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A STUDY OF EFFECTIVENESS OF INFANTRY SYSTEMS: TRAINING EFFECTIVENESS ANALYSIS, COST AND TRAINING EFFECTIVENESS ANALYSIS, AND HUMAN FACTORS IN SYSTEMS DEVELOPMENT AND FIELDING

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Ongoing programs of research were summarized in the areas of Training Effectiveness Analysis (TEA) for Infantry weapons systems, Cost and Training Effectiveness Analysis (CTEA), systems development and evaluation technology, Infantry soldier development, Military Operations on Urbanized Terrain (MOUT) requirements for sustained military operations, development and evaluation of a low-cost Multipurpose Arcade Combat Simulator (MACS), and problem analysis of map reading and land navigation. Major research products, several of which were implemented Army-wide, have been highlighted.

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Item 19 (cont'd)

Military Operations on Urbanized Terrain
Multipurpose Arcade Combat Simulator
projectile location technology
rifle marksmanship training
simulation
sustained operations
Training Discharge Program
~~Training Effectiveness Analysis~~
unit rifle markmanship

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A STUDY OF EFFECTIVENESS OF INFANTRY SYSTEMS: TRAINING EFFECTIVENESS ANALYSIS, COST AND TRAINING EFFECTIVENESS ANALYSIS, AND HUMAN FACTORS IN SYSTEMS DEVELOPMENT AND FIELDING

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A STUDY OF EFFECTIVENESS OF INFANTRY SYSTEMS: TRAINING EFFECTIVENESS ANALYSIS, COST AND TRAINING EFFECTIVENESS ANALYSIS, AND HUMAN FACTORS IN SYSTEMS DEVELOPMENT AND FIELDING

INTRODUCTION

This final report summarizes the research support provided by the Mellonics Systems Development Division of Litton Systems, Inc. to the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) during the period 1 May 1980 through 22 May 1984 under Contract Number MDA 903-80-C-0345.

During this period, the research supported ongoing ARI research programs relating to Training Effectiveness Analysis (TEA) for Infantry Weapons Systems, Cost and Training Effectiveness Analysis (CTEA), Systems Development and Evaluation Technology, Infantry Soldier Development, Military Operations on Urbanized Terrain (MOUT), Requirements for Sustained Military Operations, Development and Evaluation of a Low-Cost Multipurpose Arcade Combat Simulator (MACS), and Problem Analysis of Map Reading and Land Navigation. A complete listing of reports of research performed is provided at the end of this report.

TRAINING EFFECTIVENESS ANALYSIS FOR INFANTRY WEAPONS SYSTEMS

Evaluation of the Basic Rifle Marksmanship (BRM) Program of Instruction (POI)

The requirement of this task was to evaluate the BRM POI developed by Litton Mellonics under contract number DAHC 19-77-C-0011. In order to assess the effectiveness of this program, record fire scores were collected before and after its implementation within a training brigade at Fort Benning, Georgia (Osborne, Schroeder, & Heller, 1980).

An analysis of company average scores obtained on the record fire course indicated that marksmanship performance increased significantly ($p < .001$) following program implementation. Due to these findings, the BRM POI was approved for adoption at all Army Training Centers by the U.S. Army Infantry School (as proponent).

Development of an Advanced Rifle Marksmanship (ARM) POI

Building upon the previously developed BRM program, fully implemented at all Army Training Centers conducting Initial Entry Training, this task required the development of a follow-on ARM program to provide training in the additional rifle marksmanship skills critically needed by Infantrymen. The ARM program existing in 1981 was analyzed and three major problems were identified: (a) limited scope of training, (b) inappropriate automatic fire and night fire training, and (c) inadequate feedback (bullet location information).

An extensive analysis of Army Training and Evaluation Programs was performed for both the Infantry (ARTEP 7-15) and the Mechanized Infantry (ARTEP 71-2). This analysis attempted to identify the most important marksmanship skills required by Infantrymen, but which had not been taught in the BRM program. A revised ARM training program was then developed which reduced the extent of automatic fire training, made the conduct of night fire training more appropriate, and added new periods of instruction in three areas: quick fire, rapid semi-automatic and suppressive fire, and moving target engagement (Evans & Schendel, 1984). This program was implemented for field testing in 1982 at Fort Benning, Georgia, as part of the Infantry One Station Unit Training (OSUT) POI, and it was adopted by the U.S. Army Infantry School (as proponent). However, while the new POI represents improved ARM training, more revisions are deemed necessary.

Development of a Rifle Marksmanship Training Program for Units

The requirement of this task was to improve the effectiveness of M16A1 rifle marksmanship training in U.S. Army units, through the development and evaluation of a unit rifle marksmanship training program compatible and integrated with BRM and ARM instruction. Based upon modifications in BRM and ARM training made as a function of previous research, a training program was developed to be used by combat, combat support, and combat service support units of the Active and Reserve Components (Osborne, Evans, Lucker, & Williams, 1982). While allowing for flexibility among units with a wide range of training priorities, time, and resources, the program was designed to both reinforce and further develop those marksmanship skills taught in BRM and ARM.

Critical components of the unit program were informally evaluated in a series of field tests conducted with selected units at Forts Benning, Bragg, and Riley. Using marksmanship performance measures obtained during a U.S. Army Forces Command competitive exercise, substantial increases in shooting performance were demonstrated after less than eight hours of instruction. As a major part of this effort, the rifle marksmanship training material introduced in Change 3 to Field Manual 23-9, M16A1 Rifle and Rifle Marksmanship (1974), was developed to be used as the primary document for the development and implementation of rifle marksmanship programs within units Army-wide.

Further Development and Implementation of Rifle Marksmanship Training

The overall marksmanship research program led to the implementation of an integrated set of three training programs: basic, advanced, and unit rifle marksmanship programs of instruction. Due to the time lag between program development and the delivery of training support materials to trainers in the field, implementation problems occurred. The major requirement of this task was to further develop and implement BRM, ARM, and unit rifle marksmanship training programs.

Evans and Osborne (1983) summarized the major products of research on M16A1 rifle marksmanship training conducted between 1978 and 1983, including research designed to identify problems existing in marksmanship training and to evaluate promising solutions to these problems. Efforts which supported the implementation process were documented in the areas of equipment research, target design, range modification, training aids and devices, and instructor training. Evans and Osborne (1983) also summarized the major problems remaining to be resolved if fully effective marksmanship training is to be realized.

Although not formal contract requirements, two articles written for Infantry magazine that are related to this task objective are worthy of note. First, Smith and Osborne (1981) presented a non-technical summary of ARI's marksmanship research since 1976, with emphasis given to the rationale for the major changes in the revised BRM POI. This article was used as a vehicle to deliver marksmanship information to trainers in a timely fashion. Second, Osborne (1981) discussed the advantages and disadvantages of the M16A1 rifle and presented the results of several firing tests. He concluded that the M16A1 rifle has no serious shortcomings and that it is a capable weapon worthy of a soldier's confidence.

The Basic Rifle Marksmanship Shooter's Book is a pocket-sized booklet developed for the use of the initial entry soldier (Heller, Thompson, & Osborne, 1981). Its purpose was twofold. First, it provides the soldier with a reference to read and study as questions arise pertaining to any portion of BRM training. Second, it can be used to record one's marksmanship performance and progress during BRM. The location of hits and misses can be recorded on reduced copies of all BRM paper targets, while scorecards are provided for all periods in which pop-up targets are used. It is believed that more effective remedial or reinforcement training can be provided to those soldiers who have kept accurate records in this booklet, which is currently being used at a number of Army Training Centers.

As part of an assessment of the potential usefulness of training devices for increasing marksmanship performance, an experimental evaluation of the Superdart projectile location system was conducted using Australian soldiers as test subjects (Smith & Osborne, 1981). This system is a live-fire target device that electronically detects and locates the position of a passing supersonic projectile and displays its precise location to the firer via a video display unit. Projectile location is accurately determined, whether a target is hit or completely missed.

Experimental versus control comparisons were made of the ability of soldiers to hit both stationary and moving targets equipped with the Superdart system. Experimental soldiers received the detailed and timely location feedback from Superdart. In contrast, control soldiers were given only the hit or miss feedback that is normally available from killable pop-up targets. Despite both groups of soldiers having exhibited very high hit rates during pretest measurements, a significant performance increase was found when Superdart feedback was introduced during stationary target firing ($p < .05$). A similar, though statistically insignificant, trend was found in the results of the moving target firing.

Because the Superdart system can sequentially detect and plot up to ten shots fired in the automatic mode, and because it is possible to detect misses that are as far as five meters from the target, the system could be used for training and evaluating suppressive, night, protective mask, and assault firing techniques. In summary, Smith and Osborne (1981) concluded that the Superdart equipment demonstrated potential usefulness in three areas:

1. It can assist both students and instructors by providing the precise and timely feedback necessary for the effective acquisition of marksmanship skills.

2. It can be used to develop information about what to train and how to accomplish that training (e.g., determining the best way to engage a target with automatic fire).

3. The system could be used as a measurement instrument for evaluating the performance of weapons, ammunition, and equipment.

Assessment of Army Training Requirements for a New Rifle

The requirement of this task was to assess Army training requirements for a new rifle, partly based upon an analysis of the eight major features of the M16A2 rifle that distinguish it from the M16A1 rifle. The M16A2 rifle is the result of a Product Improvement Program (PIP) and was type classified in 1982. It is currently being produced by Colt Industries for the U.S. Marine Corps and the U.S. Army.

Osborne (1983) outlined the contrasting marksmanship training philosophies employed by the Army and Marine Corps and their relationship to characteristics of the M16A2 rifle. In particular, Army requirements were discussed in detail from a training development perspective and recommended rifle improvements considered optimum for Army use, while simultaneously meeting Marine Corps requirements, were presented. From an Army training development perspective, the M16A2 rifle which was type classified appears to have 22 major disadvantages, 10 of which likewise apply to the M16A1 rifle. For this reason, a list of recommended Army rifle features was developed which reflects training development considerations and which appears to have the highest probability of resulting in optimum combat performance.

Development of Means to Improve Implementation/Utilization of Training Programs

The requirement of this task was an attempt to improve the implementation and utilization of M16A1 rifle marksmanship training programs. A primary problem in obtaining and sustaining improvements in training is inadequate information availability due to remote training locations, instructor shortages, and a rapid turnover of trainers. For this reason, two instructional videotapes for rifle marksmanship trainers were developed to facilitate the implementation and sustainment of training programs at Army Training Centers and in units.

"Teaching Rifle Marksmanship: Part One" presents topics such as rifle marksmanship fundamentals and preparatory marksmanship training (Evans, 1984). "Teaching Rifle Marksmanship: Part Two" covers live fire training, shot group analysis, diagnosis of shooting errors, and remedial training (Evans, 1984). Copies of each videotape are scheduled to be delivered to each Training and Audiovisual Support Center (TASC) Army-wide in late 1984.

Development of a Unit Rifle Marksmanship Training Guide

The comprehensive Unit Rifle Marksmanship Training Guide, designed to assist units in planning and conducting an effective rifle marksmanship training program, was developed to fulfill this task requirement (Osborne & Smith, 1984). Containing 46 sections, most dealing with a separate rifle marksmanship topic, this research product provides guidance for training developers and instructors of BRM, ARM, and unit marksmanship.

A unit marksmanship program must include consideration for individual and collective firing proficiency. The individual portion of the marksmanship program should be designed to insure skill retention and improvement, whereas the collective portion of the program should be focused on the application of those skills in a group environment, such as an ARTEP squad firing mission. The majority of the material in the Unit Rifle Marksmanship Training Guide is directed toward individual tasks developed from a detailed analysis of rifle requirements necessary to accomplish unit combat missions. Therefore, accomplishment of the suggested individual rifle tasks will provide a high probability that, with minimum training in fire distribution and fire control, units can deliver effective rifle fire in combat.

The Guide was organized in modular form to assist a unit in developing its own unique training program. Each section can be pulled out and used as the major reference document for a primary period of training or as a concurrent training topic during other training. The Guide does not include detailed specifications for subjects, hours, and ammunition appropriate for a unit. Rather, it provides the information necessary for each unit to develop its training program based upon training status, mission requirements, and the availability of time, facilities, and ammunition. As proponent for rifle marksmanship training, the U.S. Army Infantry School has accepted the Guide for publication as a Field Circular for distribution to units Army-wide.

COST AND TRAINING EFFECTIVENESS ANALYSIS

No methodology exists for Cost and Training Effectiveness Analysis (CTEA) that is generalizable to all U.S. Army systems and nonsystems, and goes beyond the acquisition phase of systems to include the analysis of fielded systems. The requirement of this task was to determine how this need could be met through extension, development, or refinement of current methods.

Rosen, Berger, and Matlick (1981) refined and extended a previous literature search, especially to include studies conducted to determine the cost and effectiveness of Training Extension Courses (TEC). Because the authors found no current CTEA model or methodology that could be modified for developing and fielded systems, as well as for system and nonsystem training, a systematic approach to Training Effectiveness Analysis (TEA) for multiple purposes was developed. This approach considers application of the following submodels: CTEA for developing systems, Instructional System Development (ISD), training evaluation for nonsystem training, initial screening training effectiveness analysis for fielded systems, training subsystem effectiveness analysis for fielded systems, and training developments study. Methods are available for accomplishing the processes embedded in some of these submodels.

For other submodels, the required processes have been identified, awaiting the development of specific methods.

These findings, especially the systematic approach to identifying the appropriate CTEA submodel for a given problem, will be useful to training developers and researchers in this area. Detailed methods for performing some of the new submodels developed in this effort await their application, and subsequent codification by these analysts and researchers.

SYSTEMS DEVELOPMENT AND EVALUATION TECHNOLOGY

An Initial Analytic Process Model for System Measurement

Testers, analysts, and researchers too often use an incomplete or inappropriate set of human performance measures in evaluating human-machine systems. Because there is no verified analytic process for deriving the optimal measures of a system's performance or effectiveness, assessment needs are difficult to define and the process is relatively haphazard. For this reason, the primary requirement of this task was to produce an initial model of the conceptual and analytic procedures necessary for the determination and development of fully adequate systems effectiveness measurement.

Initially, over 250 documents were reviewed in a comprehensive search of the manned systems measurement literature (Edwards, Bloom, Oates, Sipitkowski, Brainin, Eckenrode, & Zeidler, 1981). Based on this review, the state of the art of manned systems measurement was assessed (Edwards, Bloom, & Brainin, 1981). Measurement capabilities and limitations were identified, so that requirements and priorities for the improvement of systems-oriented measurement could be delineated. The authors concluded that measurement models need to be further developed, supported with appropriate human performance data, refined through more consistent and comprehensive applications, and validated by independent corroboration. An initial analytic process model was then developed, based on an extension of the Systems Taxonomy Model (Bloom, Oates, & Hamilton. 1981).

An Analytic Process Model For Systems Design and Measurement

The requirement of this task was to further develop the Analytic Process Model (APM) and demonstrate its application to the analysis and evaluation of training systems. Bloom, Oates, Hamilton, and Leaf (1982) developed the APM in greater detail and demonstrated its application to the Bradley Infantry Fighting Vehicle training system. The use of the APM as a design tool for the specification of training systems required to support developing systems was also explored. This design application of the APM was examined in the context of a training system for a newly planned U.S. Army 9mm handgun. In addition, a sample application of the APM was programmed on an Apple II microcomputer, in order to demonstrate an ability to automate the routine procedures as an interactive analytic process.

The APM enables testers, analysts, and researchers to define system factors, or taxonomies, and to translate them into system measures or design requirements. The model forces one to describe the system of interest and its human elements to provide a more complete set of system-human attributes pertinent to system effectiveness. Further, the APM aids users by providing general "menus" of factors (taxa) and procedures to help translate those taxa into appropriate measures or design requirements.

Development of a Computer-Aided Analytic Process Model

The requirement of this task was to develop a computer-aided APM to provide a routinized, thorough, adaptive, and efficient procedure to help produce evaluation measures for any planned or existing training system. Bloom, Oates, Shapiro, and Hamilton (1983) produced a procedural outline and demonstration package of a computer-aided APM for deriving training systems measures. Programmed in PASCAL, the demonstration model uses an Apple II+ microcomputer with two 5-1/4 inch disk drives. It is designed to help analyze performance requirements and develop effectiveness measures for training systems. The analyst chooses from the computer's data base of recommended options or creates new options at each branch in a series of nested sets. Special instructions and help to guide the analyst through the model are available on-line and in a separately produced operations handbook (Shapiro, Bloom, & Oates, 1983). Hard-copy printouts of selected options are available immediately upon request at key stages in the analytic process.

The APM will enable testers, analysts, and researchers to routinely define sets of system performance requirements and to translate them into system effectiveness measures. It complements ISD methods by facilitating the front-end analysis of training systems. Further, the APM appears to be complementary with the Early Training Estimation System (ETES), various methods for Logistic Support Analysis (LSA), and the Human Resources Test and Evaluation System (HRTES).

INFANTRY SOLDIER DEVELOPMENT

The transition from civilian life to Initial Entry Training can be a difficult adjustment for some young Americans. In order to assist in the adjustment process, the U.S. Army provides both performance counseling and personal counseling. The requirement of this task was to evaluate the need for counseling among successful OSUT trainees and Training Discharge Program (TDP) attrites.

Structured interviews were given to 149 successful trainees and 57 TDP attrites (Schroeder, Grunzke, Slimowicz, Kemery, & Williams, 1981). The interview was designed to evaluate the current needs for both performance and personal counseling and whether those needs were being met. It also assessed the frequency of various types of problems and who the trainees preferred as counselors for those problems. Embedded in the interview was an experiment designed to determine whether subtle psychological biases might be influencing the interview results (i.e., subtle biases might exist simply due to the success or failure of the person being interviewed). In addition, less formal unstructured interviews were given to the TDP attrites in an effort to gain insights into the nature of the TDP population and to try to determine if more counseling might have prevented the discharge.

Findings indicated that both groups felt a substantial amount of performance and personal counseling was being provided, although both groups felt more performance and personal counseling was needed. Both groups expressed a need for more performance counseling, feedback about how they were doing, than for personal counseling. Results indicated a large range in frequency of occurrence for 22 selected problems and that counselor preference was dependent on the type of problem.

Information presented in this report has significant implications for Army counselors in the OSUT setting. Although it is questionable whether providing more counseling in OSUT would substantially reduce attrition, providing more counseling might increase morale. Knowledge of which problems occur most frequently and who the preferred counselors are should assist the Army counselor in deciding which counseling approaches are most appropriate. Similarly, such information should assist Army trainers in deciding which counseling methods best fit a given instructional program.

MILITARY OPERATIONS ON URBANIZED TERRAIN (MOUT)

The continued growth of urbanized areas worldwide, especially in Western Europe, has focused increasing military emphasis on fighting in, around, and through urbanized terrain. Conducting operations in an urban environment requires special training and planning procedures. For this reason, the requirement of this task was to conduct a comprehensive review of U.S. MOUT training and doctrine.

Reiss, Perkins, Evans, McFarling, and Nadler (1983) reviewed existing U.S. doctrine for MOUT, observed institutional and unit training, administered questionnaires to soldiers and instructors in OSUT, and conducted interviews with knowledgeable personnel at all levels within the Army. In addition, U.S. MOUT training and doctrine was compared to that of its European allies. The authors concluded that numerous researchable problems exist in the MOUT area. For example, there is a need for updated doctrine based on operations analysis and a need to determine the optimum map scale for MOUT operations. The incorporation of live fire training should be explored, while the use of Multiple Integrated Laser Engagement System (MILES) equipment is expanded. Urban terrain analysis and training capable of being conducted without a MOUT facility need greater emphasis. A detailed task analysis of MOUT should be conducted and the role of snipers needs to be more closely examined. Further, the need exists for developing Command Post Exercise/Field Training Exercise (CPX/FTX) MOUT scenarios and for studying the cost effectiveness of simulation as an alternative training method. Weapons and equipment most suitable for MOUT should also be identified and evaluated.

The findings of this research effort represent an overall view of existing MOUT training and doctrine. They can form the basis for a specific research project or a revision in current training procedures. In addition, research products were provided to the USAIS for their consideration and use in further training developments for MOUT.

REQUIREMENTS FOR SUSTAINED MILITARY OPERATIONS

The U.S. Army must be prepared to fight an intense and sustained war. Episodes of sustained combat have occurred in the past and could be more likely in the future, due to technological advances and the combat readiness of Threat forces. The requirement of this task was to review existing literature and to define researchable problems related to sustained operations training for infantry soldiers and units.

Perkins (1982) conducted a comprehensive review of sustained operations literature that included combat-related literature, laboratory and field studies of the effects of sleep loss on performance, reports on sustained operations in combat, and U.S. Army doctrine as primary sources of information. The literature review revealed performance considerations related to tough and realistic training, readiness for special battlefield conditions, morale, group cohesion, communications, physical readiness, and leadership. Approximately 50 researchable problems were identified that can be classified into at least one of the following training goals:

1. Insure that soldiers and units have the skills required to successfully conduct military operations for prolonged periods.

2. Create conditions in training that are as similar as possible to combat.

3. Challenge soldiers both mentally and physically.

4. Build methods of coping with fatigue and stress as soldiers learn the limits of their endurance.

Although U.S. Army doctrine recognizes the requirement to prepare for sustained operations, training has been addressed in an informal manner. For this reason, Perkins (1982) has outlined a recommended research plan to aid in formalizing training necessary to successfully conduct sustained operations.

DEVELOPMENT AND EVALUATION OF A LOW-COST MULTIPURPOSE ARCADE COMBAT SIMULATOR

The Multipurpose Arcade Combat Simulator (MACS) is a prototype simulator developed by ARI. The MACS system consists of three components: an inexpensive microcomputer, a video monitor, and a light pen attached to a demilitarized weapon. Research in this task was conducted to refine the existing M16A1 MACS system, extend its concept to other Infantry weapons, and evaluate its usefulness in training.

Applicability of Low-Cost Video Training to Various U.S. Army Weapons

The requirement of this task was to produce a list of representative U.S. Army weapons rank ordered in terms of their suitability for low-cost, microcomputer-based, video simulation/training. Perkins and Schroeder (1983) conducted a two-stage investigation to produce a rank-ordered list of suitable weapons. In the first stage, a comprehensive list of weapons was compiled and then sorted using a decision tree to produce a limited list of the most likely candidates for MACS-type simulation. In the second stage, this limited list of weapons was rated using four criteria: (1) number of hours spent training on that weapon in Infantry OSUT, (2) cost of ammunition, (3) weapon density in the Infantry, and (4) the feasibility and desirability of creating a MACS application for that weapon. The first three criteria were determined from existing objective information. In order to determine values for the fourth criterion, a structured interview was developed and administered to subject matter experts who were asked to rate the appropriateness of MACS-type training for the different weapons. Finally, a literature review was conducted to determine whether any other low-cost simulation systems currently exist.

Perkins and Schroeder (1983) found the following weapons to be the most suitable for MACS-type simulation/training, ranked in order of decreasing suitability: (1) M16A1/A2 rifle, (2) M72A2 light antitank weapon (LAW), (3) M203 grenade launcher, (4) M60 machinegun, (5) Dragon, (6) TOW, (7) .45 caliber pistol, (8) M249 squad automatic weapon (SAW), (9) M202A1 FLASH, and (10) .50 caliber machinegun. The literature search for information on currently available simulators identified several very expensive systems, but none in the price range of MACS ($3,000 - $6,000). Based on the results of this investigation, the three most suitable weapons were selected for MACS development and subsequent evaluation.

Preliminary Evaluation of the Light Pen as the Key Component in a Microcomputer-Based Simulator

The key hardware component in MACS is a light pen that reads the raster scan on the video monitor and provides the microcomputer with X and Y co-ordinates signifying where the light pen was aimed at a precise moment. The requirement of this task was to conduct a preliminary evaluation of the effects of certain variables on the reliability of the light pen.

Schroeder and Cook (1983) assessed the effects of screen color, screen brightness, light pen sensitivity adjustment, distance to the screen, ambient light, glare, location on the screen, equipment warm-up, and trigger switch closure on the reliability of light pen readings. The reliability of the light pen was found to vary widely depending on the conditions of the test. The most important finding was an interaction between screen brightness and location on the screen in their joint effect on light pen reliability. In contrast, reliability was found to be unaffected by some of the variables (e.g., ambient light and trigger switch closure). Results of this evaluation provide valuable information about the hardware and software changes needed to maximize the reliability of the MACS system.

Preliminary Evaluation of the Multipurpose Arcade Combat Simulator

The requirement of this task was to perform limited experimental evaluations of MACS configured for the M16A1 rifle, M203 grenade launcher, and M72A2 light antitank weapon. Computer training programs were written for each configuration and field tested using soldiers in OSUT (Perkins, Selby, Broom, & Osborne, 1984). The primary dependent variable was the live-fire performance of the experimental group (MACS training and regularly scheduled training) compared to the control group (regularly scheduled training only). Additionally, an opinion questionnaire was administered to the experimental group to obtain subjective reactions to MACS training.

It was found that MACS training, when given prior to live-fire instruction, may give soldiers a head start in the acquisition of marksmanship skills. In the MACS evaluations with the M203 and M72A2, which limited training to a brief exposure prior to live firing, there was a trend for the experimental groups to hit more targets and to place live rounds closer to the center of mass of the target, especially on distant targets. For the M16A1 evaluation, there were several significant training effects found within MACS performance, but the live-fire performance of the experimental group did not differ significantly from that of the control group. Soldiers in the experimental groups reported on the opinion questionnaire that MACS training was very interesting and helpful, and preferable to traditional concurrent training.

Results of this investigation indicated that MACS has potential to become a cost-effective training device. It could contribute to a more favorable learning environment by providing standardized instruction, one-on-one instruction, and a motivating head start to live-fire training. Since the results indicated that the effectiveness of MACS may vary as a function of exposure schedule, further development and investigation was recommended to determine the most appropriate stage of training to use MACS, and the amount of time needed to impart an effect.

Software Products

An integral part of MACS development and evaluation was the creation of a variety of software products. Software disks and associated subroutine hardcopy listings were produced for the M16A1 rifle, M203 grenade launcher, and M72A2 light antitank weapon MACS systems. Specifically, MACS M16A1 rifle system disks and text files were produced for the following programs:

1. steady position and aiming - pretest and posttest
2. steady position and aiming training
3. down range feedback
4. field fire I
5. field fire II
6. record fire

These M16A1 rifle computer programs are each compatible with training objectives in BRM. A text file was also created to mechanically zero the rifle/light pen for each soldier. In addition, a computer program was produced for the MACS M203 grenade launcher. Similarly, a system disk and text files were produced for the MACS M72A2 light antitank weapon. Detailed descriptions of all MACS software products have been provided by Perkins, Selby, Broom, and Osborne (1984).

PROBLEM ANALYSIS OF MAP READING AND LAND NAVIGATION

Land navigation is a fundamental military skill for every soldier. Over the last several decades, however, the intensity of land navigation training in the U.S. Army has declined, resulting in several generations of soldiers lacking proficiency in basic map reading and land navigation skills. In 1982, ARI was tasked by the Chief of Staff of the Army to conduct research to improve Army-wide instruction in map reading and land navigation. In partial response to this mission, one requirement of this task was to critically analyze existent land navigation responsibilities, doctrine, materiel, and training within the U.S. Army, other U.S. services, and selected foreign armed forces. Based on information derived from this analysis, a second requirement was to identify potential improvements to be recommended for development and implementation.

Salter and Schendel (1984) conducted a comprehensive problem analysis of institutional and unit land navigation training based on data obtained from the following sources:

1. a literature review
2. structured and unstructured interviews
3. questionnaires administered to instructors and subject matter experts
4. on-site observations of training and performance
5. participation in training

The review of relevant land navigation literature provided broad background information necessary to conduct the problem analysis. Hundreds of documents were reviewed, including:

1. Army Regulations
2. TRADOC Regulations, Bulletins, Pamphlets, and Training Circulars
3. Field Manuals
4. military journals
5. reports of Department of Defense sponsored research
6. behavioral science journals
7. books from commercial publishers

Salter and Schendel (1984) concluded that the present shortfall in land navigation performance has multiple causes requiring multiple lines of attack. Eighteen problems were identified in the analysis in the areas of doctrine, materiel, and training. Nineteen near-term recommendations and thirteen long-term recommendations were presented. The final report of this research represents a comprehensive data base for establishing action priorities and directions for future work on proposed problem solutions. Results of the problem analysis of map reading and land navigation have been presented to the headquarters of the Army Research Institute (ARI), the Training and Doctrine Command (TRADOC), and the U.S. Army Infantry School (as proponent).

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