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U.S. Army Research Institute  
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ANNUAL REPORT  
ON RESEARCH  
1979

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U.S. ARMY RESEARCH INSTITUTE for the  
BEHAVIORAL and SOCIAL SCIENCES  
5001 Eisenhower Avenue, Alexandria, Virginia 22304

**U. S. ARMY RESEARCH INSTITUTE  
FOR THE BEHAVIORAL AND SOCIAL SCIENCES**

A Field Operating Agency under the Jurisdiction of the  
Deputy Chief of Staff for Personnel

JOSEPH ZEIDNER  
Technical Director

FRANKLIN A. HART  
Colonel, US Army  
Commander

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Recognition is due to the research scientists of ARI and associated contractors who conducted the research summarized herein. Special appreciation is due to Dr. Arthur Drucker and Dr. Daniel Jones of ARI, Dr. Dean Havron of Human Sciences Research, Inc., and the many others who developed this report.

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## TABLE OF CONTENTS

	Page
Message from the Commander and Technical Director .....	1
ARI Organization .....	3
The Growth of Military Technology and People Research .....	5
ARI's Research Role .....	13
<b>Human Factors Research</b> .....	<b>17</b>
Command, Control and Communication (C <sup>3</sup> ) with Automated Battlefield Systems .....	19
Life Cycle Systems Management .....	22
Cost and Training Effectiveness Analysis .....	24
Operational Test and Evaluation .....	25
Training Effectiveness Analysis— XM-1 Tank OT II .....	25
XM-1 Training Devices .....	27
Tank Thermal Sight—M60 and XM-1 .....	29
Infantry and Cavalry Fighting Vehicles .....	30
Organizational Level Maintenance—Tanks .....	32
Remotely Monitored Sensors .....	33
<b>Education and Training</b> .....	<b>43</b>
Simulation and Training Effectiveness Planning Sources (STEPS) .....	45
TRAINVICE .....	46
Training in Rifle Marksmanship .....	47
Training Extension Courses .....	49
Research in Support of Army Aviation .....	51
Team Training .....	55
Embedded Training with TACFIRE .....	57
Tank Gunnery .....	60
Maintenance Performance Research .....	63
Unit Training: ARTEP .....	64
National Training Center .....	66
Unit Training Programs and Management Systems .....	68
<b>Personnel and Manpower</b> .....	<b>73</b>
Personnel Affordability .....	75

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## Table of Contents Continued

	Page
Recruiting . . . . .	76
Attrition and the Military Applicant Profile . . . . .	77
The Armed Services Vocational Aptitude Battery (ASVAB) . . . . .	79
TOW and Dragon Placement Models . . . . .	81
Armor Crew Placement . . . . .	82
Individual Training and Evaluation System . . . . .	83
Alienation . . . . .	85
Unit Cohesion . . . . .	85
Reenlistment . . . . .	87
ROTC Recruitment and Retention . . . . .	88
Realistic ROTC Training . . . . .	89
Army Reserve Retention . . . . .	91
<b>Simulation . . . . .</b>	<b>95</b>
Flight Simulators . . . . .	97
Engagement Simulation . . . . .	100
Command Staff Training and Performance . . . . .	104
<b>Summary . . . . .</b>	<b>109</b>

## MESSAGE FROM THE COMMANDER AND TECHNICAL DIRECTOR

The Army Research Institute for the Behavioral and Social Sciences (ARI) is the first research organization of its kind in the United States military system. (It was founded in May, 1919, and has been in continuous operation since March, 1939.) Its research program, having evolved over the years to a size which reflects our large and complex society, continues to have broad implications for the future of the Army and of military research development. Precisely because of this complexity, ARI's efforts have often been difficult for others to perceive and define.

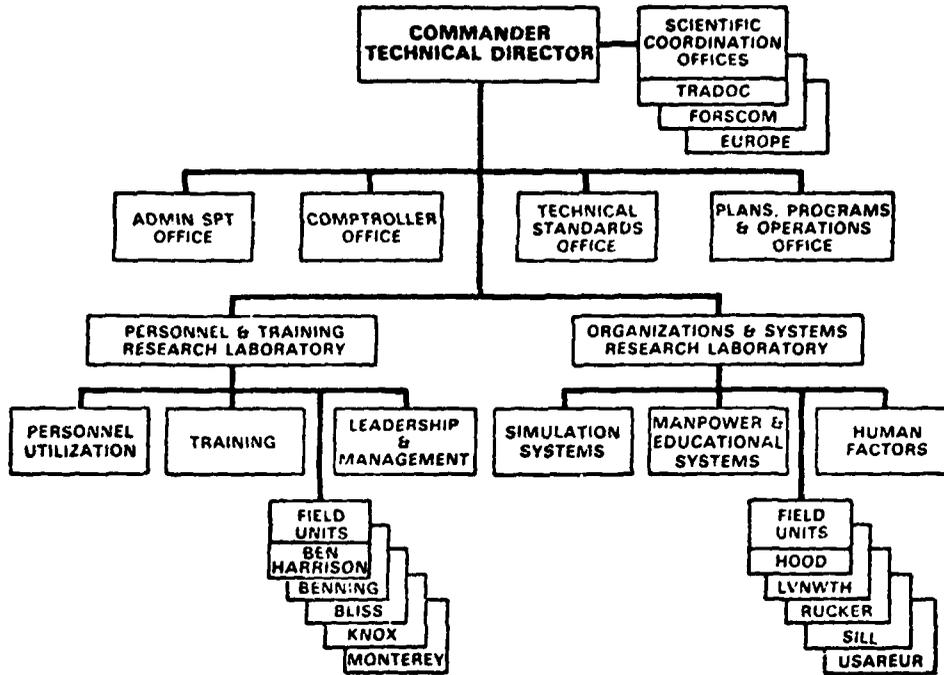
It is in response to this difficulty that the present document has been developed. It illustrates what ARI has been doing in recent times and where it is going in the future; it is ARI's first annual "Corporate Report." The body of the report describes some 40 research efforts, among 150 efforts extant during 1978-1979. These research efforts were selected to reflect the potential for application of "people-oriented" research findings to the Army's problems. The report also demonstrates the wide diversity of research under way at ARI. Some of the efforts described are in early exploratory stages, while the products of others have been extensively utilized by the Army. Four broad categories of research are covered—Human Factors, Personnel and Manpower, Education and Training, and Simulation.

The audiences for this document are many: R&D managers, scientists, other governmental agencies, and Army commanders and staff officers. We hope that it will be useful and informative to them all.

  
JOSEPH ZEIDNER  
Technical Director

  
FRANKLIN A. HART  
Colonel, U.S. Army  
Commander

# ARI ORGANIZATION



## THE GROWTH OF MILITARY TECHNOLOGY AND PEOPLE RESEARCH

Arma virumque cano.  
Of arms and men I sing.  
..... *Aeneid*

This 20th Century has seen more advances in military technology than have occurred during the twenty centuries since Virgil penned the opening lines of the *Aeneid*. World Wars I and II and the present situation provide benchmarks by which developments of increasingly sophisticated armaments can be described. Along with the accelerated pace of military technology, "people" research—human factors and military psychology research—has experienced rapid development. Consider, for a moment, the evolution of military technology and the parallel growth of supporting people research.

### **Military Technology**

Table 1 provides some examples of enormous advances in military technology. Several developments in military arms—armor, aviation, electronic warfare—had no counterparts prior to World War I.

### **Infantry**

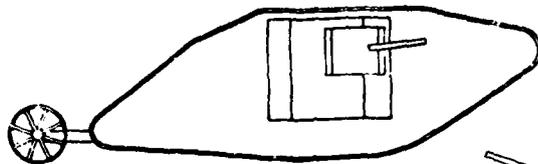
The infantryman in World War I was armed with the bolt-operated Springfield '03. By World War II, the semi-automatic Garand was issued. Currently, the lightweight M-16 provides, at the infantryman's option, single-shot or automatic fire at tremendously increased rates of fire.

### **Armor and Anti-Armor**

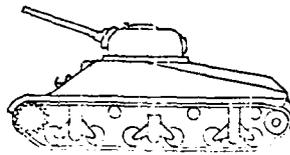
The tank was developed during World War I to break the trench warfare deadlock. Lightly-armored and geared to the speed of the foot soldier, tanks were essentially designed to support infantry operations. Between 1918 and 1940, great advances were made in development of armor. The World War II German breakthrough in France was

made possible by massed armor formations coordinated with close air support. Armies fought highly mobile tank battles in Africa, France, and Russia. Currently, the mobility and protective armor of tanks has increased still further, and the effective range of their main weapons has tripled.

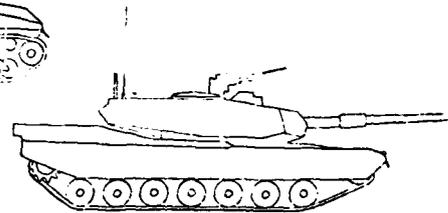
Anti-armor weapons were developed in response to the growing use of armor on the battlefield. In World War II, the infantryman's anti-armor bazooka had a range of some 100 to 150 yards. Today, wire-guided TOW missiles can hit a tank four times in five at a range of 3,000 meters. Recently, the TOW has been mounted on rotary wing aircraft. Unimpeded by ground obstacles, the helicopter provides mobility many times greater than that of the tank.



World War I



World War II



Current

### Artillery

World War I was fought primarily with artillery and infantry. The range and accuracy of artillery, as well as its throw-weight, was very limited by present standards. As shown in Table 1, the area that artillery can cover has more than tripled since World War II. Present developments promise laser-guided artillery whose accuracy is not dependent on the precise position of the muzzle when fired.

Table 1. ADVANCES IN MILITARY TECHNOLOGY

WEAPONS AND MILITARY CAPABILITIES	BENCHMARKS		
	WWI	WWII	CURRENT
<b>Weaponry</b>			
<b>Rifle</b>	Springfield M1903	Garand, M-1	M-16
● capability	bolt-action, 5rd clip	semi-automatic, 8rd clip	automatic, 650-850 rpm, up to 30rd clip
<b>Tank</b>	Renault	M-4	M-60; XM-1
● main gun calibre	37mm	75mm	105mm
● range for hit probability of .5	300m	500m	1,500m
● speed (cross country)	3 mph	15 mph	25 mph
● thickest armor	1 inch	3 inches	9 inches
<b>Infantry Anti-Tank</b>	none	Bazooka	TOW missile
● range		100m	3,000m
<b>Artillery (single gun)</b>	75mm	105mm	155mm
● area covered	200km <sup>2</sup>	400km <sup>2</sup>	2,700km <sup>2</sup>
● lethal burst area	500m <sup>2</sup>	2,700m <sup>2</sup>	7,500m <sup>2</sup>
<b>Dispersion</b>			
(Troop density/km of front)	6,000 troops/km	2,200 troops/km	500 troops/km
<b>Command, Control, Communications</b>	Radio (battalion and higher)	Improved radio (down to platoon)	Improved radio (down to squad)
	Messenger	Messenger	Secure voice and data links
	Wire	Wire/teletype	
	Pigeon		

## **Battlefield Dispersion**

More powerful weapons lead to greater battlefield dispersion. Between World War I and today, tactical troop dispersion has increased by a factor of ten, making improved means of troop command and control necessary. It also places special burdens on junior leaders who must be able to act effectively on their own, within broad mission purposes, but without specific orders from superiors.

## **Communications**

Military technology provides new means of troop control as well as the ability to interfere with the communications of enemy forces. In World War I, primitive radios were used, but the telephone, telegraph, and occasionally carrier pigeons provided the primary means of communications. Essentially the same field telephones were used during World War II, though radio was greatly improved. Today, by secure-pulsed data link electronic communications, condensed messages are rapidly dispatched in brief coded packages. Methods for locating communicators are automatically tied in with artillery target acquisition systems. Electronic measures and countermeasures are used to maintain communications security, to locate the enemy through his communications, and to confuse enemy efforts to direct his forces.

## **Some Impacts of Technology**

Such revolutionary developments in technology have compelling implications for modern warfare. The Arab-Israeli War of 1973 demonstrated that battles will be resolved much more rapidly. Should a major confrontation occur, the United States will not have the time for the year-long mobilization period afforded in World Wars I and II. Instant readiness is required.

Great advances in military hardware provide *potential* capabilities, potentials that can be realized only when men and women can be found and trained to operate, direct, and maintain the hardware. As the power and complexity of hardware increases, our ability to design equipment for compatibility and to train soldiers fully to exploit capabilities inherent in the hardware is increasingly challenged. It is ARI's mission to apply concepts and methods from social sciences and related disciplines so that the potentials inherent in military hardware can be fully realized. As General George Brown, formerly Chairman of the Joint Chiefs of Staff, said:

Fond as we are of totaling up divisions, missiles, aircraft and ships, this is not the full story . . . No weapon or system is more effective than the man who bears it or the crew which serves it.

### **People Research and Military Psychology**

During this century, people research has developed concurrently in four areas: personnel and manpower; education and training; human factors; and simulation.

#### **Personnel and Manpower**

The discipline that has come to be known as military psychology was first employed by the Army in World War I. The Army "Alpha" and "Beta" tests, which drew on the ability to measure individual differences, were used to screen volunteers and draftees. This work lapsed until 1939, when the Army established a Personnel Testing Section. This section established the Army General Classification Test (AGCT) which was administered to more than twelve million men. The same methods were used by the Army Air Corps to develop tests for the selection and classification of pilots, navigators, and bombardiers. Selection tests for pilots were used to avoid attrition in flight training.

The need for manpower and personnel research became increasingly evident following World War II. The Personnel Research Section of the Adjutant General's Office—the predecessor organization to ARI—was established in response to this need.

Since that time, research in personnel management has grown rapidly. Today, soldiers are selected and classified by a joint Armed Services Vocational Aptitude Battery. Personnel and manpower research is being applied in search for solutions to the many problems of an Army manned by volunteers—recruiting, personnel attrition, retention in the Regular Army, and like problems in the ROTC and Reserves. Today, manpower models are being developed to forecast the number of soldiers and their skills required to man some forty new weapon systems which will soon come into the Army inventory.

#### **Human Factors**

Military human factors research, or engineering psychology, began during World War II with research in synthetic tracking trainers, in Army field artillery, and in

the development of gunsights for the B-19. Many of the cornerstone concepts of human factors research originated in aviation. Displays and controls in many World War II aircraft were needlessly confusing, often causing accidents. These problems were addressed in the first human engineering studies, which applied principles of experimental design as conceptual guides. When the Air Force was established as a separate arm, this work continued in both fixed and rotary wing aircraft.

Soon after World War II, the scope of human factors research was expanded. It became evident that man and machine together must form a coherent system designed to accomplish assigned missions. Human factors analysis thus grew to consider systems factors and man/machine compatibility in complex systems. It also became evident that human factors analysis was needed early in system design to prevent expensive and time-consuming retrofits after hardware systems were developed.

Today, human factors analysis is being applied to virtually all on-line and developmental Army weapons and support systems. Further, because of increasing costs in weapons systems, cost- and training-effectiveness analysis is being applied early in system design to insure that training can be conducted at acceptable costs.

### **Education and Training**

Learning theory provides the conceptual base for research in education and training. While a few psychologists studied training during World War II, the application of military psychology for education and training is primarily a post-World War II development.

The increasing power and complexity of modern weapons place greater demands on research in education and training. Currently, extensive programs are being conducted in support of the Infantry, Armor, and Artillery branches. Research has expanded from individual and group classroom and field training—it now supports Army training managers who must maintain a high state of readiness while accommodating many other demands inherent in a peacetime Army.

### **Simulation and Simulators**

While the use of simulation to prepare for battle is centuries old, developments in the last two decades have given impetus to a much more extensive use of simulation.

This trend, supported by hardware technology such as microprocessors, computer-assisted instruction, and plasma displays, continues at a rapid pace today.

The greater lethality and sophistication of weapons systems come at a cost—costs of systems as well as costs of training soldiers to operate and maintain them. For example, firing a single wire-guided TOW anti-tank missile costs about \$4,000. Hence, simulators are being developed to train and help operators and commanders maintain their skills at acceptable costs. Mini-ranges successfully used to train riflemen and tank crews are examples.

Currently, ARI is engaged in the development and application of simulators for armor and helicopter aircraft. ARI is also supporting Army agencies in the development and use of simulators for training command and staff personnel at battalion, brigade, and division levels.

#### **A View of the Future**

The past is but prologue; developments of military technology continue at an accelerated pace. People research is being increasingly called on to support on-going developments and to help anticipate future problems.

Our problems of maintaining combat-ready military forces are compounded today by international tensions, by social changes in the United States, and changes in policies of maintaining military forces. Our once great superiority in military power at the end of World War II has been eroded. Today, United States and NATO units face the armies of the Warsaw Pact in Europe; we are outnumbered in certain critical classes of weapons, particularly in armor, interceptor aircraft, and artillery. Should conflict occur, we must rely on better-trained, more highly-motivated men to make up for our inferiority in numbers.

Future problems—in particular, problems related to acquisition of sufficient high-quality personnel—lie just over the horizon. The draft ended in 1973. Since that time, the services have had to compete with educational institutions, industry, and among themselves for young men and women who can effectively operate and maintain increasingly complex military hardware systems. But quality manpower is increasingly in short supply.

While our present status and future events will continue to be driven by advances in hardware technology, there is a growing need for concomitant people research

to assure that the potential inherent in military hardware is fully utilized in our national interests. The following descriptions of what ARI is doing today represent both a culmination of historical developments just described and an overview of research required to foresee and meet needs of the future.

## ARI'S RESEARCH ROLE

ARI brings concepts and methods from the behavioral and social sciences to bear on current Army problems and anticipated future problems. ARI efforts stem from a broad knowledge of Army policy and operations, as well as knowledge within specific subject matter areas, such as weaponry, tactics, personnel issues, and problems that confront Army training managers.

A crucial but easily overlooked role of ARI is to serve as an institutional memory and a repository of information. The ARI institutional memory provides ready access to past problems and to solutions that have been tried, and brings this knowledge to bear on current issues. An institutional memory serves in other ways as well. Solutions to problems, developed jointly by military personnel and scientists, often exhibit great imagination and insight; but because systems managers and training managers are rotated repeatedly, these insights are readily lost. Operations, however well planned by the designer, deteriorate. An institutional memory can help avoid this deterioration, keeping innovative solutions on track in current operations.

Knowledge of the Army and its operations is but one side of the coin. ARI scientists keep abreast of current developments in the social and behavioral sciences which promise needed solutions to problems. ARI encourages the development of needed concepts and methods through support of basic research by universities and contractors. Meanwhile, state-of-the-art developments in the social and behavioral sciences are being applied on a continuing basis to today's problems and to help make future problems manageable.

The four broad categories of research described earlier—human factors, education and training, personnel and manpower, and simulation—provide a convenient means of describing research. Each category promises many potential applications; but usually much greater power can be achieved by concurrent work in two or more of these areas. Thus, problems of training may be alleviated by better personnel selection and/or by human factors innovations that reduce the work load of operators or decision makers; or simulation may provide trainees needed practice in difficult tasks where practice cannot be readily provided by operational equipment because of constraints in costs, limitations in training areas, and so forth. Thus, much greater solution power is realized by considering these four categories as complementary areas for effort. The result is an approach which integrates the contributions from each area to provide more cost-effective manned systems. This is a continuous goal of ARI research.

ARI organizes its research into work units. Some 150 work units make up the

current ARI research program. Research described in pages to follow highlights some forty applications of behavioral sciences which are of broad interest in:

- Human Factors
- Education and Training
- Personnel and Manpower
- Simulation

Readers are encouraged to contact the ARI central office in Washington for further details on these applications and other work being accomplished.

**HUMAN FACTORS**

## HUMAN FACTORS RESEARCH

A prime objective of the Army is to field and operate combat weapons and major supporting systems. Human factors research supports attainment of this objective in many ways.

One way is to act as a developer and repository of information about the human element—man's capabilities and limitations as they apply to utilization of systems in fulfilling Army missions. This information is developed through the conduct of basic and exploratory research in perception, information processing, cognition, and motor behavior.

As new mission needs develop, the human factors repository can be tapped to determine the contribution of the human element to meeting mission needs. Known information is applied to determining functional requirements of hardware, doctrine, and organizations. Gaps in knowledge about human performance are identified, and research is designed and conducted to fill the gaps. The research may not be specific to a hardware system. Even if the research is system-specific, it may precede system development by several years.

During system design and development, human factors research contributes by considering the human element as an integral component of the total system as it evolves. Specific activities include job and task analysis; allocation of functions between people and hardware or software; and assistance in developing specifications for particular system components, controls and displays, operator stations, and operational procedures.

Considerations of human factors continue in recognition that evolving systems must be manned with capable and trained individuals. Products from prior human factors research serve as a basis for developing training programs, training devices, and personnel requirements.

As system development proceeds, human factors research assists in evaluation of prototype and alternative system configurations during acceptance tests and field tryouts. While development of a specific system continues, problems discovered may reveal gaps in knowledge that must be filled by new research efforts.

Human factors research continues as systems are fielded. Modifications in system hardware, doctrine, or operating and maintenance procedures occur frequently.

Such modifications often require human factors research to assure that systems fully maintain their operational capabilities.

ARI is actively involved in a variety of human factors research efforts. The examples which follow represent a sample of ARI contributions to definition, development, and operation of Army systems. Additional examples of human factors research efforts conducted by ARI are presented in Table 2, pages 37-39.

## COMMAND, CONTROL, AND COMMUNICATION (C<sup>3</sup>) WITH AUTOMATED BATTLEFIELD SYSTEMS

### The Problems

Several factors have a dramatic impact on the functions of command, control, and communications:

- Modern weapons systems and requirements for their employment place increased demands on the command, control, and communication functions. The lethality, range, and mobility of new weapons systems result in less time for control and much greater dispersion of maneuver elements than before. Because of the greater dispersion, the commander sees very little of the actual battlefield. His battlefield is represented by maps, charts, boundaries, and symbols.
- Many new systems developments in intelligence, electronic warfare, and tactical operations have increased the volume of information available to the command staff.
- Complexities of modern battlefield resources—electronic countermeasures, artillery fire support, intelligence, and air support, and their automated systems—create new opportunities and problems in communication and control.

These factors have led to the increasing use of battlefield automated systems. Over 70 separate automated systems are currently in the concept-definition, development, or production phase. Three research areas directly related to the effective use of battlefield automated systems are information management, man-computer interactions, and information display.

### Battlefield Information Management

The advent of tactical data systems provides the commander's staff with much information that was not feasible to collect and maintain in the past. Today, the volume of information can overload the commander and his staff. To enhance their performance in an information-rich tactical environment, procedures must be developed to help them choose the most relevant information from that which is available and to analyze the information once they have obtained it from the tactical data system.

ARI's role in this process has been 1) to develop procedures for information control based on current research; 2) to identify gaps in technology and between the functional requirements of the data system and the capabilities of the people who are to use/operate it. Several questions have been addressed:

- What functions must the commander/staff perform?
- What information is typically used?
- How is the information used?
- How must information be gathered, stored, processed, and manipulated so it can be used effectively?

In a developmental research effort, ARI is applying basic psychological theory on information processing and decision making to command and staff tactical information concerns. The role of simulation will be investigated to develop and evaluate the



most cost-effective procedures for commander/staff information gathering, processing, and analysis. Results will be used to further develop improved command and control doctrine, organization, and operating procedures. The research results will also establish the functional requirements of automated tactical operations and data systems. These requirements will serve as primary input to system developers.

### **Man-Computer Interactions**

Many of the current and projected systems for tactical or administrative information functions are computer-based. Current observations show that the inability of system operators and users to interact effectively with many of the current automated systems has severely compromised their total effectiveness. Data entry rates are low, and the incidence of errors is high. Information coming from the system is often arranged so that it cannot be used effectively.

Several research projects are being conducted by ARI to address these problems, using the Tactical Operations System (TOS) as a vehicle for investigation. Categories of errors in entering and retrieving data from TOS and their probable causes have been developed. ARI has also identified different ways of detecting and correcting the errors. Remediating some of the errors requires a substantial investment in developing/changing the system, and ARI is currently investigating a procedure that will provide a means of assessing the relative cost-effectiveness of using different error reduction techniques. Much of this information is directly transferable to system designers to aid them in selecting design and operating procedures as well as the characteristics of tactical computers that will best match the needs of users and the characteristics of the systems.

### **Information Presentation**

From the battalion level up through division, information about the battle and its progress is symbolic. Information about terrain and friendly and enemy location must be inferred from maps or other displays that the commander's staff has available. When determining the best way of displaying information about the battlefield and its occupants to the commander, several problems need to be resolved. What information is needed to best represent the terrain? How do the information needs for display change as echelons of command progress from battalion to division? In each case, what is the best way of displaying the information so that it can be accurately understood and used in command decision making? ARI research is providing answers to such questions.

One critical element of a commander's information set is maps. Inferences about what the terrain is really like and what it offers for maneuver, defense, cover, and concealment must be made from the maps available. ARI is developing experiments to evaluate different map formats. One area of special interest is to determine the best way of presenting topographic and vegetation information. Present findings indicate that a combination of color tints and topographic contour lines can increase the speed and accuracy of reading and interpreting maps.

Parallel to this research is the development of adequate measures of map-reading ability. These measures will help to better evaluate experimental map formats and computer map graphics as they are developed, while providing a universal map reading proficiency test.

Other recently completed research has indicated that use of color coding for map symbology versus the traditional shape coding can cut interpreting time by 30 percent, while reducing errors by a factor of 3-8. Another study has investigated the amount of map segment-to-segment overlap required when presenting staffs with partial view segments of a large operations area during tactical planning. Results have provided the best combination of processing time and planning performance.

### **C<sup>3</sup> - Summary**

Cumulatively, these research results provide information needed by agencies responsible for identifying and developing the functional requirements of information systems. While not related to a specific hardware development project, this information can be invaluable in determining functional requirements for the development of new automated tactical data processing systems. The information can be most useful in the earliest stages of system concept development, where it can have the most cost-effective impact.

## **LIFE CYCLE SYSTEMS MANAGEMENT**

Since 1975, the Army has adopted and been using the Life Cycle Systems Management Model (LCSMM) to guide major weapons systems development and acquisition.

Systems development and acquisition is a long and detailed process. Within the LCSMM, there are four distinct phases:

- The conceptual phase establishes one or more concepts of the weapons system and what it is supposed to do. Experimental hardware may or may not be available for study.
- The validation phase verifies design engineering, and prepares advanced prototypes. Operational Test I (OT-I) is conducted on prototype equipment.
- The full-scale development phase develops and field tests a representative system, including all support items. Actual troops are used for testing during OT-II.
- The production and deployment phase establishes the support system, trains the units and deploys the hardware system to the field.

The LCSMM describes the materiel acquisition process in terms of the four phases of materiel development, the steps to be accomplished within each stage, and agencies that must coordinate to accomplish the steps. The objective is to provide a framework for coordination and correlation of combat developments, research and development, logistic support, and training and personnel requirements during the four phases of system development.

Within the LCSMM framework and objectives, it is imperative that personnel, training, logistics, and human factors considerations influence the development and acquisition of materiel and weapons systems. The importance of LCSMM is underscored when the following factors are considered.

- Personnel costs account for more than 50 percent of the costs of an operational system.
- Operational costs of a system's "life" are 4 to 7 times that of development.
- Decisions that account for 70-80 percent of a system's life cycle costs are made *before* the first Operational Test (OT-I).

These factors demand that decisions about people in Army weapons systems—who they will be, where they will come from, how they will be trained—be made

early in the process. Further, these decisions must be good ones, if an acceptable balance between weapons systems cost and capability is to be achieved.

### **COST AND TRAINING EFFECTIVENESS ANALYSIS**

A sound method for conducting Cost and Training Effectiveness Analyses (CTEAs) is needed to produce valid training system inputs to Cost and Operational Effectiveness Analyses done prior to and during OT-I, and in subsequent phases. This method must explicitly link decisions about training programs to the aspects of training systems, where costs can be determined. ARI's Fort Bliss Field Unit has been heavily involved in producing and refining CTEA methodology and guidelines.

To develop the CTEA methods, ARI scientists must determine what tasks system operators and crew members are to do, what factors are critical to training in each task, what alternative methods could be used, how much time training would take, and what it would cost. Determining what is critical to each training task and what method works best for learning approaches the limits of what behavioral scientists know about the area—linking infinitely variable behaviors with estimates of costs.

In their early efforts, ARI scientists used the Missile Minder Control Van as the test system to develop the training methodology. They used available task analysis information, which indicated learning requirements, and referenced these requirements against different training concepts. Estimates of which training concepts could work best were made based on ARI background and experience. These decisions were applied to an alternative training program for crew members' jobs in the Missile Minder, and were processed through a Navy-developed instructional cost program. The results indicated that the CTEA methodology was potentially more cost-effective.

Follow-on projects by ARI-sponsored contractors have expanded the CTEA method and suggested where CTEA could best be integrated with the LCSMM. This methodology is far from complete. Each revision advances the state-of-the-art knowledge about predicting transfer-of-training to the operational environment. The potential of this method has been recognized by TRADOC agencies as playing a key role in formulating their guidance and regulations. As ARI research continues to refine and improve the method, the quality of CTEAs conducted in the weapons systems development process should also improve.

## OPERATIONAL TEST AND EVALUATION

Operational tests are major events in the validation (OT-I) and full-scale development (OT-II) phases of the LCSMM. In each, test results directly influence the decision to proceed further in the process, and show what modifications are needed in the major weapons system and its supporting subsystems—personnel, training, logistics, and maintenance—for the total system to reach its planned capability.

Human factors objectives in operational testing are to identify “people problems” in the total system. Assistance is also rendered by planning and conducting tests of issues identified by the system proponent or developer, such as training program effectiveness and personnel concerns.

Unfortunately, by the time a system reaches operational testing, wide latitude for changing the system has been reduced. If human factors has not had adequate involvement in system definition and design, problems may be discovered during operational testing that could have been easily avoided. Identification of such problems may require the system to be “backtracked” to correct the problems, at considerable expense and loss of time. This was the case for the XM-1 and the IFV/CFV development. ARI contributions to operational testing are described later for several systems.

ARI is supporting development of a guidelines manual to be used for evaluating human resources considerations in systems test and evaluation. When implemented, manual guidelines can help materiel developers to identify “people problems” earlier, before system designs and operating procedures become frozen and more costly to change.

### TRAINING EFFECTIVENESS ANALYSIS—XM-1 TANK OT-II

The Army’s inattention to the formal evaluation of its training programs, originally identified during a DoD-wide survey of such programs in 1976, was again highlighted by the Army Training Study (ARTS) group in 1978. The ARTS group found that the requirement was not clearly defined, that when it was defined there was insufficient guidance available, and that this guidance was not uniform from place to place. This was true not only for new training programs for developing weapons systems, but also for modified training in established weapons systems.



ARI was requested to develop a methodology for training effectiveness analysis that would apply across a broad spectrum of weapons systems and existing training programs. The XM-1 tank system and its training program to transition crew members from the current M60 tanks were chosen as the test bed for development and validation of materials.

A problem recognized very early was that the typical training effectiveness analyst in the service school was not sophisticated in either educational technology or operations research/systems analysis. This individual must, however, advise the training developer, plan the analysis, develop appropriate data collection forms and checklists, train data collectors, oversee data collection, analyze the data, identify performance deficiencies, and assist the training developer in modifying the training materials. Therefore, guidance materials must be written for an "unsophisticated" user and can make few assumptions about specialized backgrounds.

Existing guidance materials were tried during OT-II and were found to be inadequate. Lessons learned from that experience, along with materials and ideas from

civilian program evaluation kits, will form the basis for materiel development for OT-III. The OT-III experience will culminate in an analyst's job aid—a "how-to" manual. The manual will be written in sufficiently general language so that it can be adopted by non-Armor system analysts.

After being checked out on several diverse weapon systems, the manual and its associated job aid will enable those assigned analyst duties at TRADOC schools to plan for and conduct analyses without specialized skills or training.

### **XM-1 TRAINING DEVICES**

As the XM-1 nears final operational testing, engineering development is proceeding rapidly on several training simulators that will help to reduce the costs associated with training on operational equipment. The major training devices include:

- A Turret Organizational Maintenance Trainer, providing turret mechanics with training on trouble-shooting and repair procedures.
- A Driver Trainer and a Conduct-of-Fire Trainer, providing armor crewmen with training on normal and emergency tank operating procedures for driving and gunnery in the entry-level Basic Armor Training program.
- A Unit Conduct-of-Fire Trainer, providing the tank commander and gunner team with training on advanced gunnery procedures in the duty-station unit gunnery program.

The Armor School's Directorate of Training Developments established requirements for the XM-1 devices, and the Army Project Manager for Training Devices (PM-TRADE) is managing their development. Operational tests of the devices will be conducted by the Armor and Engineering Board. ARI is providing technical and advisory assistance to these agencies as needed during this development process.

ARI scientists have helped to define the functional capabilities required in the devices. ARI has performed a number of evaluations of gunnery devices and prototype trainers that have had a substantial impact on the XM-1 training device requirements.

ARI has helped to define the issues to be addressed and the evaluation concepts to be used in developing plans for testing the devices before they go into full-scale production. The tests must be designed to measure how well the devices train soldiers, and what modifications need to be made to make the devices train better.



## **XM-1 TRAINING SIMULATORS**



ARI is also helping to refine information on the training tasks to be performed in the simulators. This training information is part of the input to the contractors developing the devices. Detailed specific task information is important. Without it, contractors cannot build trainers that teach correct operation and maintenance procedures. By participating in design reviews of the contractor's work along with the other responsible agencies, ARI is helping to ensure that the devices will meet the requirements desired by the Armor Center.

Because of the importance of these training simulators to full-scale deployment of the XM-1, ARI will be incorporating the investigation and evaluation of the

training devices into their normal work plan. As the devices are developed, the training objectives to be met by each device will be defined, so they can be smoothly fit into the total XM-1 training program. ARI will provide detailed plans for the special training programs to be tried out in the operational tests of the devices. ARI will continue to review test plans and test results with the Armor Center to ensure that maximum training potential is extracted from each simulator.

ARI's continued and expanding involvement in the XM-1 training simulators will contribute to a continuing program of research on training simulation. This research will provide data needed for further improvement of training based on current simulators while helping to define additional requirements for simulators, such as crew or platoon trainers.

### **TANK THERMAL SIGHT—M60 AND XM-1**

In concentrating on the development of a particular weapons system, it is easy to forget that smoke and dust often obscure targets, and that systems must be designed for 24-hour operations. A recent development for armor systems, specifically the M60 series and XM-1 tanks, is the Tank Thermal Sight. The thermal sight cues on the temperature contrast between a target and its surroundings, and enables gunners to "see" through smoke, camouflage, weather, and darkness. As an adjunct to optical sights, the thermal sight can offer a significant improvement in finding and firing on enemy armor targets.

ARI was requested to review the M60A3 tank thermal sight during its operational testing. Their findings indicated that:

- Location of a manual turret traverse in the tank was potentially hazardous to crew members.
- Returning to boresight position was difficult because boresight control knob settings were difficult or impossible to read.
- Providing a glare shield on the sight would make it easier to use in sunlight.

- Brow pads for stabilizing the gunner's head should be installed to improve speed and accuracy in aiming, especially on the move.

Three of these findings have direct implications for speed and accuracy in sighting on the target, and, therefore, for system performance. They were given as recommendations for design changes to the development contractor. Using knowledge gained from M60A3 thermal sight development, ARI is continuing research to optimize the performance of armor gunners using the XM-1 thermal sight. Two specific areas being investigated are the development of methods so that gunners can quickly discriminate between friendly and enemy vehicles, and the designing of the best way to train gunners to shoot on the move.

## INFANTRY AND CAVALRY FIGHTING VEHICLES

### Background

The tank is now, and will be for the foreseeable future, *the* offensive weapon in mounted warfare. However, anti-tank missiles have about twice the lethal range of tank main guns. Therefore, the tank needs the protection of mechanized infantry to clear mines, to neutralize enemy anti-tank positions, and to help destroy enemy tanks and dismounted infantry. Today's generation of tanks has far more speed and mobility than the Armored Personnel Carrier, the replacement for which is the Infantry/Cavalry Fighting Vehicle (IFV/CFV).

### ARI and Fighting Vehicle Development

The IFV has a long developmental history. It was earlier known as the MICV (Mechanized Infantry Combat Vehicle). During early MICV development, support for human factors involvement was reduced to save costs.

Initially, ARI conducted an analysis to determine whether one or two men were required to operate the array of weapons proposed for the vehicle. As a result, ARI—Fort Knox recommended the two-man turret over the one-man turret that was the then-current design.



Because of deficiencies discovered during MICV's first operational test, a DA-level MICV task force was formed. ARI-Fort Benning was tasked to study the complexity of the MICV weapons system and operator performance to make a recommendation for one- or two-man turrets from a crew system performance perspective. ARI-Fort Benning used the initial study and further analyses to recommend a two-man turret. The recommendation was adopted for both the IFV and CFV. Subsequently, full human factors support was brought back into the continuing design/development of the fighting vehicle systems.

At the request of the Operational Test/Evaluation Agency (OTEA), ARI assisted in the human factors portion of the MICV OT-II. Field observations, questionnaire results, and soldier interviews pointed to several remaining design deficiencies:

- Infantry squad members had difficulty entering and leaving the vehicle.
- Command and control of troops dismounted from the vehicle was very difficult.
- Weapons systems controls and displays in the turret were confusing, and hampered effective use of the weapons.

ARI is continuing to participate by supporting OTEA in human factors, personnel selection, and training issues for operational testing.

### **IFV/CFV-Related Research**

ARI is addressing IFV/CFV training and personnel issues. One research area is training device requirements. The Army needed to know whether training devices would be required to train IFV/CFV crew members, and, if so, what characteristics the devices should have. To answer this question, the state-of-the-art methods for determining training device requirements had to be upgraded. Specific task data and specifications for training devices have been provided to the agencies responsible for developing the IFV/CFV training devices. The task data will also be used by the Infantry School to develop IFV/CFV training programs and documents. The method used for determining training device requirements will be described in a general handbook to be distributed to personnel in TRADOC schools.

ARI contractors have studied the manning of the IFV/CFV. Using task analysis data, they determined personnel qualifications needed in crew members. A model was developed to determine the availability of personnel in the manpower pool with the required aptitudes and abilities.

### **ORGANIZATIONAL LEVEL MAINTENANCE—TANKS**

Once the "iron is bent" in hardware development, it is difficult to make design changes. Yet there continues to be a need for evaluation and analysis of the system, to spot and to correct, when possible, problems that the system may encounter during its operational life. System maintenance is an area where problems do arise. Proper attention to maintenance problems can increase the time equipment is operated and extend its effective lifetime.

ARI Field Unit at Fort Hood, Texas, participated in a larger study called the Baseline Armor Reliability Test. Mechanics were interviewed to find possible problem areas in maintaining M48 and M60 tanks, with the following results:

- Because of design, several parts of the tanks were difficult to

service or repair, hard to reach, and often ignored by crews, resulting later in mechanical failure.

- Tool supply policies and procedures delayed repairs, because mechanics were spending much of their time borrowing tools.
- Technical repair manuals ranged from nonexistent to adequate.
- Procedures of reporting equipment problems and deciding where (field or shop) problems should be fixed resulted in inefficient maintenance system operations.

This study has resulted in an expanding ARI effort that is investigating maintenance procedures and training programs on a wide scale. This effort is described fully in the Education and Training section.

## REMOTELY MONITORED SENSORS

### Background

Occasionally, human factors experts have the opportunity for continuous input in the development, fielding, and refinements of an operational system. ARI's work in the area of Remotely Monitored Sensor systems is an example of such input. Several years of ARI research on these sensors has significantly and positively influenced the hardware, doctrine, and training in Army systems, and has provided similar aid to non-Army organizations, such as the State Department and the U.S. Customs Service. ARI's efforts were clustered in three major areas: investigating hardware; developing operator training methods; and providing information for doctrine for effective deployment and use of sensor systems

Unattended sensors, placed along roads and in areas hostile forces may occupy, are linked to a central collection-display unit that can provide early warning and target acquisition information. Such systems were developed and implemented in Southeast Asia with varying amounts of success. At present, the need is world-wide, particularly in Europe, where early warning of opposing force movement can provide a significant battlefield advantage.

## **Seismic and Acoustic Sensors**

Two types of sensors currently used are seismic sensors, which respond to ground movements, and acoustic sensors, which pick up and transmit sounds of vehicle and troop movement.

ARI evaluated two different sensing concepts using the acoustic sensor. In one concept, the sensor transmitted continuously for a specified time after being activated. In the other, the sensor transmitted "on" and "off" in four-second cycles. Operators were able to better identify numbers and types of vehicles when the sensors transmitted in an "on" and "off" mode. Thus, power requirements were reduced and battery life was extended.

Studies with seismic sensors investigated means of displaying sensed activity to the system operators. The current display, a pen on paper plotter, was compared to a "situation map" with lights on the map indicating sensor location. Experimental findings showed the present plotter to be as good or better than the costlier situation maps.

The number of sensors to display on a monitoring unit was also investigated. Operator performance data were collected for different numbers of sensors connected to the display. Results were used in making design specifications for the monitor displays.

## **Training**

ARI has improved existing sensor systems by developing training materials and operator aids. It was found that operator errors in target detection and identification and estimations of speed were reducing the usefulness and reliability of sensor-gathered information as intelligence. ARI developed programmed texts for two major sensor arrangements and a tape training aid to help operators estimate speed and numbers of targets. Operator performance was considerably improved by both texts and job aids.

Both the programmed texts and the job aids were used by the Army Intelligence Center/School.

## **Doctrine**

The Southeast Asian environment used remote sensors in a line or string

arrangement. Newer applications for sensors required them to cover/monitor area activity in depth.

ARI conducted the necessary research to determine the best spacing and display of sensors in the newer grid arrangement. Since the operator is the key link in the system, measures of his performance were used to determine the best spacing in the grid. Because operating a "grid" of sensors is a new concept, ARI also developed self-paced instruction to train operators how to detect targets in the grid setup. From these studies, ARI made recommendations to interested agencies as inputs to doctrine.

As another part of its efforts, ARI conducted a study to determine the best on-duty/off-duty cycles for operators. Reports of unreliable data had been traced to operator fatigue. Field experiments indicated that two hours on and 15 minutes to one hour off provided better performance than longer work periods. These results were used to assist in determining operating procedures of sensor field units.

As new problems develop and refinements are required, ARI will continue to conduct research on remote sensor systems.

**Table 2. ADDITIONAL ARI EFFORT IN HUMAN FACTORS**

<b>Weapon System</b>	<b>Location of Work</b>	<b>Sponsor</b>	<b>Research</b>
Remotely Piloted Vehicle (RPV)	Fort Sill	RPV TRADOC	Selection techniques for personnel as sensor station operators via simulation of the sensing task. Correlation of ASVAB scores draws on basic research on ability to sustain attention.
25mm Gun Bushmaster	Fort Knox	Operational Test & Evaluation Agency (OTEA)	Human factors requirements in firing main gun. Recommendations for increasing training effectiveness.
Firefinder	Fort Benning	PM TRADE & Field Artillery School	Development of training device for Firefinder radar system. Inputs to design decisions development, implementation of new effectiveness testing concepts.
Improved TOW Vehicle	Fort Benning	OTEA	Human engineering of vehicle data to be used for training program for operators.
Antitank Guided Missiles (ATGM)	Fort Benning	Infantry School	Development/examination of selection models. Specification of content of training programs. Participation in field tests, gunner selection procedures, skill maintenance using training aids, devices, and live missiles.
AN/TSQ-73 Missile Minder	Fort Bliss	Air Defense School	Determination of operator capabilities and limitations of operator work loads. Relationships between operator actions and system performance.

Weapon System	Location of Work	Sponsor	Research
STINGER	Fort Bliss	Air Defense School	Identification of tasks and inferring skill requirements. Examination of feasibility of development of inexpensive training facilities.
ROLAND	Fort Bliss	Air Defense School	Job task analysis. Comparative tryout of two approaches—conventional and decision aid—to analysis of tasks.
Division Air Defense (DIVAD) Gun	Fort Bliss	Air Defense School	Personnel requirements for manning DIVAD. Development of tests for selection of gunners.
PATRIOT	Fort Bliss	Air Defense School	Conduct of human factors evaluation. Conduct observations, interviews. Evaluation of operator capabilities. Development of training scenarios. Scaled and accurate measurement of operator performance. Firing doctrine, training aids, plans.
Tactical Operations System (TOS)	Fort Leavenworth	Combined Arms Combat Development Activity	Determination of staff operations in an automated information environment. Development of general functional requirements of automated tactical data systems.
Electronic Warfare	Fort Hood	TRADOC Combined Arms Test Activity	Perform human tactics evaluations of equipment and operations.

<b>Weapon System</b>	<b>Location of Work</b>	<b>Sponsor</b>	<b>Research</b>
Night Operations	Fort Leavenworth	Combined Arms Combat Development	Investigation of performance capabilities and limits of soldiers during night operations. Develop considerations for doctrine operational procedures, evaluation of units during night operations.

**EDUCATION AND TRAINING**

## EDUCATION AND TRAINING

The task of education and training in the Army is enormous and never-ending. In scope, it includes all Active Army, Reserve, and National Guard units and the ROTC. Personnel in all ranks must be trained and their knowledges and skills maintained in preparation for "come as you are" conflicts which, should they occur, would allow little time for regrouping or mobilization.

The challenges of education and training grow as weapons systems become more complex to operate and maintain, and as tactics for their employment continue to evolve. A key problem is to train relatively low aptitude individuals so they can satisfactorily operate and maintain these weapons systems.

To help meet these challenges, the Army has developed a performance-based training philosophy. The implementation of this philosophy requires extensive revisions of traditional training methods and procedures.

Education and training involves a partnership between Army personnel who plan, manage, and conduct training, and social scientists who provide research support. ARI scientists bring to this partnership a variety of concepts and techniques. Basic to all research is application of theories of learning and motivation. Job-task analyses, often available from human factors applications during system development, provide a starting point. From these definitions of tasks/functions to be performed, scientists develop measures of training effectiveness. These measures, such as criterion-referenced tests, are applied to evaluate and improve alternative training methods, programs, and curricula. A growing area involves full exploitation of advanced training technology—computer-assisted instruction, microprocessors, etc.—in development of training programs that are better standardized and more manageable. Throughout, emphasis is on making training relevant, interesting to trainees, and efficient.

Research also helps training managers to plan and organize individual programs into curricula and training systems so as to best utilize the time of trainees and instructors and available facilities. Thus, scientists design and evaluate new instructional methods required by changing force structures, recruit populations, and advances in technology.

## **SIMULATION AND TRAINING EFFECTIVENESS PLANNING SOURCES (STEPS)**

Overall management of training subsystem development in the LCSMM is usually the responsibility of the TRADOC Systems Manager (TSM). Existing regulations and system management documentation are not complete enough to provide training development managers with the information they need in order to make inputs into the training development process.

ARI is developing a concept and guidance handbook for training systems managers at TRADOC headquarters and in Army schools that will provide training subsystem developers (primarily TSMs) with information sources and procedures that are required for effective training development within the LCSMM. This handbook is called STEPS (Simulation and Training Effectiveness Planning Sources).

The current ARI effort takes each event in the LCSMM that requires training-related input and identifies the information or data the Training Systems Manager needs, where to find it, how to evaluate the information, and how to provide the information to hardware developers so that they can use it to make hardware systems design decisions. These procedures have resulted in a first iteration handbook for Training Systems Managers.

Three primary findings of this effort are:

- Many information sources need to be gathered and consolidated for each event.
- Much of the information required takes time and money to collect.
- There are many gaps between the information required for LCSMM decisions and the information available.

The implications of these findings for actions are being developed in the second iteration by field testing the handbook with its projected users, and identifying more sources of information to fill remaining gaps. An important benefit of this project is the identification of information gaps that still need to be filled. The STEPS project, together with other ARI and Army programs, will then develop methods to fill these information needs.

## TRAINVICE

Because operation of military hardware is so expensive, training devices are being increasingly used as an alternative. Training devices may also be designed to train better than can be done with operational equipment. However, training devices themselves are becoming more expensive, and their cost may exceed the initial cost of an equivalent piece of operational equipment

In achieving desired levels of training effectiveness, the need to proceed with timely training device development, the cost of the devices, and unforeseen design changes of operational weapons systems make it difficult to arrive at cost-effective choices about training devices in a timely manner. ARI is involved in a continuing research effort to develop methods whereby the effectiveness of training devices can be assessed without building them. One such method is called TRAINVICE.

To use TRAINVICE, one must first consider who is to be trained, what their tasks will be, and how the training will be done. To develop TRAINVICE, ARI and contract scientists reviewed all appropriate material related to the prediction of training device effectiveness. The resulting model was tested in two different field experiments using tank gunnery training devices. In each experiment, information about the training devices was used in the model to predict their effectiveness. The predictions were then compared to outcomes as obtained in actual use in training. In both cases, the model's predictions corresponded with the outcome of the field tests.

Efforts are continuing to refine the model and to extend its applications. A revised model has been developed. Since the intended users of the method will have a variety of backgrounds and no special training, special focus is being placed on turning the revised TRAINVICE method into an operational handbook.

If the approach continues to prove beneficial with further testing, TRAINVICE can be used to:

- Identify potentially unsatisfactory devices before they are built.
- Identify the best of proposed changes or modifications to training devices.
- Serve as a basis for selecting among competing devices.

Any or all of these uses would help training program development keep pace with the weapons they are intended to support, and save money in the process.

## **TRAINING IN RIFLE MARKSMANSHIP**

Rifle marksmanship is a fundamental and important combat skill. There is a continuing concern within the Army about the problem of how to train riflemen, which leads to periodic renewed interest in this area. The qualifications of both instructors and shooters are frequently questioned.

Current ARI marksmanship research stems from evidence that the quality of Army Basic Rifle Marksmanship (BRM) training has deteriorated and that marksmanship skills are inadequate. Another impetus was the report of a DoD blue ribbon panel which pointed to the need to reduce training cost and increase training effectiveness.

### **Research**

ARI's approach has been to update the definition of a rifleman's tasks on the modern battlefield and to determine whether present methods provide adequate training for these tasks. The approach has also emphasized training costs and effectiveness.

Research was conducted to answer two questions. First, what is the nature of the threat on the modern battlefield, and how can it best be simulated to train riflemen? Second, what programs of instruction can best enable riflemen, as individuals and groups, to deal with the threat, and how can these programs be made more cost-effective? These questions were answered by identifying marksmanship problems and by developing and testing alternative training approaches.

### **Surveys and Monitoring**

To examine the nature of the threat, research was conducted to update descriptions of what the rifleman must deal with on the modern battlefield, and from this, develop a better base of information for the construction and operation of training ranges.

Discussions with trainers and observations of existing training provided research directions. For example: Since rifle marksmanship is a complex psychomotor skill, to promote learning, accurate and timely feedback of knowledge of results is required; these are largely absent in current BRM training. Second, the quality of instruction appears to have deteriorated. Third, certain key skills, such as zeroing and transition to field firing, were found to need attention. Finally, the design of improved training targets and aids was necessary, as was careful examination of rifle range equipment.

### **Field Research**

Four experiments have been conducted so far. An experimental evaluation was made of the Army marksmanship unit's program of instruction at Fort Benning. Emphasis was placed on distance and team firing in this largely remedial training program. The program resulted in superior performance when compared with normal annual requalification.

At Fort Jackson, two experiments were conducted involving promising training innovations. Of prime importance was the reintroduction of downrange feedback permitting trainees to shoot at targets and know exactly where their bullets struck. The research also led to major improvements in training soldiers how to zero and how to engage silhouette targets.

Another experiment has examined the capabilities of the M16A1 rifle and the importance of various shooting procedures. The significant findings from these research investigations have formed the basis for a revised program of instruction, which was proven in field use.

The new program starts with training in fundamentals and moves through a natural progression in which the rifleman learns his shooting tasks in logical steps including firing on targets at 25 meters, 25-meter transition to field firing, actual field firing, and finally combat-oriented firing. Throughout, feedback is maximized.

### **Research Utilization**

ARI—Fort Benning's research has been conducted with and for the Directorate of Training Developments at the Infantry School. The revised program of basic training marksmanship has been placed in the hands of the Commandant. It is expected to become the new basic rifle marksmanship training program.

## **Next Steps**

Marksmanship as an element in Advanced Individual Training (AIT) will be studied, and recommended training improvements will be tested. With improved training at basic and AIT levels, unit training can then be further refined. Effort will be focused on how desired performance levels, once attained, can best be sustained in units.

Finally, ARI will continue to monitor equipment developments that may be incorporated into firing ranges, both to build in combat realism and to improve learning.

## **TRAINING EXTENSION COURSES**

Training Extension Courses (TECs) are being provided to unit training managers as a tool and to help standardize training content. ARI is providing assistance in development and implementation of TECs.

This research is addressing the following problems:

- Controlling the costs of the preparation of the TECs.
- Identifying the most effective delivery systems and system mixes as training media.
- Enhancing material storage and accessibility.
- Gearing the content of training to the level of capability of students.
- Validating the ability of materials to provide effective training.
- Ensuring that the developed materials are fully utilized.

## **Cost Control**

A cost-effectiveness study was conducted to assess costs of developing the

training modules. One method of developing modules involved having behavioral scientists review literature and draw content from content experts. This method proved to be very costly. In addition, it was difficult to update modules to accommodate changes in systems, tactics, and techniques.

### **Delivery Systems**

Exploratory research was conducted in cooperation with the U.S. Field Artillery School to determine whether instructors could be trained to convert self-paced audio-visual materials into a computer-assisted instructional format, and to update the materials in this format. Workshops were held for course development personnel. The first workshops trained Army lesson developers to develop and evaluate courseware materials. The second provided instruction whereby these personnel could convert additional TEC materials into a computerized format. Several observed fire TEC lessons were reviewed by subject matter experts, and a preliminary evaluation was conducted on Army students. Course developers required 128 man-hours to make the conversions to computerized instruction. Computer and telephone costs were \$681 for each lesson. Costs included computer testing, test scoring, maintenance of student records, and other data necessary for course administration. Calendar time for development and preliminary evaluation was 30 working days. It was found that Army developers can be trained to develop computerized lesson modules in a relatively short time period and at acceptable costs. Also, the format proved acceptable and satisfied the criterion of permitting easy revision of lesson plans.

### **Packaging Materials**

Research attention was directed to packaging materials to make them more readily accessible to users. A significant development in recent years has been the development of the video disc. An enormous amount of material can be stored on individual discs. But instructors and students must be provided with sure and timely means for accessing materials on the disc. Here, an innovation in computerized instruction has been exploited. The student desiring access to specific areas identifies the area/MOS of interest. The computer then gives the requester a brief test to measure his level of knowledge of the content area in question. This test serves to identify for each requester a progression of lessons geared to the trainee's existing level of knowledge/competence. This, in turn, permits each student to access those materials adapted to his existing level of competence and needs.

### **Army Use**

A number of TEC modules are now available to Army units. Preliminary surveys have shown that:

- Utilization rates are lower than desired.
- How much TECs are utilized depends on command emphasis.
- TECs, when utilized, do improve soldier proficiency as measured by Skill Qualification Tests.

### **Future Work**

The developments described above represent one approach to the full application of advanced training technology for TECs. These developments, which rely heavily on computers supported by video discs, appear to hold much promise. However, a number of other types of delivery systems are feasible, depending on the content and circumstances of training. Work in progress will provide prescriptive guidance for training developers for the selection of delivery system mixes and for adapting TECs to computer-assisted instruction.

Also planned are more intensive surveys of the use of TECs for selected MOSs and comparisons of TECs and other modes of instruction using carefully validated "hands-on" performance tests. There is a potential for matching Training Extension Courses with Skill Qualification Tests using a common delivery system for both. It should be possible, using methods developed in the TEC research, to satisfy the need for Skill Qualification Tests to provide timely feedback to trainees, trainers, and training managers.

## **RESEARCH IN SUPPORT OF ARMY AVIATION**

### **Background and Problem**

The training of aviators and aircrews is conducted at the Army Aviation Center at Fort Rucker, Alabama, as well as in operational units. An ARI field unit at Fort

Rucker provides technical advisory support to the aviation community, and conducts advanced development and research programs to support Army aviation. The location of the ARI field unit assures that Army users participate actively throughout the research. The ARI technical approach is structured to:

- Meet Army operational objectives.
- Insure flexibility to meet changes in tactics and doctrine.
- Insure utility of research products through continuing evaluation of research in progress.

Research in support of Army aviation must take into account developments in aviation technology, improvements in anti-aircraft weaponry, and resultant changes in tactics and doctrine. Threats that Army aviators must be prepared to face increase in severity; round-the-clock operations are required under all weather conditions. New and more complex aircraft are being developed at the same time that reduced dollars available to support training limit the number of flight hours available. These developments taken together add requirements to the Army-wide aviation training program—requirements that must be satisfied within stringent cost constraints.

### **Approach**

Work performed by ARI in support of Army aviation is a user-sensitive, product-oriented research effort, which has as its objective “improvement of aviator training effectiveness from Initial Entry Rotary Wing through combat proficiency maintenance in operational units.” This goal is being accomplished through research and implementation of advances in training technology and through more effective uses of flight simulation. Research designed to improve flight training includes: 1) flight simulator training; 2) aviator selection and training management; 3) aviator performance assessment; and 4) maintenance of combat unit proficiency.

### **Research in Progress and Planned**

#### **Flight Simulation**

A number of research efforts are under way to adapt simulation technology to the flight training program. As these efforts are successful, more training can be given

in simulators so that time required in aircraft can be reduced. Research in flight simulation is discussed further under Simulation.

### **Aviator Selection and Training Management**

**Selection of Aviators for Flight Training.** A battery of paper-and-pencil tests—the Flight Aptitude Selection Tests Battery—has long been used by the Army Aviation Center to select pilots. Research has been conducted on the battery to increase its validity, reduce its length, and make it easier to score. Norms were developed based on data obtained from incoming students. A revised form of the battery is currently operational. While an interim development, it is providing a potential solution to problems associated with applicant selection including selection of applicants from female and minority populations.

Implementation, starting in October, 1980, is a two-step selection procedure. The revised battery will be used to screen out applicants whose chances of success in completing training are low. Two additional test programs will be introduced. One program will be the job sample Performance-based Aviator Applicant Selection System. The other will be a battery of psychomotor, cognitive, and time-sharing tests developed for differential mission assignment. This battery will include measures of workload capacity, of vulnerability to stress, and of performance in primary helicopter pilot training. Overall, the accumulated test results should provide a more precise technique for matching trainees' abilities with appropriate mission assignment for advanced training.

Throughout the entire sequential testing program, the objective will be to obtain the best possible test data at each step from a limited number of individuals and to provide a profile of individual abilities for each phase of training and for each Army aviation mission. At any step of the testing and training process, selection or assignment will be determined by comparing an individual's profile against the minimum requirements for successful performance.

As part of the training management research, methods will be developed for tracking the rate of progress of students within a self-paced flight program, including a mission track final phase. The Aircrew Training Manuals will be evaluated to determine how effective they are as training guides for commanders and whether they can be used to collect individual job performance data for research validation purposes.

**Selection of Aeroscouts.** Because flight missions and aviation hardware are becoming increasingly complex, the Army is moving toward a curriculum in which

aviators are trained in a specific combat mission specialty. One such specialty is the aeroscout mission for which some 25% of student pilots are selected for specialized training. To define selection requirements, highly experienced aviators served as experts and through consensus identified those aviator characteristics essential to effective performance of the aeroscout mission. From this information, a selection algorithm was created which uses data from instructor pilot ratings, tactical officer ratings, the student pilot's primary phase grades, and the student pilot's ranking of helicopter missions.

A computer program was prepared which implements the algorithm. The U.S. Army Aviation Center is using the algorithm to identify the best qualified student pilots for the aeroscout mission.

### **Performance Assessment**

An underlying foundation of the entire aviation research program is the development of discriminating, manageable, and easily administered performance-based criteria for assessing success in the Army-wide aviation training program. Approaches to valid performance assessment must take account of two problems. First, the instructor pilot must serve in two roles—the role of the instructor and that of the evaluator. He must time-share between roles. Second, while criteria for evaluation of trainee performance have been used for some time, none of these criteria seem to maintain their precise meaning from flight instructor to flight instructor, nor is there Army-wide standardization as to what skill level must be achieved by an aviator to be considered "combat ready." These criterion measures must be defined in order to be used for implementing the self-paced proficiency progression concept of aviation training. Two approaches are being used to improve measurement of flight performance. One involves a detailed maneuver analysis and provision of an in-flight digital data recorder as a knee-mounted keyboard. It is believed that this method will provide more objective real-time information, while reducing the instructor pilot work load. The data collected can be keyed to critical training variables. On completion of the flight, the student will be debriefed with the instructor using data extracted from the keyboard as reminders of key training points. Concurrently with this development, criterion-referenced scoring procedures are being developed to support individualized instruction in the Initial Entry Rotary Wing training program. These procedures are expected to provide more objective data on student performance. Provisions will also be made for integration of performance data into a training management data base.

### **Maintenance of Tactical Unit Proficiency**

A number of research efforts that have as their objective measurement of unit tactical proficiency and of unit training effectiveness are currently in progress. Army Training and Evaluation Programs (ARTEPs) are being expanded for application to day and night tactical flight navigation. They will be evaluated for use in assessing unit aviator readiness levels as adjuncts to ARTEPs and Air Training Manuals. In addition, training packages for use by the unit commander in enhancing the combat readiness of his rated aviators include several training modules such as night navigation and aerial defense. Individual Ready Reserve Aviators from FORSCOM units are serving as subjects for investigations involving maintenance and retraining of aviator skills following non-flying assignments. Also being investigated are methods by which pilot workload may be reduced by training and/or redesigning component tasks. Development of a lexicon for nap-of-the-earth navigation is one such task.

### **TEAM TRAINING**

Each TRADOC school has a training group responsible for developing Army Training and Evaluation Programs for operational units. Training is commonly subdivided into individual and unit training. Individual training requirements are defined through the Interservice-Standardized Instructional System Development approach. The performance requirements of groups are specified in ARTEPs. However, there is a gap which neither current individual training nor group training completely handles for missions and tasks that require many interactions between individuals—interactions that must satisfy stringent timing requirements. In this area where individual actions are secondary to teamwork, it is difficult to define training requirements, to develop the necessary training programs, and to assess how well group performance meets established requirements.

#### **Research**

A long-term research program is under way. Research thus far has involved:

- A review of the literature on work crew performance on how best to train men in interactive skills. Results were not especially productive.

The types of group studies are diverse and difficult to compare, as are tasks performed. Measures of internal interactions within groups were few and little used. No single approach to training has proved consistently superior.

- Concurrently, a survey of the 13 Army combat arms branches to find out "what is out there." The survey of formal Army teams indicated that there are more than 1000 groups or teams that perform different functions. A broad overview provided information on the missions of these groups, their size, kinds of equipment, and ranks of personnel assigned, formal leadership structure, etc. Information was obtained on what uses are being made of current training technology, how men are being selected for groups, and problems currently being experienced (personnel turbulence, leadership problems, availability of equipment, etc.). This survey produced further findings which argue well for the success of research to begin shortly. As examples, it was found possible to obtain agreement as to whether the system was man-ascendant or machine-ascendant; whether one man can compensate for the poor performance of others; and the extent to which effective group performance depended primarily on direction from the leader, or on coordination among subordinates. It was shown that information can be obtained as to the extent of interdependence between men in group task performance across Army teams. Finally, the survey established clearly that one prerequisite to prediction of cause and effect in group performance can be satisfied—namely, that significant variability among groups in task performance is being consistently reported. Thus, it is possible to obtain reliable ratings on criteria selected to measure the effectiveness of team performance.
- Based on the above information, a provisional taxonomy of tasks and functional dimensions of performance was established.

### **Future Plans**

Performance task dimensions will be developed from functional dimensions along with a model that will relate these dimensions to team performance. This work will direct future empirical research.

This work will provide a conceptual framework for performance measurement. The concepts developed will be translated into measurement procedures adapted

to the functions and the tasks of groups being studied. Relationships found in selected intensive studies will be compared; and from these comparisons, it should be possible to generalize findings to other families of Army groups.

### **Uses of Results**

The development of theory and conduct of empirical work with groups has proven to be relatively slow in the academic community. Because of this, and in view of the complexities of the problem, claims are, at best, couched with caution, even though the program goals and general approach are clear. Guided by theoretical constructs, empirical research must establish interrelationships between the independent variables as causative factors and performance as measured in carefully-constructed tasks. The strength of these relationships and the types of groups for which they hold true must also be determined.

The foregoing research objectives require the development and checkout of reliable measures of group performance, of interactions among group members, and of group leadership as it relates to levels of performance. Using these criteria, correlations and causal relationships will be established between independent variables—training methods, skill and aptitude levels of group members—and the ability of groups to accomplish their defined missions and tasks.

These developments will help personnel at TRADOC schools to develop training programs that emphasize teamwork and to close the gap between individual and team training. Given this knowledge, it should be possible to forecast the value of alternative training methods in advance, and to develop better procedures for the assignment of personnel to and within groups in all of the combined arms branches.

## **EMBEDDED TRAINING WITH TACFIRE**

### **The Problem**

Computer systems are increasingly being integrated into the Army tactical environment. The integration of tactical computer systems involves several requirements:

- Well-trained and dedicated operators.
- Training methods for operators to maintain their skills.
- Building of team skills, since all tactical automated data systems are integrated both functionally and between echelons of command.

The requirements of tactical data systems have provided an opportunity to determine whether the hardware system in place at the unit can be used to meet these training needs.

### **Research Approach**

ARI developed the concept of what is known as "embedded training" in 1971. The objective of embedded training was to use the tactical computer hardware and program it so that operators could use their own systems to teach themselves further how to use the system. The training needs and ARI's approach to meet those needs were integrated in 1971 and 1972, when ARI was asked to further develop and test the embedded training concept on an early developmental version of the Tactical Operations System (TOS).

To develop the concept, ARI had to find and construct or refine a software system for computer-assisted instruction that could be adapted to Army tactical computers. They chose to adapt the concept of a system initially funded by the National Science Foundation called PLANIT (Programming Language for Interactive Teaching). Although the feasibility of the PLANIT software package had been developed by NSF, ARI had to validate its usefulness in an operational environment.

ARI demonstrated the feasibility of PLANIT on the developmental TOS; but in order to be fully cost-effective, PLANIT had to be easily adaptable to a number of different computer designs. For full-scale development and testing of embedded training using PLANIT, TACFIRE was chosen. TACFIRE is an integrated on-line computer system for artillery units from individual firing batteries to division artillery headquarters. Its objective is to increase the effectiveness of field artillery support by using computers to make faster and better target identifications, more effective selection of artillery resources (guns and ammunition) to engage the targets, and to increase the capability for integrated artillery operations.

Many challenges are to be faced to make the TACFIRE system work effectively. The TACFIRE system is both complex and expensive. Its effective operation requires

a high degree of individual and team skills. Full proficiency in system operation requires much more practice than can be provided in the school setting. Skills, once learned, are forgotten quickly. A month between sessions in using the equipment has been shown to reduce individuals' skills significantly. Finally, best use of the system requires teamwork—from forward observers and battery commanders up through division artillery headquarters.

ARI tested the embedded training concept by developing an adapted version of PLANIT to use TACFIRE computers to provide training and keep skill levels up by practice and testing.

When this version was tested at the Army Field Artillery School, students trained with computer-assisted instruction on TACFIRE computer systems performed slightly better than students trained in the traditional platform-lecture mode; however, when tested a month later, the computer-assisted instruction-trained students showed very little skill loss, while the traditional platform student groups' performance declined significantly.

The effective demonstration of embedded computer-assisted instruction resulted in the Field Artillery School deleting a requirement for \$10-12 million worth of extra TACFIRE computer hardware that had been in the original Artillery School TACFIRE training plan.

### **Future Work**

While successful, this effort was focused primarily on the training of individual skills. At present, emphasis on teamwork skills has been restricted to simple exercising of teams where individuals are assembled and allowed to practice together. This is not team training. ARI has done initial developmental work on the application of embedded training and computer-assisted instruction to actual training, rather than the exercising of team skills. Initial versions of software systems for team training have shown it to be feasible on TACFIRE computer hardware. Work continues on refining team training software and on practical applications of TACFIRE and other tactical data systems. Other future work involves development of embedded skill qualification tests for TACFIRE operators that will provide instant feedback and prescribe remedial training based on the individual soldier's test results.

## TANK GUNNERY

### Background

Current technologies in armor and anti-armor weaponry require tank crews to site targets at long range and to engage them within a few seconds. Sure and rapid coordination among the four-member tank crew is required. The criterion for successful performance is suppression or destruction of enemy armor and anti-armor elements.

Improved weapons systems alleviate some training challenges but pose others. Both the M60A3 and XM-1 tanks have sophisticated laser ranging, thermal sights, and automatic correcting mechanisms for leading targets, wind factors, and tank position. But gunners must now be trained to aim and fire when one or more of these systems is not working, and to use manual and fully-assisted firing techniques.

Revised assessments of threat capabilities have required changes in the engagement situations developed for measuring tank crew gunnery proficiency. Tank crews now must engage targets faster and more accurately than before. This requirement for better performance requires better training programs. Based on these factors, the Armor Center has established a need for accurate and realistic assessments of tank gunnery performance. At the same time, the Center needs to upgrade individual, crew, and unit training to reach required performance levels.

Two ARI research programs have been established to meet these needs. The first is concerned with developing sound measures of tank crew performance in gunnery exercises. The second program addresses the development of training programs and methods to improve tank crew gunnery performance.

### Development of Tank Gunnery Tests

ARI scientists and contractors have applied job analysis methods to determine what tank crews must do to perform their jobs. These investigations showed that tasks of tank crews are both varied and complex, as 225 possible ways were identified in which tank crews can acquire and neutralize targets. A comparison of 225 tasks with the then-current training showed practice was provided for less than 25 percent of these tasks.

ARI then used a cluster analysis technique to identify some 16 job clusters which, together, embrace the 200-plus critical gunnery tasks of tank crews. A live firing gunnery test was developed to evaluate crew proficiency in all job clusters. Three important problems were uncovered in the course of these studies:

- Accuracy of main gun firing is only partially a function of crew proficiency.
- Range requirements to test tank crew gunnery proficiency adequately exceed many Army range capabilities.
- Limits on firing the tank's main gun restrict the ability to conduct complete and adequate tests of crew abilities.

One solution to these problems is to develop ways to apply simulation as a partial substitute for live-fire testing. ARI is examining ways to use simulation effectively in place of live-fire training. Successful use of simulation could save money and provide more accurate measures of tank crew gunnery performance.

### **Tank Gunnery Training**

Research on crew task analysis and test development underscores an inexorable fact. Tank crew gunnery has been and will continue to be a very complex and difficult job. ARI has been conducting research in all areas of tank gunnery training, from individual soldier part-task to crew gunnery exercises.

#### **Individual Skill Training**

An obviously important part of tank gunnery is aiming. This is not simple. Getting the proper picture depends on target, sight, and ammunition being fired. ARI has tested a simple self-paced handbook designed to improve the gunner's ability to get accurate sight pictures. Results show an up to 30% reduction in sight picture errors. The handbook is now being used by the Armor School in the Officer Basic Course.

Another investigation evaluated different strategies for use by tank gunners in leading moving targets. ARI-Fort Knox found that having gunners adjust their leads to three target speed categories—fast, medium, or slow—instead of the standard lead, as currently practiced, led to dramatic improvements in first round hits. After field validation, ARI will provide research results to the Armor Center for review and possible inclusion in revised gunnery doctrine.

### **Crew Training**

Ammunition costs (about \$200 per live round fired), fuel costs, time, limits and lack of range areas seriously constrain crew training. Often, the only practice crew members get in working together occurs when they go through the tank gunnery tables. At present, there is no other place where crews can mold their individual skills into a team process. The result has been less than desirable crew gunnery performance.

ARI-Fort Knox is developing and testing a set of dry-run crew exercises to build crew gunnery skills *without* moving or firing the tank. The concept was observed by ARI personnel in Germany in the early 1970's. At that time, armor crews using the concept scored from 1½ to 2 times higher on final gunnery qualifications than teams not using it. ARI has used the job objectives developed for tank crew testing as one basis for developing the dry-run crew exercises. Thus, the program provides practice in the crew-member sequences needed to engage and fire on a target. If validated and implemented, the dry-run practice sets could significantly improve the Army's tank gunnery skills at no additional cost for ammunition.

### **Future Plans in Gunnery Testing and Training**

Continued doctrinal changes needed to meet revised threat assessments and the deployment of the XM-1 tank system provide impetus for ARI's future tank gunnery research plans.

Future plans include work in the following areas:

- Fire-on-the-move. Recent changes in doctrine require crews to fire while their tank is moving. Little is known about the skills required to accomplish this task. Even less is known about how to best train gunners in these skills.
- Conduct-of-fire trainer. The XM-1 program includes conduct-of-fire simulators which will also be built for M60 series tanks. The full training benefit of these has not been exploited. ARI will provide research/assistance in developing requirements.
- Platoon-battle-run. Threat challenges require improved tank platoon battle performance. A platoon level live fire proficiency test is being developed at ARI. When training needs are identified, research support will be provided for developing tank platoon training programs.

## MAINTENANCE PERFORMANCE RESEARCH

### The Problem

Army maintenance procedures and maintenance efficiency have been identified as major problem areas by the Department of the Army and external agencies. Abuse of equipment, failure to perform preventive maintenance, excessive replacement of repair parts, and misutilization of mechanics have been cited as examples of maintenance problems. School training for mechanics has been shortened, increasing the need for increased on-the-job training; however, the majority of maintenance units have no on-the-job or unit training programs. In addition, maintenance unit managers have no way of assessing their unit's performance or procedures so that they can tell where problems exist. The Army spends about 25% (\$7 billion) of its budget and 33% of its personnel in full-time maintenance. The problem is large in scope and complex, as will be any solutions.

### Research

Research programs have been initiated to measure the performance of maintenance units. Prototype maintenance unit information systems are being designed which will provide measures of the productivity of maintenance units, the quality of maintenance and proficiency of mechanics. Prototype information systems have been developed for maintaining the M60 tank, the M113 personnel carrier, and the 2½-ton truck. The systems require very little additional time to record the data needed. They allow commanders of maintenance units to ascertain the time required to make repairs, reasons for repair delay, percentage of repairs passing inspection or being returned, which units are sending the most repair jobs to the direct support maintenance unit, and whether items not needing repair are being submitted for repair. Job experience gained by mechanics is being measured as well.

Tests of the prototype system have been conducted. Managers participating in the test have found the system effective and are using the data obtained to diagnose their maintenance unit problems.

### Other Research and Future Plans

In conjunction with the expansion and refinement of the maintenance performance information system, several other research activities are planned or under

way. A guidebook is being developed for use with the information system. The book will help maintenance unit managers analyze the data the information system collects and decide which problems can be solved by training. A companion manual is being planned which can tell the manager how to set up and conduct training in his unit, how to test skills of new personnel, and how to match training material available with tasks to be trained.

On a broader scale, ARI plans to use the data collected by the maintenance units to assist in redesigning training programs for mechanics/repairmen. This information can be used to decide which tasks are best trained in school or on the job, and which require development of new training approaches, simulation, or job aids.

When combined, the research efforts can help the Army to reduce its maintenance problems by improving mechanics' abilities, reducing maintenance cost, and improving maintenance concepts.

## UNIT TRAINING: ARTEP

### Situation

In the future, military battles will be intense and short in duration. The winner—and loser—will be quickly identified. It will also be difficult for the loser to reorganize his forces fast enough to counter the winner's momentum. In the critical European Theatre, mobilization must be accomplished within hours or days, rather than months. Western forces must be able to fight at any moment with what they have.

ARI is engaged in several efforts directed toward helping the Army improve the quality of unit training and to help our units attain and maintain a high state of readiness. One such effort—research on ARTEP—is described below. A parallel effort in engagement simulation will be discussed under Simulation.

### Army Training and Evaluation Program

To do a better job of training in a peacetime environment, in the early 1970's TRADOC established Army Training and Evaluation Programs (ARTEPs) for unit training. ARTEPs are performance-oriented and describe conditions and criteria for the evaluation of critical missions and tasks to be performed.

ARTEPs represent an approach to unit training that will supersede the training methods used since World War II. Fully exploiting the potential of ARTEP, however, will present problems. ARI, in coordination with TRADOC, has commissioned research to:

- Analyze current practices in implementing ARTEP unit training and document problems.
- Develop unit training implementation guides for training managers and trainer/evaluators, based on successful current practices.
- Provide information and guidance on how field training—always expensive—can be integrated into less expensive modes of training and battle simulations.

#### **Conduct of Research**

An ARI/contractor team has been conducting research to satisfy these requirements since 1976. First, battalion exercises were observed and the implementation problems were documented. Based on these observations and on relevant scientific literature, certain concepts were expanded to provide guidance for conduct of field exercises:

- Systems analysis constructs to help define the function that evaluators must perform as individuals and as members of evaluator teams.
- Principles of learning applied to develop means for giving units in training feedback that is comprehensive, valid, timely, and credible.
- Psychometric improvements to improve rating formats.
- Tactical concepts to help plan exercises permitting unit leaders to use innovations in tactics. Tactical concepts also have implications for the conduct of after-action critiques.

These constructs are not limited in applications to battalion training; they apply broadly to training of tactical units.

These constructs provide guidance for conducting company and platoon level field exercises. The document that incorporates this guidance consists of two parts. The

first sets forth directions for exercise planning. The second consists of lesson plans for training evaluators. The initial guidance document was field-tested with mechanized infantry platoons, and revisions were made based on test results. The revised document has been submitted to TRADOC for review.

### **Integrating Battle Games and Field Exercises into ARTEP**

As the above work on field exercises was being conducted, the need for review of battle games became increasingly evident in the interest of integrating simulations and field exercises in training. A number of battle simulations are available or under development. Their training value is still open to question, however.

Research has produced detailed descriptions of some nine battle games and simulations for training units and their leaders. The apparent advantages and limitations of each setting and recommendations for training emphasis are presented. The field guide and analysis of training settings should help the Army improve its implementation of the ARTEP concept.

### **Future Plans**

Future plans include conducting a final checkout of the guide using Army panels as reviewers, followed by a second set of field tests. When this work is completed, ARI will make the guide available to TRADOC's Army Training Board for use by training managers and evaluator/trainers in company and platoon training.

## **THE NATIONAL TRAINING CENTER**

The Army is establishing a National Training Center to provide realistic training for battalions and for brigade staffs—training that cannot be carried out at home stations. This training will be conducted using a mixture of real and simulated battalion units. The engagements will permit valid assessments of kills in simulated two-sided battles.

ARI has been asked by TRADOC to support this effort. ARI resources come from in-house and contractor expertise developed during research on ARTEP, engagement

simulation, and wargame simulators. ARI background and support efforts are as follows.

#### **Development of Measures of Effectiveness**

The National Training Center, with sophisticated instrumentation and data storage/processing facilities, will enable a great deal of data to be collected. These data will be reduced and interpreted to provide measures of effectiveness. Casualty counts, which have been traditionally relied upon, do not provide sufficient information for training guidance. Common errors in battle can give rise to different types of errors. For effective training, it must be possible to trace information through the cascading sets of events that occur when a battalion is in action, and to attribute errors or effective performance to both circumstances and source.

ARI work in ARTEP, engagement simulation, and battle simulation for command staffs provides the experience required to insure cost-effective training at the Center. This work will aid field exercise management, stimulate use of automatic processing technologies, and facilitate development and validation of comprehensive sets of measures of combat effectiveness.

#### **Implementation of Measures of Effectiveness and Exercise Control**

The implementation of measures of effectiveness and exercise control is the responsibility of the exercise control system. In research on the Multiple Integrated Laser Engagement Simulation (MILES), both in ground and air-to-ground play, ARI, in close association with Army training personnel, has helped to devise, test, and improve control system operations.

#### **Training Programs: National Training Center and Home Station**

Effective integration of the Center into Army training will involve a preparatory training phase, training at the Center, and subsequent training at home station to correct diagnosed deficiencies. ARI will participate with training personnel in developing program plans to integrate preparatory training at home stations with Center training, and to provide continuity for remedial training when the units return to their home station.

### **Training and Feedback**

Throughout the efforts outlined above, ARI research is insuring that the principles of good teaching and learning are effectively applied in the planning and conduct of training. Effective training requires that accurate information be fed back to trainees in a timely manner. The rate of learning and the cost of training is heavily influenced by the quality and timeliness of feedback on trainees' performance.

Training feedback is essential for three levels of operations: for trainees, for training managers, and for the Army as an institution. ARI has had extensive experience in developing and implanting feedback procedures in REALTRAIN, MILES, and other battlefield simulators, which have been well received by participating leaders, staffs, and troops. Equally important is feedback to trainers and training managers. Such feedback helps identify areas for future training emphasis. Finally, feedback to higher level agencies, such as TRADOC and FORSCOM, helps to indicate areas requiring institutional emphasis in development of training programs.

## **UNIT TRAINING PROGRAMS AND MANAGEMENT SYSTEMS**

### **The Problem**

The impact of the Army's shift to individual performance-based training and testing has been felt at the Army's schools and training centers. The equipment, time, and resources required for performance-based training means that most individual soldier training must now be done within operational units. Due to unit training and readiness requirements, however, it has been difficult to train individual soldiers. Better individual training programs and ways to manage training programs are needed for operational units. In the past three or four years, ARI has worked with TRADOC's Training Development Institute, the Army Training Board, and FORSCOM units to develop programs and management systems for training the individual soldier in his unit.

### **Research**

Overall management responsibility for individual and collective training is focused at battalion level. Surveys by ARI contractors have indicated that battalion

personnel need assistance in conducting and managing performance-based training. To correct existing problems, workshops have been developed for battalion officers and NCOs. Workshops were designed to help the officers and NCOs make better training-management decisions, analyze individual and unit training needs, better manage time and personnel in planning and conducting training, and to help provide realistic incentives to do their jobs well. The workshops were tested in operational battalions. Portions of the workshop package have been adopted by the Army Training Board for use in the TRADOC Battalion Training Management System.

In conjunction with the workshops, specific training programs and management needs were identified within the battalion at the levels where training occurs—the junior NCO, the squad leader, and the soldiers. To meet this need, ARI conducted and monitored a three-year effort to design, develop, and evaluate an Individual Extension Training System. ARI contractors observed training and training management operations, and conducted in-depth interviews with commanders, staff, and troops. A model was developed including prototype components of the training system. The model stressed:

- Decentralizing individual training to the squad leader level.
- Individualizing the kinds and amount of training to each soldier's needs.
- Training specifically for the job the soldier is assigned in the unit.
- Adjusting the pace of training to the soldier's learning pace.
- Eliminating formal and structured "school" approaches.

Using the model, prototype training and training management materials were developed and tested. These materials included:

- Pocket-sized training outlines that showed how to set up, conduct, and check out training on specific tasks.
- Course management plans written for the squad leader level on what needs to be taught, in what order to teach it, what materials and equipment are needed to conduct the training, and tips for conducting the training.

- Training records (job books) for the trainer/supervisor and the individual soldiers to keep track of what they have and have not learned.
- Workshops to teach trainers and commanders how to use the training outlines, management plans, and training records.

Workshops were held on a trial basis with 56 trainers and supervisors, to see if they would and could use them. Workshop participants were very enthusiastic about what they had learned, but were skeptical as to whether it would be implemented and supported in operational units.

The concept and materials were tested in two battalions over a nine-month period. Substantial opposition was encountered because:

- Individual training in the test units observed received very low priority.
- Higher priority was given to unit training, support and house-keeping tasks, and special details.
- Trainer/supervisor personal accountability for individual soldier proficiency was lacking.

#### **Future Plans**

In spite of the lack of utilization of the prototype system, the potential payoff was felt to be sufficiently high to warrant further effort. TRADOC has adopted a portion of the training records for use. FORSCOM has reviewed the pocket-training outlines and is determining how they can be implemented. Department of the Army Headquarters and FORSCOM operations have requested ARI to conduct research to examine battalion garrison operations to determine whether they can be modified to create more opportunities for implementation of the Individual Extension Training System.

**PERSONNEL AND MANPOWER**

## PERSONNEL AND MANPOWER

### Overview

The Army personnel system is concerned with officers and enlisted men and women from enlistment until they leave the service. Manpower systems management provides the necessary policies and tools.

As we look to the next decade, the services are confronted with the impact of a declining birthrate of about one million annually from 1961 to 1973. Thus, fewer able-bodied men and women will be available for military duty. Other factors--some clearly predictable, some more nebulous--stand to worsen the personnel situation. More than a score of new and complex weapon systems are scheduled to come on-stream. It will surely be difficult to find enough people with the nimbleness of mind and hand to operate and maintain these systems and to manage the command and control systems on which a modern army increasingly depends.

The drop in birthrates is confirmed by the census. The addition of many types of new weapons is highly likely, for these weapons are products of the long R&D process. Much less certain in impact, but a factor to be recognized in trying to recruit and keep an all-volunteer force, is the apathy toward American institutions of the 1960s, which has, in some degree, persisted. One manifestation of apathy is high attrition from basic training and from the first term of service.

### Some Concerns

Personnel and manpower research addresses the many issues and problems associated with acquisition, assignment, retention, and career development of Active and Reserve Army personnel.

Among major concerns are the recruitment and retention of high quality soldiers. A "Military Applicant Profile" has been developed for screening accessions. It is used along with the joint Armed Services Vocational Aptitude Battery (ASVAB). Of special concern is a high rate of first-term attrition. Approaches are being developed and evaluated to reduce officer and enlisted attrition and to retain good people. Enlistment motivation and retention for reserve forces also receive attention.

Personnel and manpower research is extensively involved in the development of tests and procedures for measurement of aptitudes and assignment of personnel

based on measured aptitudes. Here, aptitude tests have been developed for crew positions in critical weapon systems including armor, helicopters, and anti-armor. Skill Qualification Tests have been developed to provide objective measures of achievement in hundreds of military occupational specialties.

Anticipating future needs, ARI is developing manpower models to forecast future manpower needs, to help plan assignments, and to implement concepts and models for studies of organizational effectiveness.

## PERSONNEL AFFORDABILITY

### Problem

Earlier, the Life Cycle Systems Management Model (LCSMM) was discussed.

Personnel affordability concerns have direct impact on LCSMM activities. Translated, *personnel affordability* means that, given the system's personnel and training requirements, can we afford to continue to develop and field the system? Do the personnel exist in the manpower pool with the capability to man this system? Can they be recruited? Can lesser-skilled people be trained? Will manning this system weaken other equally important systems? What tradeoffs are required between personnel availability, training system requirements and costs? These questions, and others, require answers before the personnel affordability of any system can be satisfactorily addressed.

Personnel affordability issues begin in the conceptual stage of the LCSMM. A first step is to determine the personnel requirements of the system concepts being considered. Required aptitudes, skills, and knowledges of the soldiers needed to operate and maintain the system must be identified. The approach to meeting this requirement has been task analysis—determining what each individual soldier or crew member must do to make the weapons system work as intended. Task analysis is readily conducted on existing equipment with trained operators, gunners, etc. However, at the conceptual stage of system design, when personnel requirements information is needed, there *are no* pieces of equipment; thus, the information is incomplete or nonexistent. Methodologies are needed for task synthesis, given the scant information about what a system will look like, or what it will require its operators and maintainers to do.

Early and accurate integration of training considerations is crucial to answering personnel affordability questions. From limited information, tasks that require high levels of skills and much background knowledge must be identified. Judgments concerning the difficulty of training the tasks must be made. Information about the impact of individual performance on system performance must be generated so that decisions about systems designs can be made. Finally, all methods must be able to respond quickly to changes in systems designs as different hardware alternatives are considered. All of these activities must take place in the conceptual phase of the LCSMM if wise decisions about personnel affordability are to be made.

### **ARI's Role**

ARI has formed a personnel affordability task force to begin work in FY80. Its objectives are to meet the needs identified. Specific projects are needed to:

- Develop and test methods to better determine personnel requirements (knowledge, skills, and numbers) of new systems.
- Develop test methods to project the personnel resources available to man the systems.
- Develop methods so personnel issues can be used to make accurate systems engineering tradeoff decisions.

## **RECRUITING**

### **Background**

The number of military-available young people will diminish in the 1980's because of the decrease in the birthrate between 1961 and 1973. Such reductions will increase competition among the Army and other services to recruit personnel who can man, maintain, and direct the increasingly complex hardware which will come into use in the coming decade. Efforts to improve recruiting will take two directions: to improve the capabilities of recruiters; and second, to examine enlistment motivation to determine what kinds of incentives are apt to be most salient to potential accessions. Research in support of the recruiting effort is pursuing both lines of attack.

### **Research on Recruiters**

Research was conducted which examined success in recruiting based on individual differences among recruiters. The reasoning was that if the ability to recruit could be predicted, the Army could select more competent recruiters. Initial efforts involved the development of easily administered paper and pencil tests to be used as predictors. This effort failed. One reason for this failure was that the area in which recruiters were stationed was found to be much more important to recruiter success than

were individual differences among recruiters. Moreover, while it was felt that recruiters do vary in ability, sources of these variations could not be isolated through paper and pencil tests.

Concurrent with the selection effort, ARI carried out research to define the nature of the recruiter's job more precisely. This research led to the identification and description of key recruiter requirements. Among these are the ability to explain the prospects of Army life with its opportunities and benefits, and the ability to establish and maintain contacts in the local community with key persons who can help make potential recruits aware of Army opportunities.

A modified assessment-center approach is being developed. Recruiter performance will be assessed in job simulation assessment exercises in which recruiters interact with personnel who assume the roles both of potential recruits and of people in local communities who can aid the recruiting effort. Thus far, seven exercises have been developed to assess the key aspects of the recruiter's job.

#### **Future Plans**

Plans are under way to test and validate the recently developed exercises for use as a means of recruiter selection. Job simulation exercises will be validated against success in recruiter school and recruiter success on the job.

### **ATTRITION AND THE MILITARY APPLICANT PROFILE (MAP)**

#### **The Problem; Its Significance to the All-Volunteer Force**

A chronic problem in the Army has been the attrition of enlisted soldiers during their first term, which, in some cases, has exceeded 40%. Attrition hurts in two ways: it means a loss of time invested by the Army in training, which is on the order of \$5,000-\$10,000 for each recruit; and it places an added burden on Army recruitment resources in obtaining replacements.

#### **Research Approach**

Two approaches to the reduction of attrition have been developed, and research is being conducted on both. One would screen individuals prior to their entry

into the Army. The second would help the new recruit make two transitions—from civilian life to the Army, and from Advanced Individual Training to the unit in which he or she will serve.

#### **Attrition—The First Six Months**

About one-third of enlisted attrition occurs before completion of the first six months of service. It was believed that measures of individual differences could be used to identify in advance those personnel who are not likely to stay in the Army, and screen them during recruiting. Such screening must take into account non-cognitive factors which influence soldiers' adapting to the Army organization. Accordingly, a Military Applicant Profile (MAP) has been developed. It is based on biographic and personal history data on experience in schools, in the home, and in neighborhood activities. The items have been carefully tested and evaluated on many thousand recruits. On cross-validation, scores produced correlations with "survival" during the first six months in the Army of better than .40. Thus, the MAP has proven to be a useful tool for recruiting. Properly utilized, it can reduce attrition substantially during the first six months of service.

#### **Attrition—After Six Months**

After the first six months of service, including basic and advanced training, soldiers are assigned to units. Attrition after the first six months is less dependent on individual differences; thus other approaches are required to reduce attrition.

Further research led to the finding that unit attrition appears to be due, in part, to soldiers having difficulties in making the transition to and in serving in units. These difficulties stem from a number of factors. Among these are unmet—and often unrealistic—expectations on the part of the soldier, and personnel mal-utilization by the unit, i.e., soldiers not being utilized in their MOS.

#### **Continuing Efforts**

A number of solutions to these problems are currently being developed and evaluated:

- Development of an orientation program to ease the transition from Advanced Individual Training to life in a unit. This may include "arranging expectations" to make them more realistic.
- Review of unit personnel assignment practices. In some instances, personnel were not doing work that their MOS training had prepared them for.
- Training of supervisors. Managers are sometimes not aware of how their actions can contribute to problems of attrition. They often need to be better able to counsel new men.
- Development of indoctrination film. Plans are currently underway to develop an indoctrination film which can help ease the transition from civilian life to the Army, and from Basic and Advanced Individual Training to the unit environment.

## **THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB)**

### **The ASVAB**

The Armed Services Vocational Aptitude Battery (ASVAB), consisting of a battery of ability tests, is a combined effort of the three services. Parallel forms are being extensively used for two purposes:

- The services administer the tests in high schools and provide scores to counselors at no cost. About one million youngsters in some twenty thousand high schools take the ASVAB annually.
- Comparable numbers of young men and women are tested for service applications under auspices of the Armed Forces Examining and Entrance Stations.

### **Research Support of ASVAB**

ARI's contributions to the development of the ASVAB include:

For vocational guidance:

- ARI produced test score composites for use in vocational guidance in high schools. Composites were based on factor analysis. Factors include a student's verbal ability, quantitative ability, clerical ability, mechanical ability, and trade knowledge. In addition, a general measure of academic aptitude is provided. These score composites have high reliability and relatively low intercorrelations.

For service use in the military recruitment program:

- Development of an information booklet for personnel to whom ASVAB will be administered. The booklet explains the purpose of the test and provides sample items.
- Development of a method for scoring selected ASVAB items to provide measures of literacy. This application eliminates needs for separate literacy tests.
- Development of methods for scoring ASVAB items so administrators can determine whether unauthorized assistance has been provided.
- Development of improved test score composites for Army vocational assignment.

### **Future Research**

An R&D program has been initiated through the joint efforts of the three services which may lead to major changes in current mental testing and in the ASVAB. The program involves development and utilization of real-time computerized testing and recruiting materials. Testing will be adaptive; that is, item difficulties will be matched with the ability of examinees by computer programs. This will provide more accurate measures of ability and reduce testing time. Computer testing will also measure abilities which cannot be measured by paper and pencil tests, such as the ability to track a moving stimulus. In addition, interest measures and biographical background data, which have served as a basis for the Military Applicant Profile, will be added. These innovations taken together will provide a complete bank of information which can be rapidly applied to the selection and assignment of all recruits.

## TOW AND DRAGON PLACEMENT MODELS

The TOW and Dragon anti-tank weapons are essential to modern combat, and, in particular, to the defense of Western Europe where Warsaw Pact forces can field massive formations of armor. Experience with these weapons shows how field research on selection and the development of operational methods can increase combat readiness while reducing training time. A prime objective of training is to insure a high first-round hit probability. It is worth noting that costs per round fired for these weapons run into several thousand dollars.

### Research on TOW

As initial versions of TOW were tested, the Army needed to examine processes in selection and training of TOW gunners. Three groups of soldiers were selected as TOW gunners and given different amounts of training—minimal, moderate, and high. It was found that even men who received the least training could score hits with the first round more than 90% of the time. Therefore, it was determined that no selection procedures are needed— that minimal training is sufficient.

### Research on Dragon

With Dragon, the situation is different. Initial Army tests showed gunner hit probabilities to be unacceptably low. Again, three prototype training programs, consisting of minimum training, a medium amount of training, and an extended training period, were given to three groups of soldiers of comparable ability. Findings were as follows:

- The minimum amount of training was insufficient. Gunner hit probabilities for both the first and second live missiles fired were unacceptably low.
- The programs that provided moderate and high amounts of training gave essentially the same results. For both programs, hit probabilities of the first round were unacceptably low; hit rates for the second live missile fired were marginally acceptable.

This information served as a point of departure for a program of selection developed by ARI in coordination with personnel at the Infantry School. Experimentation

yielded a two-phase selection process. First, initial screening using Army personnel data produce personnel who have a high probability of success as gunners. Second, procedures based upon observations of performance early in training are used to eliminate men who will not do well as Dragon gunners. It has been shown that, by using this two-step screening procedure and by allowing trainees to fire one live round, the average probability of a hit is 86%. This is better than the Army had set as a goal.

This work on selection and training led to more detailed analysis of the simulator now being used for training Dragon gunners. A preliminary human factors analysis of this Launch Effects Trainer suggests that certain of its features are not adequately preparing trainees for live firing. This conclusion has been confirmed in questionnaires completed by trainees. It is likely that modifications that should make the simulator a better trainer will be recommended.

The selection and training methods described above, combined with improvements in the simulator, are expected to reduce the training program from 48 to 40 hours, while producing gunners whose hit probabilities will exceed Army requirements.

## **ARMOR CREW PLACEMENT**

### **The Problem**

A major change in the initial training of Armor crews was initiated in January, 1978. In place of the former objective of producing a soldier who was both a licensed driver and a competent gunner/loader, the training program was changed to produce a soldier who was either a proficient driver *or* a proficient gunner/loader. To aid in the assignment of men to position-specific training, ARI began developing techniques for predicting which men would perform well as drivers, and which would perform well as gunner/loaders.

### **ARI Analysis**

Paper and pencil tests, which are relatively inexpensive to administer and score, were chosen as the initial basis for screening. Hands-on tests in the form of "job samples" were chosen as potential follow-up predictors. Although more time-consuming to administer and score, these performance tests can be incorporated into initial processing, before position-specific training begins.

### **ARI Research**

ARI research has indicated that paper and pencil tests can be used as statistically-significant predictors of driver and gunner/loader performance during training, and in the first assigned unit. Job sample tests, however, provide much better prediction of gunner/loader performance. Research is continuing to improve and refine the job sample measures.

### **Utilization**

Paper and pencil tests are undergoing preliminary utilization in the reception station at the Armor Center. These are used along with recruit preferences, contract-specified station of choice, and other factors for initial assignment of armor recruits to driver or gunner/loader training. Job samples are being developed for primary use in the emerging Armor system, and will be evaluated with the XM-1 tank during OT III at Fort Hood.

## **INDIVIDUAL TRAINING AND EVALUATION SYSTEM**

### **The Problem**

The Army has a continuing need for improved tests for enlisted personnel, both to provide guidance for training and to improve personnel management. Skill Qualification Tests (SQTs) were developed in response to this need. It was recognized that such tests must be valid, fair to all soldiers, and feasible for world-wide administration. Tests must be based on job performance, and it is desired that they be criterion-referenced.

### **Research**

Prototype performance tests for four MOSs were developed to refine the methods for developing SQTs, and to serve as a model for developing tests to cover a large spectrum of MOSs. The tests were built around the concept of scorable performance units. A scorable unit includes all items needed to measure the performance of

a defined task. Care has been taken to insure that all critical tasks were being tested, as were the means of performing these tasks. Concurrent with this work, prescriptions were developed for test construction and administration.

Based on experience with prototype tests, a set of general procedures was set forth as guides for developing the SQTs. Instructions covered both development and validation processes. They provided a means by which Army test developers could determine the validity and reliability of tests. The content of the SQTs can be public, and decisions by trainers and personnel managers can be based on how well soldiers attain performance standards.

In a second step, workshops were conducted by ARI in all Army schools and test development agencies. It was found that personnel lacking expertise in test development could be trained to follow the guidelines and to provide valid and reliable SQTs.

As SQTs are being developed, it has been found that all aspects of all enlisted skills cannot be conveniently measured by performance tests. To provide flexibility, written components have been developed for certain skills. In some instances, supervisors are permitted to certify that personnel have attained an acceptable level of proficiency.

#### **Product Use**

The guidelines and workshop materials have been used to train personnel in schools and in test development agencies on how to develop SQTs. Using these materials, Army agencies have developed tests for more than 300 MOSs. Often more than one test needs to be developed for each MOS to discriminate between different skill levels. The tests are being used to measure the job proficiency of the Army enlisted force. As such, they provide guides for training and for promotion. They also provide the means by which commands can attain high levels of proficiency of the enlisted force.

#### **Future Work**

ARI will continue to provide guidance and technical assistance as the system is expanded. Future efforts will involve improving scoring systems, developing means for providing timely feedback on performance to soldiers, and providing feedback to the trainers and training managers. Efforts are also underway to improve the efficiency of test administration and management.

## ALIENATION

### The Problem

Indications that a substantial number of incoming soldiers are apathetic toward the values of the American culture and its institutions are of much concern to the Department of the Army. They bring this sense of alienation with them when they join the Army. This contributes to disciplinary problems and to high rates of attrition.

This is an example of a malaise in the American culture spilling over into the military. If alienated individuals do not believe that social justice is fairly applied by civilian authorities, they are equally likely to be cynical of its application in the Army.

### Preliminary Efforts

The importance of the problem of soldier alienation is matched by difficulties in attempting to solve it. A two-step research plan is being followed. The first step involves developing attitudinal measures of alienation and establishing their validity. These measures will be validated against criteria such as supervisor ratings of morale, incidents of disciplinary violation, and measures of proficiency—such as scores on Skill Qualification Tests. Work on this step is underway. The second step will look to applications.

### Future Work

Future work will depend on the success of current efforts. A better understanding of alienation as a concept and a more valid means for identifying alienated individuals has several potential applications. Instruments could be used to screen accessions; assuming that some new soldiers will be alienated in some degree, an understanding of the concept and its manifestations might serve as a basis for providing guidance to Army supervisors.

## UNIT COHESION

### The Concept

The subject of unit cohesion is a fundamental one for the Army. A military unit is greater than the sum of its parts—its men, equipment, supplies, administration/

logistics/command and control, and management of all of these resources, including time. What makes the product greater than the sum is "cohesion," a concept like the nuclear physicist's "binding energy" (that part of the atom's mass which is transformed into energy during nuclear fission). There is no good synonym for cohesion in our current vocabulary; neither *morale* nor *esprit* nor *unity of purpose* quite define cohesion.

Cohesion is the ability of a military unit to hold together, to sustain mission effectiveness despite combat stress. That stress, which cannot really be simulated in peacetime, includes enemy violence, Clausewitz' "friction of war" (the concept that the simplest tasks become difficult under fire), fear of death and wounds, personnel turbulence, uncertainty and the often unclear connection between national purpose and military action, between national resolve and soldier sacrifice.

### **The Problem**

There is a great concern that current leadership, training, and personnel management in the Army are not developing the unit cohesion required for success on the future battlefield. Social and cultural changes in America have aggravated this situation, making the job of leading, training, and disciplining today's soldier more difficult than was the case in the past. The challenge is to strengthen the Army's small unit leadership skills and organizational climate so as to enhance cohesion without which combat effectiveness is doubtful.

### **Current Research**

There are currently three major research thrusts to address this problem: 1) to facilitate the soldier's adaptation to his unit and to the military way of life; 2) to improve the leadership of the soldier's superiors; and 3) to increase the meaningfulness of the soldier's day-to-day tasks. All three of these thrusts will focus on the ability of company level officers and non-commissioned officers, leader turbulence, soldier turbulence within and between units, and individual versus unit replacement systems. In addition, research on task performance of small crews and teams will produce findings on improved leadership and task allocation. Eventually, the research may develop systematic principles of work design for use by force developers and equipment designers.

## REENLISTMENT

### Overview

If the Army is to maintain an effective cadre of leaders/supervisors, enlisted personnel must be identified who will make effective, motivated careerists—personnel who can operate and supervise the operation and maintenance of the complex military hardware programmed for the future.

### Army Actions Indicated

The current pool of potential career soldiers is judged to be too small to meet Army needs, particularly when one considers reduced rates of reenlistment. The Army needs to learn how to identify the most effective career soldiers from the pool of first-term soldiers. It also needs to design an organization that offers these individuals a package of incentives which is effective in attracting and holding members of the modern work force, while being free of disincentives.

### Research

Research on-going and planned is taking two directions:

- An examination of perceived incentives and disincentives to reenlist among first-term soldiers who are potential career candidates. In-depth interviews, motivational surveys, and supervisory ratings are being used to collect data.
- At the Army level, in cooperation with the Army Concepts Analysis Agency, development of a model that can be used to forecast the impact of policy changes on reenlistment rates. The model and associated data will be implemented in a computer simulation program. ARI's contribution will involve collecting data to establish the functional relationships between resources that Army policy can control and reenlistment rates. Among resources that can be directed by policy are bonuses, both size and method of payment; advertising budgets; the number of career counselors; and opportunities provided. Reenlistment rates can be subdivided by MOS, sex, rates, etc.

### **Findings, Appraisal**

Preliminary results for first-term soldiers suggest that the Army Personnel Management System and the perceived quality of Army life are likely to be very important determinants of reenlistment decisions. Future work will extend the analysis to reenlistment of career soldiers and reenlistment in the Reserves. Fallout implications for initial enlistment will be fully exploited.

### **Prospectus for Army Use**

This research represents a much needed approach to a crucial Army problem. It employs the capabilities of modern computers to forecast the impact of policy changes in advance. By collecting empirical data on reenlistment rates subsequent to policy changes, it will be possible to validate the forecasts continuously. Thus, in light of experience with policy changes, assumptions about functional relationships between incentives and reenlistment rates can be examined, modified, and refined by successive approximations, using actual Army data.

While the models and data are currently being assembled, there are excellent reasons to believe that the research planned will provide a means for obtaining increasingly accurate forecasts of the impacts of changes on reenlistment policies. These means are within the state-of-the-art. Once accomplished, the model can be used to optimize reenlistment and retention of sufficient numbers of career soldiers.

## **ROTC RECRUITMENT AND RETENTION**

### **Problems**

The Army is facing significant shortfalls of officers entering Reserve components from precommissioning programs. The number of ROTC career officers is declining as a result of training attrition and non-retention as commissioned reserves—both costly factors—as well as difficulties in attracting qualified applicants.

### **Approach**

A model of the career process has been developed on the basis of existing theory, published research findings, and new research efforts. The model identifies relevant factors associated with joining and staying in the ROTC program and in the Army. It provides a basis for identifying applicants more likely to make the Army a career than not, as well as factors associated with attrition from the ROTC program.

### **Findings**

The differential interests of population sub-groups of potential ROTC applicants have been identified through a process of targeted interviews and follow-up surveys. The resulting data base provides a basis for developing advertising materials that reflect interests and values of potential applicants.

## **REALISTIC ROTC TRAINING**

### **Situation**

Approximately 75 percent of officers who enter the Army do so through the Reserve Officer Training Corps. The objectives of ROTC precommissioning training are to prepare officers newly graduated from college for the significant responsibilities they must assume in the All-Volunteer Army.

Many officers, newly graduated from the Army basic course, begin their tours by taking over a 40-man platoon, with all the leadership and managerial responsibilities this requires. The new platoon leader typically has little or no management experience. He may approach his job with unrealistic expectations. He may expect automatic obedience, which is unlikely to be accorded. Confronted suddenly with these responsibilities, he may fall back on narrowly-interpreted authoritarian leadership. Perceptions of poor leadership by NCOs and troops can lead to added disciplinary problems and attrition among the enlisted.

### **ARI Research**

ARI has been conducting research in support of the Army's ROTC and OCS precommissioning programs. This research has concentrated on leadership assessment

and training to improve the performance of the young junior officer coming into his first assignment.

This research, which has been conducted by ARI scientists with support from university and private research groups, has provided new assessment programs which are used in the selection and assignment of young officers. These include a performance-based assessment program that assesses the leadership potential, in simulated combat, of all cadets prior to being commissioned as Army officers, and a program to assess other skills and competences important in effective officer performance.

Recently, ARI in-house work and that of contractors has been oriented toward improving ROTC training. Up to now, the preponderance of ROTC training has been by classroom lecture. The purpose of ARI research has been to develop simulation techniques that will enable the officer candidates to become active participants in the training situation to enhance their ability to deal effectively with the managerial and leadership responsibilities involved. Several training modules have been developed, including:

- Problem analysis and decision-making
- Planning and organizing
- Delegation and control, and
- Interpersonal skills

#### **Use of Results**

Guides have been developed for ROTC instructors and administrators in the use of these modules. The training modules and guides were tested with ROTC cadets as they were being developed. They have been well accepted and are currently being used in many ROTC schools.

#### **Current and Future Effort**

Research is currently underway to exploit fully the principles of leadership built around specific tasks and problems that the newly commissioned officer will face.

A prerequisite of this research is to provide ROTC cadets with a better appreciation of actual operational situations. The cadet is first provided with the opportunity to learn and practice leadership principles. He is then shown how these apply to situations and problems which are encountered within the Army operating environment. These situations and tasks are currently being classified, and modules and instructions are being prepared as training materials. These modules will soon be tested. It is expected that these modules will provide indoctrination in realistic operational problems, thus providing the new officer with instructions and practice. Practice should enable the trainee to gain confidence in his ability to handle the tasks and situations he will encounter when he takes over his assignment as an Army officer.

## ARMY RESERVE RETENTION

### Situation

The Reserve forces—the Active Reserve units, the Individual Ready Reserve, and the National Guard units—represent the Army's backup forces in the event of hostilities or mobilization. The draft had served as a prime motivating factor for personnel to join the Reserves. Without the draft, it has not been possible to bring Reserve forces up to the numbers programmed. Further, unprogrammed loss rates (analogous to attrition in the Regular Army) and low rates of reenlistment have resulted in Reserve forces that are under strength.

### Research Approach

Motivational factors in unprogrammed and programmed losses in the Army Reserve components are being examined. The general methodology involves sample surveying of Reserve enlisted personnel and unit commanders concerning present incentives, community opinion, peer group influence, the impact of annual training, and geo-socio-demographic influences upon retention. Ultimately, a model will be developed for optimizing cost-benefit strategies for retention, forecasting retention levels corresponding to given strategies, and allocation of resources.

## **Findings**

Based upon research conducted to date, it has been shown that Reservists: 1) spend less than 1/3 of their time on mission-related activities; 2) are not particularly satisfied with recent accessions; 3) seek more interesting and varied activities, such as travel; 4) seek better organized training activities; and 5) seek opportunities for self-improvement, particularly in new job skills.

## **Policy Implications**

Findings thus far indicate that the Army Reserve cannot readily be kept up to strength by using current monetary incentives. More emphasis should be given to mission and training programs. The most cost-efficient methods for applying additional incentive funds to improve retention among first-termers are reenlistment bonuses, tuition assistance, and tax exemptions. Because of the significance of interpersonal relationships, it is important that the process of restoring the strength and vitality of the Army Reserve be approached on a long-term basis.

## **Future Work**

First, currently available survey data will be further analyzed to delve more deeply into unprogrammed losses, the views of unit commands, suggestions for change, and the findings reported above. Secondly, the modeling activity, also mentioned above, will serve as the basis for computer forecasting of impacts of changes in policies and in amounts of incentives provided.

**SIMULATION**

## SIMULATION

Simulators are playing an increasingly important role in Army training. Simulators permit trainees as individuals and as groups the opportunity to practice combat and combat-related tasks in a more cost-effective manner than do training methods that they replace in whole or in part. Simulators permit training in combat tasks that cannot be practiced safely or at reasonable costs using operational hardware. Simulators permit performance evaluation and provide feedback to instructors and trainees so that trainees can, in successive sessions, improve their performance.

Social and behavioral scientists, working with other disciplines and with training managers, contribute to the development and effective use of simulators in a variety of ways. These include:

- In collaboration with potential users, determining whether a simulator for a new system should be developed in view of the state-of-the-art in training technology, and costs.
- Contributing to simulator design to insure that simulators provide coverage of common and critical tasks, means for performance measurement, and feedback.
- Assisting in the effective utilization of simulators in training settings. Research may involve developing curricula, working with training managers to insure the most cost-effective mix of training as between simulators and other methods of training, and developing guidance for instructors as to how simulations can best be used in training.

## FLIGHT SIMULATORS

### Advantages of Flight Simulators

As aircraft become more complex and costly to fly, simulators are being used more and more to train pilots and crews. It is increasingly evident that simulator training has certain advantages over training in aircraft. Simulators:

- Allow attention to be directed to key piloting tasks without use of fuel/time to fly to practice airports, gunnery ranges, etc.
- Permit accurate measurement of flight performance. Pilots can be provided immediate feedback; flight segments with which trainees are having trouble can be repeated.
- Permit schedules to be established without regard to weather, air traffic, availability of aircraft, fuel, air space, etc., all of which often hinder training in operational aircraft.
- Can provide experience in the handling of maneuvers and situations too dangerous to handle in flight training.
- Can result in great savings in costs. Cost of simulator operation is typically no more than five to eighteen percent of cost of operation of the aircraft.

### Ongoing Research

Currently, simulators of rotary wing aircraft are in different stages of development and operational use. ARI researchers are supporting the Army Aviation Center in development/use of all the following simulators:

- The UH-1 Instrument Flight Trainer. Copies of this simulator have been deployed to operational units. No simulator can be expected automatically to provide effective training; how simulators are used makes a difference. One question raised is how adequately the existing operator's guide for the UH-1 prepares the instructor to make use of the simulator.

Accordingly, ARI scientists have reviewed existing materials and analyzed the instructor's task. A course of instruction was outlined and a handbook was designed for instructors. This handbook is provided in looseleaf format, which permits insertion of pages designed for training peculiar to a particular field site. It can be used to guide instruction, or as a stand-alone reference document. The course outline will serve as a revised course of instruction to be provided by the Army Aviation Center for worldwide distribution.

However, demonstration of the training effectiveness of flight simulation continues as an Army requirement. The UH-1 simulator is the first of a family of synthetic flight training systems. Optimum training programs incorporating the latest techniques in Instructional System Development remain to be developed. There is also a need for systematic research to determine the most advantageous mix of training as between simulators and aircraft.



- CH-47 Flight Simulator. This simulator provides motion with six degrees of freedom and a visual system based on a terrain model board, viewed by a TV camera. ARI is currently evaluating the capabilities of the simulator as compared with flight in aircraft by

use of a control group of pilots trained in the aircraft only, and of a matched experimental group for which half of the training time is given in the simulator and half in the CH-47 aircraft. (Total training time for the experimental group was slightly greater than for the control group.) Average scores on post-training check rides were obtained. Scores of the experimental group were slightly higher than scores of the group trained solely in the aircraft.

- The AH-1 Simulator. Research is being conducted to evaluate the capabilities of the AH-1 simulator to train co-pilot gunners. Results of work just completed show that gunners can be trained in the simulator to fire 20 millimeter rounds, 2.75 inch rockets and the TOW missile. Gunnery skills can then be verified in the aircraft. Qualifying gunners in the simulator can result in elimination of several range missions which use live ammunition. TRADOC and the Army Aviation Center estimate a cost savings of 2.4 million dollars per year.
- Exploitation of Advanced Technology in Simulators for Training for Terrain Flight. Present means of simulation of extra-cockpit cues, which use a terrain model and TV camera, have shown their value. However, the area displayed by the terrain model is limited, and greater flexibility is desired. It appears that two technological developments—computer-generated image simulation and technical capabilities that dramatically increase TV resolution—can be applied to avoid these limitations.

ARI, working with personnel at the Army Aviation Center and PM TRADE, is involved in the development of cine movies and still pictures to provide computer-generated images of terrain. ARI will take part in experimental evaluation of the value of computer-generated imagery for training in terrain flight as compared with current methods.

### **Future Challenges**

The advent of full motion and visual system simulation in the CH-47, the AH-1, the UH-60 simulators, and those of systems under development, presents an even greater challenge in the development of cost-effective training programs. Yet

to be resolved are basic issues which concern requirements for motion, the role of kinesthetic and control movement feedback in the acquisition of helicopter flight skills, the validation and acceptance of training devices in a training curriculum and a host of questions concerned with the "how" to simulate. These issues are of equal interest to all services but the uniqueness of the Army's needs lies in the requirement to simulate flight regimes which are foreign to the other services. Expertise has, therefore, been applied in the development of simulator requirements, oriented to behavioral objectives of simulator training.

The evaluation of a night visual system, computer-generated image display has led to identification of problem areas in modification of existing systems. But in the enumeration of hardware-related R&D activities, it is easy to lose sight of an important concept which has guided recent R&D efforts: the manner in which the simulator is used is as important as its hardware configuration. Major emphasis must be placed on the assessment of performance, both by the instructor and by the machine, and on the use of the automated instructional features for existing devices to develop their full potential.

## ENGAGEMENT SIMULATION

For the last several years, ARI has been pioneering a new form of unit training—engagement simulation. Engagement simulation is based on the assumption that realistic portrayal of the tactical environment provides a superior basis for training. So far, engagement simulation has successfully simulated battles between ground units and battles between air defense crews and aircraft. In both forms, it introduces into training these important components:

- Dynamic interactions between opposing sides joined in battle.
- Simulation of weapon effects.
- After-action reviews to reinforce lessons learned during an exercise.

Both applications of engagement simulation have consistently shown learning by leaders and troops in successive exercises, accompanied by high troop motivation.

## Engagement Simulation for Ground Units

Engagement simulation was designed to overcome critical deficiencies in the traditional approach to unit training. A report of a panel headed by General Abrams pointed to the need to avoid encouraging "stereotyped drill and over-developed check-lists." It was asserted that field training should be flexible and that it should encourage new ideas to emerge and be tested.

### Evolution of Engagement Simulation

In its evolution, engagement simulation for training ground units has taken three forms: SCOPES, REALTRAIN, and MILES. The method originated with SCOPES (Squad Combat Operations Exercise, Simulated), for infantry squad training. When expanded for combined arms tactical collective training, the approach became known as REALTRAIN. In both SCOPES and REALTRAIN, damage/casualty assessment is performed *manually* by a system of *maneuver controllers*. With the introduction of eye-safe laser technology, damage/casualty assessment is more nearly *automatic*; the approach is called MILES, an acronym for Multiple Integrated Laser Engagement System, which permits the training of larger tactical units through battalion level.



### MULTIPLE INTEGRATED LASER ENGAGEMENT SYSTEM – MILES



### **Tactical Training in an Engagement Simulation Environment**

REALTRAIN simulated combat exercises are planned so that the orders given the two sides bring them in contact. Casualties inflicted or ground gained by one side represent losses to the other. During the battle, controllers on each side insure valid declaration of casualties and observe mission performance. After the battle is over, leaders and troops from both sides are brought together. In guided and lively discussions, they analyze for themselves what each unit did right and did wrong in carrying out its assigned mission, thus learning from one another. Lessons learned are made explicit to all unit members and applied in exercises that follow.

The value of engagement simulation as a method of training has been repeatedly shown in comparisons of performance of units trained by the REALTRAIN method with performance of units trained by conventional field exercises. One series of exercises which matched troops trained in conventional training with those trained by the new methods produced these results:

- Units trained by engagement simulation lost 33% of their tanks; units trained by conventional methods lost 67%.
- Units trained by engagement simulation lost 30% of their infantry; units trained by conventional methods lost 55%.
- Engagement simulation-trained units achieved .089 casualties per artillery round fired; conventionally-trained units achieved .054 casualties per round fired.

In the foregoing and in other comparisons of training methods, engagement simulation-trained units have shown superior rates of learning and have been significantly more successful than conventionally-trained units in post-training "shoot-offs." Troops and leaders who participate almost unanimously state that this training is superior to conventional training.

### **Application of Method of Behavioral Sciences**

These results have been achieved by applying known principles of learning and motivation to the dynamic simulation of combat. Experimental design and evaluation techniques have been used to assess the effectiveness of this training.

### **Products and Future Plans**

Training circulars have been prepared governing the training of cavalry and mechanized infantry units. Training circulars have also been prepared for the simulation of indirect fire (mortar/artillery) and the conduct of after-action reviews. Efforts currently under way will achieve the following:

- Provide the control system to be used in conjunction with the MILES hardware for improved tactical training.
- Help integrate engagement simulation into ARTEP—the guidance documents for unit training.
- Improve tactical unit performance assessment.

### **Air/Ground Engagement Simulation (AGES)**

An air/ground application, which pits air defense weapons—Chaparral, Vulcan, and Redeye—against helicopters, is currently under way.

### **Conduct of Training**

The Cobra attack helicopter and camouflaged air defense weapons are equipped with simulators which disclose their positions when weapons are fired. As units are engaged, controllers process firing information and declare casualties, according to realistic rules of engagement.

As with REALTRAIN and MILES, an after-action review is held in which air defense soldiers and opposing aviators exchange information as to what went wrong or right and why. Thus, mistakes and successes by each side are identified and lessons learned are put into practice in subsequent exercises.

### **Assessing the AGES Method**

As part of AGES, behavioral checklists were developed to record the performance of the opposing combat elements. Field trials showed improvement in crew performance for Chaparral and Vulcan squads. AGES-trained squads were shown to be

more proficient in employing correct tactical behaviors than were squads trained by conventional methods. AGES provided a more realistic environment for training. When squad leaders and controllers were asked how they would allocate time among alternative methods of training, they gave AGES the largest proportion of training time of any competing method. Thus, AGES provided positive effects both in performance and training method preference.

### **Future Plans**

Current plans call for preliminary implementation of AGES at the Air Defense School at Fort Bliss. AGES will then be implemented in tactical units by a mobile training team. Milestones for implementation are being established by ARI in concert by the Air Defense School and the TRADOC System Manager for Engagement Simulation.

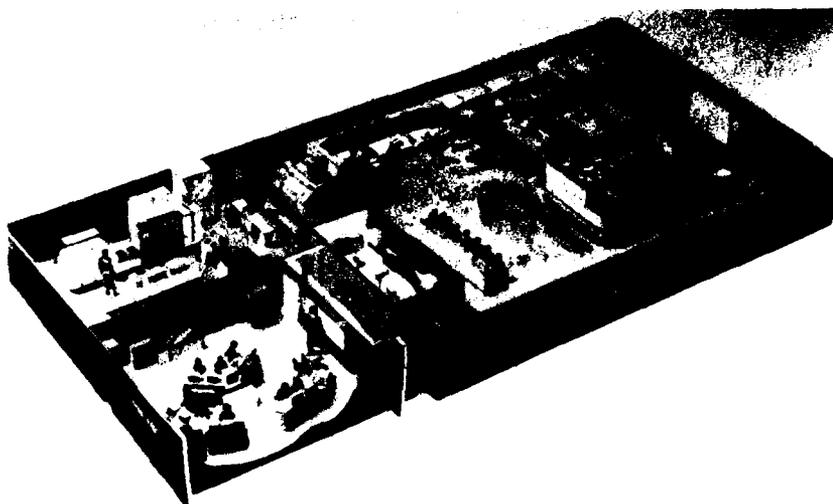
## **COMMAND STAFF TRAINING AND PERFORMANCE**

### **The Problem and Its Significance**

At battalion level and above, a most critical component of combat readiness is the performance of the commander and his principal staff. How to achieve the level of performance requisite to combat readiness in a cost-effective manner is a major Army concern. Among problems are the following:

- Commanders and staff do, of course, receive training in full-scale battalion field exercises, but this is an extremely expensive way to train. Not only must an entire battalion be fielded in order to train its staff, but a sizeable group of evaluators must be assembled and instructed.
- Command Post Exercises (CPXs) implemented by preplanned "canned" messages are somewhat artificial and permit little flexibility.
- Many important features of modern battles—air support, air defense, indirect fire, electronic warfare—are almost impossible to play realistically in battalion field exercises.

Simulation technology offers solutions to these problems. It can provide a more realistic and flexible exercise environment within which desired learning can take place without the need for frequent, costly field exercises. It can present problems with which command and staff must deal, which *cannot* be introduced in field exercises. A computer-driven battle simulation—Combined Arms Tactical Training System (CATTs), designed to exercise battalion command groups in the control and coordination of combined arms operations—was procured by the Army. Early efforts to use the simulator for training indicated that, while it did provide a viable exercise environment, the existence of the training vehicle did not guarantee an effective training system.



### Research

ARI—Fort Leavenworth, in concert with the Combined Arms Training Development Activity, attacked the problem by decomposing it into three main questions, the answers to which became research goals: “What should be trained?”; i.e., what are the major factors comprising command group effectiveness and how does performance on these factors impact on battlefield success? “How should we train?”; i.e., what are the conditions, aids, procedures and strategies which will bring about the necessary improvement in performance in the most efficient manner? “What are appropriate methods for assessing performance effectiveness and what shall be measured?”

Utilizing the CATTs battle simulation as a test bed within which these questions could be addressed (while at the same time providing training to the player group), 23 tasks were identified as being highly related to overall performance. Eleven of these tasks represent critical training needs; performance of these tasks by battalion command groups was frequently deficient.

The most critical training needs were:

**I Coordination with the Commander's Staff**

1. Identify the capabilities of the enemy
2. Gather information from all appropriate forces
3. Analyze information to predict enemy intentions

**II Planning**

1. Analyze the mission to identify the specified and implied tasks assigned to the battalion by higher headquarters
2. Plan the use of supporting artillery
3. Develop a communication plan for the mission

**III Communicate Information**

1. Disseminate intelligence to appropriate recipients
2. Communicate plans and orders to subordinate units

**IV Implementation**

1. Defeat the enemy's electromagnetic intelligence effort
2. Defend against interference with radio communications by enemy electronic warfare

**V Control**

1. Concentrate combat power at the critical time and place

In addition, improved performance measurement and performance feedback methods were developed for each staff position.

## **Future Work**

**Research is taking several directions concurrently:**

- **Incisive studies are being conducted on the battalion command as a communication system. Emphasis is on objective measures of communication effectiveness and identification of errors.**
- **Recurrent events across missions are being identified to better define generic task requirements.**
- **Currently, staffs must travel to Fort Leavenworth for training. Experience is being accumulated using player unit controllers rather than professional controllers, with the primary purpose of making the capability exportable to units at their home stations. In addition, stress will be placed on training player unit controllers.**

## **Utilization**

**This work represents a joint effort between ARI and the Combined Arms Training Development Activity. Based on better diagnosis, feedback of performance is provided to the commanders/staffs in training. Summations of recurrent deficiencies across staffs provide information to schools as to where instructional emphasis is needed. This information is also exploited in the design of simulations for training of brigade and division staffs. Finally, this accumulated experience provides guidance for specifying characteristics needed in developing and employing simulators.**

## SUMMARY

The foregoing pages have described some 40 research efforts selected from ARI's 150 work units under the headings of Human Factors, Education and Training, Personnel and Manpower, and Simulation. <sup>HAVE BEEN DESCRIBED</sup> The reader will note that the work described is most diverse. Potential applications of people research are almost infinite. It is also noteworthy that ARI research is in various stages of development. Some projects are beginning; others have produced and continue to provide products being used by Army agencies.

The forces which dictate research requirements and drive research are but partially subject to control by this nation. We are confronted by the need to maintain a rough parity with armed forces of Warsaw Pact nations. Meanwhile, we must be ready to satisfy other international treaty commitments. International tensions drive research and development of military hardware which must be integrated into ever more powerful military systems. These systems, in turn, represent evolutions that must be anticipated, solidified, and tested. Results must then be incorporated into doctrine, training materials modifications of systems and procedures, and development of simulators for training so as to fully integrate hardware and human capabilities in total system approaches. In an international arms race, hardware developments are never-ending; people research must keep up. Finally, as more powerful and complex systems must be operated and maintained, manpower projections point to future problems of finding and keeping the dedicated personnel needed to man Army units.

These problems and issues described above come to ARI as givens. ARI's rules in response are to: (1) maintain and keep updated an institutional memory, (2) translate issues and problems into researchable projects, (3) conduct these projects through in-house and contractor efforts, <sup>AND</sup> (4) aid and assist the Army in utilization and refinement of research products. ←

A comprehensive listing of all research products from 1941 to the present is now available. Your inquiries to ARI for this document or further detail will be welcomed.