Research Note 87-34

Multipurpose Arcade Combat Simulator (MACS): Year Two Report

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This research effort was focused on three major areas of further research and development of the Multipurpose Arcade Combat Simulator (MACS): (1) hardware modifications of the MACS M16A1 rifle and its component parts; (2) software development for Advanced Rifle Marksmanship (ARM) skills with the M16A1 rifle; and (3) evaluation and refinement of existing MACS Basic Rifle Marksmanship (BRM) programs. Hardware modifications involved improvements to the light pen, light pen mount, and trigger switch. Development of MACS software programs -
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involved the Light Antitank Weapon (LAW), trigger squeeze, and ARM. A major redesign of the BRM diagnostics program was completed.

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MULTIPURPOSE ARCADE COMBAT SIMULATOR (MACS): YEAR TWO REPORT

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Introduction

The first year (September 1984 - September 1985) of the Multipurpose Arcade Combat Simulator (MACS) program effort conducted under contract MDA 903-84-C-0396 utilized current and emerging technology to provide a microcomputer-based part-task simulator that would be sufficiently flexible to meet the needs of multiple weapons training requirements. Based on the recommendations of Perkins and Schroeder (1985), preliminary programs for the M16A1 rifle, M72A2 Light Antitank Weapon (LAW), and M203 Grenade Launcher were developed during Year One. The major thrust of software development during this time period was devoted to the Basic Rifle Marksmanship (BRM) training needs for the M16A1 rifle. In addition, one training program was developed for Advanced Rifle Marksmanship (ARM) in response to an ongoing research effort evaluating the use of special training devices, such as MACS, in training moving target engagement.

An additional area of interest explored the training utility and feasibility of integrating existent videodisc technology with the MACS system. This area was investigated using the U.S. Army's Interim Electronic Information Delivery System (EIDS), based on a Sony SMC-70 microcomputer and a Sony LDP-1000A Laser Video Disc Player, with existing MACS hardware and software configurations. Investigation of this question revealed several key problems that precluded further research in this area: (1) software availability and cost, (2) future standards for EIDS were projected to be for an MS DOS microcomputer, and (3) the poor cost to training benefit ratio of EIDS. Thus, further research in this area was discontinued during Year Two.

Research and development of MACS during Year Two focused on three major areas: (1) hardware modifications of the MACS M16A1 and its component parts, (2) software development for ARM skills for the M16A1 rifle, and (3) evaluation and refinement of existing BRM programs. Hardware modifications for the MACS M16A1 were undertaken to improve the durability of the training weapon, the light pen mount and the light pen, and to standardize components used in the manufacture of each MACS rifle. Evaluation and modification of programs were performed for the M16A1, the M72A2 LAW, and the MK19 40 mm machine gun. The M203 Grenade Launcher program was evaluated as being adequate for current training requirements. Software was developed for ARM skills with the M16A1 rifle for suppressive fire, rapid fire, night fire, and quick fire. Furthermore, additional diagnostic features were developed and incorporated into the moving target program.

A hierarchically organized ARM moving target program was developed with three levels of proficiency. Level One is a diagnostics program which requires the firer to engage single stationary targets at ranges from 50 - 300 m. The firer has to meet a predetermined performance gate in order to progress to Level Two. Level Two presents single exposure moving targets at various speeds and ranges. Level Three includes an attack/retreat scenario which contains single and multiple exposures of both stationary and moving targets. A detailed summary of all MACS development completed during Year Two is given in the following sections of this report.

MACS Hardware Modifications

Initial hardware development of MACS involved experimentation with various components in order to evaluate the overall design of the M16A1 training weapon. The first year of MACS research indicated that the following problems warranted further research and development during Year Two of the contracting period: (1) standardization of a suitable switch and switch mount assembly for the trigger mechanism, (2) improvement of the light pen and light pen mount, and (3) improvement of the durability of the weapon. During the initial development of MACS, several types of trigger switches and switch mounts were installed in the M16A1. Those switch components required either modifications to the trigger assembly or to the lower receiver. That in turn, resulted in inconsistent trigger weight that did not accurately simulate the trigger pull of an actual weapon. In order to alleviate the various problems associated with the trigger, an effort was made to determine the availability of an off-the-shelf component that was durable, easily mounted, and if possible, able to simulate the trigger pull in weight, travel, and action of the actual weapon. A number of switches were tested over a three-week period before such a switch was identified. The switch is a single pole, single throw switch manufactured by Arrow-Hart (model #83090C) and is readily available through electronics distributors. The switch assembly can be easily mounted in the upper receiver of the training weapon so that the push button of the switch extends down into the lower receiver allowing the trigger, when pulled, to depress the switch and complete the electrical circuit (see Figure 1). This switch configuration allows all electronic components and wiring to be located in the upper receiver of the weapon thereby precluding any modifications of the lower receiver. Furthermore, use of this switch provided a trigger that closely simulated the weight, travel, and action of the actual M16A1 service rifle. The trigger weight was tested by the U.S. Army Marksmanship Unit at Fort Benning, Georgia and was found to be 7.25 lbs. This development represents a significant improvement over previous trigger configurations in terms of standardized components, realism, and cost.

Early versions of the optically-enhanced light pen consisted of a metal light pen barrel supported by rubber rings located inside a 12-inch plastic tube with a single convex lens mounted on the end of the plastic tube. The focal length of the light pen was adjusted by moving the light pen barrel back and forth inside the plastic tube until reliable readings were produced. Once reliable readings were obtained, the light pen barrel was secured in place by tightening a single set screw located halfway along the plastic housing. With the focal length of the light pen set, the sensitivity of the light pen had to be adjusted by turning the trim potentiometer located at the rear of the plastic housing. As with the focal length adjustment, this was a trial and error procedure until constant reliable readings were obtained from all areas of the monitor screen. After completion of these adjustments, the light pen was mounted on the M16A1 training weapon by securing it with a metal hose clamp approximately two and one half inches in diameter to a molded plastic block placed on the barrel of the weapon. The light pen was aligned to the sights using a calibration program which determined the precise point on the monitor screen where the light pen was aimed and checked that these readings fell within an acceptable range. If the readings were unacceptable, then the light pen had to be moved physically on a trial and error basis. As with other adjustments of the light pen, calibration adjustments to the light pen could best be described as crude and time consuming.

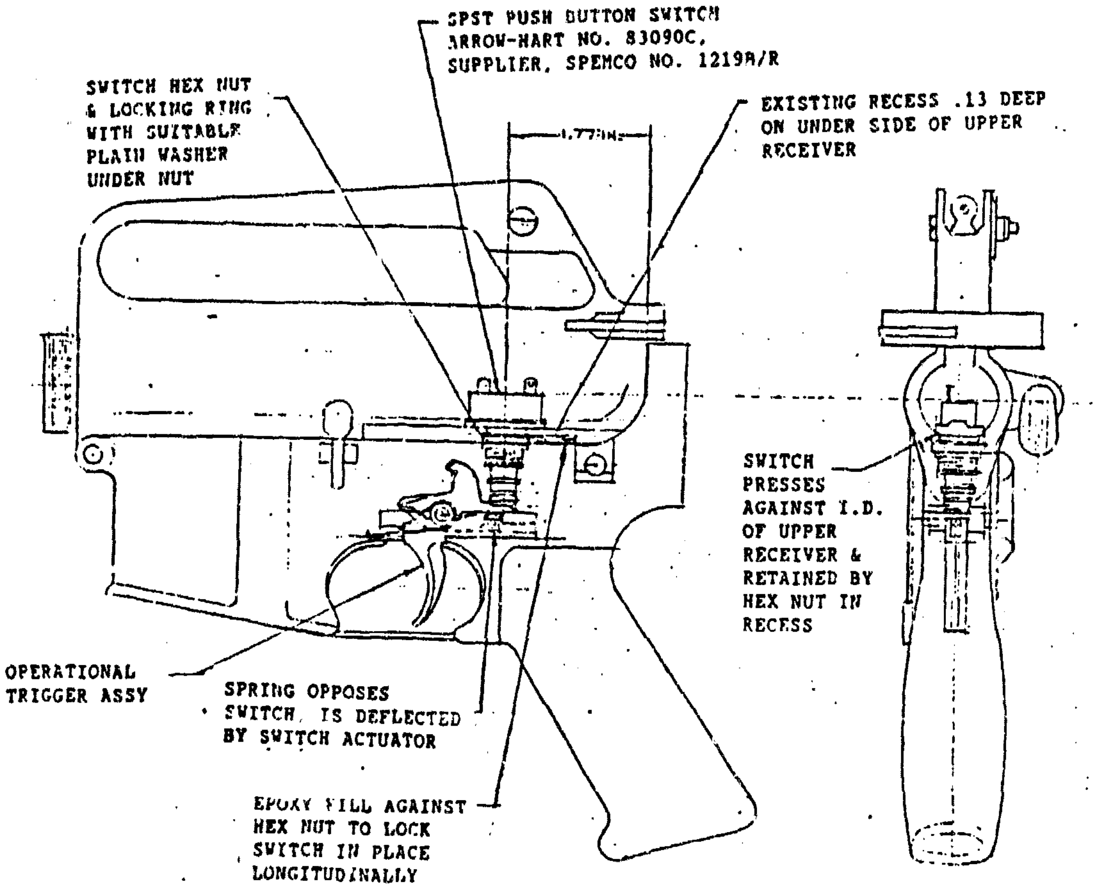

Figure 1. Side view of the new trigger switch assembly.

A new light pen and mount were designed and developed by the Naval Training Systems Center (NTSC) in Orlando, Florida and represent a significant improvement in design and overall quality of the system. The new light pen is considerably shorter (approximately 7 inches long), and has a dual lens focus system which allows very fine adjustment of the focal length. In addition, calibration of light sensitivity is done using an oscilloscope. The light pen mount is comprised of an aluminum frame (see Figure 2) that allows horizontal and vertical adjustment of the light pen. Although final costs have not yet been determined, they are not expected to exceed previous expenditures.

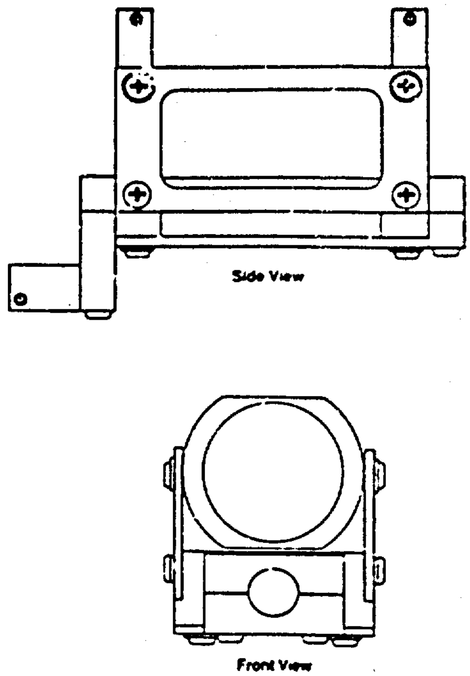

Figure 2. Side and front views of the new light pen mount.

The final hardware improvement implemented during Year Two was the M16A1 training weapon. Problems with the training weapon were mainly confined to the plastic lower receiver which was susceptible to breakage during periods of extensive use. Breakages most commonly encountered included the retaining pins tearing out, the handgrips becoming loose, and all components inside the plastic receiver becoming loose. In order to repair these breakages, it was necessary to remove the stock which made all repairs a time consuming process. With increased usage of the training weapons, the amount of service time and the loss of the weapon for training during this service were unacceptable and a more durable replacement was sought. This problem was solved by using non-serviceable M16A1 rifles and making them non-restorable. These rifles were obtained by the ARI Fort Benning Field Unit. The non-restorable service rifles provide several advantages over the original MACS training weapons: (1) durability of the lower receiver and the overall weapon, (2) ease of maintenance, (3) the weight is approximately the same as an actual service rifle, and (4) the weapons were obtained for training purposes at no cost.

Overall the hardware developments of the MACS system during Year Two have resulted in e production of a more durable weapon that is easier to maintain, is comprised of standardized components, simulates the actual weapon more closely and is comparable in cost to the original system.

MACS Software Development

The development of MACS software during Year Two has been conducted in three areas: (1) modification of Apple II software to the Commodore 64 system, (2) development of software to answer specific research questions, and (3) development of software for ARM skills. Modification of previous software was confined to the program for the LAW. Three programs were written to evaluate trigger squeeze in order to investigate the possible degradation in one of the four marksmanship fundamentals during the integrated act of shooting. Finally, five separate programs have been developed for the MACS system that emulate the current ARM program of instruction (POI) for One Station Unit Training (OSUT) soldiers. These programs correspond to the five periods of instruction dealing with night fire, rapid fire, quick fire, suppressive fire, and moving target engagement. A detailed description of all the programs outlined above are given in the subsequent sections of this report.

Light Antitank Weapon (LAW)

The LAW program was converted from the Apple II version to the Commodore 64 and substantially revised. Before firing the training scenario, the firer is given the opportunity to practice fire the LAW three times. These shot data are used to boresight the weapon by calculating an offset between the firer's sight picture and the light pen readings obtained during firing. The revised program is comprised of nine BRDM2 target exposures, three stationary and six moving targets. Prior to each target engagement the firer is given a demonstration of the correct sight picture depicted on the monitor for each target, moving or stationary, by range. After the demonstration, the same target is presented for the firer to engage. If the target is not engaged within a programmed time limit, the target reappears as the next target presentation. A hit or miss is shown by the round impact on the monitor. A replay of each target engagement is given after each round is fired. The replay depicts the firer's front sights during the target engagement and ceases when the round is fired. At the end of the program a summary screen is presented indicating hit/miss information for stationary and moving targets by range, and whether or not the firer qualified. The firer must attain a hit on two of the stationary targets and on three of the moving targets to qualify.

Trigger Squeeze

This software was developed to investigate trigger squeeze application on the M16A1 rifle with firers of different marksmanship ability ranging from novices to world-class competitors. Development of this software required one hardware modification of the M16A1 training weapon which entailed connecting the shaft of a linear potentiometer with push rods to the trigger mechanism. This arrangement allowed analog data to be collected during trigger travel. These data were the first behavioral response data collected during the integrated act of shooting that could explain possible decreases in performance due to poor trigger control.

A total of three programs, arranged in an ascending order of difficulty, were developed to investigate this problem. The first program was designed to teach the firer how to produce a smooth, controlled trigger squeeze by providing immediate knowledge of performance to the firer as the trigger is pulled. The feedback is provided in the form of a bit-map graph on the monitor in which trigger travel is depicted on the ordinate axis and time is depicted on the abscissa. The collection of the behavioral response data in a non-stress situation, where the firer is not required to aim at and engage a specified target, allows precise documentation of any errors in the trigger squeeze action. The data were collected at 60 hertz and allowed any slight hesitation in a firer's trigger squeeze to be detected. Ideally, the firer should produce a consistent, smooth response curve throughout the duration of the trigger squeeze. One untested possibility is to provide the firer with a bit-map graph of the "ideal" trigger squeeze that he/she tries to emulate while firing. Thus, the purpose of this program is to train the firer to produce a specific action, i.e., a smooth trigger squeeze, which can eventually lead to superior performance in terms of targets hit. Once the firer can consistently produce a smooth trigger action then he/she can progress to fire the stationary and moving target programs.

The stationary target trigger squeeze program consists of a total of 18 target exposures at ranges of 100, 200, and 300 meters for 5 or 20 seconds. Presentation of targets is random and target exposure time is counterbalanced by range. The firer is required to zero the weapon and confirm zero prior to starting the program. Before each shot an instructional screen is presented to the firer that indicates both target exposure time and range. Feedback is given after each target engagement and provides a cross hair on the monitor that denotes shot location information only. If the subject exceeds a programmed time limit to engage a target, the target is put back into the target array and reselected at random. The program collects 1200 potentiometer readings along with 2400 light pen readings (1200 for x and 1200 for y) and a header record containing target and shot locations, steady position, trigger squeeze, and follow-through scores for each shot. These data are stored for future analysis.

The moving target trigger squeeze program consists of a total of 72 E-type target exposures presented in three blocks of 24 targets with an unlimited break between each block. Targets appear at ranges of 75, 125, and 185 m at speeds of 0, 2.5, 3.15, and 4.2 mph for 3, 4, or 5 s. The firer must zero the weapon and confirm the zero prior to starting the program. Before each shot the firer is shown a screen containing information about the next target, its speed, and time exposure. As in the stationary target program, all targets are selected at random and if the subject exceeds the programmed time limit, the target is put back into the target array and reselected at random. Feedback provided to the firer is identical to that described for the stationary target program. The same data are collected for this program as that described for the stationary target program, however, only one-fourth as much data are collected because of the reduced time exposure of the targets.

MACS ARM Programs

All ARM programs detailed in the subsequent paragraphs utilize the same zero routine. In order to prevent repetition, an explanation of this procedure will be given prior to describing the other ARM programs in detail.

Zero Routine

This routine requires the firer to fire three rounds in a foxhole supported firing position at a scaled 250 m E-type silhouette. After each round the target temporarily disappears from the monitor and then reappears for subsequent engagements. After firing three rounds, MACS electronically determines the mean of the three round shot group and centers it on an enlarged version of the 250 m target to provide the firers with visual feedback of their performance. If the zero is unsatisfactory, as determined by the firer or the instructor, the program allows the firer/instructor to branch from the main program and repeat the zeroing procedure.

Night Fire using the AN/PVS-4 sight

This program uses a plastic replica, produced by the Fort Benning Training and Audiovisual Support Center (TASC), of an actual AN/PVS-4 night vision sight. The dimensions and operator controls of the replica and an AN/PVS-4 sight are identical, and the replica can be mounted on the MACS rifle in the same manner as an AN/PVS-4 sight is mounted on an M16 rifle. In addition, the M16/203 and M79 reticle pattern and green hue of the actual sight are duplicated in the lens of the replica. The simulated hue is provided by green translucent filters mounted on the front lens of the replica sight.

Stage One of this program consists of 12 E-type target exposures. Four target exposures are presented sequentially at ranges of 75, 150, and 200 m. Each target is exposed for an unlimited time period. After each round is fired, the firer receives immediate visual feedback of the target engagement and diagnostic measures of steady position and shot location (details of the new diagnostic measures are explained in the MACS BRM Evaluation section of this report). In order to qualify the firer must hit two targets at 75 m, two targets at 150 m, and two targets at 200 m. It is feasible, therefore, that if a firer hits successive targets at each of the three ranges only six targets are presented. Conversely, the program determines if the firer is still able to qualify with the number of rounds remaining. If insufficient rounds are available to qualify, the program is terminated. Successful completion of Stage One allows the firer to progress to Stage Two of the program.

Stage Two is comprised of a total of 18 E-type target exposures presented for an unlimited time period at ranges of 75, 150, and 200 m. Targets are sequentially presented as in Stage One, however, preprogrammed multiple exposures at all three ranges appear during target presentation. The firer is required to hit two targets at 75 m, five targets at 150 m, and two targets at 200 m to qualify. Unlike Stage One, all 18 targets are presented during Stage Two. The feedback characteristics utilized during this phase of the program are identical to those described for Stage One.

Night Fire using artificial illumination

Stage One of this program requires the firer to hit five E-type targets at 75 m with ten rounds in an unlimited time period. A replay of target engagement as well as diagnostic measures of steady position and shot location are presented after each shot. Satisfactory completion of this phase of the program allows progression to Stage Two which requires the firer to hit nine targets at [illegible] m with no more than 18 rounds within a 60 s time period. In order to simulate the illumination of a flare, the screen is programmed to quickly brighten and slowly darken using black, white, and the three shades of grey which are available on the Commodore computer. The screen will be completely black when the time limit is up.

Rapid Fire

This program is comprised of three stages arranged in ascending order of difficulty in which the manipulated variable is duration of each target exposure. Each stage of the program consists of 10 target exposures randomly presented at ranges of 50 - 300 m. F-type targets are used at 50 and 100 m, and E-type targets are used at 150 - 300 m. Target exposure duration is 4 s for Stage One, 3 s for Stage Two, and 2 s for Stage Three. Qualification for all stages of the program is seven targets hit out of 10 target exposures, three attempts are allowed to qualify before remedial training is required. Feedback is given to the firer at the completion of each stage of the program in the form of a summary screen which indicates number of shots fired, number of no fires, number of targets hit, number of targets missed, elapsed time to fire the course, and whether or not the firer qualified.

Quick Fire

Stage One of this program consists of 10 target exposures (each of 4 s duration) of a 15 m E-type target for practice quick fire. A contrasting gray circle, 4 cm in diameter, is located on the bottom third of the target for the firer to focus on when firing. The firer must obtain five targets hit out of 10 target exposures to qualify. At the completion of this stage of the program, a summary screen indicates the number of targets hit, the number of targets missed, and whether the firer qualified. The only feedback given during this phase of the program is that the target drops when hit.

Stage Two is comprised of 10 E-type target exposures of 2 s duration at 15 m and 10 E-type target exposures of 2 s duration at 25 m. Qualification requires seven targets hit at 15 m and five targets hit at 25 m. The feedback given during this phase of the program is identical to that described for Stage One. At the completion of the course of fire, a summary screen is provided which indicates the number of targets hit by range, the number of targets missed by range, and whether the firer qualified.

Suppressive Fire

This program is preceded by a visual demonstration of the effective areas of suppressive fire, at each type of target, as defined in the program. The course of fire consists of a random presentation of single and multiple target exposures of snipers, semi-concealed infantry, and trucks at ranges of 200, 250, and 300 m respectively. Firers receive thirty rounds to suppress the three areas in which targets appear. The qualification standards require the soldier to obtain at least five "area" hits on the snipers, nine "area" hits on the infantry, and one "area" hit on each of three truck exposures. A summary screen is presented at the completion of the course which indicates number of shots fired, number of truck hits, number of sniper hits, number of infantry hits, and whether or not the firer qualified.

Moving Target engagement

This program consists of sequentially presented E-type targets at ranges of 75, 125, and 185 m. Targets at each range are presented at lateral speeds of 1.41, 2.83, and 5.66 mph. A replay of each target exposure is given after each shot: the firer receives feedback on point of aim (comprised of lead and shot location scores), and steady position (comprised of trap or track score, trigger squeeze and follow through scores). In addition to these diagnostic measures, the replay depicts the perfect lead with a black front sight post for the engagement of the appropriate target and overlays the firer's front sights in white to depict their lead. The replay ceases when the shot is fired and the location of the shot is shown by crosshairs. At the completion of the program, a summary screen is presented indicating number of targets hit and number of targets missed.

MACS BRM Evaluation

Much of the early MACS software was designed for demonstration purposes to show the potential of the MACS system as a part-task trainer. While this software was valuable in terms of the conceptual information it portrayed, it was not ideally configured for instructional purposes in an applied setting (Hagman, Moore, Eisley, and Viner, in press). The program that appeared to be misinterpreted most frequently by instructors/firers and one that was comprehensively reviewed and updated was the diagnostics program. Improvements made to this program were tested in an experimental setting and subsequently implemented into other BRM programs.

The early version of the diagnostics program consisted of a total of 18 E-type targets at 250 m exposed for an unlimited time period. Firers were first required to zero and to confirm zero prior to firing the program. Nine shots were then fired from a foxhole supported position and nine were fired from a foxhole unsupported position. A replay of each target exposure was given after each shot. The replay showed the firer's front sight during target engagement and a cross hair depicting shot location after the shot was fired. In addition to the replay, the firer received feedback on steady position, trigger squeeze, follow through, and shot location. This feedback was numerically summarized for each measure on a scale of 0-100, with a high score depicting better performance. At the completion of the program, a summary screen was presented which gave average scores for the four diagnostic measures for the 18 shots. While these scores provided the instructor with summary data for each diagnostic measure, the numerical presentation of the data was open to subjective interpretation. The lack of objectivity in interpretation of the summary data represented a significant flaw in the instructional value of the MACS system because there were no normative data with which to determine a satisfactory score from an unsatisfactory score. A research effort was initiated to address this problem.

The purpose of this research effort was to establish a normative scoring procedure for the diagnostics program that provided an objective, easy-to-interpret, and unambiguous evaluation of a firer's ability. Since the MACS diagnostics program was primarily used with soldiers identified as "problem" shooters, a sample of these soldiers was used for this experiment.

Forty eight One Station Unit Training (OSUT) soldiers undergoing BRM training at Fort Benning, Georgia were tested using the MACS diagnostics program. The instruction was provided by company drill sergeant-qualified Noncommissioned Officers (NCOs) on four MACS systems. Summary data for the four diagnostics measures were collected for all soldiers and used for analysis.

Descriptive statistics were obtained for each of the diagnostic measures and the means and the standard deviations were used to determine proficiency standards, described by verbal labels rather than by a numerical score, for each diagnostic measure (see Table 1). This method insured that even though the distributions of the diagnostic measures were different, an objective interpretation was obtained for each measure. The results of this research effort resulted in several major modifications of the diagnostics program, which subsequently resulted in modifications of various routines in other MACS BRM programs.

<u>Table 1.</u>

A Summary of the Normative Scoring Procedures for the MACS Diagnostics Program

	Poor < 2 <u>SD</u> below the mean	Below Avg. 1 - 2 <u>SD</u> below the mean	Average <u>M</u> - 1 <u>SD</u> below the mean	Good <u>M</u> - 2 <u>SD</u> above the mean	Excellent > 2 <u>SD</u> above the mean
Steady Position	< 83	84-85	86-89	90-95	> 96
Trigger Squeeze	< 81	82-84	85-89	90-93	> 94
Follow Through	< 76	77-81	82-87	88-92	> 93
Shot Location	< 87	88-90	91-92	93-96	> 97

MACS Diagnostics Modifications

Three major modifications were made to the MACS Diagnostics program based on the research effort outlined above: (1) summary data for diagnostic measures were internally assessed and described by a verbal label of poor, below average, average, good, and excellent, (2) the replay routine was modified, and (3) a shot group recall was presented at the end of the program.

The summary screen for the diagnostic measures was changed to show descriptive labels of the firer's performance for each of the diagnostic measures. This was done by internally comparing the firer's score on each measure with the numerical scores shown in Table 1 and determining the appropriate descriptive label for the summary screen. This procedure insured that evaluation of each measure was objectively determined by the computer, which in turn provided each instructor with consistent feedback of the firer's performance. This modification represented a significant improvement in the previous scoring system which was both ambiguous and difficult to interpret.

Three of the diagnostic measures used in this program are derived from light pen readings sampled at discrete intervals during target engagement, and the fourth is derived by determining the radial error between bullet strike and the center of mass of the target. The equations for the derivations of the diagnostic measures and the sampling intervals are listed below:

1. Steady position (SP): $SP = \underline{SD}(lpx_i) + \underline{SD}(lpy_i)$ where $i = -31 \rightarrow -6$. Steady position is calculated by summing the standard deviations of the light pen readings for X and Y from 31 to 6 readings prior to trigger break.

2. Trigger squeeze (TS): $TS = \underline{SD}(lpx_i) + \underline{SD}(lpy_i)$ where $i = -5 \rightarrow 0$. Trigger squeeze is calculated by summing the standard deviations of the light pen readings for X and Y from 5 readings prior to trigger break to trigger break.

3. Follow through (FT): $FT = \underline{SD}(lpx_i) + \underline{SD}(lpy_i)$ where $i = +1 \rightarrow +6$. Follow through is calculated by summing the standard deviations of the light pen readings for X and Y 1 to 6 readings after trigger break.

4. Shot location (SL): $SL = \sqrt{(lpx - tgtx)^2 + (lpy - tgty)^2}$ where lpx and lpy are determined by the median X value during the sampling period two readings prior to trigger closure and three readings after trigger closure. Shot location is calculated by determining the radial error between the light pen readings for X and Y and the X and Y coordinates of the center of mass of the target using the equation above.

The replay routine was modified in two ways: (1) the feedback provided to the firer after target engagement was changed, and (2) the replay routine was shown repeatedly until the firer was ready to continue the program. The new replay shows the firer's front sight during target engagement in conjunction with an overlay of a perfect sight picture in a contrasting color. When the shot is fired, the location of the firer's sight and the perfect overlay sight are frozen and a cross hair appears where the round impacted. After a period of three seconds the sights disappear leaving a clear picture of the cross hair indicating where the round would impact. After an additional three seconds, the cross hair disappears and the replay routine is repeated. The firer pulls the trigger to continue the program. The advantages of these modifications are that they provide an opportunity for firers to evaluate their own performances and they allow an instructor to teach more than one firer. In addition, the replay routine provides more precise feedback to both the instructor and the firer which enhances the instructional setting.

The shot group recall is provided at the conclusion of the program and presents each nine round shot group for the supported and unsupported firing positions. The shot group is shown on a blown up version of the 250 m scaled E-type silhouette to allow easier interpretation of the group by the instructor. The inclusion of this analysis in conjunction with the summary data of the four diagnostic measures provides the instructor with precise information regarding the firer's performance in the supported and unsupported positions. Previously, the instructor was required to remember if the firer experienced difficulty in the supported or unsupported position and to suggest remedial training accordingly, however, the addition of the shot group recall precludes the requirement to remember the firer's difficulties.

Overall, the modifications to the diagnostics program have resulted in a program that provides an objective assessment of a firer's shooting ability in terms of the four diagnostic measures and provides more precise feedback to the instructor and firer. In addition, it allows greater flexibility in the instructional setting with a continuous replay feature.

Future Directions

Future development of MACS is expected to progress in the following areas: (1) development of software for an Antitank Weapon System, (2) development of Intelligent Computer-Aided Instruction (ICAI) software for the M16A1 rifle, and (3) development of hardware options for MACS.

Development of software for an antitank weapon system will be preceded by a needs analysis to determine the suitability of the weapon system for part-task simulation. Weapon systems to be considered are the M136(AT-4) LAW, the Dragon, the AAWS-M, and the TOW.

The development of an ICAI software package has been initiated to replace the dry-fire portion of BRM training for the M16A1 rifle. This program is hierarchically organized with 10 levels of difficulty that progress from untimed fire in a foxhole supported position to an attack/retreat scenario with multiple exposures simulating combat fire. Each difficulty level contains performance gates which are used to monitor a firer's progression through the program. The performance gates determine the progression of the firer through the program. However, if one specific level of the program needs to be taught to a large number of personnel in a short period of time without the performance gates, these options can be manually overridden. At present, the performance gates used in this program have been arbitrarily determined, the validity of these will be determined in a forthcoming research effort and appropriate modifications will be made based on the results of this effort. While this program is not a stand-alone program, it represents a significant step forward from the early versions of instructor intensive software.

One hardware option that will be investigated in the future will be interfacing MACS with an MS-DOS microcomputer. Preliminary work in this area was started in Year Two in reply to the increasing need to validate the software in the field environment. In order to collect and subsequently analyze large amounts of data as quickly as possible, an AT&T 6300 personal computer was used as the host computer for four MACS systems. The interface consisted of a board with six parallel ports, manufactured by John Bell Engineering, and a connector box and cables, built by Litton. The communication program for the host was written in Turbo Pascal and the modules for the Commodore were written in 6510 machine language. Routines were developed to allow a listing of the data files to be obtained on a printer or on the console for each of the MACS BRM programs. The next step in this phase is to permit up to 24 MACS systems to be communicating with the host computer at one time.

The use of an MS-DOS computer provides several advantages over a stand-alone MACS system: (1) allows for on-line data collection from multiple MACS systems and facilitates subsequent analysis of the data using existing statistical packages or custom statistical packages written for specific analyses, (2) provides enhanced output capability for hard copy feedback for the firer, (3) output routines can be programmed in a higher level language which allows greater flexibility over BASIC and 6510 machine language, and (4) allows one operator to monitor the progress of multiple systems at the host computer console.

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