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COMPARISON OF RIFLE DEFEATABLE THREAT CRITERIA AND THE INFANTRY REMOTED TARGET SYSTEM (IRETS)

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U. S. Army
Research Institute for the Behavioral and Social Sciences

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The Army is considering the procurement of the Infantry Remoted Target System (IRETS) as a replacement for current Record Fire ranges. It is important to know the capabilities and limitations of the IRETS. This report presents the findings of comparisons of the IRETS specifications and descriptive threat oriented criteria. It concludes that the IRETS is an upgrading of older marksmanship evaluation concepts. Further, unless corrections of problems and limitations are made, the system should not be viewed as representing a quantum leap from current Record Fire ranges to a threat oriented Record Fire facility.

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FOREWORD

The research in this report was performed by the U. S. Army Research Institute for the Behavioral and Social Sciences (ARI) - Fort Benning Field Unit. It is part of an ongoing research program directed toward the development of cost effective methods for individual and collective training. The overall objective of this program is the design, development, evaluation, and integration of cost-effective training systems for the U. S. Army.

This report presents the findings of a comparative analysis of the specifications for the Infantry Remoted Target System (IRETS) and the display and evaluative requirements for threat oriented marksmanship training. This research was conducted in support of the Training Effectiveness Analysis (TEA) effort currently underway at the United States Army Infantry School (USAIS) for M16A1 rifle marksmanship.

The end product of the rifle marksmanship TEA effort will be a systems engineered training delivery system that is performance oriented and criterion referenced to the rifle defeatable threat. Prototype marksmanship training programs will be developed. The cost and training effectiveness of these will be evaluated through field testing. Because it is likely that the IRETS will play a major role in the evaluation of the prototype marksmanship training programs, it is important to understand the capabilities and limitations of this system. Thus, this report serves as input to the development of evaluation methodology for these training programs in that it defines the extent to which the planned capabilities of the IRETS are consistent with current concepts of threat oriented marksmanship training.

The ARI research in training systems development is conducted as an inhouse effort augmented by contracts with organizations selected as having unique capabilities for research in the area. This study was conducted by personnel from the Mellonics Systems Development Division of Litton Systems, Inc. under contract to the ARI. Their work was conducted as part of ARMY RDTE Project 2Q763743A773, FY78 Work Program. It was directly responsive to the requirements of the USAIS and the U. S. Army Training and Doctrine Command (TRADOC).

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Technical Director

COMPARISON OF RIFLE DEFEATABLE THREAT CRITERIA AND THE INFANTRY REMOTED TARGET SYSTEM (IRETS)

BRIEF

Requirement:

To identify potential shortcomings in the capabilities of the Infantry Remoted Target System (IRETS) with respect to threat oriented criteria, and to recommend possible means of resolving the identified shortcomings.

Procedure:

Potential shortcomings in the evaluative capabilities of the IRETS were identified by comparing the contract specifications for the IRETS and the target presentation requirements of the United States Army Infantry Center (USAIC) defense scenario with descriptive threat oriented criteria. In addition, information derived from a visit to the manufacturing plant of the IRETS prime contractor was incorporated into the analysis of the system where appropriate.

Findings:

Comparisons of the IRETS specifications and descriptive threat oriented criteria indicate that the IRETS threat portrayal is inadequate. In addition, the IRETS capability to generate battlefield noises is limited and no capabilities for the creation of limited visibility conditions (dust, haze, smoke, etc.) exist. Finally, the analysis identified several shortcomings which may limit IRETS operations. Collectively, these findings suggest that the IRETS is not a quantum leap from the current Army Record Fire ranges to a threat oriented Record Fire facility. While the IRETS may be considered a positive step, it is only an upgrading of older concepts with moving targets, computerized operations, and more target positions at nearer target-to-firer distances.

Utilization of Findings:

This report describes the capabilities and limitations of the IRETS as it is currently configured. It identifies specific shortcomings in the system and makes recommendations for resolving these. If these recommendations are implemented or other means are idenfified for resolving the identified potential shortcomings, an improved

IRETS-like system could be constructed. This system would then represent substantial progress from current Record Fire ranges and a valid means of measuring rifle marksmanhsip proficiency in a threat oriented environment.

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COMPARISON OF RIFLE DEFEATABLE THREAT CRITERIA AND THE INFANTRY REMOTED TARGET SYSTEM (IRETS)

INTRODUCTION

At present, rifle marksmanship training and evaluation in the U. S. Army is conducted on TRAINFIRE ranges which were developed and installed during the late 1950's at selected Army Training Centers and other major U. S. Army installations. These ranges are becoming obsolete. Most are maintenance liabilities and cause not only excessive repair expenditures, but lost training time as well. Further, the control systems for these ranges no longer reflect the state of the art.[1]

In reaction to this situation, the U. S. Army is considering the procurement of a family of improved live fire ranges. One of these, the Infantry Remoted Target System (IRETS), has been designed to provide for the evaluation of rifle marksmanship training which has been conducted in a threat oriented context. The IRETS is now under development and will be tested by the U. S. Army Infantry Board (USAIB) at Fort Benning, Georgia, during 1978.

Early in 1976, the U. S. Army Infantry Center (USAIC) published threat oriented rifle marksmanship scenarios for the defense, the attack, and the counterattack.[2] The defense scenario was subsequently used to guide the IRETS specifications. This scenario, and its target presentation requirements, served as the basis for target conditions to be portrayed as well as for the live fire range specifications for the IRETS.

Under contract to the U. S. Army Research Institute (ARI), the Mellonics Systems Development Division of Litton Systems, Inc., is supporting the Training Effectiveness Analysis (TEA) research currently being conducted at the Fort Benning ARI Field Unit involving the effectiveness of training for rifle marksmanship skills in a threat oriented context. Since current rifle marksmanship Record Fire ranges are to be replaced with the IRETS, it is important to know to what extent the planned capabilities of the IRETS are consistent with current concepts of threat oriented training. This report presents the findings of a comparative analysis, conducted by Mellonics, of the specifications for the IRETS and the target presentation and evaluation requirements for threat oriented rifle marksmanship training programs.

[1] Department of the Army, Training Device Requirement (TDR) for the Infantry Remoted Target System (IRETS). Fort Eustis, VA: U. S Army Training Support Center, July 1977.

[2] Jehan, H. Threat oriented evaluation: A new approach to training with applications to rifle marksmanship training. (Draft) Fort Benning, GA: U. S. Army Infantry Center, February 1976.

OBJECTIVES

The objectives of this research were twofold:

- To identify potential shortcomings in the capabilities of the IRETS with respect to threat oriented criteria, and
- To recommend possible means of resolving the identified shortcomings.

METHOD

Potential shortcomings in the evaluative capabilities of the IRETS were identified by comparing the contract specifications for the IRETS[3] and the target presentation requirements of the USAIC defense scenario with the threat parameters as outlined by Klein and Tierney[4] and Rosen and Behringer.[5]

In addition, a visit was made to the manufacturing plant of the IRETS prime contractor. At that location, prototype equipment components for the IRETS were examined and detailed discussions were conducted concerning the anticipated performance of the system. Information derived from this visit was incorporated into the analysis of the system where appropriate.

Based on the results of the IRETS analysis, shortcomings in the display and evaluative capabilities of the system were identified. Next, means for reducing or eliminating the impact of identified shortcomings were developed. In those cases for which no simple solutions could be identified, the shortcomings were highlighted so that a more thorough evaluation could be conducted during acceptance and operational testing for the IRETS.

[3] Naval Training Equipment Center, Specification for Infantry Remoted Target System (IRETS). Orlando, FL: Author, May 1976.

[4] Klein, R. and Tierney, T. Analysis of factors affecting the development of threat oriented small arms training facilities (Task Report). Fort Benning, GA: Mellonics Systems Development Division, Litton Systems, Inc., August 1977.

[5] Rosen, M. and Behringer, R. M16 rifle marksmanship training development (Final Report). Springfield, VA: Mellonics Systems Development Division, Litton Systems, Inc., 1977.

FINDINGS

In this section the findings of the comparative analysis of threat parameters and the IRETS specifications and scenarios are presented. To provide background on the subject, the threat model for training and evaluation and the display capabilities of the IRETS (both the IRETS range and the IRETS target presentation scenario) are discussed first. This is followed by:

- Comparisons between selected operational factors descriptive of the threat in combat and the IRETS,
- Threat defeating criteria considerations,
- Potential hardware system shortcomings,
- Potential software system shortcomings.

THE THREAT MODEL FOR TRAINING AND EVALUATION

According to Jehan[6], the rifle defeatable threat is the enemy soldier armed with his weapon. The exact nature of this enemy soldier/weapon combination depends on the nature of the enemy force and the battlefield conditions at the time combat is initiated. For the purposes of training and evaluation, it is not practical to portray the complete battlefield threat, i.e., all of the personnel, equipment, and incoming fires characteristic of combat. Instead, only those factors judged to be relevant to the rifle defeatable threat are portrayed or modeled. For this reason, the standard approach has been to limit the modeled threat to collections (arrays) of man-sized targets that represent enemy soldiers armed with their individual weapons, usually the rifle. Thus, the rifle defeatable threat translates into arrays of stationary and moving targets situated in field environments similar to those likely to be encountered during combat.

This representation of the threat is not complete in that it provides no quantitative guidance from which standards of firing performance and statements of appropriate target and environmental conditions may be derived. Further, it provides no information from which realistic, detailed target arrays and firing scenarios may be developed for use during training or evaluation. The key to developing well defined threat oriented training and evaluation systems is the availability of a quantitative model of the threat. In particular, for rifle marksmanship training and evaluative systems this means a quantitative model of the assault element of an attacking threat motorized rifle squad in terms of lateral and in-depth target separations, and other dynamic operational factors descriptive of this force during combat.

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[6] Jehan, H., op. cit.

In recognition of the need for a quantitative model of the attacking threat rifle squad, recent analyses[7,8] of relevant, unclassified information sources (both military and non-military publications) have been conducted that provide a relatively consistent description of the threat rifle squad in the attack. It is the purpose of this section to review and synthesize the results of these analyses and present a micro-level description of the threat.

Klein and Tierney note that it is the defender who usually fights out-numbered. Rosen and Behringer report that current intelligence estimates indicate during an attack that threat forces will attempt to achieve force ratios from 3:1 to 6:1. For a defending eight-man U. S. rifle squad, this translates into from 33 to 66 threat riflemen to be engaged per attack.

According to Rosen and Behringer, the assault elements of a threat rifle squad normally operate across a front from 50 to 60 meters wide. For the eight man assault element, this means that there will be one threat soldier for every six to eight meters of front available for engagement. During the attack, the entire assault element moves toward its objective in 15 to 30 meter advances up to 100 meters from the objective. At this point, the threat advance is continuous, i.e., there are no breaks in movement.

Rosen and Behringer indicate that during the attack, the threat rifleman, when exposed, is likely to move at an average speed of 8 miles per hour (3.6 meters per second). In their review of field test results, Klein and Tierney report findings that are consistent with the 3.6 meters per second speed. They conclude that moving targets on a live fire range should therefore have a minimum capability of this speed in order to appropriately model individual squad member movement rates.

Of critical importance in modeling the threat is the determination of the target-to-firer distances at which arrays will be presented. Rosen and Behringer's analysis of the threat identified six sets of critical distances for combat:

- 500 to 1000 meters, the interval in which a motorized threat rifle squad is likely to dismount,
- 460 meters, the effective range of the M16A1 rifle,
- 300 meters, the effective range of the AKMS assault rifle,
- 200 meters, the final coordination line for the threat squad,

[7]Klein, R. and Tierney, T., op. cit.

[8]Rosen, M. and Behringer, R., op. cit.

- 80 to 100 meters, the threat squad's final assault line,

- 25 to 30 meters, the interval in which the final charge takes place.

Klein and Tierney found that quantitative combat data reflecting the frequencies with which targets are available for engagement at different target-to-firer distances are fragmentary. Such information is important to know if it is desired to arrange the presentation of targets so that they validly represent the combat situation. In reviewing the available data, Klein and Tierney conclude that at least 50 percent of the targets presented during a live fire exercise should be located from 50 to within 100 meters of the firer, 10 percent closer in, 30 percent scattered between 100 and 200 meters from the firer, and the final 10 percent between 200 and 300 meters from the firer.

Having established the critical distances at which targets are to be presented when modeling the threat and the frequency distribution of targets across these distances, it is necessary to determine the minimum number of moving targets to be presented at each of these distances. Rosen and Behringer note that at any given time during the attack, only two to three threat squad members can be expected to be moving for target-to-firer distances in excess of 100 meters. At distances less than 100 meters, they indicate that all threat soldiers are likely to be moving. Thus, in modeling the threat for a live fire range, three targets, at most, should be moving at any time for target presentations involving targets located at 100 meters or more. For target presentations at distances less than 100 meters, all targets should be moving.

Finally, in establishing the requirements for modeling the attacking threat rifle squad, guidelines for target exposure times are required. In reviewing the field test literature, Klein and Tierney recommend that targets appearing at distances in excess of 100 meters be exposed from four to twelve seconds. From their review of the threat literature, Rosen and Behringer recommend a comparable range of times for these targets, i.e., from five to ten seconds.

For targets located at distances of 100 meters or less, where target movement may be continuous or intermittent, target exposure times must reflect the nature of the target movement simulated. In particular, if it is desired to simulate continuous movement at these distances, Rosen and Behringer recommend the use of exposure times of 20 to 25 seconds. On the other hand, if it is desired to simulate intermittent movement, Klein and Tierney recommend the use of exposure times of two to eight seconds.

THE IRETS LIVE FIRE RANGE

As currently conceived, the IRETS live fire range consists of 10 firing lanes, each 30 meters wide and extending for 300 meters. Figure 1 shows the layout of a typical IRETS firing lane. Each lane has seven

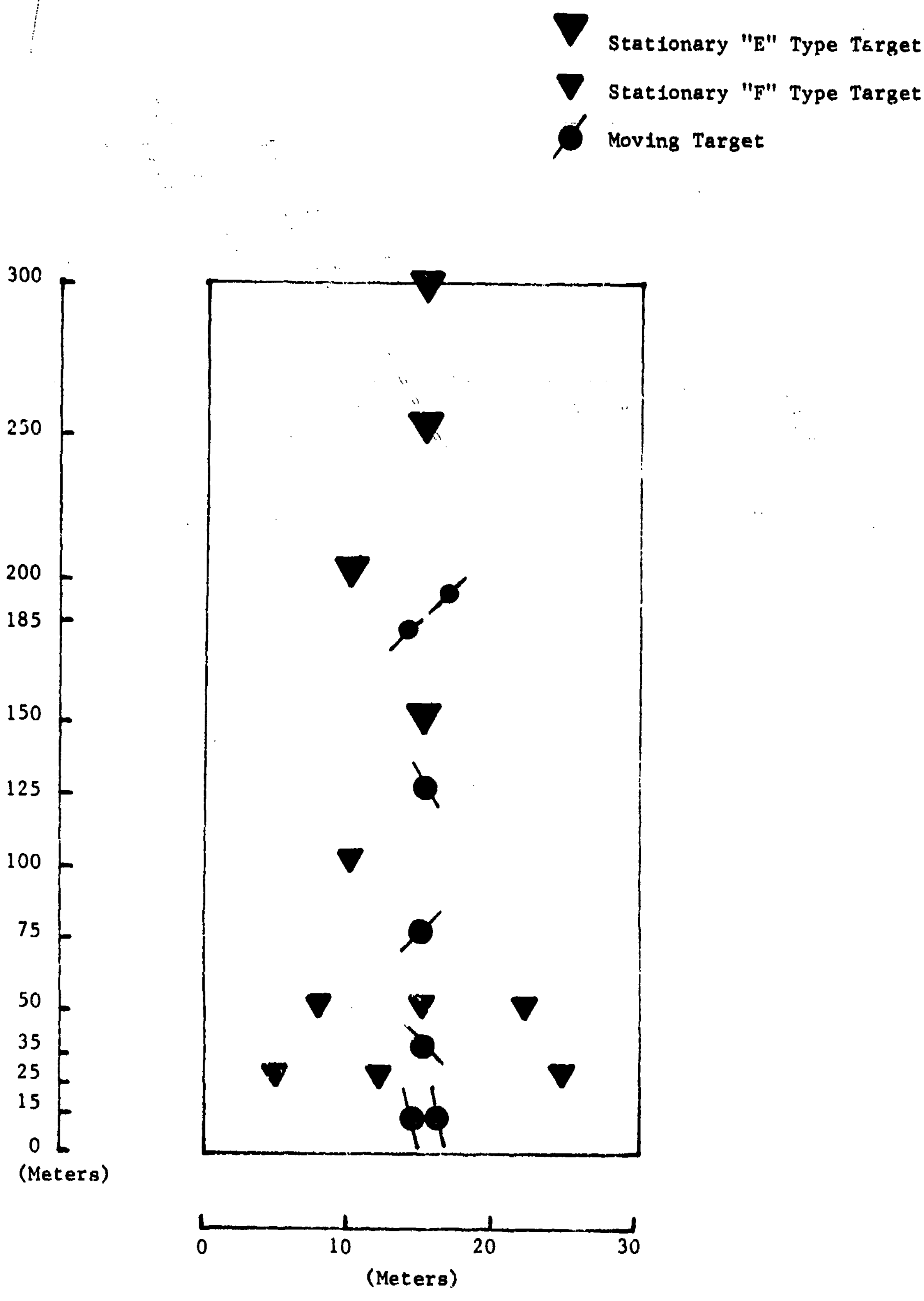

Figure 1. Layout of a typical IRETS firing lane.
(Note that lane width is not drawn to scale).

stationary and five moving target positions. Stationary positions located at 25 and 50 meters each consist of three-man target complexes, while the stationary positions at 100 meters and beyond consist of single targets. Of the five moving target positions, the 15 and 185 meter positions are two-man target complexes, while the remaining moving positions are single targets. Overall, 11 stationary and seven moving targets are available for presentation during an exercise.

As discussed above, multiple target complexes are employed at selected stationary and moving target positions. For the 25 meter stationary position, two of the three multiple targets are positioned laterally within seven meters of each other. The third target in this complex is separated laterally from the other targets by 13 meters. In contrast, the three targets constituting the 50 meter target complex are all positioned closely. The lateral separation between adjacent targets is seven meters. Finally, the multiple moving target complex located at 15 meters consists of two side-by-side targets, while the multiple moving targets located at 185 meters consist of two tandem targets. The lateral separation of the two 15 meter moving targets is two meters. On the other hand, the separation between the ends of the target paths for the two 185 meter tandem targets is five meters.

The stationary targets of the IRETS range are portrayed by two types of two-dimensional pop-up targets. At the more distant stationary position (150, 200, and 300 meters), E-type silhouette targets are used. These targets represent the front view of a kneeling soldier (head, shoulders, and upper torso) and present an exposed area of 4.59 square feet. At the nearer stationary positions (25, 50, and 100 meters), F-type silhouette targets are used. These targets represent the front view of a soldier in the prone firing position (head and shoulders). They present an exposed area of 2.38 square feet. This is about half the area presented by the E-type targets.[9]

Three-dimensional pop-up targets are employed at each of the moving target positions on the IRETS range. These are designed to present the image of a running, fully equipped threat soldier as viewed from a 45 degree angle. All of the moving targets, except the two tandem targets located at 185 meters, move along a ten meter path. According to the IRETS specification, these targets must be able to move selected distances along the ten meter path within specified increments of time as follows:

- 5.0 meters in 2, 3, or 4 seconds,
- 7.5 meters in 2, 3, or 4 seconds,
- 10.0 meters in 3 or 4 seconds.

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[9]Intrec, Inc. The evaluation of small arms effectiveness criteria (Volume 1). Santa Monica, CA: Author, May 1975.

The two moving targets located at 185 meters, in contrast to the other moving targets, are limited to movement on a five meter path. The IRETS specifications for these targets requires that they be able to move the full five meter distance in 2, 3, or 4 seconds.

Finally, according to the IRETS specification, the moving targets must be able to move both forwards and backwards. The up-and-down motions of the target and its movement along its travel path are sequenced according to the requirements of the particular scenario used to present targets for a firing exercise. In general, the operation of individual moving targets during an exercise is as follows:

- As required by the target presentation scenario, a selected moving target is commanded to an up position.
- Next, depending on the scenario requirements, the target either moves immediately or it remains stationary for up to four seconds prior to the initiation of movement.
- Upon receiving a movement command, the target moves along its travel path.
- When the target movement required by the scenario has occurred, the target is commanded to go down (unless it has previously been downed by a hit).
- Finally, depending on the requirements of the scenario, the target in the down position either returns to its initial position or remains in its terminal position awaiting a command to rise and move to the rear of the travel path.

THE IRETS TARGET PRESENTATION SCENARIO

The IRETS target presentation scenario consists of 50 target events distributed across two phases: an attack by enemy riflemen (33 events) against a defensive position and a retreat by enemy riflemen (17 events) after the attack. The first phase lasts for 197 seconds, while the second phase lasts for 103 seconds.

For both phases, each target presentation is defined by the time the target is exposed, target mode (stationary or moving) and the target-to-firer distance. Figures 2 and 3 present the phases of the IRETS scenario in terms of these factors.

In developing the IRETS scenario, a 6 to 1 force ratio was assumed by the developer for the attack phase, while a 3 to 1 ratio was assumed for the retreat phase. For the purposes of analysis, the attack phase was considered to consist of a series of successive subphases, each consisting of not less than six target presentations. Similarly, the retreat phase was considered to consist of a series of subphases, each con-

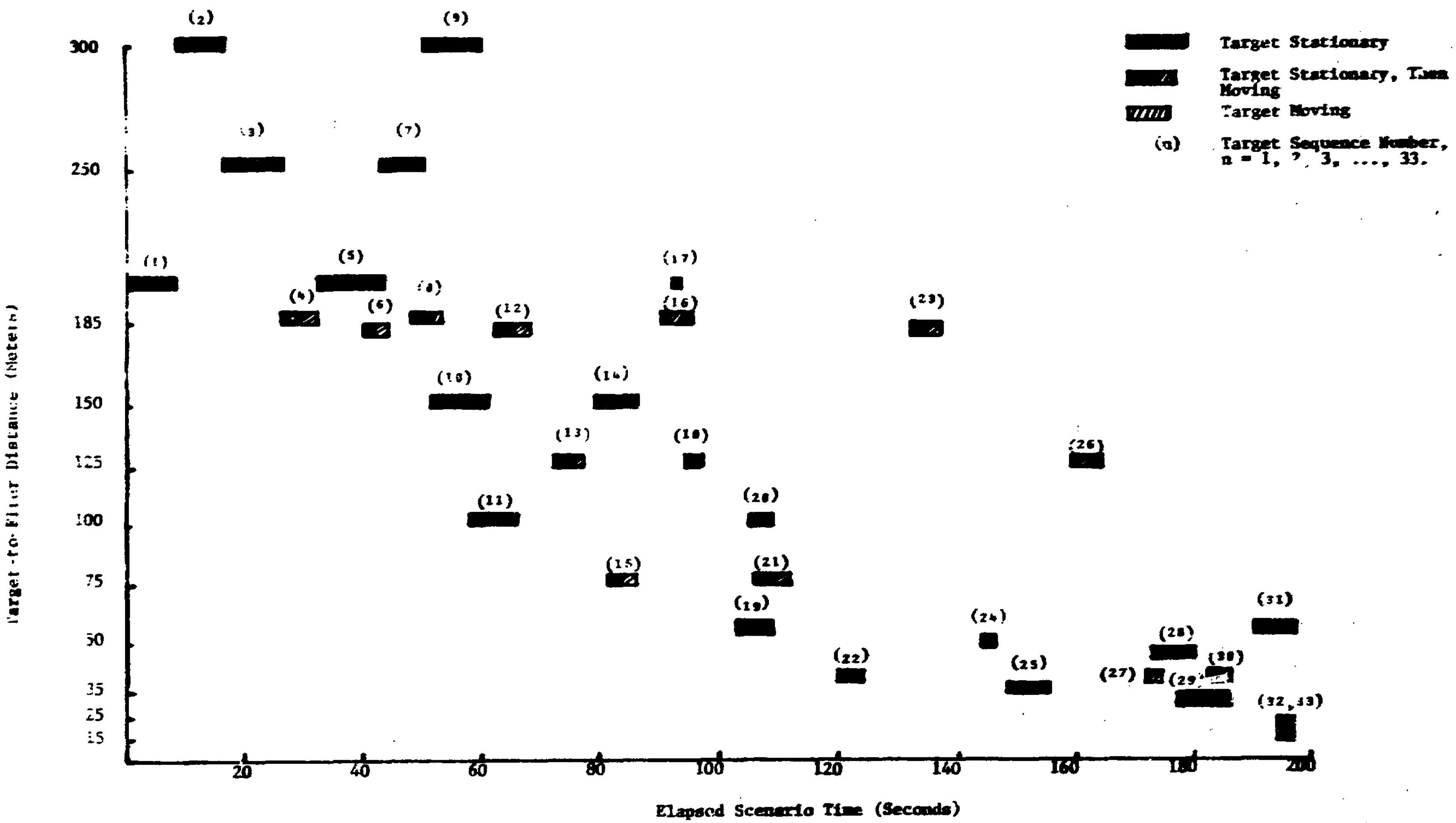

Figure 2. Attack phase of the IRETS Defense Scenario.

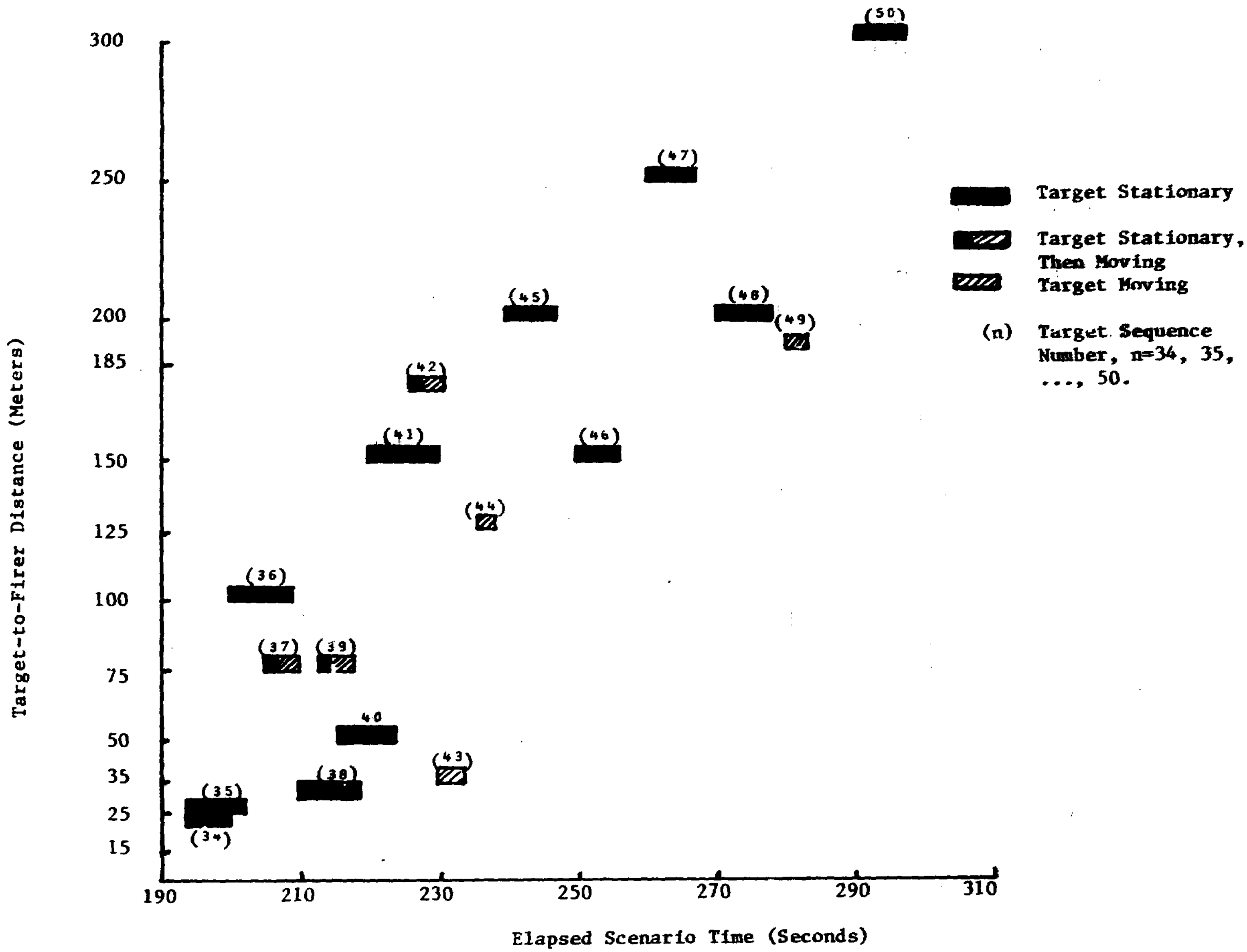

Figure 3. Retreat phase of the IRETS Defense Scenario

sisting of not less than three target presentations. Figures 4 and 5 portray the two phases of the scenario in the above terms.

As shown in Figure 4, the attack phase may be considered to consist of four sets of six target events and a fifth set consisting of nine events. One interpretation of these target sets (when taken as a function of scenario time) would be that the first four sets of events represent the movement of 6-man groups of enemy soldiers toward a defensive position with the last set representing the final assault by nine enemy soldiers on the position or multiple exposures of fewer soldiers.

Figure 5 indicates that the retreat phase of the IRETS scenario consists of four sets of three target events and a fifth set consisting of six events. When taken as a function of scenario time, the first four target sets may be interpreted as the movement of 3-man groups of enemy soldiers away from a defensive position with the fifth set representing the consolidation of the remaining elements of a retreating force just prior to breaking contact with defending forces.

COMPARATIVE ANALYSIS OF THREAT PARAMETERS AND THE IRETS PORTRAYED THREAT

In this section, the adequacy with which the IRETS portrays the the threat is discussed. The specific factors addressed in this discussion include:

- Target separation (in-depth and laterally),
- Target-to-firer distances,
- Target presentation frequency,
- Single and multiple target presentations,
- Target exposure times,
- Target sizes,
- Moving target speeds and movement distances,
- Employment of battlefield noises,
- Employment of limited visibility conditions.

The findings and conclusions concerning these factors are also displayed in a matrix in Appendix I.

In addition to these factors, a discussion of selected aspects of evaluation as this relates to the conduct of threat oriented rifle marksmanship live fire exercises is presented. These evaluation aspects are:

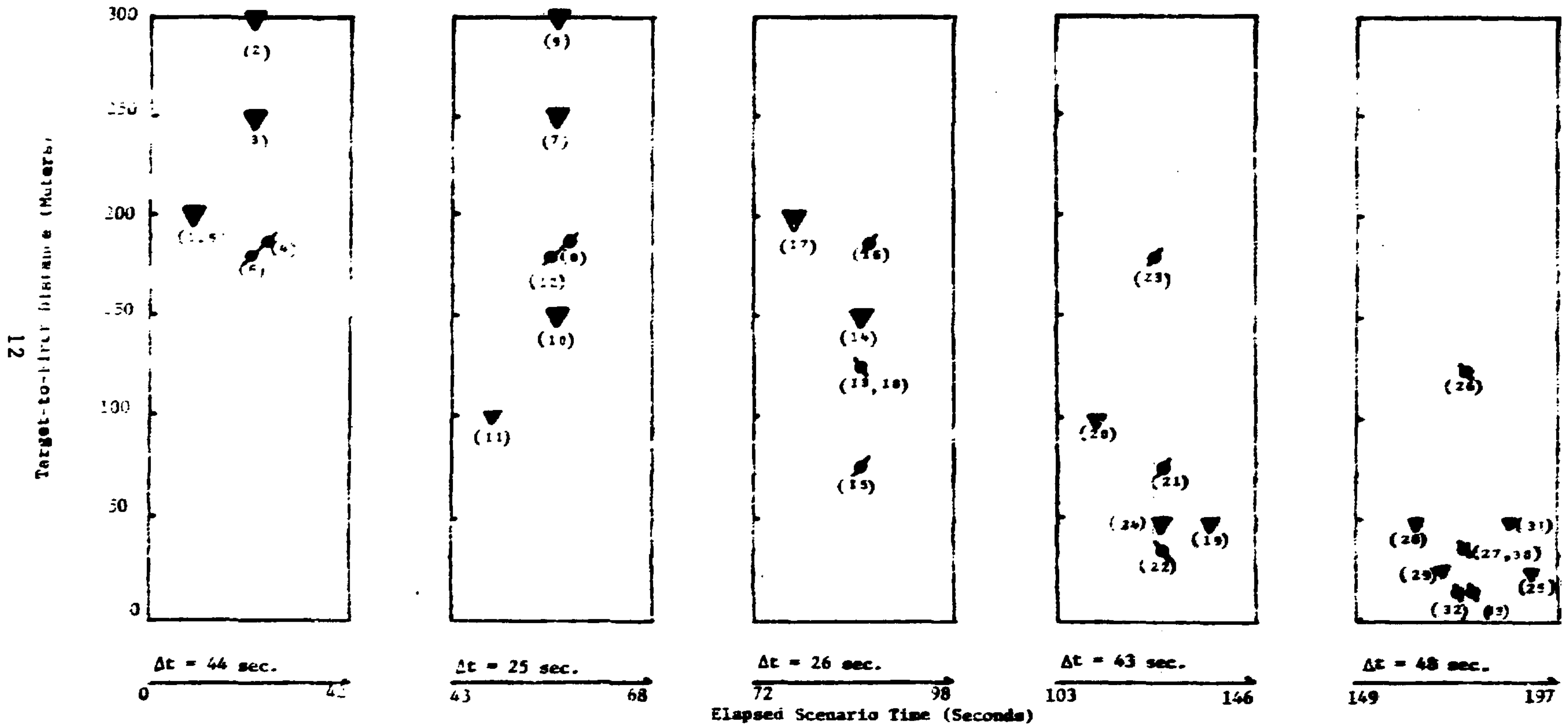

Figure 4. Attack phase of the IRETS Defense Scenario as a function of elapsed scenario time. (Note that lane width is not drawn to scale.)

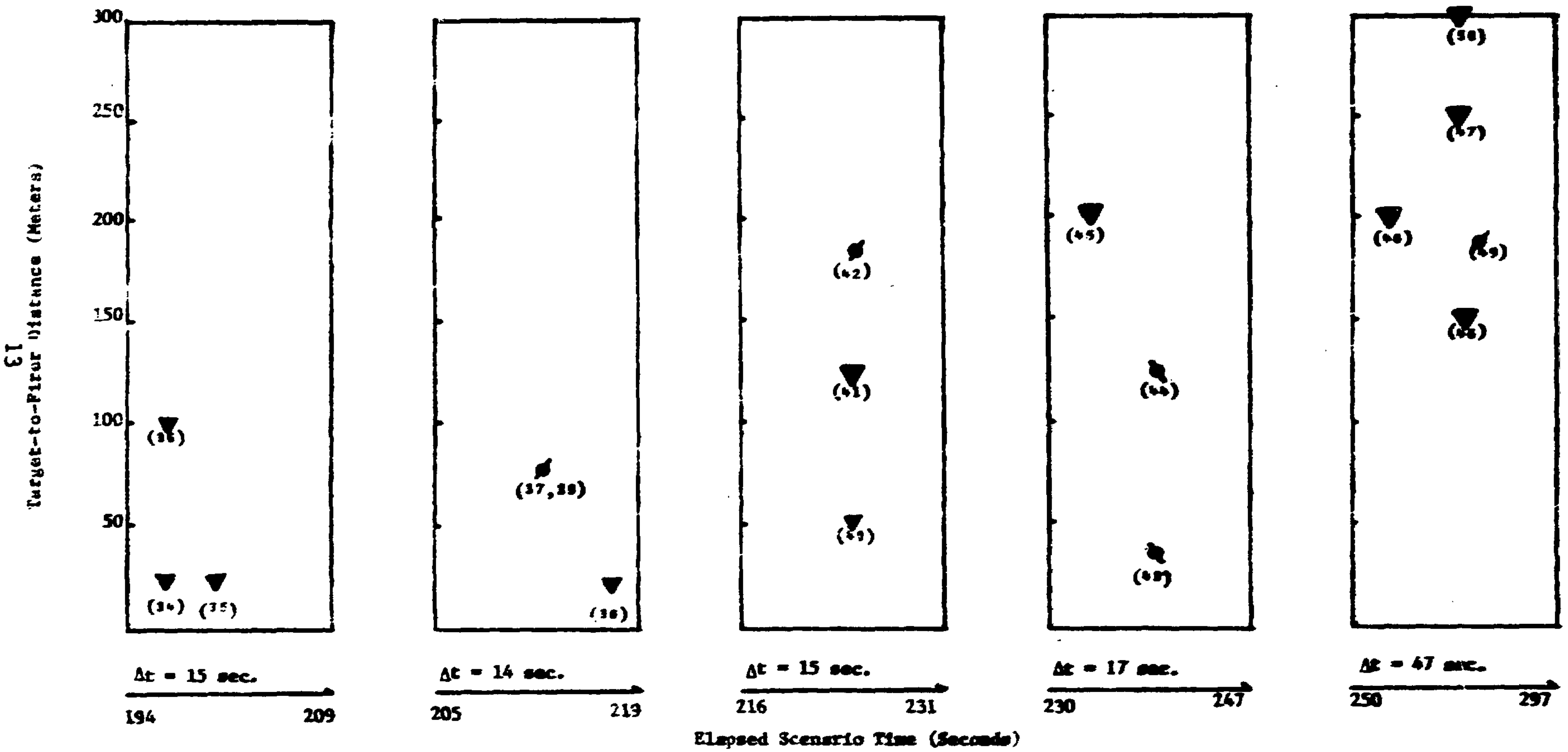

Figure 5. Retreat phase of the IRETS Defense Scenario as a function of elapsed scenario time.
(Note that lane width is not drawn to scale.)

- Firing positions appropriate for trainee use during live firing,
- Night firing considerations,
- Squad member live firing interactions,
- Diagnostic data collection on the IRETS range.

Target Separation (In-Depth and Laterally). Analyses of threat tactics[10,11,12] indicate that the threat rifle squad moves and operates as a unit during the attack. Movement is in 15 to 30 meter bounds until the squad is within approximately 100 meters of its objective. At this point, the squad halts briefly and then advances without stopping until the objective is achieved or the attack is stopped by the defender's fires. Bounds are coordinated so that a lateral dispersion of six to eight meters between soldiers is maintained. All movement occurs along an axis perpendicular to the forward edge of the squad objective. These facts suggest that the appropriate model for representing an attacking threat squad is an array of targets having more width than depth.

While ample information is available concerning the likely behavior of an attacking threat squad, little is known about the likely behavior of a threat squad in retreat. The available data suggest that under the conditions of a retreat, threat soldiers would be likely to fall back from the objective in groups of two's or three's using available cover and concealment opportunities. These facts suggest that the appropriate model for a retreating squad is a collection of target arrays, each consisting of two or three targets that are relatively close, both laterally and in-depth.

The target arrays presented during an IRETS live fire exercise are defined by the IRETS target presentation scenario. This scenario specifies which targets at what locations are presented at a given time and the order in which these presentations occur. In order to investigate the depth and width characteristics of these arrays, two analyses were conducted. One for the attack phase of the scenario and one for the retreat phase. For the attack analysis, successive target groups consisting of not less than six individual targets were considered to constitute the threat, while for the retreat phase successive groups of not less than three individual targets were considered to constitute the threat.

Tables 1 and 2 present the in-depth and lateral separations for the IRETS attack and retreat target arrays. Clearly, for the six-man target groups of the attack phase (see Table 1), the in-depth separations are relatively large, while the lateral separations are relatively small.

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[10] Klein, R. and Tierney, T., op. cit.

[11] Rosen, M. and Behringer, R., op. cit.

[12] Frasche, R. The Soviet motorized rifle company (Defense Intelligence Report DDI-1100-77-76). Washington, D.C.: Defense Intelligence Agency, June 1975.

Table 1

IN-DEPTH AND LATERAL SEPARATIONS OF IRETS TARGET GROUPS FOR THE ATTACK

Group[a]			Closest Groups of:			
	6 Targets		5 Targets		4 Targets	
	In-Depth Separation	Lateral Separation	In-Depth Separation	Lateral Separation	In-Depth Separation	Lateral Separation
1	115m	9m	65m	9m	15m	7m
2	200m	9m	150m	7m	89m	4m
3	125m	9m	75m	7m	60m	7m
4	150m	12m	65m	11m	40m	7m
Group[b]			Closest Groups of:			
	9 Targets		8 Targets		7 Targets	
	In-Depth Separation	Lateral Separation	In-Depth Separation	Lateral Separation	In-Depth Separation	Lateral Separation
5	110m	17m	35m	13m	35m	10m

[a] Six targets per group

[b] Nine targets per group

Table 2

IN-DEPTH AND LATERAL SEPARATIONS OF IRETS TARGET GROUPS FOR THE RETREAT

Group[a]	In-Depth Separation	Lateral Separation
1	75m	7m
2	50m	10m
3	139m	0m
4	165m	5m
Group[b]	In-Depth Separation	Lateral Separation
5	150m	9m

[a]Three targets per group

[b]Five targets per group

When one or two stragglers are assumed and eliminated (5- or 4-man target groups), in-depth separations are reduced, while lateral separations remain about the same. Still, for these groups, their width is far greater than their depth. For the retreat phase, in-depth separations are also large and lateral separations small or non-existent (See Table 2). These findings indicate that the threat depicted by the IRETS target presentation scenario is not the threat described in the literature reviewed, since this literature calls for target arrays that are more wide than deep.

An additional concern is the impact that the IRETS arrays have on the technique of fire employed by the firer during a live fire exercise. In combat, it can be expected that the firer will be required to shift his aim by large increments, particularly if targets are spread out across his field of view. This means the target arrays engaged during training and evaluation should require the firer to shift his aiming point over a wide range of values. Table 3 shows the lateral separations of pairs of successive targets as these are displayed to the firer by the IRETS target presentation scenario. As shown in this table, the lateral separation of successive pairs of targets tends to be small. For the first 33 targets presented (the attack phase), the average lateral separation of successive target pairs is five meters. For the remaining 17 targets presented (the retreat phase) this average is only four meters. As shown in Table 4 (which summarizes Table 3 in terms of a frequency distribution of the lateral separations), over 70 percent of the targets in both the attack and retreat phases of the scenario are separated by less than 6 meters (the minimum expected lateral separation of threat soldiers during the attack). The impact of this is that for most cases during an IRETS live fire exercise, the firer will be required to shift his aiming point only a little or not at all.

A short-range solution to these problems is simply to spread the target locations further apart laterally and concentrate them (by scenario modifications) in tighter in-depth groups. Longer range solutions may require the addition of targets and the revision of the scenario to present the following: target groups (6 or fewer in sequence) with the in-sequence lateral separations ranging from 6 to 8 meters and groups filling the lane; in-depth separations (4 of the targets) of no more than 30 meters; and provisions in a group for stragglers with more in-depth separation in the later phases of the attack. Additionally, shifts in angular movements of the firer's aim of at least 10 to 12 degrees beyond 50 meters should be required. Within 50 meters, the angular shift required should be larger, e.g., 20 to 25 degrees.

<u>Target-to-Firer Distances</u>. Table 5 presents a comparison between the distribution of targets on the IRETS range and the distribution recommended by Klein and Tierney. As shown in this table, several differences exist. Weighting of target displays centers on the 50 to 100 meter range band (50 percent) for the threat (Klein and Tierney) and on the 100 to 200 meter band (42 percent) for the IRETS

Table 3

LATERAL SEPARATION OF IRETS TARGETS BY SEQUENCE FOR THE ATTACK AND RETREAT PHASES OF THE TARGET PRESENTATION SCENARIO[a]

Attack Phase		Retreat Phase	
Targets	Separation (Meters)	Targets	Separation (Meters)
1-2	5	34-35	7
2-3	0	35-36	5
3-4	4	36-37	5
4-5	9	37-38	10
5-6	5	38-39	10
6-7	0	39-40	0
7-8	4	40-41	0
8-9	4	41-42	0
9-10	0	42-43	4
10-11	5	43-44	0
11-12	5	44-45	5
12-13	4	45-46	5
13-14	0	46-47	0
14-15	4	47-48	5
15-16	0	48-49	9
16-17	5	49-50	4
17-18	5		
18-19	3		
19-20	12		
20-21	9		
21-22	7		
22-23	7		
23-24	4		
24-25	10		
25-26	14		
26-27	0		
27-28	3		
28-29	4		
29-30	0		
30-31	9		
31-32	9		
32-33	2		
Average ($\overline{x}$)	5		4

[a]Moving targets are considered to be at the start position on their track.

Table 4

FREQUENCY DISTRIBUTION OF LATERAL SEPARATIONS FOR THE ATTACK AND RETREAT PHASES OF THE IRETS TARGET PRESENTATION SCENARIO

Phase	Lateral Separation (Meters)	Frequency	Percentage of Total
Attack	0	7	22
	1-5	16	50
	6-10	7	22
	11-15	2	6
Retreat	0	5	31
	1-5	7	44
	6-10	4	25
	11-15	0	0

Table 5

COMPARISON OF TARGET DISTRIBUTIONS FOR THE IRETS AND THE TARGET PRESENTATION DISTRIBUTION RECOMMENDED BY KLEIN AND TIERNEY

Target-to-Firer Distance	IRETS Targets Scenario Distribution (N=50)[a]	IRETS Targets Actual Range Distribution (N=18)	Klein and Tierney Presentation Distribution
0-50 meters	22%	50%	10%
50-100 meters	24%	11%	50%
100-200 meters	42%	28%	30%
200-300 meters	12%	11%	10%

[a]Thirty-three (33) targets in the attack phase with the same distribution

scenario. Half of the physical target placements on the IRETS range are, however, in the 0 to 50 meter band. Even if the three 50 meter physical targets are included in the 50 to 100 meter band, only 28 percent of physical targets are located there.

To bring the IRETS target display capabilities more in line with the threat depiction, scenario changes will be required. Some targets may also have to be physically moved further down-range to avoid repeated usage of individual targets in some range bands and little or no use of targets in other bands. Certainly, the end result should be the presentation of about 50 percent of the targets in the 50 to 100 meter band and 30 percent in the 100 to 200 meter band.

Target Presentation Frequency. Jehan[13] reports that current Soviet military doctrine calls for a force ratio of 6:1 for instigating a major attack against U. S. forces. Jehan further reports that if the enemy is repelled after an attack, then the retreating force would probably represent a force ratio of 3:1. Under the above conditions, Jehan concludes from an analysis of field experimentation data that a total of 33 target presentations are required to represent a threat attack, while 17 total presentations are required to represent a threat retreat on a live fire range. Thus, for a complete attack-retreat scenario, a total of 50 target presentations would be required for each lane of a live fire range.

Rosen and Behringer[14] indicate that a 3:1 force ratio is most likely to characterize the modern battlefield. This is because attacking threat platoons normally operate across a 200 meter front, while U. S. squads usually defend across a 100 to 125 meter front. Further, it may be reasonable to assume that a threat force would only retreat when the force ratio had been reduced to unity, e.g., 1:1[15]. Under these conditions, considerably fewer target presentations would be required to represent a threat attack followed by a retreat of threat forces. In particular, using the procedure em-

[13] Jehan, H., op. cit.

[14] Rosen, M. and Behringer, R., op. cit.

[15] The 1:1 ratio is derived by applying breakpoint data to an attack situation in which a 3:1 force ratio initially existed. A 25-man threat platoon attacking a defensive position will retreat, according to these data, when an average of 15 casualties have been sustained (60 percent). Applying the 60 percent figure to the 3 attacking men, leaves only about 1 attacker and produces the best estimate available for breakpoint.

ployed by Jehan[16], the target presentations required to represent a threat attack would be 17 presentations, while the target presentations required to represent the retreat would be 6 presentations. Thus, under the above conditions, a total of 23 presentations would be adequate for an attack-retreat scenario for each lane of a live fire range.

The ratio of 3:1, however, does not maximize (or "worst case") the threat, nor does it account for overlapping zones of responsibility and ratio changes due to friendly casualties. Under these conditions, a 6:1 ratio seems much more reasonable as a threat to be defeated than the 3:1 ratio based on averages.

With respect to target presentation frequencies, the Jehan model and the IRETS scenario appear to be adequate and no changes are apparently required.

Single and Multiple Target Presentations. As discussed earlier, the appropriate model for representing the attacking threat squad is that of a linear target parallel to the attacked position. This threat unit is expected to use fire and movement tactics, rather than fire and maneuver, as the basis of attack. One implication of these tactics is that at any given moment, at least two or three individual targets are likely to be available for engagement. Thus, in developing a valid attack target presentation scenario for a live fire range, target presentations involving multiple individual targets should be very frequent events. In addition, multiple target exposure situations should increase as distance to targets decreases.

For a threat retreat, as discussed previously, only two or three soldiers are likely to be seen at any given time together. Further, as the retreat progresses, single targets will probably characterize what the defender will see. Thus, few multiple target presentations are characteristic of the retreat, with these decreasing in frequency as the threat moves farther down range.

As shown in Figures 6 and 7, single target exposures tend to characterize the attack and retreat phases of the IRETS scenario. As shown in Table 6, during the attack phase of the scenario, single targets are exposed 58 percent of the time targets are presented, while three targets are exposed simultaneously only 5 percent of the time. For the retreat phase, single targets are exposed 66 percent of the time, while

[16] Jehan, H., *op. cit.*

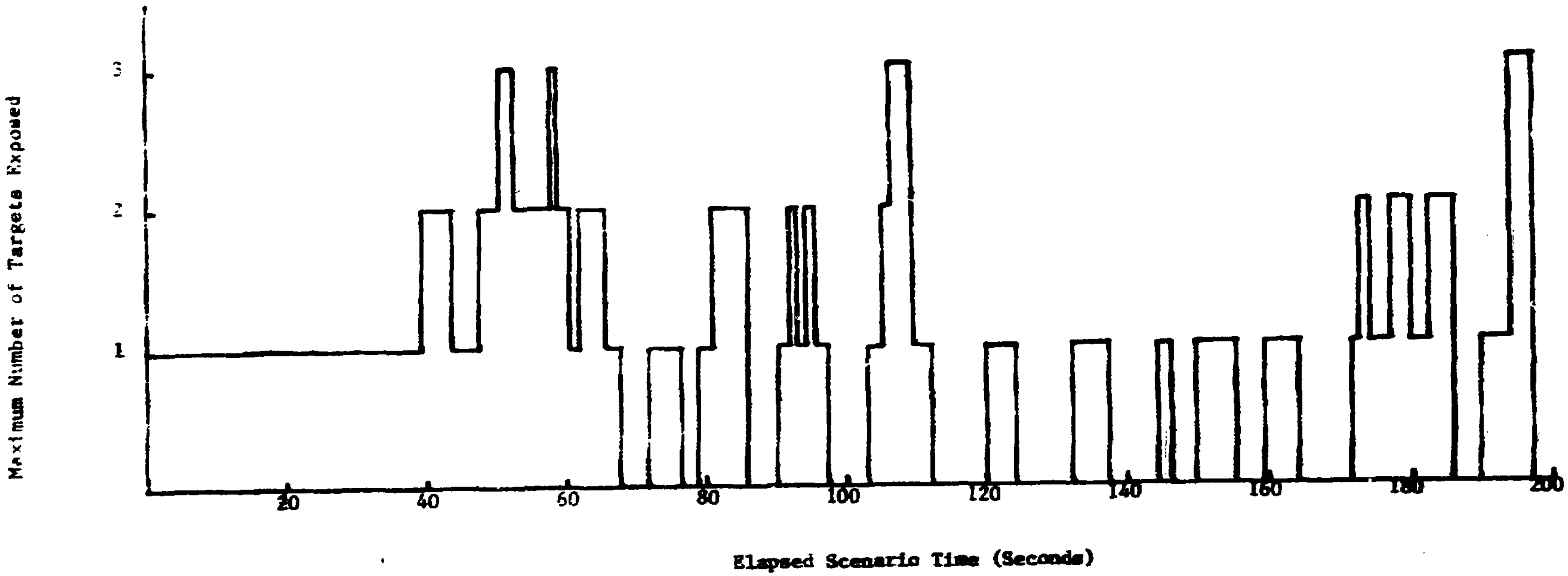

Figure 6. Maximum number of targets exposed as a function of elapsed scenario time for the attack phase of the IRETS Defense Scenario.

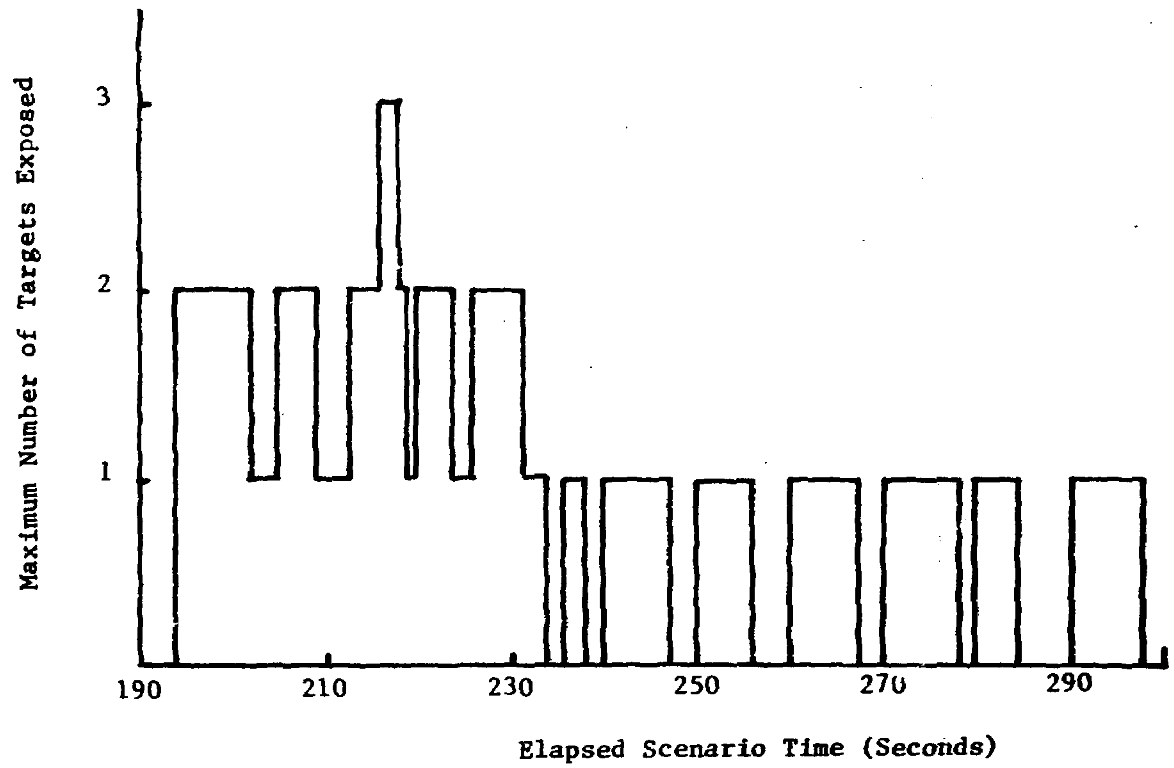

Figure 7. Maximum numbers of targets exposed as a function of elapsed scenario time for the retreat phase of the IRETS Defense scenario.

Table 6

PERCENT OF TIME VARIOUS TARGET MULTIPLES ARE DISPLAYED

Number of Targets Appearing	Percent of Total Attack Time	Percent of Total Retreat Time
None	11	21
When Targets Are Showing		
One	58	66
Two	37	32
Three	5	2

three simultaneous targets are exposed only 2 percent of the time. Also, multiple target exposures do not generally increase with elapsed time in the attack phase. Multiple target exposures do tend, however, to decrease in the retreat phase (see Figures 6 and 7).

Correction of the above described differences between the attack phase of the IRETS scenario and the threat model will require a scenario revision in this phase so that multiple targets (2 or 3) are presented more often overall and less frequently during the earlier portions and more frequently during the later portions of this phase. The retreat phase, as discussed above, appears to be acceptable in multiple target respects. Thus, no change appears necessary for the retreat.

Target Exposure Times. According to Klein and Tierney[17] and Rosen and Behringer[18], engageable threat targets can be expected to be exposed from four to five seconds up to ten to twelve seconds at target distances of 100 to 400 meters. At closer distances (less than 100 meters), engageable targets can be expected to be exposed from two to eight seconds (intermittently appearing targets) or twenty to twenty-five seconds (fully exposed soldiers in a final assault). Obviously, there will be some targets exposed for shorter times than those indicated above, but these targets are not likely to be engageable.

Table 7 lists the exposure times for the attack and retreat phases of the IRETS target presentation scenario as a function of target distance. This scenario calls for a total of 50 presentations: 20 involving relatively close targets (less than 100 meters from the firer). For the 20 close presentations, 18 involve exposures of three or more seconds. Two of these (a 35 meter and a 50 meter target) involve exposures of only two seconds. While these do not represent a deviation from the guidelines discussed above, it is possible that firers may have insufficient time to acquire, aim, and fire on these targets. For this reason, it may be appropriate to lengthen the exposure times of these targets by one or two seconds.

For the 30 distant presentations, 24 involve exposures of five or more seconds. Of the remaining presentations, three involve exposures of four seconds, and one each exposures of one (a 200 meter target), two (a 125 meter target), and three (a 125 meter target) seconds. It is unlikely that the 200 meter, one second target will be engageable. The presentations involving the two and three second exposure times may not be engageable, either. Clearly, the times for these targets should be increased to at least four seconds, the minimum time suggested by the guidelines presented above.

[17]Klein, R. and Tierney, T., op. cit.

[18]Rosen, M. and Behringer, R., op. cit.

Table 7

TARGET EXPOSURE TIMES EMPLOYED DURING THE ATTACK AND RETREAT PHASES OF THE IRETS DEFENSE SCENARIO

Phase	Target Type	Target Range	1	2	3	4	5	6	7	8	9	10	11	12
			Exposure Times (sec.)											
Attack	Stationary	25						X			X			
		50		X				X	X[a]					
		100				X				X				
		150							X			X		
		200	X							X			X	
		250							X			X		
		300								X	X			
	Moving	15			X[a]									
		35		X		X[a]								
		75					X	X						
		125			X		X[a]							
		185				X	X[a]	X[a]						
Retreat	Stationary	25						X		X	X			
		50								X				
		100									X			
		150						X				X		
		200							X	X				
		250							X					
		300							X					
	Moving	35				X								
		75					X[a]							
		125		X										
		185				X	X							

[a] Repeat exposure

Finally, as shown in Table 7, none of the targets at the close target distances involve exposure times in excess of 11 seconds. Thus, no final assault is being depicted in the sense of longer exposure times, e.g., 20 seconds or more. The targets for depicting such an assault, however, are available on the IRETS range. Some consideration should be given to modifying the IRETS target presentation scenario so that toward the end of the assault phase, a number of targets are displayed for intervals of 20 to 25 seconds. In this way, a final assault on the firer's position would be simulated.

Target Size. An important consideration in the development of a live fire range is the size and configuration (shape) of the targets used to support firing. For a small arms range, this translates into the problem of selecting targets that simulate the body area and shape that would be presented by a threat rifleman in a given combat situation. In combat, presented body area and shape depend on the posture (standing, kneeling or prone position) being assumed by the target at the time it is being engaged. Thus, the problem of target size and shape translates into the problem of choosing targets that simulate threat soldiers in postures consistent with those expected in a given combat situation.

As discussed previously, the IRETS target presentation scenario is designed to portray a threat attack and a threat retreat. It follows that the targets chosen to represent the threat soldier should represent soldiers who are assuming postures consistent with their most likely behavior in these situations. Analysis of the attack situation suggests that the appropriate representation of a threat rifleman is a man-sized target that presents a front view of a man (less any area around the feet obscured by vegetation or terrain irregularities), i.e., a rifleman moving directly toward the firer's position. Similarly, analysis of the retreat situation suggests that the appropriate representation of a retreating rifleman is a man-sized target that presents a rear view of a man (less any obscured area around the feet), i.e., a man moving away from the firer's position. In both the attack and the retreat there will undoubtedly be circumstances in which threat soldiers assume postures that reduce the amount of presented body area and alter their presented shape (relative to an upright position). The extent to which these kinds of targets are likely to occur during a threat attack and retreat is currently not known. Analyses of combat data by Klein and Tierney[19], however, suggest that these kinds of targets are relatively low probability events in heavy combat. Further, these same analyses indicate that relatively upright target configurations are the more likely case in such combat. Thus, it is reasonable to conclude that for modeling the attack and the retreat, the appropriate target representations consist of man-sized targets presenting full (upright or crouching) views (front for the attack and rear for the retreat).

It is currently planned to employ two dimensional E- and F-type

[19]Klein, R. and Tierney, T., op. cit.

silhouette targets and three dimensional man-sized images molded in the form of a running threat rifleman to represent the threat soldier of the IRETS range. The F-type targets, representing the front view of the head and shoulders of a man in a prone posture, will be employed at the nearer, stationary target positions (25, 50, and 100 meters). The E-type targets, representing the front (or rear) view of the head, shoulders, and upper torso of an upright man, will be employed at the longer, stationary target positions (150, 200, 250, and 300 meters). The three dimensional targets, which serve as the targets for all moving engagements, will be employed at both near (15, 35, and 75 meter) and distant (125 and 185 meter) moving positions.

Of the three types of targets planned for use on the IRETS range, only the F-type targets are likely to be inappropriate. This is because these targets represent a rifleman assuming a relatively low frequency posture for an attack (or retreat) situation. As a consequence, consideration should be given to replacing all of the F-type targets with E-type targets. In this way, the high frequency postures characteristic of the attack or retreat will be emphasized on the range.

Moving Target Speeds and Movement Distances. Judging from threat data, a speed of about 3.6 meters per second (8 miles per hour) over bounds of 15 to 30 meters seems appropriate for attacking soldiers. Some targets may appear in shorter segments and at speeds varying from 3.6 meters per second, but these parameters should be reasonable representations of engageable targets. For the retreat, however, little is known except that individual target presentations will probably prevail, moving at oblique angles to the defensive front.

The IRETS specifications provide for seven moving target positions in each firing lane. All of these targets are arranged so that movement is along paths generally at a 45 degree angle to the center line of the firing lane. For two of these targets (at 185 meters) the maximum travel capability is 5 meters. The remaining targets can travel up to 10 meters. Given the times to traverse paths, as contained in the IRETS specifications, movement speeds can vary from 1.3 to 3.8 meters per second. The full representation of speeds is shown in Table 8.

Under the IRETS specifications, the matching of expected threat movement distances cannot be achieved because of the limited movement (distance) capabilities of the IRETS moving targets. Additionally, appropriate movement speeds can be approximated only for those moving targets having a maximum travel capability of 10 meters. Finally, because of the limited travel capabilities of the moving targets, it is possible to achieve the long duration moving target exposure times only if moving target presentations are conducted in two phases: a stationary phase (either at the beginning or at the end of the presentation)

Table 5

TARGET MOVEMENT SPEEDS (METERS PER SECOND) FOR IRETS
AS A FUNCTION OF TRAVEL DISTANCE AND TRAVEL TIME

Travel Distance (Meters)	Travel Time (Seconds) 2	3	4
5	2.5	1.7	1.3
7.5	3.8	2.5	1.9
10	-	3.3	2.5

and a moving phase. Under these conditions, it is likely that firers will learn to fire at moving targets only when they are in the stationary phase. If this happens, hit probabilities for these targets are likely to be inflated.

Obviously, one solution to these problems is the extension of track length. When feasible, track lengths of up to 30 meters should be considered. Discussion with the IRETS prime contractor engineering staff revealed, however, that extension of moving target track length may be practical only up to 20 meters. For this reason, track length extensions of the magnitude required do not appear to be feasible at the present time.

In the shorter run, three possibilities exist to make the use of moving targets more realistic in terms of the threat without extending track length:

- the use of end-to-end tracks,
- the simulation of longer, more direct routes,
- the simulation of segmented routes.

These alternatives are shown in Figure 8.

Placing two (or more) 10 meter tracks on a single line with a gap between track segments, as shown in Alternative A, would simulate the movement of a target up to, behind and past an object. The gap should be screened from the firer by a tree or building segment. In this case, realistic movement speeds, distances and total movement times would be simulated. Software would be required to cause the targets to move, fall, rise, and move again to represent this.

Longer runs can be simulated with single 10 meter tracks as well. As shown in Alternative B, the simulated run would be in a more direct route to the attacked position. The target speed would have to be slowed and the target's facing direction would have to be changed, however.

Since rush segments need not be all in the same direction, a two (or more) segment movement could be simulated, as in Alternative C. To be realistic, the target would have to face directly at the firer for a portion of the time, then rotate in the direction of movement, then move. This appears to be the least satisfactory of the alternatives due to the stationary phase of exposure and the required additional sophistication to the moving target mechanism.

Employment of Battlefield Noises. The IRETS, as currently configured, employs hostile fire simulators (two per firing lane) to simulate the incoming fires of enemy soldiers. Rosen and Behringer[20] suggest, however,

[20]Rosen, M. and Behringer, R., *op. cit.*

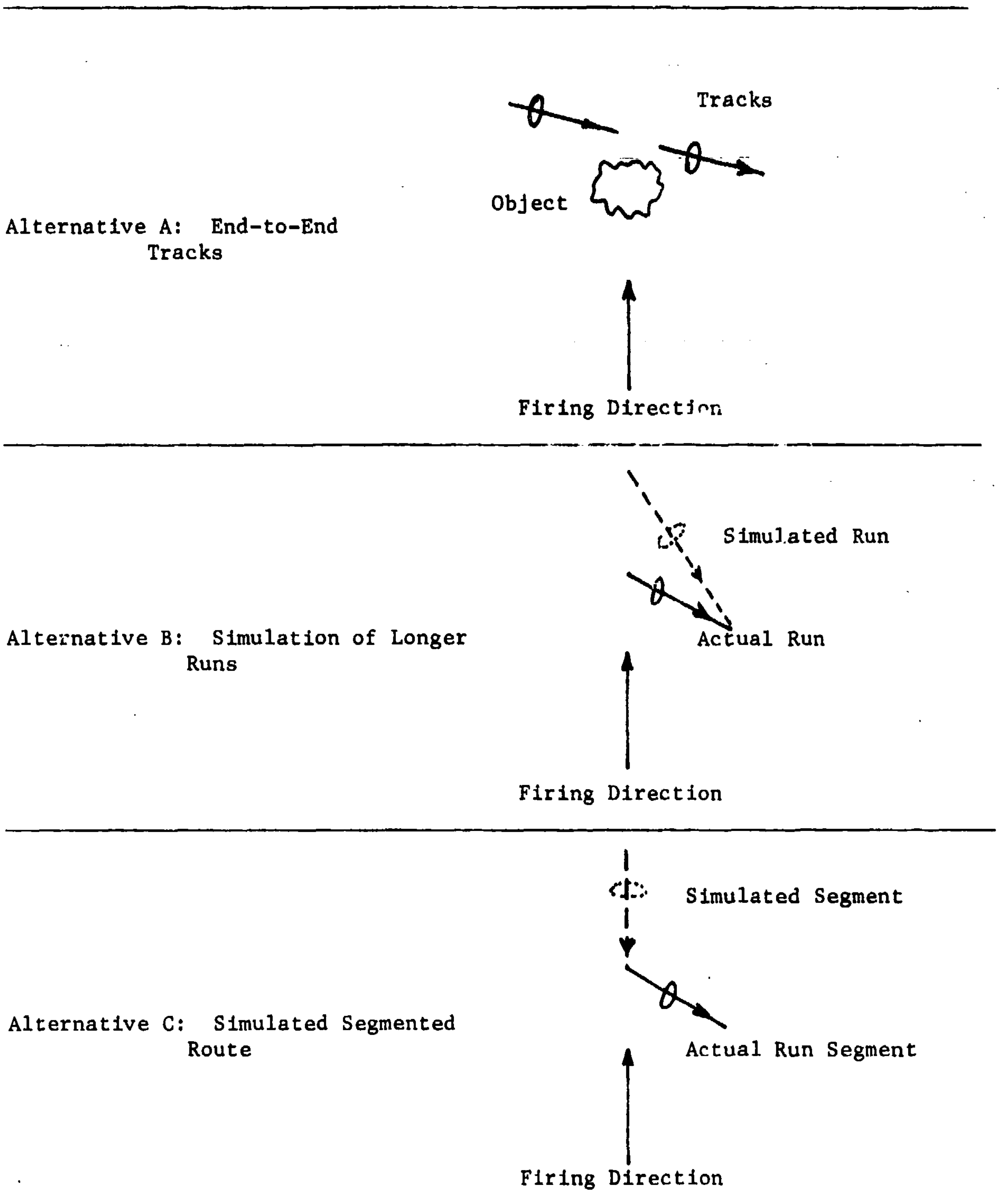

Figure 8. Alternatives to the current moving target displays not involving increases in track length.

a need exists to also provide distractions near the firer to enhance realism in the marksmanship training environment. In the past, mortar and artillery simulators have been effectively employed to provide such distractions. These influences, however, are not part of the IRETS. Therefore, some consideration should be given to the possibility of adding distractions in the form of battlefield noises to the IRETS in order to enhance its operational realism. In this regard, it might be appropriate to consider adding blast pits or additional noise simulators to the IRETS at various distances from the firer to simulate battlefield conditions in such a way that their use is coordinated with the attack and retreat phases of the IRETS target presentation scenario.

Employment of Limited Visibility Conditions. During combat, it is not uncommon for daylight visibilities to be limited by dust, haze, and smoke. Inclusion of these conditions during use of the IRETS might reduce the degree of environmental sterility that is typical of live fire ranges. As currently designed, the IRETS has no capability for producing the limited visibilities created by dust, haze, and smoke. This, however, could be accomplished in at least two ways:

- Small smoke generators or trailer mounted dust bowls actuated by blasts of compressed air could be positioned on the IRETS facility to take advantage of prevailing winds.

- Smoke could be pumped through a perforated pipe located across the range, 10 to 15 meters in front of the trainee firing positions.

Such possibilities should be considered during subsequent refinements of the IRETS. If the addition of a means to create limited daylight visibility conditions is determined to be feasible and practical, it would be appropriate to study the effect of such conditions on rifle marksmanship training. In this way, the actual benefits accruing from this firing condition could be determined. The problem created by this addition may, however, be the inconsistency of the effect from day to day. This is realistic in combat, but perhaps a detriment in evaluation.

Firing Positions Appropriate For Trainee Use During Live Firing. Current U. S. Army doctrine[21] emphasizes the use of the parapet foxhole as the prime fighting position for combat. When it is not possible to construct such a position, this doctrine stresses the use of sites that provide natural cover and concealment. In these cases, the prone firing position is emphasized.

As presently configured, the IRETS range provides for firing from the foxhole and prone positions. This is obviously consistent with cur-

[21]Department of the Army, Infantry fighting positions (TRADOC Bulletin No. 9). Fort Monroe, VA: U. S. Army Training and Doctrine Command, September 1977.

rent Army doctrine. From analysis of combat data, Klein and Tierney[22] have discovered, however, that in past conflicts, U. S. soldiers used these positions less than 20 percent of the time. Their analysis showed that the kneeling and above ground standing firing positions were dominant positions used during intense combat.

These results imply that consideration should be given to providing firing positons on the IRETS range that will allow for trainees to fire from defensive kneeling and standing firing sites. Such positions could be made available by constructing window casements, log fences, or brick walls with appropriate openings at the firer's position on the IRETS firing lanes.

Night Firing Considerations. It is planned to use the IRETS for both day and night evaluation. In the night mode, targets located at target-to-firer distances in excess of 150 meters are not employed. The assault scenario for the night mode calls for a total of 30 target presentations. This includes both moving and stationary targets. Some of the targets, when activated, produce a muzzle flash. Selected target presentations are also illuminated with overhead flares.

A potential problem with using the IRETS range for night target engagement involves the target-to-firer distances that will be played during night assault scenario. Current night firing experience on the USAIB facilities suggests that targets located at ranges in excess of 60 meters are not engageable even with use of flash simulators. Therefore, it is appropriate to determine to what extent target hits are achievable at the long target distances during the night use of the system. If it is found that little value accrues from use of the long target ranges, then it may be appropriate to consider revising the night scenario to reflect such findings.

Squad Member Live Firing Interactions. The rifleman performs on the battlefield as a member of a team. At some point in the training process, the soldier must learn to fire his weapon as a part of a team. This entails learning fire coordination, use of overlapping fire, and techniques of fire distribution.

The current IRETS range consists of non-overlapping areas of responsibility in which the control of fires are assumed by range cadre. Further, the extreme separation of adjacent lanes (30 meters) prohibits the use of this facility for evaluating squads of soldiers operating as a team. Thus, the flexibility of the IRETS is limited. Possibly, the system's flexibility could be augmented through the installation of elements of the portable IRETS equipment on the IRETS range. This should be investigated during the operational testing of the system.

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[22] Klein, R. and Tierney, T., op. cit.

Diagnostic Data Collection on the IRETS Range. The IRETS, like the TRAINFIRE Record Fire ranges it is designed to replace, is an evaluative tool for measuring post-training marksmanship proficiency. For both the IRETS and current Record Fire ranges the only measures of performance (MOPs) generated during live firing are those based on the numbers of target hits achieved (e.g., total target hits, numbers of target hits achieved at each target-to-firer distance, and the numbers of target hits achieved for stationary and moving targets). As a consequence, it is not possible to use the IRETS to diagnose other more specific aspects of a soldier's firing technique, e.g., sight alignment, aiming point placement, trigger control, breathing technique. Rosen and Behringer[23] have expressed concern that Army rifle marksmanship training programs do not have adequate capability for empirically diagnosing poor firing technique and performance. Unfortunately, the addition of the IRETS to the Army rifle marksmanship training system will not relieve this concern.

If, however, it is desired to add additional diagnostic measurement capability to the IRETS, there are several ways in which this could be accomplished. First, it may be possible to add diagnostic measuring devices to the IRETS which function in a variance reporting mode. Under these conditions, as long as the trainee does not deviate from a selected performance level, no measurements are taken. When an error condition or a particular firing problem occurs, a signal light is activated to alert the instructor that the trainee should be observed closely because he is making errors or having problems that are acting to degrade his performance.

Second, instrumentation located near each firing position could be employed to monitor the firer's response time and his rate of fire. Soldiers who fire too rapidly or too slowly may be having trigger control or sight alignment problems. Early identification of these problems based on data from the instrumentation at the firing position would allow instructors to work with the soldiers and correct the problem.

Finally, pairs of shock wave sensors could be located near selected IRETS targets, both moving and stationary. Data generated by these sensors would identify firings that are consistently off to one side of the target (or the other) for stationary targets. For moving targets, pairs of these sensors could be used to identify when the firer under- or over-leads the target. Once the nature of the error is known, instructors can then work with the trainee to eliminate the problem.

THREAT DEFEATING CRITERIA

For the most part, rifle marksmanship performance is evaluated in terms of the number of target hits achieved during the Record Fire scenario. The number of hits needed to qualify at various proficiency levels (expert, sharp-shooter, marksman) is determined from analysis of trainee range firing experience -- a norm-referenced approach. In a threat oriented environment, this may be inappropriate.

[23] Rosen, M. and Behringer, R., op. cit.

In determining how many targets must be hit for a rifleman to qualify on a threat oriented marksmanship range, some relationship between hits and the defeat of the threat must be established. This can be approached from two standpoints: viewing the threat as a continuing assault of threat soldiers in one defending soldier's sector of fire, or viewing the threat as a series of discrete events (groups of target exposures) at selected target distances, representing the threat at these distances as if none of the threat had been previously defeated.

Using the continuing threat model (and applying breakpoint analysis as described by Rosen and Behringer[24]) at least 60 percent of the targets (the mean casualty percentage in a platoon to cause the unit to break[25]) would have to be hit to defeat the threat. This means for the defending unit to defeat the threat, the average number of targets to be hit by a defending soldier would be 60 percent of six (using the 6:1 ratio), or four. The threat model, i.e., the live fire range, in the mode, is required to "remember" hits and display subsequent targets based on previous hits. If, for example, the original threat display at the longest target distance represents six attackers and the firer hits three of them, the next phase should represent only three attackers. When four hits have been achieved in total, the scenario ends or the remaining threat soldiers retreat.

On the other hand, if the discrete model is used, a slightly more complex procedure is required. Overall, the defender should still be required to hit about 60 percent of the targets exposed to defeat the threat. But, clearly, 60 percent is not adequate at extremely short target distances (since the attack must then be neutralized in its entirety) or at longer target distances (where hits are less probable). Using hit probabilities for the indicated target distances, as displayed in Table 9, about 60 percent of the targets presented will be hit.

To evaluate the performance of a firer in the discrete model, scoring by groups of targets is required. An overall total of 20 target hits out of 33 IRETS targets exposed in the attack would be required to defeat the threat.

The IRETS depiction of the threat also has a retreat phase. Obviously, if the threat unit has been forced to retreat, the threat has at least temporarily been defeated. How many of the retreating soldiers must be hit to preclude some future regrouping or attack is not now known.

Given the IRETS attack scenario of 33 targets at specified target distances and applying approximate expected hit probabilities for mov-

[24] Rosen, M. and Behringer, R. op. cit.

[25] No figures on breakpoint are available for smaller groups such as six men.

Table 9

POSSIBLE HIT SCHEME FOR OVERALL SIXTY PERCENT TARGET HITS

Target-to-Firer Distance	Percent of Targets Presented (A)	Proportion of Targets to be Hit (B)	A x B
50 meters or less	10	1.00	10
50 to 100 meters	50	.60	30
100 to 200 meters	30	.50	15
200 to 300 meters	10	.40	4
Total	100	-	59[a]

[a]This total of target hits would also be achieved using IRETS target exposures in the attack phase and substituting 90 percent for 100 percent at the closest target-to-firer distances.

ing and stationary targets in a one-target-one-shot mode[26], the number of targets an average firer can be expected to hit is about 15 (3 moving and 12 stationary). This computation is shown in Table 10. Clearly, given current knowledge about firer proficiencies and even "best casing" the average data, achievement of 20 target hits needed to defeat the threat during the IRETS attack scenario is likely to be a rare event.

To achieve a threat defeating level of proficiency for the continuous model, few targets will have to be hit. Soldiers will quickly learn also, that they should fire only on the stationary targets to achieve best results. To achieve proficiency for the discrete model, many targets will have to be hit. This will force engagement of all targets displayed and will require a high degree of proficiency in moving target engagement. While engagement procedures are beyond the scope of this paper, some consideration should be given to the use of more rounds to be fired than targets displayed[27], the use of ammunition conservation procedures and rapid changes of magazines, all of which are combat proficiency techniques. Actual realities for hits required and rounds to be fired represent, however, open questions at this time in the discrete mode and must be further explored.

POTENTIAL HARDWARE SHORTCOMINGS

Presented in this section are potential hardware shortcomings, addressed in the following areas:

- Moving target subsystem,
- Hit sensing subsystem,
- Sound simulator subsystem,
- Data collection and target interface,
- Hardware add-on capability,
- IRETS Control Console operation,
- Malfunction feedback circuits.

<u>Moving Target Subsystem</u>. Within the moving target subsystem, there are four operating characteristics which should be examined: hit scoring, target body presentation angle, duration of target exposure, and the

[26]Klein, R. and Tierney, R., <u>op</u>. <u>cit</u>.

[27]Rosen and Behringer suggest a factor of 20 rounds per hit is likely in combat, yielding 400 (!) rounds to be fired.

Table 10

COMPUTATION OF EXPECTED HITS FOR AN AVERAGE FIRER ON THE IRETS RANGE

Target Type	Target-to-Firer[a] Distance (Meters)	Hit Probability[b,c]	Number of Attacking Targets	Expected Number of Hits
Stationary	50 or less	.90	6	5.40
	50 to 100	.75	2	1.50
	100 to 200	.60	5	3.00
	200 to 300	.45	4	1.80
Total			17	11.70
Moving[d]	15	.35	2	.70
	35	.30	3	.90
	75	.25	2	.50
	125	.15	3	.45
	185	.10	6	.60
Total			16	3.15
Total (All Targets)			33	14.85

[a]From the IRETS scenario

[b]Klein and Tierney, op. cit.

[c]Estimated from Klein and Tierney data using the best case data for moving targets.

[d]Moving targets are considered for hits only when moving, eliminating any stationary phase.

chain drive for the moving target. The IRETS specifications[28] state that a range control console will record and produce a hard copy output of the total moving target hits for each firing lane. Moving target hits are also to be recorded on the target lifting device. Since the moving target carrier uses a trailing wire to carry the hit signal to the range control console, the wire is subject to: (1) abrasion if it is dragged along the ground, (2) severing by projectiles if it is suspended above the ground, or (3) cracking if it is repeatedly wound in and out on a reel attached to the carrier track. The USAIB should be made aware of these potential problems, since they could limit the reliability of the moving target subsystem.

The IRETS specifications for the moving target subsystem state that the angle of approach of the moving target will be between 35 and 45 degrees from the axis between the firing position and the target. However, attention should also be paid to the angle of presentation of the target body, that is, that part of the target simulating an enemy soldier. If the target body faces directly toward the firer, the area exposed is likely to be unrealistically large compared to that achieved with a more oblique exposure. If the target body is facing in the direction of movement, its three dimensional configuration should be sufficient to represent the thickness of an average enemy soldier's body.

Target exposure times represent a problem since, at a speed of 8 miles per hour, the 10 meter track will be traversed in less than three seconds. Longer exposure times will require either a stationary target phase or a slowing of the target speed. This problem is addressed more thoroughly on page 29.

A final moving target concern is the chain drive. Two potential problems are wear (due to oxidation and weathering) and stoppages (due to twigs and debris). An assessment should be made to determine if these potential problems occur and with what frequency during operational testing.

Hit Sensing Subsystem. The current hit sensor is a piezoelectric sensor mounted at the base of the target which senses the "thumps" of the projectile as it hits the target. The sound moves through the target body to the base of the target. According to contractor tests, the signal is seriously attenuated as it passes through severe curves in the molded body. Hits in the target's head area seem to create the largest problem, especially with the .22 caliber long rifle projectile. Sensor output could be amplified to increase the signal-to-noise ratio thus improving sensitivity. This action, however, would also increase the sensor's sensitivity to extraneous noises caused by the vibrations, debris, and shockwaves from near misses. There is also the related problem of a

[28]Department of the Army, July 1977, op. cit.

deteriorated sound carrying capability after the target has been perforated by many hits. Temperature variations are also likely to affect operation of this system. The potential problem areas should be thoroughly examined during acceptance testing.

The IRETS specifications[29] state that the IRETS equipment must operate at 95 percent humidity. This can be interpreted as not being required to operate while raining. Summer in the Southeast, however, is typified by afternoon thundershowers which can come and go rather quickly. Although the humidity reaches 100 percent in the immediate area of the storm, it can drop quickly as the storm moves away. If after being soaked, a sustained dry-out period is required, a significant amount of time can be lost, even though a storm of very short duration passes through the area. This area should also be examined during testing.

The current three-dimensional target body, when presented at the prescribed angle of 35-45 degrees, is subject to being hit twice as the projectile passes through. The current counting rate is one hit per 12 milliseconds, which should preclude the scoring of double penetrations. At the same time, it should permit individual scoring of multiple hits from a single burst of automatic fire. A firing rate of 10 rounds per second (600 rounds per minute) allows 100 milliseconds between rounds. However, testing should be conducted during the acceptance period to identify any problems in this area.

Sound Simulator Subsystem. The function of small arms sound simulators on a training facility is to add to the realism of the training situation by providing realistic audio cues as aids to the trainee in localizing enemy firing positions. The IRETS specification[30] calls for two sound simulators on each firing lane of the IRETS range. These simulators are to be located within 30 meters of selected targets. It is unlikely that two simulators will be adequate to represent the audio cues for 18 targets spread over an area of 30 by 300 meters. Serious consideration should be given to increasing the number of sound simulators and locating these at specific target locations.

The contractor for the IRETS is currently testing two types of sound simulators: an oxygen-propane (OP) system and a sound amplifying (SA) system. Initial tests of the two systems have shown that the OP system produces a louder, more realistic noise than the SA system. The OP system, however, is more expensive than the SA system. For this reason, it may be too costly to provide many such systems per lane of the IRETS. Consideration should, therefore, be given to a less costly system, even though it may be necessary to accept less realism under these conditions. One such system might consist of a collection of megaphone speakers located at each target, to a single, large amplifier and signal generator. As a given target in the system is raised, a switch would turn on its co-located speaker. At this time,

[29]Department of the Army, July 1977, ibid.

[30]Department of the Army, July 1977, ibid.

the small arms firing signal being generated at the system's source would be put out by the speaker. In this way, a directional, audio cue would be provided each time a target was presented. More investigation in this area appears to be warranted.

Data Collection and Target Interface. According to the IRETS specifications[31], the target controller and the data recording systems are not necessarily connected. The lack of such an interface may seriously reduce the IRETS value as an evaluative system. For example, future research may indicate that a more fluid or dynamic scenario would be appropriate for evaluating trainee performance. To achieve this capability, the control system would have to respond to incoming target signals.

If a computer system is used to drive the evaluation facility and collect incoming data, it may be possible to use the computer's "decision-making" ability to vary target presentations as a function of the accuracy and volume of trainee fire. Sporadic and ineffective fire (as indicated by the number of hits) could cause the computer to increase the rate of advance of incoming targets. Conversely, accurate fire (many hits) could slow the rate of advance or even cause a simulated retreat. If this capability is inherent in the data collection and control hardware, it should be exploited.

Discussions with contractor personnel indicate that, although the computer handles both control and data collection functions, the capability discussed above is not present in the current IRETS design. Further, it cannot and could not be introduced without major system changes. Thus, IRETS is limited to preprogrammed target scenarios and does not have a dynamic control capability as defined above.

Another related problem is the degree of flexibility in programming different scenarios. Ideally, range cadre should be able to develop different target presentation scenarios to simulate various combat actions (mass assault - all targets up; sniper action - brief repeated appearances of long range targets). The current software system does provide an editor program which facilitates scenario preparation. Since the only output device is the console printer, positioning the line pointer and typing in new instructions may not be an easy process for range control personnel who do not have some computer experience. The addition of a plug-in CRT display device, on which several lines of code can be displayed to the operator while he programs the scenario, would greatly facilitate the programming process.

The only output device, other than console display lights (which can show only one firing lane at a time), is the printer. Mechanical printing devices, similar to electric typewriters, are relatively fragile and are sensitive to the environment in which they operate. The range environment is in no way similar to that of an environmentally

[31]Department of the Army, July 1977, ibid.

controlled computer facility. The printer may be subject to temperature changes, humidity variations, and dust and dirt. Since no back-up system is provided, prolonged down-times could occur if the printer breaks down. A back-up printer, or at least a plug-in CRT, should be made available.

Hardware Add-On Capability. Discussions with the contractor indicated that two input-output channels are available with the current IRETS for the addition of range devices. Relatively major changes, however, would be required to add subsystems beyond those already on the facility. For example, the 25-meter targets, which are commanded by a single line, could not be switched to individual control. Thus, it may be appropriate to consider designing future IRETS control systems so that additional subsystems may be added without creating the need for major system control changes.

IRETS Control Console Operation. The IRETS control console is complex and may require operator training and specific operator skills, especially in the automatic mode of operation, for diagnostic equipment testing and alibi firing. This potential problem area should be examined during the operational testing for the IRETS. While the IRETS does have a manual mode of operation, it is likely, due to the complexities of the IRETS target presentation scenario, that this scenario could not be played in this mode. This potential problem should also be examined during operational testing.

Malfunction Feedback Circuits. Discussions with contractor personnel raised a question concerning malfunction feedback. A malfunctioning target mechanism has a direct feedback loop through which the problem causing a malfunction is relayed to the console. However, a malfunctioning target hit sensor has no such feedback loop. This could result in a target that is "dead" for some time before discovery. Reliability of the hit sensing system will play an important role in determining the need for such a system, but this situation should also be closely examined during acceptance testing. If reliability is not close to 100 percent or is unknown, a hit operation indicator system is probably required. A solenoid driven target tap system is a probable solution.

POTENTIAL SOFTWARE SHORTCOMINGS

This section discusses potential software shortcomings and addresses the following areas:

- Time Based Measures of Performance
- Hit Recording Subsystem

Time Based Measures of Performance. As discussed previously, the only MOPs generated during live firing on the IRETS are those based on the numbers of target hits achieved. Such measures fail to provide a complete description of the firer's performance. Time based MOPs, such as time to first round, time to first hit, or time to shift targets, can serve to complete this description. The lack of such measures in the IRETS is viewed as a limitation of the system. Additionally, the IRETS has no miss-position indicator. The lack of such an indicator makes it difficult to determine (in the case of moving targets) whether firers consistently lead or fire behind the targets. If these capabilities could be added to the IRETS, the system's ability to evaluate firers would be significantly enhanced.

Discussions with contractor personnel indicated that time based data cannot be directly collected. Events, however, could be measured or timed externally and the finished event occurrence could be fed into the IRETS. A near miss indicator could measure, without aid from IRETS, whether near misses passed to the left or right of the target. After measurement, the amount of elapsed time or the fact that a round passed to one side or the other could be fed into the system. Times to first hit could be handled in the same manner, measured externally and then inserted into the IRETS computer. Thus, if it is desired to provide a more complete description of the firer's performance via the IRETS, consideration should be given to augmenting the IRETS with a time based and miss-position measurement capability.

Hit Recording Subsystem. The prime contractor for the IRETS is also developing the hit recording system. If the developed system uses a computer to collect information concerning target hits and operating status, it is highly probable that all firing lanes will share the same input channel (bus bar). (It is common for various input-output equipment to share channels since, under computer control, they are not used simultaneously). Hits, however, which are generated by the firers are not under computer control. If the various hit data links share a given input channel, there is the remote possibility of data loss, should two hit signals arrive within a given time period. Thus, the length of that time period is critical to the successful collection of hit data. For this reason, the length of this time period should be adjusted so that the probability of data loss is minimized. The examination of the hit recording system during operational testing should thus address this area in order to determine if a deficiency exists. Finally, for diagnostic and remedial purposes, scores for various target characteristics (target-to-firer distance, movement mode, target groups) should be available. This does not currently appear to be possible.

CONCLUSIONS

In the previous section, the findings of analyses of the display and evaluative capabilities of the IRETS were presented. Two aspects of the IRETS were addressed: the adequacy with which the IRETS models the threat and the adequacy of selected hardware and software components of the IRETS. Potential shortcomings and possible means of resolving these were identified and discussed.

In this section, the implications of these findings are discussed as they relate to the intended replacement of current record fire ranges with the IRETS.

Comparisons of the IRETS specifications and descriptions of a threat unit in the attack indicate that the IRETS threat portrayal is inadequate. In particular, the analyses show that:

- IRETS target arrays (groups of exposures) have too much depth and not enough lateral separation when compared to target arrays expected in combat.
- Required lateral shifts in aiming point will be too narrow when compared to those expected in combat.
- Too few near (50 to 100 meters) and too many medium (100 to 200 meter) range targets are displayed by the IRETS scenario.
- Too few multiple target exposures (two or three) occur during the attack phase of the scenario and, of those which occur, too many occur early and too few late in the scenario.
- For both near (less than 100 meters) and longer range (100 to 300 meters) targets, there are several instances of too short exposure times.
- Stationary targets at 100 meters or less are portrayed only by F-type targets. These represent soldiers in a prone firing position, a low frequency posture for the scenario situation.
- Due to limited movement distances of the IRETS moving targets, expected threat movement distances are not achieved. Expected movement speeds for threat soldiers can only be achieved by targets with 10 meter tracks. Sufficient exposure times at realistic speeds can only be achieved if the target presentation includes a stationary phase.

In addition, the IRETS capability to generate battlefield noise is limited and no capabilities for the creation of limited visibility conditions (dust, haze, smoke, etc.) exist.

Finally, the analysis identified several potential hardware and software shortcomings which may limit IRETS operation. These shortcomings include:

- The electrical wire trailing from moving targets is subject to abrasion, severing or cracking. If this occurs with a high frequency, the accuracy of commands and hit recording will be seriously reduced.
- The moving-target chain drive is subject to wear due to oxidation and other weathering, and to jamming on twigs and other debris. These factors may seriously affect reliability.
- The accuracy of target hit recording will vary as a function of temperature and where the hits occur due to the type of hit sensing system planned.
- Efficient use of the system may be degraded during "dry-out" periods following rains.
- The two sound simulators in each lane are not likely to fully represent the audio cues for the targets displayed.
- The system does not appear capable of generating dynamic target presentation scenarios which vary as a function of hit performance.
- Reprogramming of scenarios may be beyond the capabilities of range personnel.
- No target malfunction feedback system is incorporated into the IRETS. "Dead" targets will not be easy to identify.
- Evaluation of firer performance is limited to target hits on the various targets.
- Depending upon the final design of the hit recording system, some data may be lost if hit signals arrive too close in time to each other.

Taken together, these findings suggest that the IRETS is not a quantum leap from the current Record Fire ranges to a threat oriented Record Fire facility. While the IRETS may be considered a positive step, it is only an upgrading of older concepts with moving targets, computerized operations, and more target positions at nearer target distances. If adequate solutions to the problems discussed above can be achieved, however, an improved IRETS-like system could be constructed. This system would then represent substantial progress from current Record Fire ranges and a valid means of measuring rifle marksmanship proficiency in a threat oriented environment.

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APPENDIX A

ANALYSIS FACTOR MATRIX
(ASSAULT PHASE)

APPENDIX A

ANALYSIS FACTOR MATRIX (ASSAULT PHASE)

Analysis Factor	IRETS Range Display[a]	Threat Demands on a Range[b]	Other Considerations	Suggested Solutions to Differences
Target Separation				
- In-Depth	115 to 200 meters for target groups (mean for 6-target groups: 145 meters; mean using only closest 4 of each 6-target group: 51 meter).	15 to 30 meters for target groups, based on bounds.	The threat description does not account for stragglers and fixed, wounded attackers *still* firing.	In the short run, targets should be more dispersed physically across lanes and the scenario *revised* (if flexible enough) to display in-sequence separations of 6 to 8 meters. Long run plans should include the addition of targets, the rearrangement of target locations and the following scenario considerations: target groups (6 in sequence) with in-sequence lateral separations of 6 to 8 meters, in-depth separations (4 of the targets in a group) of not more than 30 meters and stragglers separated more in the late stages of the attack.
- Laterally	4 to 12 meters of width of groups (6-target groups: 9 to 12 meters; closest 4 of each 6-target group: 4 to 7 meters). Mean separation distance for targets in sequence: 4.75 meters (72% of targets less than 6 meters separation; 22% with no separation).	6 to 8 meters between targets; lane widths of at least 30 to 40 meters.	To portray a 6 to 1 threat, at least 30 meter lane widths are required, not including separation of targets from lane boundaries. IRETS lanes are 30 meters wide.	
	.07 lateral/depth ratio for 6-target groups.	1.56 lateral/depth ratio for 6-target groups.		

[a]Based on 6 man attacking groups (9 target exposures in final assault), in scenario sequence.
[b]Based on Rosen and Behringer, and Klein and Tierney.

(continued)

APPENDIX A

ANALYSIS FACTOR MATRIX (continued)

Target-to-Firer Distances	Percentage of targets: 15 - 50 meters, 22% 50 - 100 meters, 24% 100 - 200 meters, 42% 200 - 300 meters, 12% Distances 15 to 300 meters.	Percentage of targets: 0 - 50 meters, 10% 50 - 100 meters, 50% 100 - 200 meters, 30% 200 - 300 meters, 10% Distances 0 to 300 meters.	Practical and safety considerations will probably cause targets of less than 15 meters to be eliminated on firing ranges.	The scenario should reflect a shift of 10% to 15% of total target displays from beyond 100 meters and about 10% of total target displays at 0 to 50 meters to the 50 to 100 meter zone.
Target Presentation Frequency	33 in attack against and 17 in retreat from a one-man sector of a defensive position (based on 6 to 1 and 3 to 1 ratios, respectively)	17 in attack against and 6 in retreat from a one-man sector of a defensive position (based on a 3 to 1 and 1 to 1 ratios, respectively).	A 3:1 ratio does not maximize the threat (averages only), account for overlapping with adjacent sectors or consider the effects of friendly casualties. A 6 to 1 ratio seems reasonable when considering these circumstances.	No change in the presentation frequency is required if the 6 to 1 ratio is utilized.
Single and Multiple Target Presentations	Simultaneous Targets / % of Time 0 — 11% When targets are exposed: 1 target — 58% 2 targets — 37% 3 targets — 5% Note: more multiple targets occur early in the scenario.	2 to 3 targets of a threat squad moving at one time at 100 to 400 meters; all in final assault within 100 meters. More multiple exposures occur later in the scenario.	For a 6 to 1 ratio, an average of 1.5 to 2.25 simultaneous exposures for the threat per one-man sector of a defensive position.	Rearrange the scenario to display more targets at one time, using overlaps of exposure times and/or simultaneous exposures. Multiple targets should appear more often at shorter distances than at farther distances.

(continued)

APPENDIX A

ANALYSIS FACTOR MATRIX (continued)

Target Exposure Times	100 to 400 meters: 1 to 4 secs = 4 targets 5 to 10 secs = 15 targets 10 + secs = 1 target Less than 100 meters: 2 to 4 secs = 6 targets 5 to 10 secs = 7 targets	4 or 5 to 10 or 12 seconds at 100 to 400 meters, in bounds. 20 to 25 seconds at less than 100 meters in one advance, or 2 to 8 seconds, depending on the source.	During the final assault, targets may be displayed as segments of the assault rather than all together.	Extend exposure times for targets exposed less than 4 seconds at ranges greater than 100 meters.
Target Sizes	25 to 100 meters: F-type 150 to 300 meters: E-type moving targets: mansize, three-dimensional, upright (15 to 185 meters).	Man-size, primarily in moving crouch, viewed from the front.	Target surface area should coincide with actual sizes of threat soldiers in expected positions, viewed from expected angles.	Consider replacing all F-type targets with E-type targets.
Moving Target Speeds and Movement Distances	2.5, 1.7 and 1.3 m/sec for 5 meter distances. 3.8, 2.5, and 1.9 m/sec for 7.5 meter distances. 3.3 and 2.5 m/sec for 10 meter distances.	3.6 m/sec (8MPH), in 15 to 30 meter bounds.	IRETS target exposure times and movement distances coupled with threat speeds will cause some exposure times to be in a stationary mode. Trainees will soon learn to shoot when the target is not moving.	Increase track length to threat related rush distances and increase movement speeds to 3.6 m/sec, or reorient target facing directions and slow target speeds to simulate longer rush distances, or place 2 or more tracks end-to-end.

(continued)

APPENDIX A

ANALYSIS FACTOR MATRIX (completed)

Battlefield Noises	2 hostile fire simulators in each lane (100 and 200 meters down range).	Artillery, mortar, machinegun, grenade and rifle noises; friendly and enemy.	The distraction factor in some training and evaluation situations may not be desirable.	Add blast pits and/or noise generators to range facility at various distances 0 to 300 meters to simulate battlefield conditions and coordinate their use with phases of the scenario.
Limited Visibility	None incorporated into range system.	Dust, haze, smoke; varying light conditions.	Consistency between firing days is very difficult to achieve. While realistic, this causes problems for comparative firing data between groups.	Consider adding smoke generators and/or dust bowls to simulate battlefield visibility conditions.

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