Research Note 84-137

Developing a Field Artillery Training System Based on Devices and Simulations: Evaluation of Training Devices and Simulations

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I. INTRODUCTION

A. Program Context

The general subject of this Task Three report is a system development program being performed under contract to the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). The program is under the technical cognizance of the ARI Field Unit at Fort Bliss. The essential objective of the program is to develop the description of a system for unit-level training in the Field Artillery. That system will be specified to achieve highly efficient use of all training resources. Special consideration will be given to the use of training devices and simulations (henceforth, referred to collectively as "training technologies" or "synthetic means").

This program was contractually directed to consider only the integrated activities of the gunnery team during target acquisition and engagement. Considered in light of all the activities performed by an entire battery, this subset is a relatively small one. However, it is perhaps the most critical set of activities with regard to system performance. Also, it is a set of activities in which integrated team performance is critical. It is for these latter two reasons that this program was so defined. In carrying out this program, however, a decision was made to initiate the analysis for all operational tasks involved in a representative fire mission. This includes all of the Soldier's Manual tasks directly involved in a fire mission, but none of the general tasks, such as first aid, use of personal weapons, etc. The purpose behind this decision was threefold:

- It was useful for program staff indoctrination to the Field Artillery processes.
- It helped insure completeness of coverage for the defined subset.
- It produced a description of the total system operation that will be useful to the Field Artillery in other settings.

The more comprehensive analysis was later narrowed down to engagement tasks only, for which detailed subtask descriptions and subsequent analyses were completed.

The ultimate training system to be defined should provide cost-effective training of the gunnery team in target acquisition and engagement while controlling the expenditures of scarce and/or costly resources, such as fuel and ammunition. To arrive at that system definition, the program was structured into four contractual tasks which are more or less discrete activities performed in sequence:

Task One:	Baseline System Analysis
Task Two:	Training Analysis of the Baseline System
Task Three:	Evaluation of Training Devices and Simulations
Task Four:	Training System Definition

The purpose of Task One was to analyze a baseline system and develop a data base for the subsequent tasks. For this program, it was a contractual requirement to use a 155-mm cannon system as a baseline. The exact system selected is a 155-mm Self Propelled Field Artillery Battalion organic to a "Division 86" Heavy Division using the M109A2/3 howitzer and equipped with the Battery Computer System (BCS), Ground Laser Locator Designator (GLLD) and Digital Message Devices (DMD), including the Fire Support Team with the FIST DMD. This system is documented in a TOE (1)* and an ARTEP (2).* The baseline data were to be used as an exemplar and lead to generic results.

Task Two involves the derivation of training needs for the baseline, expressed in a way that facilitates the performance of the last two tasks. The products of Tasks One and Two constitute a data base for the second two tasks. The third task undertakes the assessment (or evaluation) of current Field Artillery training technologies as well as of technologies not now used by the Field Artillery. The assessment is of how well the baseline training needs are now met and new applications or development initiatives are identified. Finally, in Task Four, the baseline-determined training needs and the synthetic training assessment results are brought together in the description of a system for unit training. While that description derives from the baseline, it will have application to a wide range of Field Artillery systems. As a result of this structure, there will be four technical reports, one for each task.

This report describes the Task Three evaluation of existing and planned FA training technologies. The evaluation starts with the aggregation of training requirements (as originally developed in Task Two) and proceeds by examining the FA training technologies (devices and simulations) in the light of the aggregated requirements plus other factors. Task Three has been carried out primarily by the collection and analysis of earlier Dunlap project reports, published FA manuals and less formal reports from such sources as USAFAS. In addition, valuable information was obtained from subject-matter experts (SMEs) in training and operational capacities, whom Dunlap interviewed at USAFAS.

The link between the Task Three results and the final product of this program (i.e., the specification of an integrated FA training system) is the identification of: 1) ways to improve existing training technologies, and 2) implications for developing new training and integrated technologies.

B. Purpose of Task Three

The results of this task will ultimately be reflected in the definition of synthetic means (devices or simulations) for training the gunnery team in target acquisition and engagement. As indicated in the title of this program**, that definition is a critical product. The specific purpose of this task, then, is to compare training technology characteristics to the requirements (or training implications) of the several aggregated tasks, to produce three kinds of information:

*See References.
**The contractual title of this program is Developing a Field Artillery Training System Based on Devices and Simulations.

- o Identification and evaluation of training technologies effectively applicable to the derived requirements.

- o Description of feasible modifications to improve the applicability of those technologies.

- o Implications for developing an integrated training system, using devices and simulations, for better meeting the training requirements.

C. Scope of Task Three

Task Three includes a comparison of currently available and planned Field Artillery training technologies to the training requirements established in Task Two. The comparison includes both applicability and training effectiveness. For example:

> Does the technology simulate or exercise an appropriate part of the system?
>
> Does the technology provide for trainee performance evaluation as well as exercise (or practice)?

The scope of this task encompasses the gunnery team performing the target acquisition and engagement functions. The tasks performed by each section (FO/FIST, FDC and Howitzer) in carrying out those functions were analyzed in Task Two. In that analysis, the suitability of various training media (for each Soldier's Manual [SM] task) was determined. Also, for each task, the training requirements (i.e., the activity to be trained and the measures of performance) were identified. Determining the extent to which available Field Artillery training technologies meet these requirements is the concern of Task Three.

Initial steps in this evaluation have been the identification of technologies and the "aggregation" of the SM tasks within each gunnery team section. By first analyzing the target acquisition and engagement processes into the component SM tasks and the components of such tasks, it was possible to define clearly the activity to be trained as well as the performance criteria. Now in the process of evaluating training technologies--which are equipment oriented--it is necessary to synthesize or aggregate the components relative to the operational equipment involved. The aggregation process does not affect the scope of this evaluation, but provides a more convenient and logical structure for the analysis.

Implicit in this task is also the need to address cost characteristics --dollars, people, time, facilities and other resources--associated with each device. In general, such cost information is sparse or inadequate. Consequently, the statements of costs are not in every case directly in dollars nor are they each of the same accuracy or precision. The intent of the cost consideration is to at least describe the devices in terms of relative costliness in addition to training effectiveness.

In summary, the scope of this task encompasses: 1) particularizing the training needs of the gunnery team in its integrated performance of target acquisition and engagement, and 2) assessing all training technologies (existing and planned) for the Field Artillery training inventory in the context of those needs.

D. Approach

The analytic approach to Task Three is illustrated in Figure 1. It begins (Box 1) with a review of results from the Task Two determination of training requirements, in preparation for matching those requirements to existing and planned training technologies. Next, the relevant training devices and simulations are identified (Box 2) and their pertinent characteristics (mainly technical and cost) are described (Box 3). Because usage of training technologies is also determined by non-technical factors, the next step (Box 4) is to identify those other factors (such as motivation, conflicting priorities, lack of information, logistics, availability and subjective perceptions).

Using the training requirements and the descriptions of training technologies as a working data base, those two sets of information are next transformed so as to be compatible for comparison or matching (Box 5). This includes both the aggregating of task descriptions and the describing of technologies, in terms of what needs to be trained/measured and what is actually measured/used. To help make the technologies analysis more manageable and compatible with the task requirements, the training devices and simulations are sorted according to the gunnery team section(s) with which they are associated (Box 6).

Next, an item-by-item assessment is completed for each existing device and simulation in terms of its adequacy in training each of the aggregated gunnery team tasks (Box 7). In keeping with the relatively less detailed information available, a more general review is then made of planned technologies (Box 8). The detailed findings are summarized in terms of the overall adequacy of technologies for training the required tasks, modifications that could improve their adequacy, and training requirements for which new technologies would be necessary (Box 9). Finally, and as a bridge to Task Four, a description is given of implications for an integrated system of engagement training (Box 10). Those implications are based upon gunnery team tasks that need to be trained/evaluated, existing and planned training devices and their technical plus practical assessments, and the state of the art in training technology. That general effort is intended to guide the development of future specifications that could eventually lead to an actual system of hardware, facilities and personnel for integrated engagement training of gunnery crews.

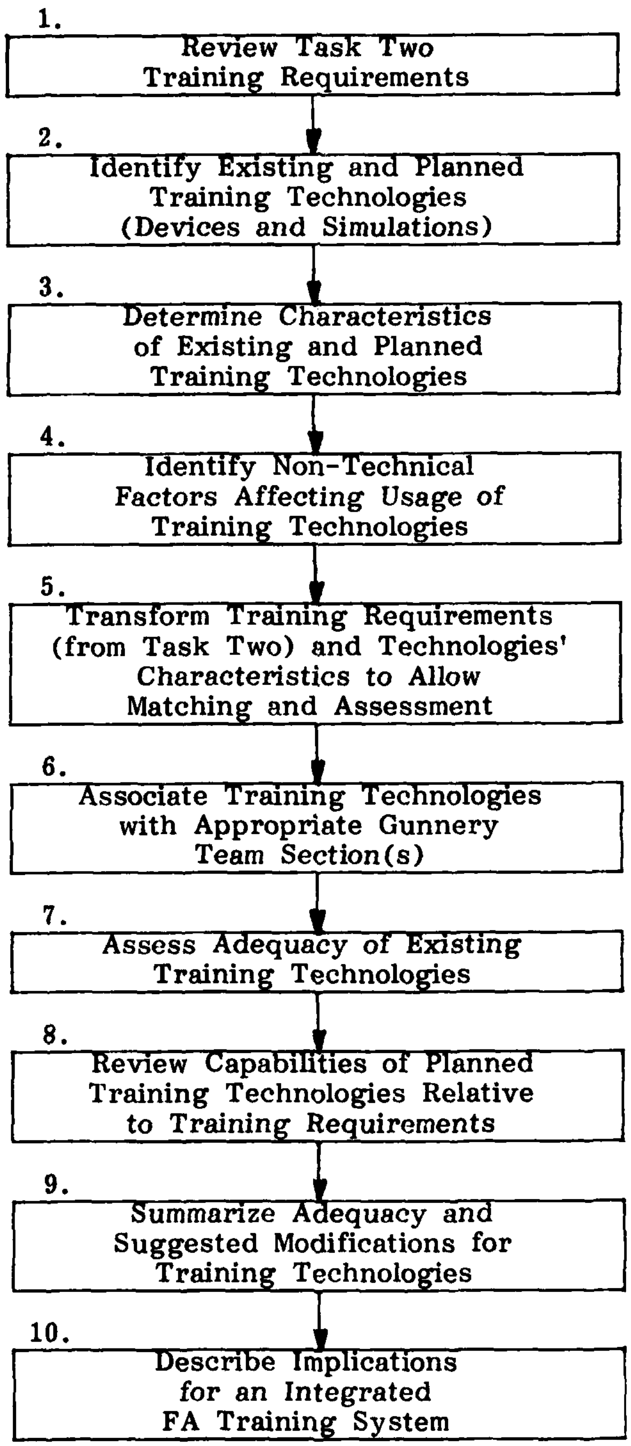

Figure 1. Task Three Approach

II. RESULTS

A. Review and Aggregation of Tasks

The Task Three evaluations of existing and planned training technologies and of the need for new training technologies follow directly from the work completed earlier in Task Two (3).* The baseline (M109A2/3) artillery training and evaluation system was continued as the context for the Task Three analysis.

The tangible outcomes of Task Two are a set of completed Input-Process-Output (IPO) forms for all engagement-related ARTEP and Soldier's Manual (SM) tasks, training requirements indexes (TRIs) for all tasks, performance requirements and measures, implications (or general requirements) for an integrated training system and an assessment of training media for each task. The total number of tasks analyzed in Task Two for the Howitzer, FDC and FIST/FO Sections are 9, 15 and 33, respectively. The average number of elements in each Section's tasks are 4, 2 and 6, respectively. The average TRI is 58, 74 and 70, respectively. These statistics lead to the following observations relevant to this program:

1. There are only a small number of Howitzer Section tasks and these are performed in all fire missions. They appear to be less complex than many of the tasks in the other two sections. They are procedural and equipment-centered.

2. By contrast, there are many tasks in the FIST/FO Section and these tend to be unique or especially adapted to each type of fire mission. Because some of these tasks are variable and because they contain six elements each, on average, it can be inferred that training for these is more complex than for the other two sections.

3. The FDC tasks using the BCS appear to be less mission-specific than those in the FIST--only 15 are required to account for all fire missions. These tasks are procedural and equipment-oriented.

4. The average TRI suggests that the Howitzer Section tasks merit a lesser training commitment than either FIST or FDC, and the latter two sections merit essentially equal commitment.

These observations indicate, in a general way, the emphasis that must be reflected in the training system to be specified. Emphasis should be given to the more complex, variable tasks and to the positions within the gunnery team that need to learn and sustain the largest number of tasks.

Further review of the Task Two report reveals the presence of systematic relationships among the training requirements associated with gunnery team tasks (3).* Those relationships permit the aggregation of certain tasks for

*See References.

purposes of evaluating or specifying training devices and simulations. The last analytic step for each SM Task in that report's Appendix shows the list of tasks to be trained and evaluated ("Implementation Areas"), such as: "Using the BCS to process TACFIRE messages related to adjust fire and fire for effect." When all of those implementation items are examined for the gunnery team subsystems and their engagement ARTEP/SM Tasks, one can reorganize groups of task items that can be trained together because they involve members of the same section and/or the same operational equipment and/or the same set of operating conditions. It was found that the first such grouping of tasks is by section (i.e., Howitzer Section Tasks, FDC Section Tasks, FO/FIST Section Tasks). The next clear grouping of tasks is by the operational equipment involved (i.e., BCS, GDU/SCA, G/VLLD, Howitzer, Compass/Map/Scale, DMD, etc.). Using just those two groupings, the SM tasks and subtasks to be trained are readily collected into 4, 5 or 6 aggregate tasks (for the FDC, Howitzer and FO/FIST Sections, respectively). It is then quite manageable and realistic to assess these aggregate tasks in terms of their Training Media potential as well as their Training Requirements Index (TRI). Also, each available FA training device can be evaluated for effectiveness in the training/evaluation of those aggregate tasks.

Figures 2, 3 and 4 show the aggregated engagement tasks to be trained and evaluated for the Howitzer, FDC and FO/FIST Sections, respectively. Each SM Task entering into the aggregate task is identified, as is each section position involved. The Training Media Assessment shown for each aggregate task is the mean of all SM subtasks entering into the aggregate, and is normalized to the nominal 0-3 scale. On that scale: 0 = not feasible/appropriate; 1 = not fully feasible/appropriate; 2 = feasible/appropriate; and 3 = most feasible/appropriate. Likewise, the mean TRI is an average of the component SM Tasks.

The media assessments show no aggregate FA engagement task which is best trained by instruction alone or with simple demonstration materials. Training Devices are judged best for training the routine use of specific pieces of equipment (e.g., Howitzer, BCS, DMD/FIST DMD, GLLD, LRF, map/compass/plotting tools). Simulations are judged best for training more complex cognitive tasks, such as voice communications, some autonomous digital message preparation/communication, and decision-making (especially by FO/FIST) at all phases of engagement operations. Simulations are also judged best for conducting training of any task under extreme environments and constraints (e.g., limited visibility, moving vehicles, extreme temperature/humidity, precipitation, terrain variations, high work loads, restrictive personal equipment/clothing, and tactical operating conditions). Augmented operational equipment is found to be best for training the combined cognitive and routine equipment skills that one finds in the task of insuring safe howitzer operating procedures (including the taking of corrective actions) during engagement.

Finally, with regard to the TRI, it can be seen in Figures 2, 3 and 4 that all FO/FIST and most FDC tasks achieved higher ratings than did the howitzer tasks. It should be remembered that the TRI is derived from an evaluation of SM tasks which was performed by subject-matter experts (SMEs). A group of SMEs was assembled for each gunnery team section. Each of these groups reviewed every SM task (within its area of expertise) and arrived at a consensus rating of the following four characteristics for each task:

Figure 2.

Aggregated Engagement Tasks to be Trained

Howitzer Section

SM TASK NUMBER 061-266-1506	061-266-2229	061-266-3315	061-266-3318	061-270-1507 (L)	061-270-1507 (F)	061-271-1215	TBD	Engagement includes the following topics (aggregated) to be trained in a team setting	Section Position Trained: ChSec	G	AG	C1	C2,3,4,HD	Training Media Assessment (Mean): Instr Alone	Instr Demo Mtls	TDs	Sims	Aug Opl Eqt	Opl Eqt	Aggregate TRI (Mean)
X	X	X	X	X		X	X	1. Using GDU/SCA and/or voice to receive, annouce and repeat communications related to all fire missions.	X (GDU/SCA & Announce)	X Rpt by voice	X Rpt by voice	X Rpt by voice	X Rpt by voice	0.1	0.6	1.9	(2.6)	2.2	2.0	57
X		X		X				2. Initiating, observing, evaluating and correcting operating procedures/conditions to insure safe handling and firing of the howitzer and ammunition.	X			X	X	0.3	1.7	2.0	2.0	(2.7)	2.0	61
	X		X			X		3. Aiming the Howitzer in elevation and deflection, using the elevation quadrant/range quadrant/direct fire scope and the pantel/collimator, respectively.	X Gunner's Quadr Coord W/G	X Deflection Collimator	X Elev'n Range Quadr			0.2	0.7	1.5	1.7	(3.0)	2.2	54
X				X	X			4. Loading, firing and clearing the Howitzer.				X load breech fire swab clear	X shell fuze charge	0.3	1.0	(2.8)	2.3	1.3	2.0	61
X	X	X	X	X	X	X	X	5. Timely operation under stated environmental conditions.	X	X	X	X	X	0.0	0.0	1.5	(2.5)	2.1	1.9	58

Figure 3.

Aggregated Engagement Tasks to be Trained

Fire Direction Center

S M T A S K N U M B E R													Training Media Assessment (Mean)						
061-279-2002 BCS	061-279-2003 BCS	061-279-2004 BCS	061-279-2002 TACF	061-279-2003 TACF	061-279-2004 TACF	061-279-2005 BCS	061-279-2016 TACF	061-279-2017 BCS	TBD (FP) TACF	TBD COP-PER HEAD	Engagement includes the following topics (aggregated) to be trained in a team setting	Section Position Trained	Instr Alone	Instr Demo Mtls	TDs	Sims	Aug Opl Eqt	Opl Eqt	Aggregate TRI (Mean)
X	X	X						X		X	1. Using BCS to process and evaluate RFAF (Autonomous) messages related to adjust fire, fire-for-effect, quick fire and Copperhead (target-of-opportunity) missions.	BCS Operator (Computer)	0.0	0.4	(2.5)	(2.5)	2.0	1.0	74
			X	X	X		X		X		2. Using BCS to process TACFIRE messages related to adjust fire, fire-for-effect, time on target and and specified fire plan missions.	BCS Operator (Computer)	0.0	0.0	(3.0)	2.0	2.0	1.0	74
						X					3. Plotting/replotting targets on map, using BCS to receive and transmit related data.	BCS Operator (Computer)	0.0	0.5	(3.0)	2.0	2.0	2.0	40
X	X	X	X	X	X	X	X	X	X	X	4. Timely operation under stated environmental conditions	BCS Operator (Computer)	0.0	0.0	2.0	(3.0)	2.0	1.0	71

Figure 4.

Aggregated Engagement Tasks to be Trained

Forward Observer/Fire Support Team

SM TASK NUMBER

Topic	061-273-1003	061-274-3973	061-274-3974	061-274-3976	061-274-3977	061-274-3979	061-274-3980	061-274-3986	061-274-3989	061-283-1001	061-283-1002	061-283-1003	061-283-1004	061-283-1011	061-283-1013	061-283-1014	061-283-1015	061-283-1052	061-283-1952	061-283-1953	061-283-1959	061-283-2001	061-283-2003	061-283-2004	061-283-2021	061-283-2022	061-283-2101	061-283-2102	061-283-2103	061-283-2205	TBD C/C FM
1.	X					X	X	X	X	X				X	X	X	X					X	X	X	X	X	X	X	X	X	X
2.		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X					X	X		X	X		X	X	X	
3.											X	X		X	X	X	X		X	X	X	X	X		X	X		X	X	X	
4.		X				X		X		X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X
5.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
6.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-

Engagement includes the following topics (aggregated) to be trained in a team setting	Section Position Trained: FO	FIST Ch	FS Sgt	Training Media Assessment (Mean): Instr Alone	Instr Demo Mtls	TDs	Sims	Aug Opl Eqt	Opl Eqt	Aggregate TRI (Mean)
1. Using the DMD and FIST DMD to prepare, transmit, receive and forward messages related to all fire missions.	X DMD	X FIST DMD	X FIST DMD	0.2	0.7	(2.6)	2.2	2.0	1.2	70
2. Using the GLLD to measure range and to illuminate targets; using on stationary or moving targets; using in daylight or night-time operations.	X	X	X	0.1	0.8	(2.6)	2.4	2.1	1.5	71
3. Using the LRF to measure range.	X	X	X	0.1	0.7	(2.8)	2.6	2.2	1.4	73
4. Using visual/manual devices (map, plotting equipment, binoculars, compass) for: determining object location, altitude; recording data; drawing and using terrain sketch.	X	X	X	0.2	1.0	(2.6)	2.4	1.9	1.6	71
5. Decision-making related to all fire missions. Including: a) Target detection, identification, classification, threat assessment and location relative to zone of responsibility. b) Target selection, based on threats, priorities and commander's guidance. c) Command fire to engage selected target (fire, adjust fire data). d) Evaluate mission to determine call for further adjustment or EOM. e) Safe operating procedures.	X	X	X	0.8	1.0	1.7	(2.0)	1.4	1.2	70
6. Timely operation under stated environmental conditions.	X	X	X	0.0	0.8	1.7	(2.7)	2.1	1.4	70

- o Criticality to system performance
- o Inherent difficulty
- o Amount of practice required to maintain proficiency
- o Tolerable delay in task performance

Subsequently these ratings were combined into a single value which was named Training Requirement Index or TRI. The TRI reflects the inherent need for training in each task as well as its impact on system performance. Thus, the TRI can be interpreted as an indicator of the amount of training development or resource expenditure that is justifiable for each task. The TRIs do not denote absolute values; they provide only an ordering of significance among numerous tasks.

B. Identification of Training Devices and Simulations

A detailed review of FA sources and technical documentation was conducted to help identify the relevant FA training devices and simulations for assessment in this program. The acquired documents include evaluation reports, TD fact and information sheets, Training Device Requirements (TDRs), Training Device Need Statements (TDNSs), Training Device Letter Requirements (TDLRs), development plans, and other miscellaneous FA technical documents. Data were collected and reviewed for the following existing FA training technologies:

Firing Battery Trainer (FBT)
Artillery Direct Fire Trainer (ADFT)
Multiple Integrated Laser Engagement System (MILES)*
M31 Subcaliber Trainer
Miniature Moving Target
Field Artillery Shootable Practice Round (FASPR)**
Training Projectiles and Fuzes (including nuclear and Copperhead)
Low Cost Indirect Fire Training Round (LITR)
Battery Computer System Interface Training Simulator (BCS/ITS)
Battle Simulations (CAMMS, Dunn-Kempf, Pegasus, Blockbuster)
Ground/Vehicular Laser Locator Designator-Trainer (G/VLLD-T)
G/VLLD with TV Camera
Training Set Fire Observation (TSFO)
Forward Observer Trainer (FOT)

Plain (uninstrumented) operational equipment was also included in the analysis of existing training technologies.

Information was likewise obtained to help review the following FA training devices and simulations which are in various stages of planning or development:

Artillery Control Environment (ACE)
FA Fire Support Training System (FAFSTS)
Indirect Fire Engagement Simulation (IFES)

*MILES, developed for tactical maneuver training, is also useful for FA training.
**Technically still under development, the FASPR is included among the existing training technologies for this review. Its role may be filled by the existing LITR.

Closed Loop Training Concept
FIST Vehicle Training Devices--FIST/FO Interactive Videodisc Trainer
Howitzer Recoil Simulator
Copperhead Moving Target
Simulated Tank Antiarmor Gunnery System (STAGS)
Battle Simulations (COLTSIM, ARTBASS, FBBC, STABS)

The existing FBT, FASPR and TSFO are used together in the prototype "closed-loop" training concept.

C. Assessment of Existing Training Devices and Simulations

1. General Summary

Next, the existing FA training devices and simulations are evaluated for adequacy in training/evaluating each aggregate task. The ultimate measure of training effectiveness, according to many experts, is the proficiency of the team in carrying out its mission. One is concerned here with the effectiveness of specific devices and simulations that are used in conducting the training that yields such proficiency. The technology assessments are intended to rate how effective a given item is in training each of the mission's aggregated tasks to an acceptable proficiency level. In the absence of controlled experimental data to evaluate the quality of that link between specific training technologies and proficiency of mission performance, various mediating factors were considered. These include the ability of the technology to:

a. Set up and vary all of the necessary conditions and stimuli for training the aggregate tasks.

b. Facilitate adequate practice for positively reinforcing the learning process.

c. Measure the critical performance behaviors and consequences.

d. Provide timely, meaningful and reinforcing feedback to the trainees and instructors.

e. Facilitate the process of diagnosing poor performance.

f. Facilitate the process of correcting poor performance.

To be most effective, all of these capabilities must be readily available and convenient, easy to use, safe, reliable, accurate and require no extranormal resources or user attributes. Finally, the specific training technology must be of sufficiently reasonable cost that it can be developed, purchased, operated, maintained and stored by all those units that require it.

The summary charts for this analysis are seen in Figures 5, 6 and 7. A six-point scale is used in the summary charts to identify adequacy (Absent, Poor, Fair, Good, Excellent, Not Applicable). A rating of "Absent" is generally used when the technology is not designed or intended to help train the subject task. A rating of "Poor" is given when the technology is not intended to train the subject task, yet has a small contribution (very insufficient by itself) to make in that effort. A rating of "Fair" suggests a somewhat

Figure 5.

TRAINING TECHNOLOGY: ADEQUACY AND NEW REQUIREMENTS

Howitzer Section

Engagement includes the following topics (aggregated) to be trained in a team setting	Adequacy of Existing Training Devices (Absent, Poor, Fair, Good, Excellent, Not Applicable)											Need for New Training Technology (None, Minor, Moderate, Major)
	1. Uninstrumented Equipment	2. Firing Battery Trainer	3. Artillery Direct Fire Trainer	4. Multiple Integrated Laser Engagement System	5. M31 Subcaliber Trainer	6. Miniature Moving Target (with M31)	7. FA Shootable Practice Round	8. Training Projectiles and Fuzes	9. Low Cost Indirect Training Round	10. Battery Computer System / Interface Training System	11. Battle Simulations	
1. Using GDU/SCA and/or voice to receive, announce and repeat communications related to all fire missions.	Poor	Good	N/A	N/A	N/A	Fair	N/A	N/A	N/A	Good	Fair	Minor
2. Initiating, observing, evaluating and correcting operating procedures/conditions to insure safe handling and firing of the howitzer and ammunition.	Absent	Poor	Fair	Fair	Poor	Fair	Fair	Poor	Fair	N/A	Poor	Moderate
3. Aiming the howitzer in elevation and deflection, using the elevation quadrant/range quadrant/direct fire scope and the pantel/collimator, respectively.	Absent	Good	Poor	Poor	Poor	Good	N/A	N/A	Poor	N/A	Poor	Minor
4. Loading, firing and clearing the howitzer.	Absent	Good	Poor	Poor	Poor	Fair	Fair	Poor	Fair	N/A	Poor	Minor
5. Timely operation under stated environmental conditions.	Absent	Poor	Poor	Poor	Poor	Poor	Poor	N/A	Poor	Poor	Fair	Major

Figure 6.

TRAINING TECHNOLOGY: ADEQUACY AND NEW REQUIREMENTS

Fire Direction Center

Engagement includes the following topics (aggregated) to be trained in a team setting	Adequacy of Existing Training Devices (Absent, Poor, Fair, Good, Excellent, Not Applicable)			Need for New Training Technology (None, Minor Moderate, Major)
	1. Uninstrumented Operational Equipment	2. Battery Computer System Interface Training Simulator (BCS/ITS)	3. Battle Simulations	
1. Using BCS to process and evaluate RFAF (Autonomous) messages related to adjust fire, fire-for-effect, quick fire and Copperhead (target-of-opportunity) missions.	Fair	Good	Fair	Minor
2. Using BCS to process TACFIRE messages related to adjust fire, fire-for-effect, time on target and specified fire plan missions.	Poor	Good	Fair	Minor
3. Plotting/replotting targets on map, using BCS to receive and transmit related data.	Poor	Fair	Good	Moderate
4. Timely operation under stated environmental conditions.	Absent	Poor	Fair	Major

Figure 7.

TRAINING TECHNOLOGY: ADEQUACY AND NEW REQUIREMENTS

Forward Observer/Fire Support Team

Engagement includes the following topics (aggregated) to be trained in a team setting	Adequacy of Existing Training Devices (Absent, Poor, Fair, Good, Excellent, Not Applicable)							Need for New Training Technology (None, Minor, Moderate, Major)
	1. Uninstrumented Operational Equipment	2. G/VLLD Trainer	3. G/VLLD with TV Camera	4. Training Set Fire Observation (TS FO)	5. Forward Observer Trainer	6. Miniature Moving Target	7. Battle Simulations	
1. Using the DMD and FIST DMD to prepare, transmit, receive and forward messages related to all fire missions.	Fair	N/A	N/A	N/A	N/A	N/A	Fair	Moderate
2. Using the GLLD to measure range and to illuminate targets; using on stationary or moving targets; using in daylight or nighttime operations.	Poor	Good	Good	N/A	N/A	Good	Poor	Minor
3. Using the LRF to measure range.	Poor	N/A	N/A	N/A	N/A	Good	Poor	Minor
4. Using visual/manual devices (map, plotting equipment, binoculars, compass) for: determining object location, altitude; recording data; drawing and using terrain sketch.	Fair	N/A	N/A	Good	Fair	N/A	Good	Moderate
5. Decision-making related to all fire missions including: a) Target detection, identification, classification, threat assessment and location relative to zone of responsibility. b) Target selection, based on threats, priorities and commander's guidance. c) Command fire to engage selected target (fire adjust fire data). d) Evaluate mission to determine call for further adjustment or EOM. e) Safe operating procedures.	Absent	N/A	N/A	Fair	Fair	Good	Good	Moderate
6. Timely operation under stated environmental conditions.	Poor	Poor	Poor	Fair	Poor	Fair	Fair	Major

greater but still insufficient capability. "Good" is used when the technology is feasible and appropriate for training most or all of the subject task, though there is room for improvement (e.g., through greater flexibility/accuracy, automated sensing/recording/analyzing, reduced size/weight/cost, easier setup/use/disassembly/maintenance/storage). The highest rating of "Excellent" is used when the technology is fully suitable and useful to train the task in its entirety and under all required conditions. Finally, "Not Applicable" refers to items which are designed for other purposes and are not intended to or capable of helping to train the subject task.

For each FA Battery Section, a detailed statement is provided below for each training technology to explain each adequacy rating on Figures 5, 6 and 7. Following the adequacy assessments of all technologies, the consequent needs for new, team-compatible training technologies are described. A four-point rating scale is used to describe new technology needs (None, Minor, Moderate, Major). Those ratings reflect the probable quantity, complexity and cost of the new training technology.

2. Detailed Assessments

Each device and simulation is described in greater detail and assessed on a task-by-task basis in the following paragraphs. Additional comments are included, based on the overall analysis and discussions with subject-matter experts at USAFAS.

a. Howitzer Section (Ref: Figure 5)

1) Uninstrumented Operational Equipment

Like all operational equipment, the FA howitzer, GDU, etc., are designed for operational use--not for training. They allow practice but do not facilitate team training or evaluation. Virtually no performance measurements are made as part of ordinary operation. Externally developed training regimens have to be applied to the system in use, and measurements must be made by some combination of additional sensors, instrumentation and human expert observers. The main advantage to using the uninstrumented operational equipment is the realism that comes with practicing on the actual devices that ultimately must be used in combat. From a broader training viewpoint, however, the existing operational equipment does not make it easy to drill crews in various learning exercises or to measure/evaluate performance under the variety of conditions that must be imposed for thorough training. With that in mind, the uninstrumented operational equipment is assessed as follows for training and evaluation of each task.

For Task 1 (Poor) of the Howitzer section engagement sequence, training and evaluation of communications activities using the GDU/SCA are not facilitated by that equipment alone. However, voice commands and their repetition by crew members can be carried out fairly well in the uninstrumented setting where the Ch Sec simply listens for accurate and timely repetition of the fire commands. The Ch Sec still must have some kind of job aid or check list to insure that all representative missions and commands are exercised and that all crew performance is assessed.

For Task 2 (Absent), the howitzer and its ammunition do not make any special provision for exercising and evaluating safe operating procedures. While the crew can use the operational equipment in practicing such activities, there is no predetermined routine or assessment capability to train and reinforce the safe handling and firing of the howitzer and ammunition. That capability must be provided by an instructor or expert observer using a fire mission scenario that exercises safety-related crew activities, such as: determining if commanded target locations are within the safety limits, determining hazardous conditions and taking corrective action, confirming ammunition and howitzer settings, checking for firing obstructions, and initiating/executing safety-related commands (e.g., "Check Fire," "Misfire"). No means are provided on the operational equipment to record and evaluate the accuracy or timeliness of the crew's performance, so that activity must be carried out by the expert observer.

For Task 3 (Absent), the absence of integral routinized or automated training exercises and evaluations for aiming the howitzer also places the burden for training on an instructor or expert observer. The operational equipment allows the observer to read entered angle settings, bubble level and cross-level positions, and Pantel-Collimator alignment. There is no instrumentation on the howitzer for routinized exercising of the aiming tasks or for recording and assessing the accuracy or timeliness of crew performance. The comprehensive training and evaluation capability would include assessment of such actions as: announcing fire commands, "Set" and "Ready"; the repeating of commands by the crew; the use of the Gunner's Quadrant; the use of the direct fire scope; and, of course, the use of the indirect aiming devices.

For Task 4 (Absent), the operational equipment here again does not provide an integral capability for conducting routinized training and evaluation of loading, firing and clearing the howitzer. All procedures must be superimposed on the equipment by an instructor or expert observer, who must assess the accuracy and timeliness of selecting the projectile, selecting/setting the fuze, selecting/preparing the charge, inserting the prepared separate loading ammunition into the howitzer, loading the primer, positioning the firing mechanism, attaching the lanyard, firing, clearing and inspecting the howitzer.

For Task 5 (Absent), there is no provision on the uninstrumented operational equipment for producing the extreme environmental and operating constraints to be used in the training and evaluation of Tasks 1-4, above.

In summary, while one might expect training and evaluation to be at least satisfactory when using the operational equipment, it is clear that the uninstrumented equipment provides virtually no capability (automatic, semi-automatic or otherwise) for the instructor to create the training conditions, select the fire missions, record the crew's actions, time the tasks' intervals, or evaluate the results in the team training situation. All of those capabilities must be added to the equipment through additional instrumentation, expert observers, training regimens and evaluation procedures.

Currently the uninstrumented howitzer and its associated equipment and ammunition have been employed in various levels of howitzer training (individual, section and battery) primarily without the aid of any specialized instrumentation to diagnose or evaluate trainee, section or team performance. Cannoneer, section and even battery performance are measured by implementing primarily subjective criteria, e.g., performance is subjectively evaluated as satisfactory/unsatisfactory, go/no go or, more globally, the effectiveness of "steel" (rounds) on target.

It would be wrong to assume or say that the uninstrumented howitzer does not aid in training. In fact, it serves as a very useful device in conducting individual and section training. In the conduct of individual and section training, the unit's chiefs of section are the principal trainers. Although the commander has the overall responsibility for the quality and effectiveness of the training, he must delegate the training to his junior leaders and non-commissioned officers. The chief of section, within the confines of the howitzer's immediate training area, conducts individual and section training. He observes trainee performance and can immediately diagnose and correct individual/section deficiencies through repetitive, personalized, performance-oriented training. Some subject-matter experts (SMEs) interviewed at USAFAS for this assessment expressed the view that uninstrumented equipment maximizes the functioning of the chief of section. It is felt that instrumenting the equipment to monitor performance would degrade the motivation of the chief of section. The SMEs also state that instrumentation and other devices added to the howitzer would change the howitzer appearance and make it "appear monsterlike with all those gadgets." They are not convinced that the cost of the instrumentation to monitor team training performance on the howitzer is warranted. However, a problem that arises in section training is the variance of section chiefs' qualifications and, more importantly, their ability to train their sections to uniform performance evaluation standards. Another problem is that each section may be conducting training in different individual and collective tasks, whereas, in battery-level training, the Howitzer Sections must perform virtually all the same tasks. The unit commander can spot-check individual and section training, but he must rely mainly on the section chief to effectively train and evaluate his own section. At the section training level, there is limited use of instrumented performance data. However, recorded data may serve as a record of section performance.

All artillery training exercises are intended to prepare artillery crews for combat. The field artillery battery must attain and maintain a high degree of combat readiness through effective training. The commander must train the firing battery to respond to calls for fire with few or no delays or errors if they are to be effective or survive in combat. To achieve responsiveness in team training, the commander must be able to diagnose and evaluate performance of each section separately and the team as a whole. He should be able to accomplish this in real time by both objective and subjective means. Time to respond, for example, is a critical factor. Currently, time is measured manually. Often, time is recorded from the initiation of a call for fire until fire-for-effect is achieved. The time interval may also be measured serially to calculate overall team time. That is, one can add together the FO/FIST mission-related time, FDC mission-related time and Howitzer Section mission time. Usually, time measurement is evaluated after the training is completed, since it is observed and recorded at different locations by different observers.

When a battery of six, eight and eventually twelve uninstrumented howitzers are spread over a wide area, it is very difficult for the commander to diagnose and evaluate these sections in a team-training setting unless multiple observers are used. Again, even with multiple observers the commander must usually wait to combine these manual evaluations for a later, non-timely critique.

In terms of section accuracy in performing fire-mission-related tasks, the commander has little data of why rounds were not effective. Was it due to FO error, FDC error or howitzer crew error? It is difficult to diagnose these types of questions accurately using uninstrumented equipment. Yes, observers can provide some of these answers, but usually with a significant degree of delay and limited reliability.

It is conceivable that howitzers with special instrumentation would provide timely, accurate fire-mission-related data and limit the use of observers. Training diagnosis and evaluations of an entire firing battery could then be accomplished almost immediately at a central location.

2) Firing Battery Trainer (FBT)

The FBT is an error-measurement and feedback device. Error measurement is accomplished by instrumenting the pantel and quadrant and by providing a hand-operated unit to indicate ammo preparation errors. The M117 Pantel is modified by adding sensors to detect the azimuth errors of entered value, sight pattern, level and cross-level, along with hi/low error lights to provide positive feedback if an error exists. The M15 quadrant is likewise modified to detect errors of entered value, level and cross-level. The ammunition preparation errors are detected by an instructor observing the crew, and are entered on the handheld monitoring unit. The errors are projectile type, fuze type, fuze time, and charge. Each of the above items is connected to the instructor's console for control of the training exercise. Error data accumulated by the FBT are fed back to the instructor as well as to each of the gun crews.

The Firing Battery Trainer (FBT) helps in the training and evaluation of an entire battery simultaneously. Any number of weapons, from one to eight, can be connected to the system. A single instructor or battery commander can monitor the speed and accuracy of certain tasks for each gun crew from a single instructor's console. The control of a training mission by the instructor is accomplished through the use of the Mission Keyboard. The Mission Keyboard permits the instructor to start or stop a training mission, enter new laying commands, set up either fixed-target or moving-target scenarios, and print the accumulated error data. It is assumed that improved versions of the FBT provide digital fire command messages in appropriate format to the GDU/SCA.

A printout, summarizing the error data for each of 8 gun crews for up to 10 rounds of fire, is available at the completion of a training mission. Each crew's printout can be divided into the following groups:

a) Gunner's Laying Performance:
Deflection (DF)--commanded and entered deflection and all four sources of error (entered value, sight pattern, pitch level, cross-level).

b) Assistant Gunner's Laying Performance: Quadrant (QE)--commanded and entered quadrant and all three sources of error (entered value, level, cross-level).

c) Crew's Direct Fire Performance: Times--lay time and fire time (fire time is recorded for moving targets only).

d) Cannoneer's Ammunition Task Performance: Ammo--four sources of error (projectile type, fuze type, fuze time, charge).

The FBT data (QE and DF) allow for computing (manually) and plotting a "did hit" grid or an input to the TSFO (in the closed-loop concept) for display of the "impact" point.

The adequacy of the FBT for helping to train the five aggregated Howitzer Section tasks, in a team setting, ranges from "poor" (for two tasks) to "good" (for three tasks).

For Task 1 (Good), team training in communicating fire commands is facilitated by the digital messages provided to the GDU/SCA by improved versions of the FBT. However, there is no built-in provision for recording or assessing the accuracy or timeliness of Ch Sec-announced and crew-repeated fire commands, or the reported elevation "Set" condition.

For Task 2 (Poor), team training to insure safe operation is not adequately provided for by the FBT. While the accuracy of gun and ammunition settings are recorded, there is no provision for training and evaluating the crew's ability to insure that the commanded settings are/are not within safety limits, that commands have been correctly announced and repeated, that corrective actions have been properly taken, that safety hazards (e.g., obstructions) have been correctly and promptly acted upon, and that safety commands (e.g., "Check Fire," "Misfire") have been correctly and promptly executed.

For Task 3 (Good), the FBT facilitates team training in aiming the howitzer by determining the measures and errors of set/laid elevation (using the M15 quadrant) and deflection. It does not directly assess elevations that are set by use of the Gunner's Quadrant or aiming with the direct fire scope. In terms of measuring performance times, the FBT measures "lay time"--that interval from the instructor's announcement of a new command to the gunner's announcement of "Ready" (deflection adjustment completed). However, it does not make an automatic comparison of that time with the performance criterion time (15 seconds), nor does it provide any indication of when elevation "Set" is completed. In other words, some information which would be helpful in diagnosing poor performance is not provided directly by the FBT. Furthermore, there is a possibility that instructor errors (e.g., between the keyboard entries and the announced commands) can be confounded with, and inseparable from crew laying errors.

For Task 4 (Good), the FBT provides some help in training and evaluating loading and firing, but not clearing of the howitzer. The assistant instructor uses an Ammo Monitor Unit to manually enter observed error/no error for projectile type, fuze type, fuze time and charge. Ideally, this determination should be automated to eliminate the possibility of observer errors in perception and keyboard operation. The FBT provides for no assessment of crew announcements or other relevant ammunition preparation activities (cleaning, inspecting, verifying and handling of ammunition components). No measurements or evaluations are made of ammunition preparation time. As for the actual loading task, other than providing the initial fire command and the final "Ready" announcement, the FBT does not provide for any additional training and evaluation. That is, it does not measure the accuracy or timeliness of such loading activities as positioning the rammer, placement of the projectile, ramming, stowing of the rammer, propellant placement, closing the breechblock, loading the primer and positioning the firing mechanism. As for the firing task, the FBT provides for recording the transmission and completed execution of the "Fire" command for moving target missions (which are in the Fire-on-Command mode). The instructor presses the "Fire" button while announcing the Fire order to the gun crew. When the round is actually fired, the Ch Sec pushes the "Ready" (shot-out) button. The FBT measures "Fire Time" as the difference between those two events, and allows a maximum of eight (8) seconds before declaring time-out and producing an error message. As for post-firing activities, the FBT does not facilitate training or evaluation of opening the breechblock, clearing and inspecting the bore, or announcing "Bore Clear."

For Task 5 (Poor), the FBT does not facilitate the introduction of extreme environmental or operational constraints, although it provides for some important measurements (as in Tasks 1-4, above) if and when those conditions are achieved.

In summary, the FBT is one of the most useful artillery training devices available to the Howitzer Section; yet it still does not facilitate the training or evaluation of some important team tasks. Field use of the FBT has resulted in some recommendations to improve its utility (4,5)*. These recommendations include some interfacing changes to enhance its use with the TSFO and BCS in the closed-loop concept, some configuration changes to make it simpler and less conspicuous on the howitzer, the alleviation of its sensing equipment's reactivity to high temperatures, and modifying its power input circuits to operate off sources in the firing battery rather than 110VAC. The latter recommendation has apparently been carried out and the FBT now operates off the 28VDC howitzer power supply.

The SMEs state that the FBT could provide the commander/trainer with "true team performance." However, the system should be designed to insure that the chief of section's role is not compromised. The chief should be provided with a real-time display of operator performance in order to maximize effectiveness of corrective actions. Further, they state if the device requires excessive set-up time, calibration and/or maintenance, it would detract from training and become a burden. In the flow of fire mission events, the device, in their opinion, should not require artificial pauses to process performance or mission data. These SMEs are not convinced that an FBT is required to monitor howitzer crew performance since they believe that

*See References.

few errors are made in setting off announced data and that FDC (via the BCS displays) can and does monitor fire command processing.

To best use the FBT for team engagement training and evaluation, it is recommended that the device be incorporated into the closed-loop concept for full battery exercises. If the FBT is to be used effectively, careful consideration should be given to the final configuration of FBT components. The FBT instrumentation of the howitzer must not increase howitzer crew response time in fire missions. The system should be passive in the sense that data transmission to and from the howitzer must not interrupt the flow of "normal" communications of fire mission data. Howitzer crew members participating in actual fire-mission-related tasks should not be required to perform any FBT-related tasks. Special care should be exercised in the configuration of the howitzer-mounted FBT components. They should be as small and inconspicuous as possible. Further, any required wire cabling should be designed so as not to interfere with the performance of fire mission duties. They should not create an additional "tripping hazard."

The FBT should permit the performance of any type of fire mission. For example, studies indicate that the current configuration limits the missions to "At My Command" type missions due to communication procedures required by the FBT in the closed-loop concept. Finally, if the FBT is going to be used by units, it must require minimal setup and calibration time while providing immediate, accurate and reliable data.

Design of final FBT components must consider system operation in either daytime or nighttime, and in adverse weather conditions. In other words, the system must be capable of withstanding environmental conditions comparable to the uninstrumented howitzer. Unit commanders as well as the unit's trainers are less likely to use any device for very long if the previous-mentioned characteristics are not met.

A preliminary estimate of the acquisition cost for a single FBT system is approximately $71,000.

3) Artillery Direct Fire Trainer (ADFT)

The Artillery Direct Fire Trainer (ADFT) is a training device developed for use with the 155-mm and other howitzers to train crews in direct fire techniques against stationary and moving targets, without use of service ammunition. It is an adaptation of the Laser Tank Gunnery Trainer M55.

The ADFT uses an eye-safe helium neon laser that is attached to the top of the howitzer tube with a C-clamp mount assembly. The device has lead angle and elevation compensating controls and is activated by an electrical "lanyard." It uses a 1/10 scale range at actual ranges of 40-160 meters, representing full-scale ranges of 400-1600 meters. By using proper direct fire procedures, the gun crew can get a "hit" on the retroreflective target. A "hit" is identified by the crew member who sees the retroreflected flash while visually observing the target. No automatic (e.g., photoelectric) sensor or counting device is used to detect and record "hits" with the ADFT, such as is done on the XM56 SIMFIRE (6)*. The ADFT facilitates year-round training of section personnel in standard direct fire techniques without expending service or subcaliber ammunition and without moving to range areas.

The SMEs state that the Direct Fire Trainer is seldom used in units since typically no one in the unit knows how to use it or mount it to the howitzer. The device employs a laser beam to provide feedback of hits. The word "laser" has a negative connotation to the SMEs since it is interpreted as a safety hazard and, therefore, constitutes another reason of why it is not used. Accountability and serviceability are also stated as reasons for not using it. One ADFT is issued per battalion. The device is considered expensive, and commanders are afraid of "breaking it" or "losing it." When actually used, the device aids in DF training since it exercises procedures and feeds back "hits." However, crews receive little or no feedback of "overs" or "shorts" when no hits are achieved.

Because the present study focuses on the integrated functioning of the gunnery team, and the ADFT is used primarily to train the howitzer crew alone (and only in direct fire), this device is of secondary interest here. It is seen in Figure 4 that ADFT design yields poor ratings on the integrated training criteria. There is no provision, capability or intent for using the ADFT to train Task 1 (Communications); fair capability to help train Task 2 (Safe Operating Procedures); and poor capability to train Task 3 (Aiming for Indirect and Direct Fire); Task 4 (Loading, Firing, Clearing) and Task 5 (Extreme Environments). For direct fire missions, the ADFT provides a single overall indication that the howitzer was/was not accurately aimed and fired. While this is an important measure of task performance, it is not sufficient for effective training/evaluation of proper and timely operating procedures and corrective actions. It does not stimulate, monitor, record or assess the procedures employed and times required by the crew in executing the shot.

In summary, the ADFT provides a means for practicing direct fire at relatively low cost and in relatively small training areas. Its value as a training device could be enhanced if it were modified to allow the monitoring and possibly recording of the elements of trainee performance. That modification could be used to evaluate and diagnose performance and to give feedback to the trainee during the training process, itself. In a recent Fact Sheet (12 March 1984) the cost of the ADFT was estimated to be $6,000. This cost, plus the cost of the suggested modification, does not appear excessive for the level of training that could be achieved with the measurement and evaluation of performance.

While direct fire is an important task for the Howitzer Section, the Battery's overall training/evaluation effort must give adequate attention to the more complex process of indirect fire. The ADFT is not able, nor is it intended, to help in training indirect fire.

*See References.

4) Multiple Integrated Laser Engagement System (MILES)

As with the ADFT, the use and effects of live ammunition are simulated in MILES by means of eye-safe laser transmitters and detectors (at the guns) and reflectors (at the targets). "Near misses" and "hits and kills" are registered automatically. Because MILES was developed primarily for tactical maneuver training, FA use is limited to direct fire weapons systems training. The design now requires that a line-of-sight pathway exist between the laser/detector (gun) and the reflector (target) so that "hits" can be achieved by the uninterrupted passage of the laser beam to and from the target. A large training gap therefore exists, which indicates a need for devices and methods to realistically play indirect fire and G/VLLD-Copperhead systems in MILES exercises.

The SMEs state that MILES provides excellent training for maneuver elements against maneuver elements. However, it provides no indirect fire training for fire support elements, such as field artillery units. Whereas it can provide excellent direct fire practice training for the Howitzer Section, it cannot provide training for the other gunnery team subsystems.

Although there have been some problems in fitting MILES into the training process at some locations, it was reported by commanders of one infantry division to be the most powerful training device the Army has ever fielded. This view was supported by independent Army experts observing training within that division.

Since the existing version of MILES is used, like the ADFT, to train the howitzer crew alone and only in direct fire, this device is presently of secondary interest here and is rated poorly. There is no provision, capability or intent for using MILES to train Task 1 (Communications); fair capability to help train Task 2 (Safe Operating Procedures); and poor capability to train Task 3 (Aiming for Indirect and Direct Fire); Task 4 (Loading, Firing, Clearing) and Task 5 (Extreme Environments). For direct fire missions, MILES provides an automatic indication of "near misses" and "hits and kills" which reflect how well the howitzer was aimed and fired. While this is an important measure of task performance, it is not sufficient for effective training/evaluation of proper and timely operating procedures and corrective actions. It does not stimulate, monitor, record or assess the procedures employed and times required by the crew in executing the shot.

In summary, MILES provides a means for practicing direct fire at relatively low cost (based on the absence of live ammunition). Its value as a training device could be enhanced if it were modified to allow the monitoring and possibly recording of the elements of trainee performance. That modification could be used to evaluate and diagnose performance and to give feedback to the trainee during the training process, itself. While direct fire is an important task for the Howitzer Section, the Battery's overall training/evaluation effort must give adequate attention to the more complex process of indirect fire. At present, MILES is not able, nor is it intended, to help in training indirect fire. A series of relevant potential modifications under development can be found in the later description of Indirect Fire Engagement Simulation (IFES). No detailed information was available to this program team regarding the acquisition cost of MILES.

5) M31 Subcaliber Trainer

This 14.5-mm artillery training device allows for the firing of smaller, less expensive ammunition either from the actual 155-mm howitzer (by means of breech and inbore adapters) or from a separate tripod-mounted barrel. It is designed for use on a small (1/10 scale) firing range, to provide individual and collective task training for the gunnery team. The M31 projectile ignites, produces an audible report and a puff of smoke. For added realism, it is used in conjunction with the Miniature Moving Target (MMT), a 1/10-scale model of a T62 Soviet tank. In addition, the FO can use standard binoculars while the FDC uses scaled-down firing tables to carry out the live-fire, subcaliber training exercise. Upper-limit subcaliber firing distances of about 750 meters are "equivalent" to full-scale distances of 7500 meters. With the possibility of firing to such subcaliber distances as 750 meters, the M31 (with or without the MMT) theoretically can be used to train gunnery crews in indirect fire as well as direct fire. It has been reported, however, that the M31 impact-dispersion pattern is so large as to overwhelm any relatively fine adjustments called for by the FO in indirect fire exercises.

For the Howitzer Section, the SMEs state that the M31 provides training mainly for the gunner and assistant gunner. Very little training is provided for the remainder of the Howitzer Section. When the M31 is bore-mounted, the gunner and assistant gunner apply announced fire commands as normally done in an actual fire mission and, consequently, operate the normal howitzer's traversing and elevation controls. When the system is stand-mounted, the section no longer regards it as a useful howitzer training device. The device has no recoil signature and therefore may teach bad safety habits. Gun crews can be seen standing near the breech during firing. The M31 does not provide realistic ammunition training for the howitzer crew. Although the system provides little or no maintenance problems, the SMEs state that, when the M31 is stand-mounted, it is nearly impossible to maintain boresight. As a general comment, the M31 quickly bores the Howitzer Section; therefore, maintaining motivation is a big problem. The Howitzer Section as a whole just does not have enough tasks to perform during M31 firings.

The cost per item of the 85-pound, M31 trainer is reported on a TD Information Sheet, dated 12 March 1984, to be $1,100. Earlier (1981-82) documents describe full battery kits (two M31 tripod mounts, six inbore devices, firing tables, FADAC tapes and appropriate user manuals) for the 155-mm howitzer, M109, as costing $7,457 each.

The M31 Subcaliber Trainer can be used with or without the MMT, although the MMT is used only in conjunction with the M31. Consequently, for purposes of this analysis, the following adequacy ratings are for the M31 Subcaliber Trainer alone. Ratings for using the two (M31 and MMT) devices together appear under Item 6, the Miniature Moving Target.

For Task 1 (N/A), there is no provision or capability for the M31 to exercise, record and assess the digital and voice communications associated with conducting fire. The use of this device does, however, provide more opportunities for the instructor/observer to monitor and evaluate communications if that is desired. It is up to the individual instructor to decide which fire missions to program and which crew activities to evaluate in any given training exercise. Clearly, different instructors will do this differently in the absence of a routinized and built-in training function.

For Task 2 (Poor), the M31 provides the potential for increased opportunities to train safe operation of the howitzer, although it will not be as realistic as full-caliber training can be. Likewise, for Task 3 (Poor), the M31 can increase opportunities to train the task of aiming the howitzer. Also, for Task 4 (Poor), there are more (though less realistic) opportunities to practice loading, firing and clearing; and for Task 5 (Poor), there are similar opportunities to operate under extreme environmental and operating constraints.

In summary, the M31 Subcaliber Trainer (without the MMT) increases the opportunities for instructors to carry out their own training programs and assessments, by allowing for scaled-down ranges and lower costs for ammunition. However, the 14.5-mm M31 round is so dissimilar to the full-caliber 155-mm round that some of the specific training benefits relating to the handling of the larger, operational ammunition are virtually lost (e.g., fuze setting, safe handling and loading procedures, post-fire clearing). Primarily, there is an absence in the M31 package of built-in training exercises and assessment capabilities to insure that all representative missions and tasks are practiced and proficiency is achieved.

6) Miniature Moving Target (MMT)

The Miniature Moving Target (MMT) is a remotely controlled 1/10-scale model of a T62 Soviet tank. As reported in a recent (12 March 1984) fact sheet, it provides an economical and realistic simulation of a moving target for use during training of adjust-fire procedures on moving targets with the M31, 14.5-mm Subcaliber Trainer. A garden hose is laid on the ground along the path the instructor wants the MMT to follow. The speed of the MMT is remotely controlled by the instructor and allows observers to conduct realistic planning and engagement of a moving (or movable) target in a local training area. No capabilities are noted for automatic recording or assessment of performance in using this device. The MMT was built by the Training and Audiovisual Support Center (TASC), Fort Sill, Oklahoma, and fielded in 1978.

Because the MMT is intended to be used with the M31, 14.5-mm Subcaliber Trainer, the adequacy ratings assume that both trainers (MMT and M31) are being used together. Those ratings range from "poor" (for one task), to "fair" (for three tasks), to "good" (for one task).

For Task 1 (Fair), the training and evaluation of communications are somewhat facilitated by the use of the MMT and M31 trainers. Similarly, for Task 2 (Fair), safe operation of the howitzer can be trained somewhat more readily. There is no automated assessment of either digital or voice communications; neither is there any kind of programmed routine to insure that all representative missions, commands, decisions and actions are exercised and assessed. However, live-fire training exercises potentially are more convenient and practical (e.g., smaller firing ranges and lower ammunition costs) when using the MMT and M31. An instructor at the Howitzer Section can observe, listen, measure and evaluate performance for accurate and timely execution when those exercises are carried out.

For Task 3 (Good), the MMT trainer in combination with the M31 trainer facilitates opportunities, but not systematized assessment, for training the crew in aiming the howitzer using the elevation quadrant, range quadrant, pantel, collimator and direct-fire scope. Accuracy and timeliness must be determined by an expert observer who, in turn, must have a training plan or prepared sequence of fire missions to insure that all required tasks and operating conditions are exercised.

For Task 4 (Fair), the MMT with M31 once again provide the increased opportunities, but not the routinized assessment capabilities, to train the crew (using a somewhat unrealistic simulation) in loading, firing and clearing of the howitzer. As in the case of the uninstrumented operational equipment, all training procedures and conditions must be superimposed on the given configuration of equipment and soldiers. That must be done by an instructor or expert observer who can then assess the Howitzer Section's accuracy and timeliness in selecting the projectile (poor realism here since the M31 training round is the only one used), selecting/preparing the charge (somewhat better realism is possible here), inserting the prepared separate loading ammunition into the howitzer (quite dissimilar to the real ammunition), loading the primer, positioning the firing mechanism, attaching the lanyard, firing, clearing and inspecting the howitzer. No training takes place in selecting/setting fuzes, and much of the rest is dissimilar from these same operations using the real, full-caliber ammunition.

For Task 5 (Poor), the MMT (with or without the M31) makes no provision for producing the extreme environmental and operational constraints, other than introducing a moving target, for training and evaluating the above Howitzer Section tasks.

The SMEs state that the Howitzer Section training benefit with the MMT is minimal. Only the chief of section, gunner and assistant gunner receive howitzer-related training; the remainder of the section is quickly bored. If the associated M31 is stand-mounted, the Howitzer Section training benefit is even further degraded.

In summary, the primary benefit that is possible from using the MMT (with the M31), is an increase in training opportunities because of smaller (1/10th-scale) training area requirements and lower ammunition costs. Still, no routinized exercises or automated sensing, recording or evaluation capabilities are built in to those trainers. All program sequencing and assessments must be carried out manually by instructors or expert observers. The motivation for commanders and trainers to use the MMT is closely related to the pressure they experience for reducing the more realistic full-caliber training, their motivation for using the M31 Subcaliber Trainer, and their action in setting up scaled ranges.

7) Field Artillery Shootable Practice Round (FASPR)

The Field Artillery Shootable Practice Round (FASPR) is a full-caliber, limited-range, dummy projectile used in a local training area for realistic howitzer crew drill during closed-loop training. Both the fuze and projectile are inert. For training ammunition preparation tasks, FASPR replicates high explosive, improved conventional munitions, illumination, HC smoke, white phosphorous, FASCAM, and Copperhead rounds. It can be rammed/loaded and it provides bang (without recoil) while not requiring the same kind of impact area as is necessary for explosive rounds. When fired, the round projects no further than 200-300 meters downrange, and it is reusable. In a closed-loop configuration, it is utilized with the Firing Battery Trainer and the Training Set Fire Observation, for economical and realistic training.

A preliminary training development study estimates a cost goal of just under $25 per FASPR shot, as compared to a cost of just under $250 per shot for the live 155-mm service round. No additional personnel requirements are expected in order to implement use of the FASPR; likewise, storage and security requirements for the FASPR components should be no more stringent than for the service projectiles.

As a result of problems in funding the FASPR development program, the M804 Low Cost Indirect Fire Training Round (LITR) is being considered for use in the 155-mm FASPR role by the end of FY 1985.

The adequacy ratings described here are for the FASPR alone rather than as part of the closed-loop concept (in order to avoid ratings that are confounded with those from other devices).

For Task 1 (N/A), there is no provision, capability or intent for using the FASPR to train digital or voice communications. However, the use of that round does provide opportunities for practicing and training all crew tasks.

For Task 2 (Fair), the FASPR provides (through intentional design) the practice and training opportunities for insuring the use of most safe operating procedures. Nevertheless, it is still incumbent upon the instructor to prepare the appropriate fire missions and operational conditions, as well as to make all the required observations and evaluations. None of those training elements are intrinsic to or automatically generated by the FASPR.

For Task 3 (N/A), the FASPR does not facilitate training in aiming the howitzer. As in Task 1, however, it does provide opportunities to practice and train that task.

For Task 4 (Fair), the FASPR facilitates practice and training in loading, firing and clearing the howitzer, but evaluation and feedback must still be conducted by a trainer or skilled observer. The specific procedures for using the FASPR must also be assessed to insure that only positive training occurs. Some chance of negative training had been seen in one set of FASPR procedures which called for loading (for practice) and then unloading a simulated real charge, followed by loading a small (unrealistic), mortar-type charge for actual firing. A very recent development now provides a consumable simulated charge (stuffed with flash paper) so no unloading is required.

For Task 5 (Poor), the FASPR does not facilitate the introduction of extreme environmental or operational constraints, although it helps to provide firing opportunities under those conditions.

The SMEs state that the FASPR round provides realistic training in the tasks of ammunition preparation, loading and "almost realistic" firing. Currently when the round is fired, there is no recoil. This could provide negative training to cannoneers, resulting in their not staying clear of the breech during actual recoil.

In summary, the FASPR by itself (not in the closed-loop concept) has some value, in that it provides a means for practicing fire at relatively low cost and in relatively small (local) training areas. For effective training, however, it requires the capabilities of using programmed missions, and automatic recording and assessment of crew performance in the significant operational tasks. Some of those requirements are met when the FASPR is used in the closed-loop concept with the TSFO and FBT.

8) Training Projectiles and Fuzes (including nuclear and Copperhead)*

Training projectiles and fuzes which replicate howitzer projectiles and fuzes are built by the Training and Audiovisual Support Center (TASC) and issued to requesting artillery units. These training projectiles allow crewmembers to practice fuzing operations and recognition of projectile markings. They are particularly useful to refamiliarize cannon crewmembers with fuzing operations prior to live-fire exercises.

The 155-mm nuclear training projectile, M455, can be used to practice technical operations associated with actual war reserve nuclear projectiles. Nuclear containers enable units to plan for and execute procedures for storage, transport and security during training.

The Copperhead training projectile, M823, provides cannoneers with realistic crew drill on a dummy, full-caliber 155-mm howitzer-launched guided projectile. Like the other training rounds, this one does not leave the tube and must be extracted through the breech.

These devices are not shootable, and therefore do not lend themselves to training of the entire gunnery team. They are used for individual or remedial practice and training. Consequently, they are of only secondary concern in this program which focuses on integrated team training. It is seen that these devices yield only "Absent" or "Poor" ratings on the integrated training criteria (Figure 4). There is no provision, capability or intent for using training projectiles and fuzes to train Task 1 (Communications); poor capability to help train Task 2 (Safe Operating Procedures); no provision, capability or intent for helping to train Task 3 (Aiming the Howitzer); poor capability to help train Task 4 (Loading, Firing, Clearing); and no capability to help train Task 5 (Extreme Environments).

The SMEs state that, at the unit level, the Copperhead training round provides excellent practice in unpackaging and round preparation, including laser code setting. The remaining training projectiles and fuzes are primarily used during institutional (school) training.

*Not included here, but rather listed separately, are the FA Shootable Practice Round (FASPR), the Low Cost Indirect Fire Training Round (LITR), and M31 Subcaliber Trainer round.

In summary, these nonshootable training projectiles and fuzes provide a means for part of the howitzer crew to practice preparation, loading and extracting of the projectiles safely and at relatively low cost. These exercises are necessary but insufficient when the interest is on team training.

9) Low Cost Indirect Fire Training Round (LITR)

The 155-mm (M804) Low Cost Indirect Fire Training Round (LITR) is a nonexploding training round developed for the 155-mm (and 8-inch XM 844) projectile. It is ballistically matched to the parent HE service round and provides a visible smoke signature at 4000 meters. It allows units with noise-abatement problems and relatively small impact areas to gain the full training benefits from artillery live fire, since no fragmentation or explosion is produced. Used for indirect fire, it allows the full gunnery team to train simultaneously. If used in the closed-loop concept, LITR will allow the FO/FIST, FDC and Howitzer crews to retain their proficiency through integrated training.

The LITR can be substituted one-for-one for HE rounds in a live-fire exercise; however it has been recommended (by the Standards in Training Commission, 1982) that the substitution not exceed 60% so forward observers can have training with actual HE bursts. It has also been recommended that the mix of LITR to HE should be a major Army Command (MACOM) decision based on local noise-restriction policy, size of training areas, and availability.

The M804 LITR projectile costs about $128 as compared to $149 for the M107 HE projectile, according to a 1984 Fact Sheet. The $21 savings remain the same when propellant, primer and fuze costs are added. It is not reusable. Thus, the LITR round currently produces a less than 10 percent dollar savings when compared to the M107 high-explosive round when looking at complete rounds, or 14 percent savings if just looking at projectile cost. However, the other benefits of LITR are in terms of the increase in available impact areas, reduction of noise-abatement problems for certain training locations, and increased cannon participation in combined arms exercises.

As with so many of the other "training" devices described here, LITR provides increased opportunities to practice gunnery team tasks but does not facilitate performance evaluation (i.e., it does not provide for sensing, recording, comparing or displaying of performance measures). Consequently, the adequacy ratings tend to reflect those practice benefits, and not evaluation capabilities. Those adequacy ratings for the LITR ranged from "absent" for one of the aggregate tasks, to "poor" for two tasks, to "fair" for two tasks.

There is no provision, capability or intent for using the LITR to train Task 1 (Communications); fair capability to help train Task 2 (Safe Operating Procedures); poor capability to train Task 3 (Aiming the Howitzer); fair capability to train Task 4 (Loading, Firing, Clearing); and poor capability to help train Task 5 (Extreme Environments). In all of these tasks, any performance diagnosis and evaluation must be done by an instructor/observer with a separate set of test, recording and assessment procedures.

The SMEs state that the LITR round costs almost as much as a service round, therefore provides little or no cost saving. However, when used, it provides excellent training for the Howitzer Section since it is live fire. It facilitates training in the tasks of preparing ammunition, loading and firing. However, the round requires that it always be fired with a charge 5 and fuze PD, thereby limiting its ammunition preparation training. As opposed to FASPR, the FO/FIST observers actually adjust fire with LITR. However, realism is compromised since there is no explosion, only a smoke signal. Considering the cost factor, the SMEs feel a service round will provide better training than the LITR round.

In summary, the LITR provides the means for more frequent practice (compared to using the full-service HE round), by reducing the need for major training areas. A slight cost reduction can also be realized. However, greater realism (e.g., charge, fuze and explosion) and assessment capabilities must be added to realize full training effectiveness.

10) Battery Computer System Interface Training Simulator (BCS/ITS)

Although oriented primarily to training FDC personnel by simulating BCS message inputs from peripheral interfacing devices, when connected to the GDU the BCS/ITS simulates the BCS. This simulation or emulation of normal tactical operational functions allows the GDU operator to experience total system capability when the actual BCS interface is not available.

The intent of this device development appears to focus on individual operator training, yet the potential exists for section (primarily FDC) and some multisection training. It is not designed for use under extreme field conditions, but can be used in garrison training environments. Unit training is expected to utilize Extension Training Material (ETM) lessons. The cost per BCS/ITS is listed in a Fact Sheet (1 May 1984) as $4,070. A manpower/force structure assessment indicates that the BCS/ITS, when fully introduced in accordance with current plans, generates no manpower requirements. Total Army personnel resource requirements are thus unaffected.

The adequacy of the BCS/ITS in helping to train the five aggregated Howitzer Section tasks, in a team setting, ranges from "not applicable" (for three tasks), to "poor" (for one task), to "good" (for one task).

For Task 1 (Good), team training in communicating fire commands is facilitated by the digital messages provided to the GDU/SCA by the BCS/ITS. However, there is no built-in provision for recording or assessing the accuracy or timeliness of Ch Sec-announced and crew-repeated fire commands, e.g., the Assistant Gunner's reported elevation "Set" condition.

For Task 2 (N/A), team training to insure safe operation is not provided for by the BCS/ITS. There is no provision for training and evaluating the crew's ability to insure that the commanded settings are/are not within safety limits, that commands have been correctly announced and repeated, that settings and corrective actions have been properly made, that safety hazards (e.g., obstructions) have been correctly and promptly acted upon, and that safety commands (e.g., "Check Fire," "Misfire") have been correctly and promptly executed. Similarly, for Task 3 (N/A), the BCS/ITS is not applicable to team training in aiming the howitzer, and for Task 4 (N/A), it is not applicable to loading, firing and clearing the howitzer.

For Task 5 (Poor), the BCS/ITS does not facilitate the introduction of extreme environmental or operational constraints, although it provides for exercising the system (as in Task 1, above) if and when those conditions are achieved.

The SMEs state that the BCS/ITS stimulates the GDU and provides excellent training for the section chief, gunner and assistant gunner in processing fire commands. Although each BCS message is acknowledged by the chief of section and subsequently displayed at the BCS, there is no performance evaluation.

In summary, the BCS/ITS facilitates the realistic receipt of fire mission messages at the Howitzer Section, but it still does not exercise the execution or perform the evaluation of most important team tasks. Most of its functions, as far as the Howitzer Section is concerned, may be better met with the improved FBT (see Item 2, above).

11) Battle Simulations

Several manual and computer-assisted battle simulations are currently in use with differing degrees of relevancy to engagement training of the gunnery team. In general, "simulations" (or "war games") tend to exercise commanders and staffs of artillery units, while "simulators" tend to exercise the FA units, themselves. However, when commanders are required to participate in simulation exercises, there is often a consequent emphasis on preparation and training passed down to the units. Battle simulations may, therefore, be more important for motivating gunnery team training than for providing the training, itself.

Most battle simulations train command groups at maneuver battalion, brigade, and division or higher level to attain and sustain control and coordination of combined arms operations in a simulated environment, against a realistic opposing force. Some simulations are designed for training at company level or below in small-unit tactics, weapons system capabilities and lethality, weapons, employment, and the relationship of terrain to such weapons. Depending upon how commanders elect to implement these simulations, the exercises can be more or less practical (in terms of resource consumption). For example, units that pool their simulations and resources with one another are reported to find them more practical.

Among the existing simulations, those that are likely to have the most impact on engagement training of the gunnery team are:

- The Computer Assisted Map Maneuver Simulation (CAMMS)
- Dunn-Kempf

- Pegasus
- Blockbuster

According to Fact Sheets of 19 April and 1 May 1984, these simulations can be described as follows:

The Computer Assisted Map Maneuver Simulation (CAMMS) is designed to exercise commanders and staffs at battalion through brigade level. CAMMS is capable of accommodating an exercise consisting of all infantry, armor, and cavalry units, with normal combat support and combat service support elements, in a tactical environment against an appropriate enemy force. Artillery, air, mortars, helicopters, administrative and logistical functions are handled as they would be in actual combat. According to the Fact Sheet, field use has proven CAMMS to be a valuable and cost-effective tool.

Dunn-Kempf is a maneuver battle simulation consisting of Threat and US tanks, armored personnel carriers, and other systems. It is reported to be particularly appropriate for training at company level and below. It teaches small unit tactics, weapon systems lethality, weapons employment and the effects of terrain. Of all the simulations listed here, Dunn-Kempf comes closest to requiring actual participation at the gunnery team level.

The Pegasus battle simulation is a maneuver command post exercise control system which employs a free-play manual simulation as the exercise control medium to train battalion and/or brigade commanders and their staffs.

Blockbuster is a battle simulation designed to teach company-level leaders to plan and execute Military Operations in Urbanized Terrain (MOUT) using artillery, helicopters, close air support, air defense artillery, and engineers. It was fielded in June 1983, and the rules were being revised as of April 1984.

Because the primary mechanism for implementing these simulations are the scenarios and their sequences of tactical decisions and consequence evaluations, there is not often an opportunity to fire weapons or to practice other specific sensorimotor skills on operational equipment. This is reflected in the adequacy ratings of battle simulations in helping to train the aggregated gunnery team tasks. For the Howitzer Section, battle simulations are rated from "poor" (for three tasks) to "fair" (for two tasks).

For Task 1 (Fair), the battle simulations can provide opportunities for using the GDU to implement a battle scenario and execute decisions, including the composing, transmitting, receiving and processing of fire commands. The accuracy and timeliness of those activities generally require manual evaluation, since automatic communications recording, timing and assessment are not part of typical battle simulation systems.

For Task 2 (Poor), Task 3 (Poor) and Task 4 (Poor), the battle simulations typically provide very few opportunities for operating the howitzers, especially with live ammunition. A trainer may elect to have the howitzer crew perform those three tasks of insuring safe operation, aiming the howitzer and carrying out the loading, firing and clearing activities, respectively. However, these are not part of the simulation packages, and all performance evaluation for those tasks would have to be planned and conducted by the trainer.

For Task 5 (Fair), the battle simulations do establish tactical operating conditions under which the battle scenario is to be carried out. In that respect, some facilitation of training is available for the requirement of timely operation under extreme environmental or operational constraints.

In summary, four of the existing simulations that appear most relevant are reviewed here. One other existing technology of some interest is Salisbury's Command, a stand-alone simulation to exercise the tactical aspects of a Multiple Launch Rocket System (MLRS) battery or battalion. Overall, the battle simulations provide structured opportunities, but not necessarily evaluation capabilities for helping to train the howitzer crew in aggregated Howitzer Section tasks. Consequently, they rank poorly on training the use of operational equipment, but are better for training decision- making tasks of varying complexities.

b. FDC Section (Ref: Figure 6)

1) Uninstrumented Operational Equipment

The operational FDC equipment includes the Battery Computer System (BCS), Plotting Equipment, Maps, Stopwatch, and Digital/Voice Communications Equipment. No performance recording/evaluation is carried out on any of that equipment as part of ordinary operation. Performance testing and evaluation procedures must be added to the uninstrumented operational equipment if training is to be effective. For that reason, the training adequacy ratings for uninstrumented equipment range from "absent" (for one aggregated FDC task), to "poor" (for two tasks), to "fair" (for the fourth task).

For Task 1 (Fair), the uninstrumented FDC equipment is somewhat capable of facilitating training for the BCS operator (Computer) in processing autonomous messages, especially if an ordinary digital message device (DMD) is available to provide input data to the BCS. It is also possible to compose an autonomous (RFAF) message via the BCS keyboard, a task similar to that performed in actual practice when mission data are being received by voice from an untrained observer. Furthermore, if the digital communications link is operative between the BCS and Howitzer Section, then the FDC messages and Howitzer Section messages can be exchanged. However, there is no automatic provision for timing those FDC tasks for which performance time criteria exist. Neither is there any way of insuring that data are entered correctly via the keyboard (BCS or DMD), although the BCS will display an error message if an unauthorized keyboard entry is made or will fill in default values when a message field entry for a specific message is omitted.

For Task 2 (Poor), it is considerably more difficult to simulate a BCS input of TACFIRE messages for training purposes. For training this task on uninstrumented equipment, the TACFIRE link should be operational and prepared messages should be used. This training setup may be more difficult to achieve for administrative (e.g., scheduling) reasons. Team training for TACFIRE messages would also be enhanced if the FDC-Howitzer digital link is operational.

For Task 3 (Poor), there is no built-in capability in the uninstrumented FDC to facilitate training for plotting/replotting targets using BCS data. Here, also, the data would have to be entered manually (either from a DMD or directly on the BCS keyboard), then conveyed to the FD Specialist (Chart Operator) for graphical execution and action. Diagnostic evaluation of target-charting performance would have to be done by an instructor/observer with a separately prepared target exercise routine, evaluation criteria, and recording/assessment capabilities.

For Task 4 (Absent), there is no provision in the uninstrumented FDC for producing the extreme environmental and operating constraints to be used in the training of Tasks 1-3, above.

According to the SMEs, BCS operators enjoy training with their equipment because the BCS processes both communication messages and computes gunnery solutions. When interfaced with TACFIRE, operators feel they are strictly "button pushers." However, in the autonomous role, they must call up appropriate fire mission related message formats and fill in appropriate data in the message fields before the BCS can execute gun orders. In the units, the BCS can be set up and operated in various training environments ranging from the classroom to the motor pool to the field. When mounted in the FDC vehicle, SMEs note that no more than two individuals can train with the system at any one time due to limited space. Since the BCS prompts the operator and displays errors and unsafe or unachievable solutions, FDC personnel quickly gain confidence in the BCS. It is currently the primary means for calculating howitzer gunnery solutions. The FDO or section chief must look over the shoulder of the BCS operator in order to be assured the message fields are filled out properly.

In general, the SMEs state that the FDC personnel are the easiest to train since they normally operate in a "sterile environment," as opposed to the other gunnery subsystems. The FDO can easily create many different FDC scenarios to train and drill the section utilizing both the BCS and the manual means of calculating gunnery solutions using the "charts and darts."

In summary, there is practice potential but no built-in performance evaluation capability in the FDC equipment to help train the team in sequencing through and processing fire missions, charting and determining/entering coordinates/altitudes for targets, reviewing and transmitting gun orders, calculating and timing (coordinating) events, and evaluating Howitzer mission accomplishment. If training is to be effective, the diagnostic evaluation component must be provided by instructors with prepared routines and recording apparatus to insure that all required tasks are exercised under all required conditions.

2) Battery Computer System Interface Training Simulator (BCS/ITS)

The BCS/ITS is a digital message-generating device that transmits preprogrammed messages to the BCS. When connected to the BCS, this device simulates message inputs from peripheral interfacing devices including: Digital Message Device (DMD), other BCSs, Gun Display Unit (GDU), TACFIRE, and Variable Format Message Entry Device (VFMED). When connected to the GDU, it simulates the BCS. This simulation or emulation of normal tactical operational functions allows the BCS or GDU operator to experience total system capability when those other interfacing devices are not available.

The training device uses a magnetic tape unit containing preprogrammed digital messages that are transmitted in sequence as required. The preprogrammed digital messages are recorded on standard cassette cartridges. The trainee selects the correct data from the tape to support a specific lesson by depressing a start key. Since the device does not provide an indication of incorrect responses, existing BCS error-warning messages must be used to alert the operator when an error has been made.

Although the intent of this device development appears to focus on individual operator training, the potential seems to exist for section (FDC) and some multisection (FDC and Howitzer) training. Furthermore, the BCS/ITS can be used to train fire direction personnel in missile and rocket systems, such as the Lance and the Multiple Launch Rocket System (MLRS). It is not designed for use under extreme field conditions, but can be used in garrison training environments. Unit training is expected to utilize Extension Training Material (ETM) lessons. The cost per BCS/ITS is listed in a Fact Sheet (1 May 1984) as $4,070. A manpower/force structure assessment indicates that the BCS/ITS, when fully introduced in accordance with current plans, generates no manpower requirements. Total Army personnel resource requirements are thus unaffected.

The adequacy of the BCS/ITS in helping to train the four aggregated FDC tasks, in a team setting, ranges from "poor" (for one task), to "fair" (for one task), to "good" (for two tasks).

For Task 1 (Good) and Task 2 (Good), team training in processing autonomous and TACFIRE messages is facilitated by the BCS/ITS which provides preprogrammed digital messages to the BCS (and to the GDU in the Howitzer Section). Preprogrammed tapes and lessons can provide practice in processing the various types of messages that must be executed during engagement. Diagnostic assessment and performance evaluation are carried out by the instructor who can be aided by the BCS error-warning messages.

For Task 3 (Fair), the BCS/ITS helps in practicing the task of plotting/replotting targets by fulfilling the BCS interfacing needs for transmitting and receiving related target data. However, there is no diagnostic evaluation capability in the BCS/ITS to assess performance in that target-charting task. Consequently, the performance evaluation aspect of training is the responsibility of the instructor who must use any curricula or training plans that may be available.

For Task 4 (Poor), the BCS/ITS can provide for the practice exercises in the three tasks above that must be conducted in the required extreme environmental and operating constraints. The device does not contribute to producing those extreme conditions, however. Nor does it provide the evaluation capability needed along with practice for effective training.

The SMEs state that the BCS/ITS is an excellent device which stimulates the BCS and provides the operator practice in processing TACFIRE, DMD and VFMED digital messages. The BCS prompts the operator and displays operator errors.

In summary, the BCS/ITS provides significant potential for practicing the FDC tasks, but falls short in evaluating operator performance on those tasks. Fortunately, some automatic assessment is provided by the BCS, itself, through its error-warning messages. The rest must be provided by the instructor with any available "lesson plans" plus observation, recording, and comparison with appropriate criteria.

3) Battle Simulations

As described previously for the Howitzer Section devices, several manual and computer-assisted battle simulations are currently in use with differing degrees of relevancy to engagement training of the gunnery team. In general, "simulations" (or "war games") tend to exercise commanders and staffs of artillery units, while "simulators" tend to exercise the FA units, themselves. However, when commanders are required to participate in simulation exercises, there is often a consequent emphasis on preparation and training passed down to the units. Battle simulations may, therefore, be more important for motivating gunnery team training then for providing the training, itself.

Among the existing simulations, those that are likely to have the most impact on engagement training of the gunnery team are:

- The Computer Assisted Map Maneuver Simulation (CAMMS)
- Dunn-Kempf
- Pegasus
- Blockbuster

Brief descriptions of these simulations were provided in the Howitzer Section part of this chapter, and are not repeated here.

Because the primary mechanism for implementing these simulations are the scenarios and their sequences of tactical decisions and consequence evaluations, there is not often an opportunity to fire weapons or to practice other specific sensorimotor skills on operational equipment. This is reflected in the adequacy ratings of battle simulations in helping to train the aggregated gunnery team tasks. For the FDC, battle simulations are rated from "fair" (for three tasks) to "good" (for one task).

For Task 1 (Fair) and Task 2 (Fair), the battle simulations can provide the opportunities for using the BCS to implement a battle scenario and execute decisions, including the composing, transmitting, receiving and processing of both RFAF (Task 1) and TACFIRE (Task 2) commands. The accuracy and timeliness of those tasks generally require manual evaluation, since automatic communications recording, timing and assessment are not part of typical battle simulation systems.

For Task 3 (Good), the battle simulations can provide opportunities for the training of plotting/replotting targets, using BCS data, by defining tactical operating conditions and establishing the battle scenario. Theoretically, every type of target situation can be exercised through the scenario. The evaluation of the plotting and BCS-usage task, however, remains unaided in typical simulations, and must be set up and executed by the trainer.

For Task 5 (Fair), the battle simulations facilitate the training of the gunnery team to carry out its tasks in a timely way under extreme environmental or operational constraints. This facilitation results from the fact that battle simulations define the tactical operating conditions and scenario of events. However, these simulations do not create realistic, hostile environments or provide for automatic performance monitoring and assessment.

In summary, the battle simulations provide structured opportunities, but not necessarily evaluation capabilities for helping to train the gunnery crew in aggregated FDC Section tasks. Consequently, they rank poorly on training the use of devices, but are better for training decision-making tasks of varying complexities.

c. FO/FIST Section (Ref: Figure 7)

1) Uninstrumented Operational Equipment

The operational FO/FIST equipment includes Binoculars, Compass, Map, Plotting Equipment, Digital Message Device (DMD), FIST DMD, Laser Range Finder (LRF), Ground Vehicular Laser Locator Designator (G/VLLD), G/VLLD Night Sight and Copperhead Footprint Template. No performance evaluation is carried out on any of that equipment as part of ordinary operation. Performance testing and evaluation procedures must be added to the uninstrumented operational equipment if training is to be effective. For that reason, the training adequacy ratings for uninstrumented equipment range from "absent" for one aggregated task, to "poor" for three tasks, to "fair" for two tasks.

For Task 1 (Fair), the uninstrumented FO/FIST equipment is somewhat capable of facilitating training in using the DMD and FIST DMD to prepare, transmit, receive and forward digital fire mission messages. This is especially true if the interfacing uninstrumented FDC equipment (i.e., the BCS) is available to receive, display and transmit in collaboration with the FO/FIST equipment. There is no automatic provision for timing those FO/FIST tasks for which performance time criteria exist. Neither is there any way of insuring that data are entered correctly via the keyboards. Those performance assessments must be conducted manually by the instructor. Likewise, the instructor must provide the systematic routines to insure that all required tasks and conditions are exercised.

For Task 2 (Poor), it is considerably more difficult to evaluate training performance in using the uninstrumented G/VLLD to measure range and illuminate stationary or moving targets. Without any sensing device to provide feedback of proper aiming, tracking and measurement execution, the trainee has no objective indication of performance quality. The best he/she can do is to judge performance by staying aware of how well the target remains positioned in the G/VLLD eyepiece reticle pattern. Special precautions must be followed because of the danger to vision of the invisible laser beam which can cause eye damage at distances in excess of 20 miles. Live firing is limited by the high cost of the operational Copperhead projectile.

For Task 3 (Poor), it is also difficult to evaluate performance in using the uninstrumented LRF to measure range. The problems and possibilities are similar to those described for using the G/VLLD (Task 2, above). The laser hazard also requires special precautions.

For Task 4 (Fair), instructors can make use of known or previously prepared terrain/target information in combination with observed performance to help train the FO/FIST team in using uninstrumented visual/manual devices for graphical recording and measurement. There is less obvious need for built-in or automated training capabilities in these devices.

For Task 5 (Absent), there is no capability in the uninstrumented operational equipment for training unit personnel in decision-making related to fire missions. This kind of training usually requires something like a scenario of simulated events as well as a set of criteria for expected decision-making performance. The decision areas to be trained include: target detection, assessment and selection; formulation of fire mission commands; fire mission evaluation; operational safety. Training of this sort with the uninstrumented operational equipment must be accomplished by the instructor's providing scenario exercises, observations and assessments.

For Task 6 (Poor), the uninstrumented operational equipment provides a task practice capability but no built-in provision for imposing the extreme environmental and operating constraints required here.

The SMEs note that uninstrumented FO/FIST equipment permits practice in both individual and team training. The instructor/trainer must actively monitor trainee performance in the conduct of observed fires. Many times there is subjective disagreement between what the trainee observed versus what the instructor observed. The SMEs state that the entire gunnery team currently trains together with uninstrumented equipment very few times in the training year, and usually only during live fire exercises. One of the main reasons for limited gunnery team training is that FO/FIST Sections are assigned to the Headquarters Battery and many times train with the Infantry maneuver units in fire support planning procedures.

In summary, there is practice potential but no built-in performance evaluation capability in the FO/FIST equipment to help train the team in originating and processing fire missions, measuring range and illuminating targets, charting and determining/entering coordinates/altitudes for targets, decision-making with regard to fire missions, or operating under extreme environmental conditions. If training is to be effective, the diagnostic evaluation component must be provided by instructors with prepared routines and recording apparatus to insure that all required tasks are exercised under all required conditions. Special precautions and severe restrictions are also required because of the laser hazard associated with the G/VLLD and LRF, including the need for suitable training ranges and little (if any) participation in combined arms live fire exercises. In addition, live fire exercises using the G/VLLD are severely limited by the prohibitive cost (over $70,000 each) of full service Copperhead munitions.

2) Ground/Vehicular Laser Locator Designator--Trainer (G/VLLD--T)

This device is a full-scale facsimile of the tactical G/VLLD that incorporates a TV camera from the Maverick missile system instead of laser components. The trainer is connected to an instructor scoring console which gives an automatic digital score of how well the operator tracked one of several, moving miniature T-62 tanks on the G/VLLD Trainer Tracking Board. A nominal distance of 200 inches (representing 3,000 meters) is used between the G/VLLD--T (with close-up lens) and the front of the tracking board. By activating the appropriate combination of switches on the tracking board control box, the instructor can select one of 14 possible target scenarios. Each tracking run lasts about 20 seconds, at the end of which the instructor at the console reads off (and records) the mean and standard deviation of the trainee's angular tracking errors. The mean azimuth and elevation scores reflect any tendencies of the trainee to track ahead/behind or above/below the target, respectively. Videocassette tapes can be made and later reviewed for follow-up to the exercise. Range measurement is not a capability of this device.

It has been recommended, in a recent (1984) article by a former training officer at the USAFAS, that the entire gunnery team should train together as often as possible since timing is critical for a successful Copperhead mission. Likewise, the associated command, control and communications tasks should be exercised whenever possible to insure overall proficiency. A recent (12 March 1984) TD Information Sheet indicates the cost per item of the G/VLLD--T (and instructor control console) to be $114,000, and that of the Tracking Board to be $1,500.

As an equipment-specific trainer, the G/VLLD--T is not applicable (N/A) to four of the six aggregate FO/FIST tasks: Task 1 (use the DMD and FIST DMD), Task 3 (use the LRF), Task 4 (use visual/manual devices for graphical recording and measurement), and Task 5 (decision-making related to fire missions).

For Task 2 (Good), the G/VLLD--T provides both practice and performance measurement in using the G/VLLD for tracking and illumination of targets. This training device does not train the measurement of range, however. In addition, it is possible to train with stationary or moving targets. By controlling the lighting in the training room, it is also possible to simulate a limited-visibility environment, though the absence of the night vision sight (AN/TAS-4) and a low light level video camera on the G/VLLD--T prohibits training in full nighttime conditions.

For Task 6 (Poor) the G/VLLD--T can provide some practice and evaluation of tracking and illumination skills under the required extreme environmental and operating constraints. However, sight and camera modifications would be required for training under nighttime conditions. There is still no capability for the training of range measurement under any conditions.

The SMEs note that the current basis of issue is one (1) G/VLLD-T per DIVARTY. FIST Section personnel have limited access to this device. When available, it provides the operator excellent hands-on practice. Although the G/VLLD-T provides trainee tracking scores, it does not provide the instructor a display of actual tracking performance. This device is not currently used as a team training device; it is considered an individual skill training device.

In summary, the G/VLLD--T provides significant potential for the individual training of tracking and illumination skills under daylight and somewhat limited visibility conditions. It does not provide for range measurement training. The ability to use scaled-down training areas with multiple training devices and "targets" facilitates more convenient practice and performance evaluation sessions than would otherwise be possible.

3) Ground/Vehicular Laser Locator Designator (G/VLLD) with Television (TV) Camera

This device consists of the actual operational G/VLLD with a TV camera and associated monitor. The TV camera is mounted on the night-sight interface of the G/VLLD tripod and is boresighted to the tactical G/VLLD. Cross hairs to simulate the reticle of the G/VLLD are marked on a small, locally manufactured clear plastic disc and inserted behind the TV camera lens. On the TV monitor, the instructor watches the results of operator tracking and critiques the operator's performance. By using a videocassette recorder, the instructor can make a permanent record of the operator's tracking session and play it back later for a critique session. The camera has a zoom-lens capability for viewing targets and tracking out to about 1,000 meters.

Targets and ranges must be laser safe to train with this operational equipment. All personnel operating downrange from the G/VLLD must wear laser safety goggles, and reflective surfaces (especially in the target area) must be removed or covered with nonreflective materials. Since areas and accessories for active laser ranging and illumination (designation) often are not available or practical, either of two accessories can be used. First, an attenuator filter assembly is available to reduce the intensity of laser energy emitted by the G/VLLD. With the attenuating filter and laser mode switch adapter in position, the eye hazard distance is reduced from about 8 km to about 2.4 km and the G/VLLD is prevented from operating in the designate mode (to protect the filter from heat damage). Second, if no laser energy at all is to be emitted, a laser-inhibiting (shorting) plug can be used. Since no laser emission occurs with the shorting plug, the operator can track a target anywhere and merely simulate ranging and designation functions. Target direction (azimuth) and vertical angle are displayed in the eyepiece but, since no target distance is determined, the range display remains at a fixed number (9,760 meters).

No published cost information was available to the project staff for this device. A very rough cost estimate for the TV camera, camera reticle, monitor, cables, mounting bracket, attenuating filter and shorting plug is about $1,000.

As also noted for the previous device (G/VLLD--T), the G/VLLD with TV Camera is designed to train operators in the use of one specific piece of equipment (the G/VLLD). As such, this device is not applicable (N/A) to four of the six aggregate FO/FIST tasks: Task 1 (use the DMD and FIST DMD), Task 3 (use the LRF), Task 4 (use visual/manual devices for graphical recording and measurement), and Task 5 (decision-making related to fire missions).

For Task 2 (Good), the G/VLLD with TV Camera provides practice and monitor-aided assessment in using the G/VLLD for tracking and illuminating (designating) targets. No display of range measurement is available on the instructor's monitor, so that number has to be read from the actual G/VLLD reticle display. The laser hazard from using the operational G/VLLD is significant, and precautions must be taken at the training location to avoid accidental eye damage to nearby personnel. Laser-inhibiting accessories can reduce or eliminate this problem, but they impose restrictions on the lasing activities that are supposed to be practiced and evaluated. Finally, the high cost of Copperhead munitions severely limits the opportunities for total gunnery crew training with live fire.

For Task 6 (Poor), the G/VLLD with TV Camera provides for some practice and evaluation of lasing skills under the required extreme environmental and operating constraints. Some moderately complex mechanical and electronic modifications would be required to implement nighttime operations, because the TV camera now uses the night-sight mounting bracket. That camera would have to be changed to a low-light-level type and would have to be mounted differently to allow room for mounting the night-vision sight (AN/TAS-4). Other extreme weather conditions could affect the commercial TV camera before affecting the more rugged G/VLLD, itself.

The SMEs state that this device provides excellent training in tracking skills and uses actual operational equipment. Trainee performance can easily be observed on the TV monitor and/or can be recorded for a later debriefing session. When the shorting plug is not used, safety precautions associated with the use of laser energy seems to degrade training--however, not significantly. When the device is used, it inhibits the GLLD's ranging function. This can be considered a negative training since range has to be estimated or simulated. Currently, the device provides training more in the realm of individual training rather than the engagement function team training.

In summary, the G/VLLD with TV Camera provides good potential for practicing and assessing operator skills in tracking targets. Assessment of range measurement skills are less convenient due to the absence of a remote readout of lased range. The eye hazards from direct and reflected laser beams on a large range are significant, and various precautions must be taken to protect nearby personnel. Total gunnery crew training with live fire is seriously limited by the cost of Copperhead munitions.

4) Training Set, Fire Observation (TSFO)

The Training Set, Fire Observation (TSFO) is a computerized,, audiovisual device that utilizes terrain and image projectors in an amphitheater setting to simulate battle scenes, targets and the delivery of artillery indirect fire. It is used to train forward observers (FOs) and fire support teams (FISTs) in the skills required when calling for and adjusting indirect fire. It has been described as an enhancement trainer in procedures and techniques, designed to sustain observer proficiency between live fire exercises.

As presently designed, the TSFO can train up to 30 observers concurrently. It can simulate the visual and aural effects of four 8-gun batteries, each equipped with 155-mm guns and a variety of ammunition types, including HE air/graze/mixed bursts as well as illumination and smoke. Various day and night operations can be simulated, all of which are conducted to scale with respect to observer-target range. Artillery sounds produced include HE bursts (bangs), shell passages (whooshes) and bursting charges (flare and smoke). The illumination and smoke missions can be fired with realistic wind-speed and direction simulation. Scaled-down binoculars are used by the observers being trained. The TSFO can be used individually or in conjunction with the Firing Battery Trainer and the FA Shootable Practice Round in the Closed Loop Training Concept.

The TSFO can be operated by one person. However, for more flexible operation, the scenario is controlled by an operator at the console while a separate instructor provides direction and critique to the trainees. The instructor directs the trainees in determining target location, fire control data, 'FIRE' orders, adjust-fire data and end of mission. Performance evaluation is conducted by the instructor during the exercise or during a computer-controlled replay at a later time. Any or all calls-for-fire (up to 64 rounds, in up to 8 calls for fire at up to 8 rounds each) may be replayed, displaying the same rounds under the same ambient conditions as existed when the original rounds were fired. A recent (12 March 1984) TD Information Sheet reports the cost per item of the TSFO to be $135,000, plus a manufacturer's maintenance contract cost of $11,000 per year per device.

The adequacy of the TSFO in facilitating observer training is "fair" to "good" for those tasks directly concerning the proper determination of target location, fire-control data and adjust-fire data. The TSFO is not applicable (N/A) to training of other devices in the FO/FIST section, namely, Task 1 (using the DMD and FIST DMD), Task 2 (using the G/VLLD) and Task 3 (using the LRF).

For Task 4 (Good), the TSFO provides for (in fact, requires) the trainees to use visual/manual devices for determining and recording object locations. Trainees sit at desks and use binoculars (optically modified for TSFO-scaled use), maps and plotting equipment to carry out their tasks. The maps are matched to the terrain scenes projected on the TSFO screen. The instructor can walk around to observe each trainee's performance for assessment and guidance.

For Task 5 (Fair), the TSFO provides at least fair capability to help train the observer in decision-making related to fire missions.

It provides a simulated tactical environment in which to practice and assess target detection and evaluation, target selection, generation of fire commands, mission evaluation and the adherence to safety precautions in operating procedures. Some of those decision-making areas (such as the generation of fire commands and use of safe procedures) can be trained more realistically or effectively than others. The TSFO, because of simulator limitations, is somewhat less realistic or effective in areas such as target detection and evaluation. However, when the TSFO is used in the closed loop concept, additional training opportunities become available, such as: Task 1 (using the DMD) and the mission evaluation area of Task 5 (d).

For Task 6 (Fair), the TSFO provides for training of observer skills under some extreme environmental and operating constraints. Specifically, nighttime operations can be simulated, as well as "heavy" enemy activity on the battlefield. There is no built-in capability in the TSFO for creating extreme weather conditions that also fall into this task area.

The TSFO is considered by the SMEs to be a valuable device for training basic observed fire procedures and map reading. It helps to avoid disagreements between trainees and instructors about observed fire. Through the use of photographic slides, the device provides the opportunity to vary terrain, seasonal conditions, day/night illumination, some environmental conditions and targets, but it does not provide the observer with a realistic experience of the environmental conditions. For example, the observer is in a warm, sometimes air-conditioned room, while a snow scene from Korea is projected. In the real situation, he would experience the cold temperatures and wind, would handle cold equipment and would wear heavier clothing and gloves. The SMEs consider the targets displayed to be not at all realistic (i.e., they are white). They also believe that it is difficult to estimate range since the slides do not provide a realistic depth of field.

The TSFO does provide the opportunity for the observers to train and practice with both voice and digital communications equipment, as well as binoculars, maps and plotting equipment. The SMEs state that the TSFOs they have used for training suffer from too much maintenance downtime.

In summary, the TSFO has the potential of providing good training for the target observation/charting and decision-making tasks. Additional potential is provided when the closed loop concept is employed, such as for using the DMD.

5) Forward Observer Trainer (FOT)

The Forward Observer Trainer (FOT) utilizes a lighted terrain board and special binoculars to train observers in adjustment of indirect fire without expending service ammunition. Although replaced by the TSFO, a number of FOTs remain in use in USAREUR and available through TASC for Reserve and National Guard Units.

According to a recent (12 March 1984) FOT Fact Sheet, the device consists of a 4 x 4 x 1 foot plywood box which houses a plastic, vacuum-formed relief map. The observer uses a specially designed pair of binoculars to identify scaled target(s). He plots the location(s), requests a fire mission, and an instructor or operator on the opposite side of the FOT manipulates controls to move a penlight underneath the map to simulate the burst of the round. The FOT is powered by either 110VAC line current or twelve 24VAC batteries.

The FOT is reported to be a good procedural trainer for small numbers of personnel. It is not designed for training large groups in an institutional environment due to the 1:1 student-to-instructor ratio. Students are able to learn and practice adjust fire procedures using these techniques: grid coordinate, shift from known point, polar plot, and mark center sector.

No cost data were available to the project staff for this device.

The adequacy of the FOT in helping to train observers is rated as "poor" to "fair" for those tasks concerned with determining target location and developing fire control (including adjust fire) data. The FOT is not applicable (N/A) to the training of other FO/FIST devices, namely, Task 1 (using the DMD and FIST DMD), Task 2 (using the G/VLLD) and Task 3 (using the LRF).

For Task 4 (Fair), the FOT is estimated to be somewhat less effective than the TSFO in training the observer to locate and measure target positions using visual/manual devices. Trainees use special binoculars and plot targets, but the FOT representation is judged to be less conducive to the positive training of range determination than is the TSFO representation.

For Task 5 (Fair), the FOT is considered almost as good as the TSFO in the decision-making aspects of fire mission processing. Decision-making related to target location/assessment is probably trained better using the TSFO. The two devices are probably equivalent when used to train decision-making with respect to selection of targets, generation of fire commands, mission evaluation and the adherence to safety precautions in operating procedures.

For Task 6 (Poor), the FOT provides very little benefit for training observer skills under extreme environmental and operating constraints. Possibly, nighttime operations can be simulated, as can "heavy" enemy activity, but not as well as with the TSFO. There is no built-in capability in the FOT for creating the extreme weather conditions that also fall under this task.

The SMEs state that the FOT is an observed fire procedural trainer and is used mainly to improve individual skills. It is not considered useful in a gunnery team training environment. The SMEs believe that the FOT is too "artificial" and can simulate only limited terrain scenes.

In summary, the FOT has fair potential for helping to train target observation/charting and decision-making skills. This device has been made obsolete by the availability of the TSFO.

6) Miniature Moving Target (MMT) with M31 Subcaliber Trainer

The Miniature Moving Target (MMT) is a remotely controlled 1/10-scale model of a T62 Soviet tank. As reported in a recent (12 March 1984) fact sheet, it provides an economical and realistic simulation of a moving target for use during training of adjust-fire procedures on moving targets with the M31, 14.5-mm Subcaliber Trainer. A garden hose is laid on the ground along the path the instructor wants the MMT to follow. The speed of the MMT is remotely controlled by the instructor and allows observers to conduct realistic planning and engagement of a moving (or movable) target in a local training area. No capabilities are noted for automatic recording or assessment of performance in using this device. The MMT was built by the Training and Audiovisual Support Center (TASC), Fort Sill, Oklahoma, and fielded in 1978.

Because the MMT is intended to be used with the M31, 14.5-mm Subcaliber Trainer, the adequacy ratings assume that both trainers (MMT and M31) are being used together. On the applicable tasks, those ratings range from "fair" for one task to "good" for three tasks. The MMT/M31 combination is not applicable (N/A) to the training of Task 1 (using the DMD and FIST DMD) or Task 4 (using visual/manual devices), although use of the MMT does provide more opportunities for training those tasks.

For Task 2 (Good), the MMT/M31 combination provides a controlled scenario which enhances training in the use of the G/VLLD. It provides similar benefits for Task 3 (Good) in training the use of the LRF. However, the training officer still is required to superimpose instruction and performance assessment on the engagement scenario. The distance requirements are scaled down to 1/10th their actual values and munitions effects are minimal. Although this allows for more convenient selection of training facilities, the eye hazard from direct and reflected laser beams remains significant and precautions must be taken to protect nearby personnel.

For Task 5 (Good), the MMT/M31 combination provides a good capability to help practice decision-making activities in the FO/FIST Section. It provides a scaled-down tactical environment in which to practice and evaluate target detection and assessment, target selection, generation of fire commands, fire mission evaluation and adherence to safe operational procedures. The limitations of training under these conditions come from the less-than-full-scale targets and tactical situations, and the absence of fully exploding shells and accompanying target destruction to be evaluated. In addition, this combination of devices provides fine practice opportunities but no automatic or aided assessments of performance. The training officer is required to add a mission regimen and performance evaluation capability in order to accomplish real training.

For Task 6 (Fair), the MMT/M31 combination provides more opportunities to practice observer skills "in the field" and thus under available extreme environmental and operating constraints. Theoretically, this combination of devices can be used to produce "heavy" tactical and engagement activity, and nighttime operations can be conducted. There is no built-in capability to create the extreme weather conditions under which these tasks must also be trained.

The SMEs believe that the MMT/M31 combination provides excellent training for FO/FIST personnel in observed fire procedures on moving targets. They also believe that it provides excellent training for FO/FIST personnel in determining "trigger points" for Fire for Effect missions. The novice FO receives practical training benefits when adjusting M31 fires by learning basic gunnery procedures. Although the overall ammunition burst signature is good, the SMEs note that the M31's trajectory is very erratic in windy and adverse weather. Consequently, the FO may experience negative training and lose confidence in his abilities (as well as in the M31's effectiveness) whenever any wind conditions exist.

In summary, the primary benefit that is possible from using the MMT/M31 combination is an increase in training opportunities because of smaller (1/10th-scale) training area requirements and lower ammunition costs. Still, no routinized exercises or automated sensing, recording or evaluation capabilities are built in to those trainers. All program sequencing and assessments must be carried out manually by instructors or expert observers. The motivation for commanders and trainers to use the MMT is closely related to the pressure they experience for reducing the more realistic full-caliber training, their motivation for using the M31 Subcaliber Trainer, and their action in setting up scaled ranges.

7) Battle Simulations

As described previously for the Howitzer (and FDC) Section devices, several manual and computer-assisted battle simulations are currently in use with differing degrees of relevancy to engagement training of the gunnery team. In general, "simulations" (or "war games") tend to exercise commanders and staffs of artillery units, while "simulators" tend to exercise the FA units, themselves. However, when commanders are required to participate in simulation exercises, there is often a consequent emphasis on preparation and training passed down to the units. Battle simulations may, therefore, be more important for motivating gunnery team training than for providing the training, itself.

Among the existing simulations, those that are likely to have the most impact on engagement training of the gunnery team are:

- The Computer Assisted Map Maneuver Simulation (CAMMS)
- Dunn-Kempf
- Pegasus
- Blockbuster

Brief descriptions of these simulations were provided in the Howitzer Section part of this chapter, and are not repeated here.

Because the primary mechanism for implementing these simulations are the scenarios and their sequences of tactical decisions and consequence evaluations, there is not often an opportunity to fire weapons or to practice other specific sensorimotor skills on operational equipment. This is reflected in the adequacy ratings of battle simulations in helping to train the aggregated gunnery team tasks. For the FO/FIST section, battle simulations are rated from "poor" (for two tasks), to "fair" (for two tasks), to "good" (for two tasks).

For Task 1 (Fair), the battle simulations can provide opportunities for using the DMD and FIST DMD to prepare, transmit, receive and forward digital fire mission messages. This is especially true if the interfacing FDC equipment (i.e., the BCS) is available to receive, display and transmit in collaboration with the FO/FIST equipment. There is no automatic provision in typical battle simulations for timing those FO/FIST tasks for which performance time criteria exist. Neither is there any way of insuring that data are entered correctly via the keyboards. Those performance assessments must be conducted manually by the instructor.

For Task 2 (Poor), using the G/VLLD and for Task 3 (Poor), using the LRF, the battle simulations typically provide few opportunities for measuring range and illuminating targets in the field, and even fewer for using live Copperhead munitions against stationary or moving targets. The simulations often do not fully employ the operational equipment and there are rarely any automatic recording and assessment aids. However, the trainer may still direct the FO/FIST team to carry out its tasks with the laser devices under carefully established field conditions. Special precautions must be followed because of the danger to vision of the invisible laser beam which can cause eye damage at long distances. Live firing is also limited by the high cost of the operational Copperhead projectile.

For Task 4 (Good), the battle simulations can facilitate training of the FO/FIST team in using visual/manual devices for graphical recording and measurement. Specifically, the simulations can provide terrain and target information under a wide variety of simulated environmental and tactical conditions. Once again, the recording and assessment of performance is typically unaided and is the responsibility of the trainer. On the other hand, there is less apparent need for built-in or automated training capabilities in these visual/manual devices.

For Task 5 (Good), the battle simulations provide many opportunities for the training of decision-making related to fire missions. This kind of training usually requires a scenario of simulated events as well as a set of criteria for expected decision-making performance. Battle simulations provide such features. The decision areas to be trained include: target detection, assessment and selection; formulation of fire mission commands; fire mission evaluation; operational safety.

For Task 6 (Fair), the battle simulations establish tactical operating conditions under which the battle scenario is to be carried out. In that respect, some facilitation of training is available for the requirement of timely operation under extreme environmental or operational constraints.

In summary, the battle simulations provide structured opportunities, but not necessarily evaluation capabilities for helping to train the gunnery crew in aggregated FO/FIST team tasks. They rank poorly on training the use of devices, but are better for training decision-making tasks of varying complexities.

D. Review of Planned Training Devices and Simulations

1. General

The training technologies currently in various stages of planning, development and prototype testing are reviewed next. These include the nine devices and simulations identified earlier (Section II.B.), for which available data are typically incomplete. In most cases, the information available is sufficient to prepare general descriptions, but not enough to describe the technologies' systematic and evaluative training capabilities. Guidelines in this review include the same criteria as listed in Section II.C.1.

2. Technology Descriptions and Assessments

Figure 8 summarizes the relevant training devices and simulations that are in development, and their potential for meeting the needs of gunnery team training. Specific descriptions of each item is given next, followed by an explanation of the assessments.

a. Specific Technologies for Gunnery Team Training

1) Artillery Control Environment (ACE)

At the time of this writing, the project staff has not received requested information on this system, the technology of which is currently in use at the Human Engineering Laboratory (HEL). ACE is also being investigated to assist in developing tactical automated data processing (ADP) systems and to serve as the core of a future FA Fire Support Training System (FAFSTS).

From the recent (1 May 1984) but brief fact sheet available to our staff at the present time, the Artillery Control Environment (ACE) and its status can be described as follows. It is a real-time, interactive, multiplayer simulation designed as a research tool for studying artillery fire support control. With ACE, components of the fire support ADP system can be played in a number of ways using emulation, simulation, or actual equipment. Any combination of components may be used for the desired application or the organization and operation to be played. The ETHER program allows wartime communications to be studied while a large screen display allows evaluators to monitor real-time message flow to instantly extract data regarding the conduct of the mission.

The Field Artillery School is currently investigating ACE for use as a training simulator and in other research on current and projected tactical ADP systems. The Data Systems Office (USAFAS) has acquired a UNIX operating system which will facilitate loading ACE software exported by Ballistic Research Laboratory (BRL) and Human Engineering Laboratory (HEL). The Field Artillery School is also investigating ACE as a possible core to a fire support system using actual equipment.

Because our staff does not have the information describing what is measured/evaluated by ACE, how it carries out its training functions,

Figure 8.

FA Training Devices and Simulations in Planning and Development

Item	1. Artillery Control Environment	2. FA Fire Support Training System (FAFSTS)	3. Indirect Fire Engagement Simulation (IFES)	4. Closed Loop Training Concept	5. FIST Vehicle Training Devices FIST/FO Interactive Videodisc Trainer	6. Howitzer Recoil Simulator	7. Copperhead Moving Target	8. Simulated Tank Anti-armor Gunnery System (STAGS)	9. Battle Simulations*
Potential Value for Gunnery Team Training (Poor, Fair, Good, Excellent)	Fair	Good	Excellent	Excellent	Good	Excellent	Good	Good	Fair

*Battle Simulations include:

- The Company/Team Level Training Simulation System (COLTSIM).
- The Army Training Battle Simulation System (ARTBASS).
- First Battle: Battalion-Corps (FBBC).
- The Stand Alone Tactical Artillery Battle Simulation (STABS).

or how costly it is, no further assessment is provided here regarding the use of ACE in training the aggregated gunnery crew tasks listed in Figures 5, 6 and 7.

2) Field Artillery Fire Support Training System (FAFSTS)

According to a Fact Sheet dated 19 April 1984, the Field Artillery Fire Support Training System (FAFSTS) is a concept which ties Artillery Control Environment (ACE) technology together with diverse training simulators, emulators, and actual equipment to train various portions of the Fire Support System. A Joint Working Group (JWG) from USAFAS, Ballistic Research Laboratory, Human Engineering Laboratory, Army Training Support Center, and Project Manager Training Devices has been formed. A steering group also was established by USAFAS to define the training requirements, establish system development milestones, and draft the requirement documents necessary for development, procurement, and fielding.

The 1984 FAFSTS Training Device Need Statement (TDNS) notes that new automated fire support systems cannot be effectively trained due to the severe lack of tactical hardware, realistic modern battlefield scenarios, and expertise on how to score and determine adequacy of training on the new systems.

The planned strategy is to develop and field an institutional (USAFAS) and, possibly, a field-exportable training system which integrates all fire support agency assets and communication mixes at each level of coordination, in order to train each level of fire support personnel. The initial operating capability (IOC) is established for the end of the 1986 fiscal year (4QFY86).

Just as for the ACE technology described earlier, the unavailability of technical information regarding FAFSTS measurement/evaluation/operation/cost prevents further assessment as a training device for the aggregated gunnery crew tasks.

3) Indirect Fire Engagement Simulation (IFES)

This concept refers to a series of devices under development that allow indirect fire weapons to participate in MILES engagement simulation exercises. According to a recent (19 April 1984) Fact Sheet on IFES, five distinct elements of simulation need to be addressed:

a) Audio/Visual Cue. For this simulation element, an audio/visual cue is activated at the simulated grid of impact. This cue (smoke, bang, flash) does not simulate every round fired, but a representative number gives the Artillery Observer and other players an appreciation of the suppression/killing power of their supporting artillery/mortars and insures that the attacked unit is clearly aware of why it suffered the casualties/damages it did and what preventive measures could or should have been taken.

b) Casualty/Damage Assessment. For this simulation element, the system automatically assesses casualties and damage according to the distance from the impact grid of the simulated rounds, the type of munitions employed, and the protection available to the players at the moment of impact. In contrast with earlier techniques, this simulation is not dependent upon the subjective decisions of a fire marker controller on the battlefield (e.g., with a controller's laser gun). It is being developed to provide timely and accurate portrayals of indirect fire effects using MILES kill or near-miss cues.

c) Firing Battery Involvement. For this simulation element, FDC data and howitzer crew actions are used to develop cues and assessments, thus affording the entire gunnery team a more realistic involvement in the exercise. The integration of training devices, such as described later in this section for the closed-loop concept, may be applicable here. The "did hit" coordinates determined by a central computer could be used as the basis for the casualties assessed on the battlefield. Those coordinates would be based on the FDC's computations and subsequent data applied to the howitzers. In this manner, the firing battery and FDC personnel have direct input to the success/failure of the field artillery in engagement simulation exercises. In conjunction with the measuring equipment on the howitzers, a Shootable Practice Round could be used to increase the total involvement of the howitzer crews.

d) MILES-G/VLLD for FIST. For this simulation element, a G/VLLD simulator will allow Copperhead and Hellfire to be played in MILES exercises. A trainer which looks like a G/VLLD or an adaptation to the actual G/VLLD, itself, will be developed to interface with existing MILES equipment. FIST personnel then can simulate the coordination and laser designating skills involved in the employment of laser-guided munitions. Thus, they can realistically simulate the engagement of targets with laser-guided munitions on the MILES battlefield.

MILES-G/VLLD training begins with the FIST using the digital message device (DMD) to send the Copperhead fire mission request to the appropriate battery or battalion FDC. The FDC processes the FIST's request, computes firing data, and relays this information to the Howitzer Section(s) selected to fire the mission. The FDC digitally notifies the FIST when the round is fired. At the appropriate time, based on time of flight (approximately 20 seconds to impact), the FIST DMD automatically illuminates the green fire command (designate) light in the MILES-G/VLLD eyepiece. Then (13 seconds prior to impact), the FIST lases and continues to track the target at ranges of 3,000 to 5,000 meters, depending on light conditions. If the target is successfully acquired and tracked, it presents the appropriate MILES "near miss" or "kill" signature. The MILES-G/VLLD will allow maneuver commanders to integrate the use of G/VLLD-Copperhead into combined arms exercises and will permit the FIST chief and armor or infantry commander to conduct essential training for the FIST and supported maneuver units.

e) Target Acquisition System. For this simulation element, a digital target designation device will be used to allow various target acquisition elements (such as the Firefinder radar) to participate, or to allow for a simulation of their participation, in the exercise.

The actions underway for these five simulation elements can be summarized as follows. The Audio/Visual Cue and Casualty/Damage Assessment elements are both being incorporated into an ongoing development entitled Simulation of Area Weapons Effects (SAWE)--Indirect Fire (IF). The Firing Battery Involvement element is expected to be satisfied with a combination of devices, including the Firing Battery Trainer (FIST) and the FA Shootable Practice Round (FASPR), in a configuration such as the Closed Loop Concept described below. The MILES-G/VLLD for FIST element is programmed for development and fielding by PM-TRADE in coordination with USAFAS and ATSC. The Target Acquisition System element is still in the early conceptualization stage of development, according to a recent IFES Fact Sheet.

4) Closed Loop Training Concept

According to the Fact Sheet (dated 12 March 1984), the Closed Loop Training Concept is a training strategy that will provide realistic training of the total field artillery cannon system, without the expenditure of full service ammunition. The Closed Loop Training Concept will occur with the development, fielding and interconnection of the following training devices:

a) The Training Set, Fire Observation (TSFO) is being fielded to each active Division Artillery and selected National Guard and Reserve Component locations. The TSFO can provide the Forward Observer location, impact area, and "did hit" computation and depiction capabilities during Closed Loop Training. The "did hit" computer could be the TSFO computer, BCS, TACFIRE, or a separate "training-only" computer. Details of the TSFO were described previously, with the other existing devices.

b) The Firing Battery Trainer (FBT) will measure firing data with measuring devices located on the howitzer. With the addition of a microprocessor on the FBT, these data can be used to compute a "did hit" location for the training round fired, for digital transmission and display on the TSFO screen. One prototype FBT has been developed by the Human Engineering Laboratory (HEL). Details of the FBT were described previously, with the other existing devices.

c) The Field Artillery Shootable Practice Round (FASPR) is being developed to provide a full-caliber, limited-range training round for live fire training. Use of the FASPR will facilitate realistic live fire howitzer crew training in the local training area during Closed Loop Training. Both the fuze and projectile will be inert and when fired, the round will be projected no further than 200 meters downrange. The FASPR may be reusable. The FASPR is unfunded for development; however, USAFAS and the Army Training Support Center (ATSC), in conjunction with ARRADCOM, are evaluating the potential use of the M804 Low Cost Indirect Fire Training Round (LITR) in the FASPR role. Both the FASPR and LITR were described in greater detail previously, with the other existing devices.

d) There is a need for a recoil simulator for the artillery cannon system to incorporate the recoil/counter-recoil and breech opening cycle during training with the Field Artillery Shootable Practice Round (FASPR). The small amount of propellant needed to propel the FASPR 200 meters downrange will not activate the recoil system. With the recoil simulator, howitzer crews will experience full service capability. In February 1984, a Training Device Need Statement (TDNS) was approved by ATSC (see Item 6, below).

When exercising under the Closed Loop Concept, the Fire support Team (FIST) trains with the Training Set, Fire Observation (TSFO) in garrison. The FIST passes the call for fire to the Fire Direction Center (FDC) which computes firing data and sends it to the howitzers, collocated with the FDC in the motor pool or local training area. The Howitzer Sections load a type dummy projectile (Field Artillery Shootable Practice Round) while measuring equipment on the howitzers (Firing Battery Trainer) feeds data to a central computer which determines the impact location. A burst/flash symbol is displayed on the TSFO screen at the "did hit" location.

The Closed Loop Concept is a major step forward in the technology of total team training. Because it is a composite of existing devices, however, it carries with it some of the combined shortcomings of those devices. For example, the FBT does not "automatically" evaluate: 1) the crew's safety assessment of fire commands, or their following of correct communications procedures in general; 2) the proper use of the Gunner's Quadrant or direct fire scope; 3) the interval for setting/laying the howitzer for deflection in comparison with the 15-second criterion (it simply allows up to 59 seconds); 4) the interval for setting elevation; 5) errors that may be entered by the instructor on the keyboard; 6) the time required to prepare ammunition; and 7) the accuracy and timeliness of subtasks associated with loading, clearing and inspecting the howitzer after firing. As for the FASPR, the shortcomings are in the process of being corrected. Namely, the need to unload a dummy charge has been overcome recently by a new consumable dummy charge, and the absence of recoil may be overcome shortly by the recoil simulator under development. The lack of an explosion with FASPR is also considered by some to be a shortcoming in realism. As for the TSFO, there is a lack of realism for the FO in terms of target appearance (white) and environmental conditions. There also remain the questions of how valid and transferable to the real world the training of range estimation is, and whether the TSFO is properly dealing with the governing parameters when using photographic images to train that task (see Chapter IV, Observer Tasks).

The SMEs consider the Closed Loop Concept to be the next best thing to live firing. They have a primary criticism regarding the basis of issue. Because there will be just one system per division, the SMEs feel that the gunnery team can train only once every three or four months. Technically, they feel that the instrumentation of equipment will provide realistic team performance measurement. However, they would be concerned if the FBT sensing equipment and recoil simulator were to remain mounted on the howitzers, and also concerned if those devices have to be removed and reinstalled each time they are used. In either case, the SMEs note that degraded use of the FBT can result if special handling, storage and maintenance procedures are required under the Closed Loop Concept. The SMEs also note that the Howitzer Sections and FDC could function in a realistic environment while the FO/FIST Sections would be in a classroom environment that is not realistic and gives the FO/FIST a misleading view of operational conditions.

5) FIST Vehicle Training Devices

According to the Fact Sheet (dated 12 March 1984), the devices still in development under this heading are the FIST/FO Interactive Videodisc Trainer and the Turret Maintenance Trainer. Development of three other planned devices was cancelled in early 1984. Those devices were: the Turret Tracker Trainer, the FIST V Crew Trainer and the Targeting Station Control and Display (TSCD) Trainer. Of the two remaining devices, the only one of concern in the present review of engagement training is the FIST/FO Interactive Videodisc Trainer. The other device relates to maintenance and falls outside our scope of interest.

According to its Fact Sheet (also dated 12 March 1984), the FIST/FO Interactive Videodisc Trainer will be used to train the Fire Support Team (FIST) and Fire Support Officers (FSO) in a stressful simulated combat environment. The desired essential characteristics include the following:

a) Utilize interactive videodisc technology.

b) Present terrain scenes and maps.

c) Present a simulated tactical scenario.

d) Provide interactive replication of DMD or FIST DMD.

e) Be a table/desk mounted training device.

f) Stress the student in target engagement, fire planning, and fire support coordination.

g) Have a scoring capability.

h) Provide visual representation of effects of student's target plan and target engagement.

i) Train the student on conventional and laser-guided munitions.

This training device will be used in resident and nonresident FIST/FSO instruction, and fielded to Active, Reserve, and National Guard Field Artillery units. At USAFAS, the FIST/FSO trainer will interface with the computer-controlled Field Artillery Fire Support Training System that is described earlier in this section.

6) Howitzer Recoil Simulator

As referenced previously in Item 4 (Closed Loop Training Concept), the Training Device Need Statement (TDNS) of February 1984 recommends the development of this recoil simulator as part of the FA Shootable Practice Round (FASPR) development.

The Howitzer Recoil Simulator is needed to cause howitzer recoil during training with the FASPR. The FASPR is a full caliber artillery projectile that will be fired, recovered, and reused in training. Approximately 4.5 ounces of M10 mortar flake is all that is required to propel the FASPR 200 to 300 meters, and this does not activate the howitzer recoil mechanism. Without this capability, howitzer crews will not experience full system capability, and may be subject to a safety hazard during follow-on live fire training with full service ammunition.

The TDNS notes that one prototype recoil simulator was produced by the 124th Tactical Reconnaissance Group (National Guard) in Boise, Idaho. A recoil simulator similar to that provided in prototype design, with an improved recoil cycle of one to two seconds, is required. It is recommended that the development of a recoil simulator be given the highest priority due to its potential in training to prevent serious injury from a recoiling howitzer. In order for the howitzer recoil simulator to be used in the Closed Loop Training Concept, the TDNS notes that an initial operating capability (IOC) of 4QFY86 is required.

The SMEs expect that the Howitzer Recoil Simulator will greatly improve FASPR firing with realistic recoil action. The cannoneers will not learn unsafe habits with the advent of this device. The SMEs also note that current developments include powder increments, for training purposes, which are more like the actual powder increments in size and weight. The improved increments will alleviate the need to unload a simulated charge and will also provide training in the task of checking that the powder chamber and tube are clear after firing.

7) Copperhead Moving Target

This device consists of a full-scale, canvas target mounted on a railroad car, for firing upon with laser-guided munitions. Little additional information is available to the project team on this device which was dropped from service for reasons of impracticality.

8) Simulated Tank Antiarmor Gunnery System (STAGS)

As described briefly in a recent (January-February 1984) report in the Field Artillery Journal, the Simulated Tank Antiarmor Gunnery System (STAGS) was developed by the Naval Training Equipment Center for the U.S. Army and the U.S. Marine Corps to provide training for a family of antiarmor and laser weapon systems. The report notes that system's success with the Dragon and TOW weapon systems. For the G/VLLD-Copperhead systems, it will provide realistic firing scenarios to include sound, "kill" or "near miss" effects, and true sight pictures for either optical or thermal sights. No cost or schedule data were found for this development effort. Neither is there any information that would clarify the similarity or relationship of this device to MILES-G/VLLD for FIST, which was described earlier as Item 3)d) (under IFES).

9) Battle Simulations

Currently at various stages of development are several manual and computer-assisted battle simulations, some of which are of potential use in gunnery team engagement training. As with the existing simulations, described earlier, these planned simulations may be more important for motivating gunnery team training than for providing the training, itself. Among the developments that are likely to have the most impact on engagement training of the gunnery team are:

- The Company/Team Level Training Simulation System (COLTSIM).

- o The Army Training Battle Simulation System (ARTBASS).

- o First Battle: Battalion-Corps (FBBC).

- o The Stand Alone Tactical Artillery Battle Simulation (STABS).

According to Fact Sheets of 10 June 1983, 19 April 1984 and 1 May 1984, these simulations can be described as follows:

The Company/Team Level Training Simulation System (COLTSIM) is a proposed battle simulation being designed to train maneuver company commanders, executive officers, first sergeants, and FIST chiefs. The Training Device Need Statement (TDNS) for COLTSIM was approved by the Army Training Support Center on 2 February 1984. The Training Device Requirement (TDR) is being written at Fort Leavenworth, KS. The front-end analysis for COLTSIM was recently reviewed by USAFAS, and comments were returned to correct errors.

The Army Training Battle Simulation System (ARTBASS) is a follow-on to the Combined Arms Tactical Training Simulator (CATTS). It is intended to improve the battalion command group training methodology currently used in CATTS. ARTBASS will be a mobile, highly realistic battle environment when fielded.

First Battle: Battalion-Corps is an expanded version of the existing First Battle to train control and coordination of combined arms operations in a simulated tactical environment, from battalion to corps levels. It will replace Pegasus (for battalions and brigades), First Battle (for divisions), and War Eagle (for corps). Fielding and instructor training was scheduled to take place in June 1984.

The Stand-Alone Tactical Artillery Battle Simulation (STABS) will be used to train cannon Field Artillery commanders and staffs on tactical operations.

b. Assessment of Potential Values (Ref: Figure 8)

These assessments must be considered as very preliminary in most cases due to the scarcity of information necessary to compare the characteristics of developing technologies with the gunnery team tasks. In order to use these assessments for the program's ultimate objective of specifying an integrated training system for the FA gunnery team, the ratings of these technologies are made to reflect not only what they appear to be in fact, but also their potentials as training concepts. The tentative and preliminary nature of these ratings cannot be overemphasized, and the text below attempts to explain the limited reasoning behind them.

1) The Artillery Control Environment (ACE) is aimed at exercising and studying the fire support tasks involving digital processing. This is interpreted as addressing the DMD, decision-making and possibly target locating tasks (but not those which involve laser locating). With that

limited amount of information, and the relatively narrow focus in relation to the entire gunnery team, this technology is rated as potentially Fair in the present training context.

2) The FA Fire Support Training System (FAFSTS) is seen to extend the automated-fire-support training capabilities of ACE by adding additional technologies. Like ACE, it still trains a limited portion of the gunnery team, but may have more potential for integration into broader crew training. On that basis, the FAFSTS appears to have greater applicability than ACE, and is rated as potentially Good in the context of overall gunnery team training.

3) The Indirect Fire Engagement Simulation (IFES) addresses the more important issues of gunnery team training by focusing on the realistic training of indirect fire. Its contribution is seen to be directly responsive to existing training inadequacies. It provides such capabilities as: adding audio/visual cues (smoke, bang and flash) to the simulated fire mission; assessing "casualties" and "damage" based on calculated impact points; involving the entire gunnery team in an integrated fashion; incorporating a training capability in MILES for laser-guided munitions; and incorporating other target acquisition systems (e.g., Firefinder) into the integrated exercise. On the basis of these highly relevant features, the IFES is rated as a potentially Excellent technology for gunnery team training.

4) The Closed Loop Training Concept, in essence, is seen to be very similar to (if not the same as) that portion of IFES which provides firing battery involvement. As such, it is rated as potentially Excellent, though more limited in scope than IFES.

5) The FIST/FO Interactive Videodisc Trainer is capable of providing more realistic interactive simulations than other devices for FIST/FO training. When connected to other devices like the FAFSTS, the training can then include more digital message processing and decision-making tasks. Because of these capabilities, it is rated as potentially Good for gunnery team training.

6) The Howitzer Recoil Simulator is another development that addresses a recognized inadequacy in the existing training technologies. Because it adds a significant element of realism to the training experience of the howitzer crew at relatively low cost, and helps to insure the positive training of safety procedures, this device is rated as potentially Excellent.

7) The Copperhead Moving Target also answers a need in existing training technology, by facilitating practice with laser-guided munitions. If there are to be training exercises with laser-guided munitions, there is a need for

more realistic moving (or movable) targets. Although the development of the Copperhead moving target was impractical in its attempted implementation, there remains the moving target requirement. As such, the technology is rated as potentially Good.

8) The Simulated Tank Antiarmor Gunnery Systems (STAGS) is also directed at training with laser-guided munitions. It appears to permit some integrated training of the FO/FIST, FDC and Howitzer Sections, and as such is rated as a potentially Good technology for overall gunnery team training.

9) The Battle Simulations which are under development (COLTSIM, ARTBASS, FBBC and STAGS) are viewed as more relevant to higher echelons of command than to the gunnery team. Because their use is mostly in providing motivation for training at the gunnery team level, these simulations are rated as potentially Fair in the present context.

One other developing technology of potential interest, because it was very recently funded for implementation, is GuardFist II, a variation of the Closed Loop Training Concept utilizing low-cost interactive videodisc technology. Conceived for National Guard training, and supported by USAFAS, GuardFist II will measure or simulate howitzer data, while the observer adjusts burst representations on an interactive videodisc device. Fire computations will be determined as for normal missions.

Overall, many of the technologies under development are seen to be of potentially high value. This is due to the fact that, for the most part, they are derived from actual needs assessments. Unfortunately, these potential values appear largely unattained upon implementation--at least in the present stages of prototype development. Often, these disappointments are seen to result from an absence of adequate diagnostic capabilities or from problems of reliability, complexity, maintenance, logistics, and other less technical factors. The next section of this report discusses some of the non-technical factors affecting the use of existing and newly developing training technologies.

E. Non-Technical Factors Affecting the Use of Training Technologies

Throughout the course of this program, and amidst a large volume of technical data and analytic processes, it was apparent that the use (or non-use) of training devices and simulations is often determined by highly subjective factors. For example, career soldiers are not surprised to learn that certain new, complex and expensive items for which a commander is responsible, may be locked up for safekeeping and may never be used. This can be for no valid technical reason, but simply because the particular commander does not want the inconvenience of unpacking and setting up the item, or because he does not want to risk its damage or loss. In other cases, commanders may feel that the old way is the best way, and may resist new items or changes in general. In yet other cases, rumors or horror stories may spread about certain items, and their use may be precluded before any attempt is made to try them out. The point is that, despite sound technical analyses and objective arguments, various training technologies may not get used--for non-technical reasons. The reasons are subjective and emotional rather than objective and rational. They are based on inner fears, ambitions, conflicts of interest, personal and group attitudes, and the psychological motivations of a lifetime. Books (7,8)* and articles (9)* have been written on this singular phenomenon, and yet it frequently remains unaddressed in technical programs such as this one.

The purpose of this section is to serve as a reminder to the reader that subjective, personal, emotional, and social-psychological factors must be given due weight when determining if and how training technologies (or any other resource) will be accepted and used. There is no attempt made here to suggest how those motivational factors should be handled, but rather that they be recognized and kept in mind during the development of training programs.

At best, professionalism and traditional military values of preparedness, leadership and unit cohesiveness will prevail--and gunnery teams will eagerly use all authorized means at their disposal to maximize their combat skills and effectiveness. Individual members of the team will internalize the organizational values, and the mission execution will ultimately profit.

At worst, narrow self-interest and conflicting values will prevail--at the expense of the unit and its mission. Career survival, group pressure and efficiency reports may appear in opposition to, and loom larger than, the Code of Honor. Frustration with the "bureaucracy" and uneasiness with changing methods or doctrine may spark rebelliousness. Typical human tendencies to seek convenience, familiarity and simplicity may lead to rationalizations that circumvent directives and resources. Contradictory bureaucratic practices may lead to cynicism and the belief that doing a good job in training is not really to one's benefit (e.g., one is only going to be transferred to a new job before long and the unit will dissolve).

There is a general awareness among military personnel and analysts, which is both published and spoken, that training generally carries a low priority among the troops. The level of enthusiasm for training programs leaves much to be desired. All kinds of reasons are given to discourage new or changing training requirements. For example, the programs or devices are claimed not to work, or to be inappropriate, or the troops have other things to do. It is not always easy to get an entire group of soldiers--a unit--to all be at the same place at the same time. Many troops prefer to remain unnoticed, to avoid commands as much as possible--and still appear to be compliant (e.g., by means of superficial behaviors).

The responsibility at higher echelons is to convey the importance and priority of training, and to reinforce this attitude in numerous ways. Many efforts have been made toward this end. For example, group cohesiveness has been the subject of various projects--some modelled after the Regimental system of keeping groups together throughout the entire enlistment periods of their members. One such project was labeled "cohesive operational readiness testing" or COHORT. Unquestionably, much more needs to be done.

*See References.

The subject of troop attitudes and motivations is vast. A good brief review of military sociology and motivational psychology can be found, along with other identified references, in the previously noted books (7,8).* Suffice it to say that the development of new training technologies must include elements which can contribute to (or, at least, not be contrary to) the notion that training is essential, vital, and rewarding to the individual and the group.

F. Summary

The results of Task Three attest to the complexity of the training system development challenge. It begins with an extensive data base, developed in Task Two, which is used to help determine which skills and knowledge must be trained, and under which tactical and environmental conditions. The list of tasks is clearly bounded, being those for the gunnery team (Howitzer, FDC and FO/FIST Sections) during engagement. In preparing to assess relevant training devices and simulations (training technologies) with respect to those many (nearly 60) tasks, and each of their several subtasks, it was necessary to develop a smaller, but still meaningful, number of tasks. This was accomplished by exploiting the fact that they could be grouped into larger aggregated tasks that still retained the essential information for conducting the technology assessments. Fifteen (15) aggregated tasks resulted, and the assessment could then proceed.

The Task Three technology assessment also required the identification and designation of all relevant training technologies. An extensive search of the FA literature and discussions with USAFAS personnel resulted in a set of 14 existing and 9 planned or developing technologies for assessment. A review of related documentation was made, and interviews with subject-matter experts (SMEs) at USAFAS were conducted on several occasions. This provided the descriptive information necessary for the analytical assessment, and the subjective information necessary for user reaction assessment, for each training device and simulation.

None of the existing training technologies was assessed as "Excellent" on any aggregated task. Those that were considered "Good" for certain tasks include:

- Firing Battery Trainer (FBT), for three of the five Howitzer Section Tasks (communications using the GDU/SCA; aiming the howitzer; loading, firing and clearing the howitzer).

- Miniature Moving Target (MMT) with the M31 Subcaliber Trainer, for the one Howitzer Section task of loading, firing and clearing the howitzer and for three of the six FO/FIST Section tasks (using the G/VLLD; using the LRF; fire mission decision-making).

- Battery Computer System/Interface Training System (BCS/ITS), for one Howitzer Section task of communicating with the GDU/SCA, and for two of the four FDC Section tasks (using the BCS for FM-related messages; using the BCS for TACFIRE messages).

*See References.

- Battle Simulations for the one FDC Section task of mapping target information, and for two FO/FIST Section tasks (mapping target information; fire mission decision-making).

- G/VLLD Trainer, for the one FO/FIST Section task of using the G/VLLD.

- G/VLLD with TV Camera, for the one FO/FIST Section task of using the G/VLLD.

- Training Set Fire Observation (TSFO), for the one FO/FIST Section task of mapping target information.

The rest of the training technologies were, at best, "Fair" on a variety of aggregated tasks. Virtually all the devices are aimed at practicing skills at the Section level, although some (FBT, FASPR and TSFO) can be used in combination to accomplish a form of integrated (closed loop) training for the entire gunnery team. None of the technologies reviewed does a "Good" job in creating the various extreme tactical and environmental conditions necessary for complete and thorough training of the target acquisition and engagement tasks, and "Major" developmental efforts are foreseen if that capability is to be achieved. "Minor" to "Moderate" developmental efforts are seen as necessary to provide technologies that yield acceptably adequate training capabilities for every other task.

Some of the necessary improvements in training technology are being attempted with the devices and simulations currently under development. In this preliminary assessment, three of the nine developing technologies are considered to have potentially "Excellent" capabilities, at least in concept if not in practical implementation and prototype testing. Those items are the Indirect Fire Engagement Simulation (IFES), the Closed Loop Training Concept and the Howitzer Recoil Simulator.

In the same vein, four of the developing technologies are considered to have potentially "Good" capabilities. They are the FA Fire Support Training System (FAFSTS), the FIST/FO Interactive Videodisc Trainer, the Copperhead Moving Target and the Simulated Tank Antiarmor Gunnery System (STAGS).

Finally, it is expected that the BCS/ITS will be useful in training the use of the DMD and FIST/DMD when those FO/FIST devices are fielded.

In addition to examining the different training technologies for objective and tangible attributes, the reader is reminded of various subjective and emotional factors which help determine if and how those technical developments are accepted and used by FA personnel. The implications of this reminder are that training developers and other administrators must pay attention to motivational factors and military sociology if their products are to be perceived as valuable and utilized in ongoing training programs.

III. SPECIAL ISSUES

The results of Task Three must now be translated into guidelines for an integrated training system. In addition to the relatively straightforward assessments and some of the issues they have raised, a number of other distinct topics have emerged that require further discussion. They include: 1) the quality of training effectiveness and cost measures; 2) the tendency of some current approaches to equate training with practice alone, rather than with practice plus diagnostic evaluation and correction; and 3) apparent gaps in the overall training of the gunnery team, especially regarding certain aspects of training for the Forward Observers. This section discusses those several shortcomings, and offers general concepts for overcoming them so as to improve the quality of training technologies and supporting data. Those concepts will be incorporated, along with the other information generated in Task Three, into the forthcoming specification of an integrated training system (Task Four of this program).

A. Present Measures of Training Effectiveness and Cost

As evidenced by the technology descriptions in the previous portion (Chapter II) of this report, effectiveness and cost measurement data appear to be seriously deficient for FA training devices and simulations. It is as if the system-oriented performance criteria and measures were not clearly specified in the early design stages, or that they were permitted to be forgotten, or that otner circumstances caused the diversion of resources to other issues. System-oriented criteria for engagement training of the FA gunnery team were developed in Task Two of this program. They were then used in Task Three to specify the training needs against which devices and simulations were assessed. Performance characteristics of specific technologies were identified by analyzing each of the equipment features, and the concluding assessments tended to represent that of the design potential. It was not always possible to determine if those performance potentials are actually achieved in practice. As a result, attempts to make realistic assessments and comparisons of technological developments are frustrating and disappointing--the available information is insufficient or inadequate to do the job.

Regarding effectiveness, the current focus of FA training resources tends to be on individual soldiers (rather than teams or systems) and the development of their individual proficiencies. Second, there tends to be an absence of measures that are referenced to system criteria for evaluating performance and, consequently, training. It is often the case in Field Artillery training--and perhaps in military training generally--that training effectiveness is described in terms of task proficiency. Even the training of so-called collective or team tasks is approached in this way. While it is true that a group of proficient individuals will probably perform well as a group, such group performance could be better insured if the individuals were trained toward group or "system" measures of performance. By doing this, training resources are applied to the ultimate criterion and thus are probably used most effectively. In addition, the relationship of each individual's performance to system performance, and the required interaction or integration of individual efforts must be established and be included in training. Put in another way, each individual task must be defined in both system terms and task-proficiency terms. Then training results can be assessed by measures of system (or group, or team) performance. All criteria used in measuring effectiveness should be justifiable by being traceable to overall system performance criteria.

Regarding the cost of FA training technologies, the overall observation is that the information found during this program is sparse. The Information and Fact Sheets reviewed in this analysis typically report "Cost per Item." The Training Device Need Statements (TDNSs) often refer to other costly items (e.g., maintenance requirements, basis of issue, additional manpower requirements), but these references tend to be quite general and without specific cost estimates. As a result, the cost figures in this review (Section II.C.2) convey relatively little information. At best, there is a sense of one-time unit costs for some of the existing devices, but none for the simulations or the technologies under development. For example, at the low end of the cost spectrum are the FASPR (at about $25 per reusable round as compared to about $250 for a live 155-mm service round), the LITR (at about $190 per expendable round, or a savings of about $21), and other training projectiles that provide some kind of cost savings (which may vary from 10% to 90%). In the mid-range of costs are the G/VLLD with TV camera (at an estimated $1,000 per device), the BCS/ITS (at about $4,000 per device), the ADFT (at about $6,000 per unit) and the M31 Subcaliber Trainer (at about $7,500 per full battery kit of 2 tripod mounts, 6 inbore devices, FADAC tapes and supporting documentation). At the high end of the cost spectrum are the FBT (at approximately $71,000 per single system), the G/VLLD-Trainer (at about $115,000 per training G/VLLD, instructor control console and tracking board), and the TSFO (at $135,000 per item, plus maintenance of $11,000 per year).

For the most part, as seen here, one finds a dollar figure for the capital expense in acquiring a specific device. There is rarely an adequate description of what is received for that amount, or any reference to the costs for carrying it (i.e., storage, assembly, operation, instructor training, maintenance, provision of supporting resources, disassembly, disposal, and various other indirect costs). In economic terms, the one-time dollar purchase costs generally given do not consider the full range of fixed and variable costs in the technology's life cycle (i.e., research, development, production, support). Furthermore, it is important for administrative reasons to identify which organization is responsible for paying each of those acquisition and ownership costs. In addition to dollars, costs can also be expressed in terms of other valuable resources, including required numbers of personnel, vehicles, buildings, ranges, curricula and other software, and time. All of the above factors must be considered when specifying and developing training technologies. References to them are virtually non-existent in the documents reviewed.

While it is beyond the scope of this program to specify a complete, standardized cost breakdown, it is considered helpful to remind the reader of the many elements contributing to the overall cost of any technological system. The next paragraphs briefly identify and describe some of those elements.

The first set of elements to be highlighted are those related to life-cycle costs--those which take into consideration the different phases in the overall life of a system, rather than simply "acquisition." Life-cycle costs can be divided into a few broad categories (e.g., acquisition and ownership) or several more detailed categories (e.g., research, development, test and evaluation, procurement, operation, maintenance, support, and disposal). The important idea is that one looks beyond the simple one-time "purchase" cost. Some other concepts that come into consideration when taking a life-cycle viewpoint are:

- Time value of money--equal dollar amounts spent at different times have different present values which depend upon interest or "discount" rates.

- Service life--longer lived systems allow for the more gradual amortization of development and acquisition costs, effectively "reducing" the annual ownership costs.

- Sensitivity analysis--certain costs are more or less sensitive to certain variations in system design or administration; it is important to know how small changes in one parameter can cause large changes in costs.

Within each life-cycle phase, the costs can be further differentiated into economic and non-economic costs. Economic costs are the ones most people generally think about--those that are usually expressed in terms of money (e.g., dollars). However, the economic costs do not have to be expressed only in dollars, but may be more informative if expressed as quantities of other scarce resources, such as personnel, vehicles, time, ammunition and real estate. Even though those resources can often be converted to dollar equivalents, money may be only one of several important factors emphasized by using the original unit of measurement. The non-economic costs of system implementation can also be very important--even prohibitive--in some cases. They include the social and political costs associated with certain courses of action (such as placing nuclear devices in foreign countries).

Third, the reader should be aware of how the different costs are affected or unaffected by system usage. To classify those differences, economic analysts use the terms one-time costs, fixed costs, semi-variable costs and variable costs. The cost to purchase a self-propelled howitzer would be considered a one-time cost. Continuing steady costs, such as wages for the battery personnel or equipment maintenance contracts, may be considered fixed costs. The costs of ammunition and fuel (which depend directly on howitzer usage) would be variable costs, while the costs of storing that ammunition and fuel would be semi-variable costs that change in a stepwise fashion (since new storage facilities are required only after the existing facilities are filled to capacity).

Finally, all costs can be characterized as direct costs or indirect costs. The direct costs are those closely related to the actual acquisition or operation of the system, while the indirect costs generally refer to the expense of providing necessary support (e.g., sleeping quarters, food services, toilet facilities, personnel administration, etc.).

To evaluate or compare systems at any or all life-cycle stages, one may specify a common set of conditions or parameters (e.g., system configuration, operational demands or utilization), apply those parameters to the previously defined cost elements, and determine standardized cost figures for evaluation. In reporting the evaluation or comparison, the parameters used in determining detection and location are assumed; these activities in fact are not even mentioned by name. Likewise, the Soldier's Manual devotes all of its detail to equipment operation (GLLD and communication gear). Other observer functions are described, but again the detection and location functions are not.

It appears that these functions are assumed to be learned in school, along with map reading and orientation. It seems also to be assumed that proficiency can be maintained with unstructured practice because there are no training standards of either time or accuracy related to these functions. The Training Set Forward Observer (TSFO) does provide a controlled environment for, and allows for supervision of, the detection and location functions. In the review of TSFO documentation and an examination of the installation at Fort Sill, the tasks of target detection, location and classification appeared to be trainable to different degrees of proficiency. Despite the elaborate and commendable degree of realism achievable with the TSFO, target detection conditions remain unrealistic because the observer sees a white target silhouette projected on the screen rather than one that is, say, brown or camouflaged. There is also an absence of other target image details, more realistic movements, and subtler tactical conditions by which the classification (i.e., type of target, friend or foe, degree of threat) task can be effectively trained.

Of the various FO tasks, target location is probably the one that is trained best on the TSFO. Even for target location, however, there appear to be some serious limitations from the training viewpoint. Mainly, the ability of trainees to estimate absolute FO-to-target range using the TSFO may depend very much on the various visual cues contained in the image, the camera's viewing angle in the photographic image, nearness of the target within the picture, type of terrain shown, and whether the view is uphill, downhill or level. Some research on the topic of photographic simulations suggests that satisfactory training of distance estimation can be achieved if the simulation image parameters, as just listed above, are set properly (10).* The quality of distance estimation using the TSFO should be demonstrated, if it has not yet been determined. It appears to this program staff that those kinds of target location tasks that require absolute estimates of FO-target distance would be the most difficult to train on the TSFO (see Task Two report, Operational Sequence Diagram, FUNCTION/TASK 3-III-2-2, "Locate Targets") (3).* Those include the SM Tasks entitled: "Locate Target by Grid Coordinates" and "Locate Target by Polar Plot." The TSFO would also be inadequate for laser ranging; however, other training devices serve that purpose. The TSFO is probably most effective as a trainer for locating targets through adjustment from a previous impact point, such as the SM tasks entitled: "Locate Target by Shift from a Known Point" and possibly "Locate an Unknown Point on the Ground by the Indirect Fire Technique." In any case, the transfer of TSFO experience to actual observation must be examined and established for all tasks for which the FO is being trained. The expected outcome of such an examination, if done on a system-oriented basis, would be the definition of processes to be trained and related measures of performance for diagnosis and evaluation.

*See References.

IV. IMPLICATIONS FOR AN INTEGRATED TRAINING SYSTEM

The systematic approach to FA training has thus far yielded operational performance requirements (behaviors, conditions, standards) for the gunnery team, a review of how well FA training technologies address those requirements, and a brief discussion of social-psychological factors which influence the utilization of the training technologies. To determine how this information influences the design of an integrated training system, one must consider the information's impact at each step of the design process and for each component of the training system. For example, the next design step is to translate the specific baseline FA training system requirements (from Task Two) into specific design requirements for a generic FA training system. Previous research (12)* has shown such a generic training system to include the following major functional components:

> The principal generic function of training systems is learning, defined as any activity involving the senses that affects behavior in some purposeful fashion. Learning is a human function: it is people who carry out the sensory activities to experience the intended behavioral effects. The principal generic operator/staff member of a training system, thus, is the learner.
>
> The other major generic function of training is helping to learn, defined as providing an efficient learning environment to the learner. Numerous types of people, using a variety of equipment, may work in any given training system to make it conducive for the learner to learn. All such people are learning helpers. They acquire more specific titles in accordance with the particular types of help they provide.
>
> The two major functions can be divided into more detailed subfunctions. These can be grouped conveniently into six functional (not necessarily organizational) training subsystems, as follows:
>
> - The administrative control, or Command Subsystem--which deals with identifying needs for training, allocating resources, recruiting training personnel, monitoring and evaluating learner performance, etc. Training administrators construct and manage the system in which the learning activities can take place.
> - The curriculum development, or Design Subsystem--which is responsible for planning the instructional activities, selecting training technology, assembling content material, defining instructor and student requirements, etc. The Design Subsystem is the portion of the training system in which the Instructional Systems Development (ISD) model is applied. Curriculum developers determine the specific behavioral effects that are needed and plan the sensory activities that will lead to those effects.

*See References.

- The facilities development, or Emplacement Subsystem--which constructs or acquires and assembles all facilities and equipment needed to support the sensory learning activities. The Emplacement Subsystem takes the plans developed by the Design Subsystem and insures that all materials, equipment, installations, supplies, etc., needed to carry out those plans are made available. Facilities developers provide the tools needed to carry out the learning activities.

- The logistics support, or Logistics Subsystem--which deals with maintenance of facilities and equipment, housing, feeding and recreation of training system personnel, replenishment of consumables, transportation of people and supplies, etc. Logistics supporters attend to the myriad of details necessary to keep the training system running smoothly and free of discomfort and distraction.

- The instructor preparation, or Enabling Subsystem--which deals with familiarizing instructors with the plans, content, equipment and facilities involved in the intended learning and with preparing the instructors to supervise the training effectively. The Enabling Subsystem also is responsible for tailoring the general plans and material to the specific learning needs of a particular group or team of learners. The principal staff of the Enabling Subsystem are the instructors, training officers, professors, and others who directly assist the learner in carrying out the prescribed sensory activities. Collectively, these facilitators present information, demonstrate techniques, coach the learner's efforts, evaluate and correct performance.

- The instructional implementation, or Delivery Subsystem--which is where the learning/training actually takes place. In the Delivery Subsystem, the prescribed sensory activities are carried out, and the learner experiences the intended behavioral effects. The learner is helped by all of the other staff members identified above.

It is functional, not organizational, structure that is of interest here. The organizations of two particular training systems may differ widely, but each will accomplish the same basic functions required of any training enterprise. One can use this generic viewpoint to consider how the Task Three results affect the training system design.

In general, the Task Three results affect design requirements for an integrated training system as follows:

- At the administrative control level of the integrated training system, Task Three justifies the need for applying resources to an improved system that will better meet the gunnery team training requirements. It points out those tasks that must be trained and the inadequacies of existing technologies and procedures. It is up to the training administrators to insure that the resource justification is valid, to evaluate the design requirement in the context of other available information, to initiate appropriate modifications of the design concept and to allocate the necessary resources for carrying out the final recommendation.

- At the curriculum development level, Task Three has reiterated (from Task Two) the tasks to be trained, and has illustrated the need for relevant training technologies, technical support and non-technical (i.e., motivational) support. The curriculum developers must define even more precisely the skills and knowledge to be trained (practiced and evaluated) by those supported technologies, so that the appropriate apparatus and facilities can be built and operated effectively. A first attempt at this effort will be the product of Task Four.

- At the facilities development level, Task Three's contribution is less direct. Its impact on the production of learning technologies is mediated by the curriculum developers' specifications for apparatus, real estate, structures, instructional aids and other learning material. The Task Three results remain a resource that can provide greater understanding or clarification of original intent for the facilities and equipment providers.

- At the logistics support level, the Task Three results provide the first indication for necessary support services and facilities. Use of devices and simulations rather than full operational configurations, for example, directly impact the required quantity (and cost) of such consumables as ammunition and fuel. Use of local (e.g., motor pool) training areas rather than major firing ranges impact such logistics issues as special housing and feeding accommodations.

- At the instructor preparation level, Task Three has shown that, when training technologies are inadequately designed, the burden of compensating for apparatus shortcomings (e.g., in programming, observing, measuring, recording, assessing, feeding back and re-programming) falls on the human helper--the instructor. Implications for a new training system include the requirements that instructors be well trained with the technology they are using, and that the apparatus incorporate more of the above-listed training functions, so that standardization, efficiency and thoroughness are achieved while the excessive demands on the instructors can be moderated.

- At the instructional implementation or learner level, Task Three has indicated the necessity for an adaptive or tailored learning experience, with diagnostic evaluation of performance and selective repetition of training regimens. This will help insure the desired levels of initial acquisition and long-term retention of skills and knowledge. Practice tends to promote acquisition and testing tends to promote retention. It is also important to understand how certain controllable factors can reduce the degree to which skills and knowledge are forgotten. For example, it is reported that the best predictor of forgetting is the number of steps required in a task, and that steps most likely to be forgotten include those related to safety and those that are not cued by the equipment or previous steps. The implication here is to "overtrain" those tasks or steps most likely to be forgotten. Finally, training that can be tailored to individual learners is needed to compensate for the differences in ability among those learners. It has been found that if taken to the same level of initial acquisition, both higher- and lower-ability learners will demonstrate equal retention. Many of the above observations and findings come from previous ARI research projects, and are summarized in the references (11)* for this report.

A variety of additional design implications for an integrated training system derive in one way or another from the Task Three effort. They are based upon the particular focus of this program (i.e., the entire FA gunnery team during engagement; applicability to "all" FA systems; necessity to conserve ammunition, fuel, real estate and other resources; the availability of new scientific devices and techniques; shortcomings in the existing and developing training devices and simulations; and ineffective utilization of present FA training technologies). These additional implications for the integrated training system are as follows:

- It should provide controllable types of practice for the critical gunnery team tasks. The practice must be valid and sufficient.
- It should provide useful diagnostic evaluation of performance. Measured performance should be evaluated in relation to established objectives and standards.
- It should provide controllable remedial training in areas found to require improvement.
- It should provide a record of training for future comparison and long-term evaluation, and as a data base for training technology research.
- It should be flexible so as to interface with all varieties of FA systems (i.e., conventional, rockets, missiles).
- It should provide guidelines for the sequence of training (e.g., sequences based on operational sequence diagrams), and make use of criticality or priority ratings (e.g., the TRI).
- It should be associated with an administrative structure that controls the entire unit to be trained. Typically, the FO and FIST Sections are now assigned to the headquarters unit and are not always available to train with the Howitzer and FDC Sections.
- It assumes, and should insure, that the individual members of the team being trained are all MOS-qualified.
- It should include a logistics and maintenance structure that insures the availability of the training system where and when it is needed.
- It should include periodic review and updating of mission scenarios and tasks to insure validity and usefulness.
- It should insure that performance is, in fact, measurable as required.

*See References.

REFERENCES

1. Department of the Army, Tables of Organization and Equipment (TOE), Draft: "Division 86" Heavy Division TOE6-365J210, TOE6-365J220, TOE6-366J210, TOE6-366J220 and TOE6-367J200, December 1982.

2. Department of the Army, Army Training and Evaluation Program (ARTEP) 6-100, The Field Artillery Cannon Battery, 17 February 1984.

3. Dunlap and Associates East, Inc. Developing a Field Artillery Training System Based on Devices and Simulations--Task Two: Training Analysis of the Baseline System. ARI Contract MDA903-82-C-0289. Norwalk, CT: D&AE, July 1984.

4. McMullen, Major K.E. Independent Evaluation Report of the Closed Loop Training Concept by USAFAS: Final Report. Ft. Sill, OK: U.S. Army Field Artillery School, 15 November 1983.

5. Yowell, Major R.A., Garcia, Capt. F., Walton, SFC R., Hutton, SFC A.T., and Hudson, Mr. B.J. Concept Evaluation of Closed Loop Training: Final Report. Ft. Sill, OK: U.S. Army Field Artillery School, 13 October 1983.

6. Powers, T.R., McCluskey, M.R., Haggard, D.F., Boycan, G.G., and Steinheiser, F., Jr. Determination of the Contribution of Live Firing to Weapons Proficiency. ARI Technical Report, FR-CD(C)-75-1 (HumRRO), March 1975. AD A036060.

7. Gabriel, R.A., and Savage, P.L. Crisis in Command: Mismanagement in the Army. New York: Hill and Wang, 1978.

8. Ingraham, L.H. The Boys in the Barracks: Observations on American Military Life. Philadelphia: Institute for the Study of Human Issues, 1984.

9. "The Top Brass: Can They Fight a Modern War?" (Special report: a series of articles). Newsweek, 9 July 1984. Pp. 32-38+.

10. Mitchell, N., Kraft, R., and Martin, A. Terrain Travel Simulation: Data and Applications. Proceedings: Psychology in the Department of Defense, 9th Symposium, USAF Academy, Colorado Springs, April 1984.

11. Hagman, J.D. Retention of Military Tasks: A Review. Human Factors, 1983, 25(2), 199-213.

12. Bloom, R.F., Oates, J.F., Jr., Shapiro, R.G. and Hamilton, J.W. The Analytic Process Model for System Design and Measurement: A Computer-Aided Tool for Analyzing Training Systems and Other Human-Machine Systems. ARI Contract MDA903-80-C-0345. Norwalk, CT: Dunlap and Associates East, Inc., 28 February 1983.

GLOSSARY

ACE - Artillery Control Environment
ADFT - Artillery Direct Fire Trainer
ADP - Automatic Data Processing
AG - Assistant Gunner
Ammo - Ammunition
Aug Opl Eqt - Augmented Operational Equipment
ARI - U.S. Army Research Institute for the Behavioral and Social Sciences
ARRADCOM - Army Armament Research and Development Command
ARTBASS - Army Training Battle Simulation System
ARTEP - Army Training and Evaluation Program
BCS - Battery Computer System
BCS/ITS - Battery Computer System Interface Training Simulator
BRL - Ballistic Research Laboratory
C [C1,C2,C3,C4] - Cannoneer [number indicates cannoneer position number]
CAMMS - Computer Assisted Map Maneuver Simulation
CATTS - Combined Arms Tactical Training Simulator
C/C - Control/Coordinate
Ch Sec - Chief of Section
COHORT - Cohesive Operational Readiness Testing
COLTSIM - Company/Team Level Training Simulation System
Demo Mtls - Demonstration Materials
DF - Deflection
DF - Direct Fire
DIVARTY - Division Artillery
DMD - Digital Message Device
EOM - End of Mission
ETHER - Realtime Software Simulation of Communications Nets
ETM - Extension Training Material
(F) - Fire
FA - Field Artillery
FADAC - Field Artillery Digital Automatic Computer
FASCAM - Family of Scatterable Mines
FAFSTS - FA Fire Support Training System
FASPR - Field Artillery Shootable Practice Round
FBBC - First Battle: Battalion-Corps
FBT - Firing Battery Trainer
FDC - Fire Direction Center
FDO - Fire Direction Officer
FD Specialist - Fire Direction Specialist
FIST - Fire Support Team
FIST Ch - Fire Support Team Chief
FIST DMD - Fire Support Team Digital Message Device
FIST V - Fire Support Team Vehicle
FM - Fire Mission
FO - Forward Observer
FOT - Forward Observer Trainer
(FP) - Fire Plan
FSO - Fire Support Officer
FS Sgt - Fire Support Sergeant

G - Gunner
GDU - Gun Display Unit
GLLD - Ground Laser Locator Designator
G/VLLD - Ground/Vehicular Laser Locator Designator
G/VLLD-T - Ground/Vehicular Laser Locator Designator-Trainer
HC Smoke - White Smoke Projectile
HD - Howitzer Driver
HE - High Explosive
HEL - Human Engineering Laboratory
IFES - Indirect Fire Engagement Simulation
Instr - Instructor
IOC - Initial Operating Capability
IPO - Input-Process-Output
ISD - Instructional Systems Development
JWG - Joint Working Group
(L) - Load
LITR - Low Cost Indirect Fire Training Round
LRF - Laser Range Finder
MACOM - Major Army Command
MILES - Multiple Integrated Laser Engagement System
MLRS - Multiple Launch Rocket System
MMT - Miniature Moving Target
MOS - Military Occupational Specialty
MOUT - Military Operations in Urbanized Terrain
N/A - Not Applicable
Opl Eqt - Operational Equipment
Pantel - Panoramic Telescope
PD - Point Detonating (Fuze Action)
PM-TRADE - Program Manager-Training Devices
QE - Quadrant Elevation
RFAF - Request for Additional Fire
SCA - Section Chiefs Assembly
SIMFIRE - Simulated Fire
Sims - Simulator(s)
SM - Soldier's Manual
SMEs - Subject Matter Experts
STABS - Stand Alone Tactical Artillery Battle Simulation
STAGS - Simulated Tank Antiarmor Gunnery System
TACF - TACFIRE
TACFIRE - Tactical Fire Direction System
TASC - Training and Audiovisual Support Center
TBD - To Be Determined
TDs - Training Device(s)
TDLRs - Training Device Letter Requirement(s)
TDNSs - Training Device Need Statement(s)
TRI - Training Requirement Index
TOE - Table of Organization and Equipment
TOW - Tracking Optical Wire Guided Missile
TSFO - Training Set Fire Observation
TV - Television
USAFAS - U.S. Army Field Artillery School
VAC - Volts Alternating Current
VDC - Volts Direct Current
VFMED - Variable Format Message Entry Device

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This assessment of FA training technologies (devices and simulations) begins with a review of nearly 60 gunnery team tasks, and their subtasks, as determined earlier in this program. For purposes of matching those tasks to be trained against each of the FA training technologies, they were grouped into 15 aggregated tasks. Next, a set of 14 existing and 9 planned technologies was identified. Those technologies were evaluated analytically by comparison with the tasks to be trained and the basic principles of good training and effectiveness

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) assessment. They were also evaluated practically through interviews with subject matter experts (SMEs) at the Army's Field Artillery School (Ft. Sill). None of the existing technologies is considered "Excellent" on any aggregated task, while 7 of the 14 are considered "Good" (on the scale: N/A, Poor, Fair, Good, Excellent). In terms of concept and potential training capabilities, the 9 planned or developing technologies include 3 that are rated as "Excellent" and 4 rated as "Good." Strengths and shortcomings are discussed in terms directed toward the design of an integrated gunnery team training system.

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