



ARI Research Note 87-40

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A COST AND TRAINING EFFECTIVENESS ANALYSIS (CTEA)  
OF MOVING TARGET ENGAGEMENT TRAINING PROGRAMS  
FOR THE M16A1 RIFLE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) In June 1985 a research effort was initiated to examine current Advanced Rifle Marksmanship (ARM) Training at the Fort Benning Defense Test Range (DTR). This research effort examined alternate methods of training moving target engagement. Several variations of training devices and procedures were developed and evaluated. This note provides a cost and training effectiveness analysis (CTEA) of each alternative developed for training moving target engagements.		

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COST AND TRAINING EFFECTIVENESS ANALYSIS (CTEA)  
OF MOVING TARGET TRAINING PROGRAMS  
FOR THE M16A1 RIFLE

**PURPOSE.** This report documents a cost and training effectiveness analysis (CTEA) of moving target engagement training programs with the M16A1 rifle. It compares the effectiveness of current moving target training and three alternative training programs utilizing a combination of special training devices.

**BACKGROUND.** The current Advanced Rifle Marksmanship (ARM) program was implemented in 1982 (Evans & Schendel, 1984; USAIS OSUT POI, 1985). Moving target training in the ARM program utilized the Aid to Improved Marksmanship (AIM) book, a Dry Fire Moving Target Trainer, and taught five lead rules for moving target engagement based upon range and speed of the target. In September 1985 a two month research effort to develop a training program that will significantly improve the soldier's ability to hit moving personnel targets was conducted (Hunt, Parish, Martere, Osborne, & Evans, in preparation). The research effort introduced device-based training, an intermediate live-fire exercise and a single lead rule for moving target engagement. Substantial improvements in the ability of trainees to engage moving targets were found as a result of this instruction. Performance criteria were based on a new 42-target/42-round (42/42) scenario devised by the U.S. Army Infantry School (USAIS) and implemented at the Defense Test Range (DTR) equipped with a Remoted Target System (RETS). The alternatives in this CTEA were based on the training programs used in the ARM research effort and used a combination of the various devices; the Multipurpose Arcade Combat Simulator (MACS), the Weaponer II, and the Superdart Location of Miss and Hit (LOMAH) system.

**PROBLEM.** Moving targets are the most commonly encountered and difficult to hit targets on the modern battlefield. The current ARM Program of Instruction (POI) was found to be less effective than the proposed alternatives utilized during the current ARM research effort. In addition, certain aspects of the current ARM POI inhibited the effective engagement of moving targets (Hunt et al., 1986). At present there is no available CTEA for the current ARM POI and there is no CTEA comparing the current ARM POI with the alternative training programs conducted during the recent ARM research effort. This report addresses this problem.

**PROPOSED SOLUTIONS.** The research conducted using device-based training and modified live-fire training enhanced the ability of soldiers to engage moving targets (Hunt et al., 1986). The new POI may consist of: (a) device-based training prior to live-fire of the 42/42 scenario at the DTR; (b) intermediate live-fire by incorporating an intermediate 39-target/39-round (39/39) scenario prior to live-fire of the 42/42 scenario at the DTR; or (c) a combination of both device-based training and modified live-fire prior to live-fire of the 42/42 scenario at the DTR. These modifications to the current ARM POI will increase instructional requirements from 8 hours to either 12 or 16 hours depending on the training requirements of the particular POI.

SCOPE. For the purpose of this CTEA, the base case used was the current moving target POI as taught at the DTR. Nine alternative programs were considered for the purpose of this CTEA:

. Base Case - the current moving target POI and live-fire of the 42/42 scenario at the DTR RETS range.

. Alternative 1 - modification of the current moving target POI, intermediate live-fire practice using a 39/39 scenario and live-fire of the 42/42 scenario.

. Alternative 2 - device-based training using the MACS, Weaponeer II, and LOMAH devices, and live-fire of the 42/42 scenario.

. Alternative 3 - device-based training using the MACS, Weaponeer II, and LOMAH devices, intermediate live-fire using the 39/39 scenario and live-fire of the 42/42 scenario.

. Alternative 4 - device-based training using the MACS system and live-fire of the 42/42 scenario.

. Alternative 5 - device-based training using the MACS system, intermediate live-fire using the 39/39 scenario, and live-fire of the 42/42 scenario.

. Alternative 6 - device-based training using the Weaponeer II and live-fire of the 42/42 scenario.

. Alternative 7 - device-based training using the Weaponeer II, intermediate live-fire using the 39/39 scenario, and live-fire of the 42/42 scenario.

. Alternative 8 - device-based training using the LOMAH system and live-fire of the 42/42 scenario.

. Alternative 9 - device-based training using the LOMAH system, intermediate live-fire using the 39/39 scenario, and live-fire of the 42/42 scenario.

#### ASSUMPTIONS.

(a) Alternatives 1, 4, 6, and 8 are projected to be one-day training programs. Other proposed alternatives are expected to be either one-and-one-half or two-day POIs.

(b) The modified POI will be implemented in FY86.

(c) Current device facilities would be insufficient to support the modified POI. Ten MACS systems, 10 Weaponeer II systems, and a 10-lane LOMAH range were used for this CTEA.

(d) The MACS and Weaponer II systems would be housed in a central location.

(e) It was assumed that three troop transporters would be required for transportation.

(f) It was assumed that an average training company would consist of 160 personnel.

DETERMINATION OF COST. Cost was calculated using the following equation:

$$C_{ave} = (R + T + A + I + S + D_{om} + D_{ed1}) \times L / N_{tot}$$

where:

$C_{ave}$  = average cost of training per trainee.

R = range operation and maintenance (O & M) costs for personnel and equipment for the DTR for FY85.

T = transportation costs to transport a company of 160 soldiers to and from a training area. The cost of a transporter was \$1.56 per mile and the cost of a driver was \$9.33 per hour.

A = ammunition costs for all live-fire used for a particular training schedule. These figures were computed using exact ammunition requirements, based on a figure of \$0.16 per round.

I = instructor salaries (pay rate x fraction of day preparing for and providing instruction summed over all instructors).

S = salaries of trainees (pay rate x fraction of day in training summed over all trainees).

$D_{om}$  = device operation and maintenance costs for all devices used in the training program. It was assumed that there would be 10 systems for each training device.

$D_{ed1}$  = device  $E_{d1}$  for all devices used in the training program. The equation used for calculating  $E_{d1}$  was as follows:

$$E_{d1} = ( E / L \times N_r ) \times N_1$$

where:

E = training equipment costs.

L = expected life of equipment in years.

$N_r$  = number of trainees using the equipment per year.

$N_1$  = number of trainees per current application.

Notes = total number of trainees over all applications.

This analysis will use FY86 dollar costs provided by various U.S. Army agencies at Fort Benning, Georgia, and by manufacturers of the training devices used during this research effort (see Note 1). The projected CTEA is for a 10 year period through FY96 without an inflation factor.

Ammunition, manpower, range facilities, and transportation costs were provided by various Army agencies at Fort Benning, Georgia. These agencies were the Ammunition Supply Point, Finance and Civilian Personnel Budget Office, Chief of Range Control, and the Transportation Cost Planning Office, respectively. Operation and maintenance (O & M) costs for the MACS, Weaponeer II, and LOMAH devices were provided by the U.S. Army Research Institute Field Unit, Fort Benning, Georgia, Spartanics Ltd., Rolling Meadows, Illinois and Australasian Training Aids, Columbia, South Carolina respectively.

It is important to note that there is a definite cost savings associated with shooting on one of the three devices mentioned in this report compared with shooting on a live-fire range. The average cost of firing one round on a DTR range is \$.58, compared with \$.22 per round on the LOMAH system, \$.02 per round on the Weaponeer II, and \$.01 per round on the MACS system. These data provide important information in determining the relative value of device-based training compared with live-fire training.

ANALYSIS OF COST. The cost analyses for the base case and the nine alternatives are outlined below.

Base Case (1 Day): current moving target POI and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 41454.27
Ammunition costs per year	:	\$153753.60
Instructor costs per year	:	\$ 14177.02
Trainee costs per year	:	\$145745.60
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TOTAL	:	\$555724.72
TOTAL FOR FY86-96	:	\$5557247.2

$C_{ave} = \$5557247.2 / 228800$   
 $= \$24.29$

Alternative 1 (1 Day): modification of the current moving target POI, additional live-fire using an intermediate 39/39 scenario and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 41454.27
Ammunition costs per year	:	\$296524.00
Instructor costs per year	:	\$ 14177.02
Trainee costs per year	:	\$145745.60
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TOTAL	:	\$698495.12
TOTAL FOR FY86-96	:	\$6984951.2

$C_{ave} = \$6984951.2 / 228800$   
 $= \$30.53$

Alternative 2 (2 Days): device-based training using the MACS, Weaponeer II, and LOMAH devices; and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$226969.60
MACS O & M costs per year	:	\$ 750.00
Weap. II O & M costs per year	:	\$ 4500.00
LOMAH O & M costs per year	:	\$ 10000.00
Ed: for MACS per year	:	\$ 6.99
Ed: for Weaponeer II per year	:	\$ 272.73
Ed: for LOMAH per year	:	\$ 349.65
Instructor costs per year	:	\$ 28354.04
Trainee costs per year	:	\$291491.20

TOTAL	:	\$821454.41
TOTAL FOR FY86-96	:	\$8214544.1

Cave = \$8214544.1/228800  
= \$35.90

Alternative 3 (2 Days): device-based training using the MACS, Weaponeer II, and LOMAH devices; an intermediate 39/39 live-fire scenario and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$369740.00
MACS O & M costs per year	:	\$ 750.00
Weap. II O & M costs per year	:	\$ 4500.00
LOMAH O & M costs per year	:	\$ 10000.00
Ed: for MACS per year	:	\$ 6.99
Ed: for Weaponeer II per year	:	\$ 272.73
Ed: for LOMAH per year	:	\$ 349.65
Instructor costs per year	:	\$ 28354.04
Trainee costs per year	:	\$291491.20

TOTAL	:	\$964224.31
TOTAL FOR FY86-96	:	\$9642248.1

Cave = \$9642248.1/228800  
= \$42.14

Alternative 4 (1 Day): device-based training using the MACS system and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$153756.60
MACS O & M costs per year	:	\$ 750.00
Ed <sub>1</sub> for MACS per year	:	\$ 6.99
Instructor cost per year	:	\$ 14177.02
Trainee cost per year	:	\$145745.60

TOTAL	:	\$573196.41
TOTAL FOR FY86-96	:	\$5731964.1

Cost = \$5731964.1/228800  
= \$25.05

Alternative 5 (1.5 Days): device-based training using the MACS system, an intermediate live-fire exercise using a 39/39 scenario, and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$296524.00
MACS O & M costs per year	:	\$ 750.00
Ed <sub>1</sub> for MACS per year	:	\$ 6.99
Instructor cost per year	:	\$ 21265.53
Trainee cost per year	:	\$218618.40

TOTAL	:	\$795925.12
TOTAL FOR FY86-96	:	\$7959251.2

Cost = \$7959251.2/228800  
= \$34.79

Alternative 6 (1 Day): device-based training using the Weaponeer II and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$153756.60
Weap. O & M costs per year	:	\$ 4500.00
Ed1 for Weap. per year	:	\$ 272.73
Instructor cost per year	:	\$ 14177.02
Trainee cost per year	:	\$145745.60

TOTAL	:	\$577212.15
TOTAL FOR FY86-96	:	\$5772121.5

Cost = \$5772121.5/228800  
= \$25.23

Alternative 7 (1.5 Days): device-based training using the Weaponeer II, an intermediate live-fire exercise using a 39/39 scenario, and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$296524.00
Weap. O & M costs per year	:	\$ 4500.00
Ed1 for Weap. per year	:	\$ 272.73
Instructor cost per year	:	\$ 21265.53
Trainee cost per year	:	\$218613.40

TOTAL	:	\$799940.86
TOTAL FOR FY86-96	:	\$7999408.6

Cost = \$7999498.6/228800  
= \$34.96

Alternative 8 (1 Day): device-based training using the LOMAH system and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$226969.60
LOMAH O & M costs per year	:	\$ 10000.00
Ed <sub>1</sub> for LOMAH per year	:	\$ 349.65
Instructor cost per year	:	\$ 14177.02
Trainee cost per year	:	\$145745.60
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TOTAL		\$656002.07
TOTAL FOR FY86-96	:	\$6560020.7

$$C_{ave} = \$6560020.7/228800 \\ = \$28.67$$

Alternative 9 (1.5 Days): device-based training using the LOMAH system, an intermediate live-fire exercise using a 39/39 scenario, and live-fire of the 42/42 scenario at the DTR.

DTR O & M costs per year	:	\$200594.23
Transportation costs per year	:	\$ 58165.97
Ammunition costs per year	:	\$369740.00
LOMAH O & M costs per year	:	\$ 10000.00
Ed <sub>1</sub> for LOMAH per year	:	\$ 349.65
Instructor cost per year	:	\$ 21265.53
Trainee cost per year	:	\$218618.40
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TOTAL		\$878733.78
TOTAL FOR FY86-96	:	\$8787337.8

$$C_{ave} = \$8787337.8/228800 \\ = \$38.41$$

DETERMINATION OF EFFECTIVENESS. The outlined alternatives represent a list of possible modified POIs that could be implemented using the current range facilities and assuming that 10 units of each of the three devices were available if required by the alternative selected. The cost-effectiveness of the alternatives using just one device, however, cannot be determined because the recent research effort did not evaluate the effectiveness of one device over the other. Alternatives 4-9 are included to provide some insight into the cost involved in implementing a POI using each of the respective devices and current range facilities.

The cost-effectiveness of the base case and the first three alternatives were computed using a baseline performance figure of trainees who had completed

Basic Rifle Marksmanship (BRM) training but had received no ARM training. The performance criterion used for this baseline was the mean number of target hits on the DTR. The purpose for this was that it provided a measure of importance to scoring above the base line, whereas an absolute numerical scale assigns no measure of importance to one number over another. The comparisons for the base case and alternatives 1-3 are reported below:

1. Base Case vs. Alternative 1

Base Line Mean = 18.17 target hits = 100%

Base Case Mean = 17.95 target hits = 98.8%

Alternative 1 Mean = 21.43 target hits = 117.9%

Alternative 1 is 19.1% more effective than the Base Case.

The Base Case costs \$24.29 per trainee for no performance improvement above Base Line. Alternative 1 costs \$30.53 per trainee. The superior performance of Alternative 1 over the Base Case costs  $\$30.53/19.1 = \$1.60$  per 1% improvement, or  $\$30.53 - \$24.29/19.1 = \$0.33$  per 1% improvement if the cost of the Base Case is considered.

2. Base Case vs. Alternative 2

Base Line Mean = 18.17 target hits = 100%

Base Case Mean = 17.95 target hits = 98.8%

Alternative 2 Mean = 21.89 target hits = 121.0%

Alternative 2 is 22.2% more effective than the Base Case.

Alternative 2 costs \$35.90 per trainee.

The superior performance of Alternative 2 over the Base Case costs  $\$35.90/22.2 = \$1.62$  per 1% improvement, or  $\$35.90 - \$24.29/22.2 = \$0.52$  per 1% improvement if the cost of the Base Case is considered.

3. Base Case vs. Alternative 3

Base Line Mean = 18.17 target hits = 100%

Base Case Mean = 17.95 target hits = 98.8%

Alternative 3 Mean = 20.52 target hits = 112.9%

Alternative 3 is 14.1% more effective than the Base Case.

Alternative 3 costs \$42.14 per trainee.

The superior performance of Alternative 3 over the Base Case costs  $\$42.14/14.1 = \$2.99$  per trainee for a 1% improvement, or  $\$42.14 - \$24.29/14.1 = \$1.27$  per 1% improvement if the cost of the Base Case is considered.

An additional comparison was made which contrasted the Base Case with good shooters and poor shooters (see Hunt et al., in preparation) from the device-based training program (Alternative 2). This comparison is reported below:

Base Case Pretest Mean = 17.46 target hits = 96.1%

Base Case Posttest Mean = 17.95 target hits = 98.8%

Poor Shooters Pretest Mean = 11.48 target hits = 63.2%

Poor Shooters Posttest Mean = 19.32 target hits = 106.33%

Good Shooters Pretest Mean = 23.0 target hits = 126.6%

Good Shooters Posttest Mean = 21.89 target hits = 120.5%

The Base Case costs \$24.29 per trainee for a 2.7% increase in performance, however, this is not above Base Line. The costs for good shooters in Alternative 2 was \$35.90 per trainee for no performance improvement, however, their performance for both pretest and posttest scores were consistently above Base Line.

The costs for poor shooters was \$35.90 for a 43.1% increase in performance (6.3% above Base Line). The superior performance of the poor shooters over the Base Case costs  $\$35.90/43.1 = \$0.81$  per 1% improvement, or  $\$35.90 - \$24.29/43.1 = \$0.27$  per 1% improvement if the cost of the Base Case is considered.

RECOMMENDATIONS. The analysis indicated that Alternatives 1 and 2 represented viable POIs for moving target engagement. Alternative 1 could be implemented immediately because it utilizes existing range facilities and does not require the procurement of special training devices. Alternative 2, in contrast, requires procurement of 10 MACS systems, 10 Weaponeer IIs, and a 10-lane LOMAH system. The cost-effectiveness of these alternatives is almost identical (\$1.60 and \$1.62, respectively); however, when the diagnostic capabilities of Alternative 2 are compared with Alternative 1, the use of special device training in conjunction with live-fire appear particularly attractive.

The cost-effectiveness data for poor shooters in Alternative 2 indicated a considerable decrease in cost (approximately 50%) compared with Alternative 1. In addition, this improvement in performance was achieved without the need for increased ammunition costs. In summary, the implementation of Alternative 1 would increase hit probability for moving target engagement for a modest cost increase for each trainee over the current training cost. However, if the proposed special devices are procured and Alternative 2 is implemented then a comparable level of performance could be obtained, additional diagnostic capabilities would be realized, and the cost of additional ammunition required for Alternative 1 would be negated. If Alternative 2 is implemented this would also allow the cost-effectiveness of Alternatives 4-9 to be investigated which could result in further cost reductions depending on the specific requirements of the chosen Alternative POI.

FOOTNOTE

Note 1. More detailed information regarding costs and sources of cost data are available from the authors.

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