS would enable us to assess the soldiers' views on whether their jobs have become more difficult or easier.

6) The hypothesis could be advanced that as technology advances, unit cohesion decreases. Advanced technology leads to increases in MOS specialization. Increasing specialization means that jobs, job skills, and knowledge are not transferable from soldier to soldier. As MOS proliferate, and specialization increases, soldiers are less able to substitute for each other in garrison or in the field. Consequently, communication between soldiers, especially in situations of crisis, might be hampered, the ability of a soldier to rely on his buddy decreases, and ultimately decreasing unit effectiveness. The converse scenario could also be hypothesized -- that advanced technology might require more interaction between soldiers, more bonding, and greater effectiveness.

IV. CONCLUSION

The overview provided by this report clearly illustrates that as regards the impact of technology on the military, the questions are numerous and the answers are few. We know that changes in the civilian sector, whether economic or demographic, will result in a changing available, recruitable pool of young men and women. The number of youth which must be recruited is also dependent upon the retention ability of the armed forces. We know that weapon systems and military equipment are becoming more sophisticated, more computer-oriented, and sometimes more difficult to maintain and operate. Years of research has established that cohesion, motivation and leadership are critical human dimensions in a combat unit's ability to fight. Unfortunately, data on the merging of these trends and the interaction of technology with these dimensions is lacking. We also do not know if, in the future, the structure of the military will alter substantially, requiring increased numbers of

MOS in combat support and service support units to maintain and support technology, with a simultaneous decrease in actual combat units.

But, the most fundamental question we must ask is how far we will go with technology. To what extent will the U.S. military be transformed from labor-intensive to technology-intensive? Simply put, the answer is twofold. It depends on 1) what it takes to win wars and, 2) how much money we have. The list of research questions is long, and a prioritized agenda is necessary to begin the process to answer them.

To some degree, events have overtaken this last question. Drastic budget cuts proposed in a five-year plan as well as the rapidly changing events in Eastern Europe indicate that the Congress and military policy-makers will be required to make choices between the deescalation of production of major weapon systems (such as the B2-Stealth Bomber) and the shrinking of the active duty force. Some believe that the technology will go. For example, Retired Admiral Elmo R. Zumwalt Jr. told the Washington Post, "The coming money crunch may finally persuade the military to use cheaper and less-sophisticated weapons" (Wilson, 1989, p. A12). Other analysts predict both the size of the force and technology will be reduced: ". . .smaller, faster and more lethal [forces] will be back after decades of fascination with high-tech weaponry" (Wilson, 1989, p. A12). It is also assumed that with the reduction of the active force will come an increase in the reserve force. Armed forces of other industrialized Western nations, which have smaller portions of the national budget devoted to defense spending and therefore, have fewer and less advanced military technology, have learned to do without state-of-the-art weaponry and have compensated with cohesive, highly motivated and well trained fighting forces. This may be the future for the U.S. military. However, there is some concern that soldier training does not reflect the perception that future conflict is most likely to be low intensity. In short, technology does not necessarily give you the edge. Whatever the level and nature of military technology, it is only as good as its user. In view of this, research on technology and the military are a first priority.

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