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FIELD ARTILLERY SCHOOL

COUNTERFIRE DEPARTMENT STUDY

APPLICATIONS OF INTERACTIVE TECHNOLOGY TO TRAINING

FINAL REPORT

By: *Organizational Media Systems*

1 JULY 1982

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AND
DOCTRINE COMMAND
Fort Monroe, Virginia 23651

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This report has been reviewed and is approved.

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In 1981 a training research team was contracted to conduct a detailed study of the Counterfire Department (CFD), US Army Field Artillery School (USAFAS), Fort Sill, OK. The following tasks were to be performed: (1) Identify training methodology areas amendable to solutions by technology, (2) Recommend the delivery system be suitable for the training need identified, (3) Identify the technology that offers the most reasonable solution, (4) Provide the rational for selected and alternative technology, (5) Describe the method of using the recommended technology in the training.

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EXECUTIVE SUMMARY

Increases in efficiency of up to 50% or increases in effectiveness of up to 500% are possible through the dual application of Integrated Visual Active Design (IVAD) and Visual Electronic Digital Media (VEDM) in the 36 Programs of Instruction (POI) trained by the Counterfire Department (CFD) of the U.S. Army Field Artillery School (USAFAS). These increases are possible in both resident and non-resident instruction, and in both individualized and collective training.

IVAD is a design concept based on the dynamic integration of all training materials and exercises. It includes the use of visual rather than verbal explanations and exercises, the use of active rather than passive learning and the use of a modular design so the pace and emphasis can be modified for different audiences, achievement levels and environment.

VEDM is a system which synergistically combines separate media systems and technologies which have already been proven in separate applications. It combines television, visuals, computers, programmed instruction, interaction and other media. On the surface it looks like the currently popular videodisc, but under the surface it is a synergistic system with capabilities for outstripping those of either the videodisc or computer assisted instruction.

The projection of a 50% increase in efficiency is based on addition of the increases in efficiency of the separate methodologies and media which are combined into IVAD and VEDM. For example, studies of applications of video-based instruction show increases of 50% or more when compared to traditional instruction. Studies of computer assisted instruction shows increases of 30% or more. The actual percentage increase would be higher than 50% with straight percentage addition. For example, a 50% increase from video, a 30% increase from CAI, and a 20% from programmed instruction would yield a 100% increase. However, portions of each increase are duplicative so a conservative 50% increase is projected.

Students who practice a skill 10 times will not be five times, or 500%, or more effective than students who practice only twice. However, students in the CFD using IVAD and VEDM could practice the required skills 15 more times in the same amount of time, and the practice could be designed to reinforce gradually, more complex actions.

The projected increases are averages of evaluations performed on all 36 POI's in the CFD. In some POI's the increases could be greater, in others it could be less. Since the amount of material to be analyzed was so extensive and the actual increase depends on specific applications of IVAD and VEDM and on the ability of the instructional developers and the students, an attempt to provide greater accuracy would be an exercise in mathematics rather than a valid professional judgement.

A pilot project to verify the projected increases is recommended. Three potential projects were evaluated in detail to see which could provide the best validation of the projected increases and the highest immediate payout to the U.S. Army. A pilot program in map reading, target location and land navigation for junior officers would meet both objectives.

This report provides the background and rationale for the recommended pilot program.

The projections in effectiveness are based on the capability of the systems to provide more actual practice by the student. If a student can practice more, their ability to do a job--their effectiveness--will increase. The actual increases in effectiveness are not linear, but decline with repetition according to some variation of the "learning curve."

The CFD because of previous advances in individualized instruction and familiarity with electronic technology would provide an excellent environment for proving the projected increases. Three analysts spent three months looking at the 36 POI's in the CFD with additional emphasis on the 13 proponency POI's and detailed emphasis on three subjects--mapping, targeting and remotely piloted vehicles (RPV). The data analysis requirements were so vast that only general trends and data were analyzed. However, given the overlap of task clusters across the POI's and the instructional methods, the increases look feasible.

A pilot project will prove the increases, provided the resources are committed to link the IVAD with the TRADOC Systems Approach To Training (SAT) and the VEDM to the component media.

The subject recommended is mapping because the subject is needed, has a large payoff, is simple, is visual, attracts high interest, is easily validated and sources of material, scenes and examples are readily available.

The pilot project should be assigned to a task force of specialists including: a task force manager, course developers, subject matter experts, design artists, computer programmers, computer system designers, television editors. Each of these team members should have special expertise in interactive visual systems and be familiar with military instruction techniques.

This calls for a joint government/contractor team which will add a responsibility definition dimension to the project, but sole assignment to a government group would increase the time for completion and the sole assignment to a contractor would increase the cost.

At least three modules should be developed and at least 10 student VEDM units should be purchased or leased. The development time is estimated at 40 man months and the equipment costs at about $250,000. However, the equipment costs will vary with the actual system developed and the availability of equipment at Ft. Sill and within the TRADOC system.

Due to the requirement to further define the system and to develop the joint government/contractor task force, an immediate start should be made on the development of specifications and a valid statement of work.

If the assumptions of increases are proven, the IVAD and VEDM could provide the system for training soldiers in the complex, integrated electronics weapons systems of the future at large savings in time and money.

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INTRODUCTION

1. Background

a. The Challenge

Increasing the effectiveness and efficiency of training by the CFD, or by any other unit for that matter, is not a simple challenge. Many intelligent and dedicated people within the CFD, the USAFAS and TRADOC have been working on the challenge for years. Compared to the effectiveness and efficiency of training a few decades ago, great progress has been made. About every theory, every technique and every technology has been implemented, integrated and improved. Most of these have been successfully used by the CFD. However, despite gradual, but significant progress over the years, the challenge just seems to keep expanding. Despite the new theories including a systems approach to training, despite new techniques such as individualized instruction and despite new technology such as television, the need for more graduates who are more qualified continues to grow.

To see why the challenge continues to expand despite a dedicated effort, and to appreciate the information, conclusions and recommendations in this report, a background view of not one, but a number of separate but related factors is essential. These factors are listed below and a brief background summary of each is included in the following paragraphs.

- The Trainers
- The Trainees
- The Theory
- The Technique
- The Technology

b. The Trainers

The CFD as an instructional department of the USAFAS trains a wide range of skills involving a wide range of technologies.

The trainers vary from recently enlisted graduates of basic training up to recently commissioned officers up to experienced non-commissioned officers, warrant officers, company grade officers and field grade officers. Approximately 30% of the instruction provided by CFD consists of the same basic information, but it is used by a widely different group of trainers.

The skills which the CFD trains vary from basic map reading up through operation of highly complex weapons and target location systems, up to the maintenance of these systems and on up to the advanced deployment of the different targeting assets of Division, Corps or Army.

The technology which the CFD trains soldiers to use varies from simple optical equipment, up to advanced electronic systems and on up to integrated systems using lasers, solid state electronics and multiple computers. Some of the equipment used in survey is similar to that used thousands of years ago by the Egyptians and the Chinese. Some is based on technology developed within the last decade.

It is essential to see the CFD as a department responsible for a wide variety of "things." The "things" are related to target acquistion, but not in many other ways. Even the divisions within the CFD have widely different objectives. The skills involved in operating a radar screen and maintaining a radar system are widely different, even on the same radar. In some ways, the CFD can be viewed as a command of 27 or more separate training functions.

Consequently, while this study dealt with all 36 POI's taught by the CFD, in only a few cases will the specific conclusions about one POI be applicable to another. However, the general conclusions relating to increases in effectiveness and efficiency do apply.

c. The Trainees

The trainees, students, learners, participants, or whatever one wants to call an individual receiving training from the CFD is typical of others in the USAFAS and other service and civilian schools. Much has been written about the ability and motivation, or lack thereof, of the modern student. So, one should neither expect, nor will one find, any significant differences between trainees in the CFD and trainees in other departments, schools or training groups. However, there are a number of factors that should be considered, and these were confirmed in interviews with the CFD staff and faculty.

1. Decline in Reading Skills

The continual decline in reading ability up to 1981 on the standard reading tests for high school graduates is a documented fact. The fact that reading skills did not decline in 1981, but remained the same as the previous year is a small consolation. The average student in high school today reads less than 98 minutes daily.

The decline in reading skills of students enrolled in two of the POI's in the CFD has been unofficially verified by one of the instructional managers who has been giving trainees a simple reading and vocabulary test for over a decade.

Despite the continual decline in reading skills, the requirements for reading have increased within the enlisted POI's of the CFD by two factors. First, is more complex systems. Comprehension of an advanced computerized weapons system requires more time and therefore in most cases more reading. Second, is the increased use of individualized instruction. The CFD is among the leaders in adopting the TRADOC directed individualized instruction methods, and these require additional reading.

2. <u>Decline in Mathematical Skills</u>

The same decline in reading skills has been documented, both officially and unofficially, in mathematical skills. This decline appears to be for both computational and reasoning skills. Some evidence is available to support the contention that this is linked to the increasing capability and decreasing cost of the electronic calculator and computers. Yet, the operation and programming of computers and of the computerized systems within the CFD requires high mathematical reasoning skills.

Calculators and computers are beginning to perform the mathematical calculation functions required for the operation and maintenance of CFD related equipment. The development of mathematical reasoning, which is a visual rather than a verbal ability is now being taught in individual sessions by individual instructors. Consequently, despite the new and advanced training systems available, one of the most critical skills required for the majority of CFD related training is being learned in the oldest and most inefficient way--the one-on-one tutoring of trainees.

d. <u>The Theory</u>

The learning theory used by the CFD is the behavioral psychology based "Systems Approach to Training" (SAT) directed by TRADOC. This theory is valid, as far as it goes, and has produced major increases in effectiveness and efficiency in most areas within the U.S. Army and other DOD agencies where it has been applied. The theory focuses on behavior, not on the process of acquiring that behavior.

Yet, the process cannot be ignored, and in fact, it isn't. The process is implied in SAT. The implied process is to learn through a series of linear, graduated actions. However, the process is not actually implemented, nor can it be, in objectives which require reasoning. To learn to reason, a model must be internalized.

The word "integrated" drives the behaviorist wild. The behaviorist isn't interested in how behavior occurs. By the same token the word "behavior" drives a Gestaltist wild, but in the final analysis both behavior and process are critical.

Because the SAT emphasizes behavior to the exclusion of process, the individualized instructional methods have not been adopted in the POI's involving officers and senior enlisted men. This presents an interesting contradiction and challenge.

The contradiction is that despite the SAT, the officers and enlisted persons with the highest experience, reading and mathematical reasoning levels are in courses which require the least of it for learning. The enlisted men in the individualized learning POI's of the CFD who have the least experience, reading and mathematical reasoning levels are in the individualized training methods which require them to a high degree.

e. The Techniques

There are a number of techniques, or methodologies used with the CFD and the USAFAS. Among these are:

- Individual Tutoring
- Individual Reading
- Individualized Instruction
- Classroom Lecture/Discussion
- Practical Exercises
- Field Exercises
- Programmed Instruction

Seldom is any one technique used exclusively within a POI, and each technique has advantages and disadvantages for different objectives and different skill levels.

As detailed in the previous section, the older classroom method is the dominant technique in the POI's for more advanced trainees, and the individualized instruction techniques are dominant for the more basic.

There is a relationship between techniques and technology, but the two are not the same. The confusion that exists within TRADOC doctrine and literature and with the CFD over the destination between techniques and technology is one of the reasons for the less than full realization of the benefits of either or both techniques and technology. It is also the root cause of resistence to new techniques and new technology within instructional units.

f. The Technology

The technology or media used in a training system is the device or equipment system which carries or "mediates" a training message or action. Just as there are differences in techniques, there are differences in technology. The simplest technology is print on paper. The most complex is a person. Some people object to viewing a "teacher" or "instructor" as a type of technology. However, when one considers the definition and purpose of technology in training, it's logical that a person mediating a message or action is a form of technology.

Attempts have been made to classify technology or media. DOD has funded a number of these studies. Among them are "A Taxonomy of Educational Media" by Rudy Bretz of RAND Corporation.

To date no media device or media system has been able to match the flexibility and effectiveness of an instructor. However, other media systems can perform some training functions with a much greater efficiency.

The major error made in the implementation of media into training programs, in both military and civilian organizations, has been to focus on the improvements in efficiency of a technology and sacrifice declines in effectiveness. If managers trying to improve training focus on efficiency improvements without considering the effect on the effectiveness, the implementation of a new technology usually backfires.

The technique driving this study--Interactive Video--is the most complete and flexible non-humor media system yet developed. It could offer major increases in effectiveness and efficiency, but only if the impact of the technology on effectiveness is evaluated along with the impact on efficiency.

g. The Situation

From the outset there were differences in perception about the technologies and techniques to be evaluated. The use of the same word or term to describe different systems, equipment, applications and objectives created a constant semantic challenge which still exists. For example the word "videodisc" is used to describe:

- An equipment system which will display a video image and its accompanying sound on standard television device. In this application, as far as the student is concerned, there is no difference between a videodisc and videotape and there are no differences among the types of videodisc technologies currently available. The videodisc would be used as a playback machine, not as a programmed interactive instructional device.

- An equipment system which allows random access through a time code or linear distance address to any segment of a video and audio motion sequence or a still frame picture with or without audio. In this application the videodisc is no different than a videotape system with a similar addressing control; the difference is in the access time.

- An equipment system which allows a high-speed feedback of video and audio motion sequences based upon action taken by the user. In other words, the visual display is determined at any point by the action of an operator. In this case the videodisc has some capabilities beyond that of a videotape.

- An equipment system which combines a videodisc with a micro-, a mini- or a mainframe computer to provide functions not directly related to the visual display. There are many functions, but the most common are those included in the term "computer assisted instruction." This system would also allow for enhancing the video display by manipulation of the information.

- Differences in perception about the technologies to be evaluated also existed. For example, the term "self-paced" is used to describe:

  - A methodology where the learner progresses through a course or a series of related objectives at his or her own pace.

  - A methodology where the learner uses programmed instruction materials.

  - A methodology where the learner obtains information from various materials and advances based on testing of retention of those materials.

  - Any combination of the above.

h. The Priorities

The major instructional challenges prioritized by the CFD for analysis were not in training areas in which technology is now being applied, but in more traditional areas--target analysis, map reading, planning, etc., where they recognize the training challenges. As a matter of fact, the priorities were in inverse order when compared with the adoption or implementation of more advanced technology or methodology. The priorities are listed below in the ranked order they were assigned.

1. Targeting
2. Mapping
3. Target Acquisition Specialist
4. Survey Specialist
5. Position Azimuth Determining System (PADS)
6. Meteorological Data Systems (MDS)
7. Remotely Piloted Vehicle (RPV)
8. Weapons Locations and Target Location Radar Operation and Maintenance
9. Meteorological Operations

2. Purpose

a. General

The purpose or objective of this study as written in the statement of work is to "address the application of technology to improve the methodology, media, efficiency and effectiveness of training in the CFD. The report shall provide the basis for the USAFAS to make decisions necessary to obtain and implement, in a systematic manner, those technologies and applications deemed most beneficial to the CFD mission."

b. Specific

The following specific tasks were listed in the statement of work:

1. Survey all courses in the CFD that will be identified at the initial on-site orientation and:

   - Identify training methodology areas amendable to solutions by technology.

   - Recommend the training delivery system be suitable for the training need identified.

2. Make an in-depth study of 36 training areas to include two forth coming instructional courses, and provide recommendations for technology that may improve the training program.

3. Prepare the report, in decision making form, in such detail and with recommendations:

   - That identify with each training area, the technology that offers the most reasonable solution.

   - Provide the rationale for the selected and alternative technology.

   - Describe the method of using the recommended technology in the training.

   - To enable management to make valid, value judgements as to which training areas offer the greatest return on implementation.

3. Evaluation Design

a. Realities

To achieve the purposes of the study ana report, some major limiting decisions had to be made.

First, the CFD wanted all 36 POI's considered. This is a massive amount of instructional material. Detailed evaluation would have required far more manhours than were allocated. It would take over 3 man years just to get through all the sessions instructed. Priorities for detailed evaluation had to be established, and those were decided on and prioritized by the CFD staff.

Second, the only technology which had any chance of producing a significant improvement in the effectiveness of CFD training was an "Interactive Video System" which, while based on the videodisc system, does not exist except in the prototype stage. All other technologies have been applied in one form or another within the CFD and either adopted or rejected.

Third, the technology would not produce any significant increases in effectiveness unless the factors listed in the Background paragraphs were considered. The challenge, the trainers, the trainees, the theory, the techniques, the situation and the priorities were just as critical in the success or failure as the technology.

Fourth, if the technology were to be applied with a correct and creative consideration of the other factors, the increases in effectiveness and efficiency would exceed any values anyone would believe. Applied correctly, a new approach would be so valuable that it would require a complete "rethinking" of all 36 POI's in the CFD and all POI's in the USAFAS.

b. Direct Approach

Given these realities and the previous knowledge and experience of the evaluators in training program, evaluation and cost-analysis and in training and communication technology, evaluation and cost-analysis, a decision was made to take a direct approach. Instead of backing into a conclusion that the new "Interactive Video Technology" would provide some increases in effectiveness and efficiency, a decision was made to directly ask, "what would be required to improve the effectiveness and efficiency using the new technology." The results would allow evaluation of the mass of material in relation to a prototype technology.

c. Visual Electronic Digital Media (VEDM)

The technology which would provide the flexibility and other attributes needed to realize an increase in training efficiency is a combination of available media systems. It is based on a videodisc and a microcomputer, but includes other devices as well. To provide a clear relationship and destination, the new technology is titled "Visual Electronic Digital Media" or VEDM. A more complete description is included later in this report.

d. Integrated Visual Active Design (IVAD)

The technique of developing the software and the courseware to be used on the VEDM technology is a combination method called "Integrated Visual Active Design" or IVAD. This technique will provide increases in effectiveness.

e. Experienced-based Projections

Given the mass of information, the experimental nature of the technology and the other factors involved, a detailed numerical analysis system would have been an exercise in creative mathematics. So eight critical dimensions and eight critical variables were identified. The effort of the technique and technology in these factors was based on the projections of individuals who had experience in training in the CFD and related areas.

f. Critical Dimension

The total amount or extent of the potential increases in both efficiency and effectiveness which could be obtained by the application of the IntegratedActive Visualized Design (IVAD) and Visual Electronic Digital Media (VEDM) was evaluated along eight dimensions

- Experience Extension - Extends the availability, realism and difficulty level of exercises which provide job-related, combat-relevant experience. Practice in training can be more like actual combat situations, and there can be more of it.

- Excellence Extension - Extends the availability and challenges for the practicing and improving skills beyond those considered to be "satisfactory" and/or beyond the level needed for "graduation". Students can practice and become confident in more complex applications and can practice more often.

- Exercise Extension - Extends the availability, duration and realism of practical exercises. Students can get more practice, take as long as they need and be more involved in realistic challenge and time frames.

- Environmental Extension - Extends excellence, experience and exercises in geographic areas or environments similar to those in which the learner may be expected to operate in combat. Training can be conducted on the actual terrain in which combat is anticipated.

- Entry Extension - Extends the entry location or entry time. A complete or partial training cycle or program can begin, continue or be repeated at any garrison location and in some cases in any field location at any time.

- Equipment Extension - Extends realistic job training and practice without using actual combat-type equipment. More training can be conducted with less equipment. In many situations each student can have his or her "own equipment".

- Employee Extension - Extends the time and realism of training, but at a lower employee per student per accomplishment ratio. More training can be conducted with fewer instructors or supervisors.

- Expendibles Extension - Extends the training value or eliminates the need for expendibles such as ammunition, fuel, spare parts, paper forms, etc. Less supplies will be required.

The first five dimensions relate to effectiveness and the last three relate to efficiency. These can be separated if desired to compare the effectiveness or the efficiency of two or more systems.

g. Critical Variables

In addition to the eight dimensions some critical variables must be considered. Some of these variables can be controlled by units developing or conducting the training--divisions, departments, school, commands, etc. Some of the variables require action beyond the authority or scope of the command. Eight major variables which will affect the value of a methodology, technology, media or technique were identified:

- Task Validity - The correlation between the tasks and the tasks performed on the job. How much do the tasks performed in training compare with tasks performed on the job?

- Cue Validity - The correlation between the cues available and/or presented in training and the cues available and/or received on the job. How close is what the student sees, hears, feels, smells and tastes to these cues on the job?

- Feedback Validity - The correlation between the feedback received in training and the feedback received on the job. Will the information about an action taken be the same as it would be on the job?

- Condition Validity - The correlation between the conditions under which training is conducted and the conditions on the job. How realistic will the environment, pressure, pace, etc., be?

- Consequence Validity - The correlation between the consequences of training performance and the consequences of job performance. Will the results of action be the same as they would be on the job?

- Training Time - The time measured from the time a specific training program or exercise commences until it ends measured in whole 24 hour days. May include pretraining time--the time between leaving a job and starting training, and post training time--the time between leaving training and returning to the job. How many days are spent in training compared to some arbitrary standard?

- Training Cost - The cost to the organization and the individual for preparing, and providing the training. Includes the total cost of a training installation, activity, group, etc. Includes the cost of personnel facilities, equipment, etc. What would be saved if training stopped compared to some arbitrary standard?

- Training Availability - The capability of obtaining the training regardless of the time or cost. Can the training be obtained? Total availability would be 100% or 1.0.

As with the eight dimensions listed previously, the first five variables relate to *effectiveness* and the last three relate to efficiency.

In a general way the dimensions are expressions of inherent, fixed or "hardware" attributes. In other words, the dimensional values are based on things that are relatively obvious and would be obtained by acquiring or using technology or methodology. The variables relate more to application, creative or "software" attributes. In other words, how a VEDM system would affect the dimension can be determined by specifying or describing the use of a system. However, the value of the variables would depend on what the courseware or software did, said or caused the learner to do or say.

4. <u>Population Discussion and Treatment</u>

The 36 POI which were evaluated using the eight dimensions and the eight variables are listed below. Only an overview analysis was made of all 36. A more detailed analysis on 13 of the above POI's was conducted. These are denoted by an asterisk (*).

1.	Field Artillery Officer Basic	FAOBC	2-6-C20-13E
2.	Field Artillery Officer Basic - Reserve Component	FAOBC-RC	2-6-C25
3.	Field Artillery Officer Advanced	FAOAC	2-6-C22
4.	Field Artillery Officer Advanced - Reserve Component	FAOAC-RC	2-6-C26
5.	Field Artillery Cannon Battery Officer	FACBOC	2E-13E
6.	Field Artillery Target Acquisition/ Survey Officer	FATASOC	2E-13D
7.	Pershing Officer	POC	2F-13C
8.	Field Artillery Pre-Command	FA-PRE-COMMAND	2G-F23
9.	Communication and Electronics Staff Officer	CESOC	4C-25A
10.	Marine Field Artillery Fire Controlman	MFAFCC	041-0844
11.	Marine Artillery Scout Observer	MASOC	250-0846
12.	Marine Artillery Operations Chief	MAOCC	250-0848
13.	Pershing NCO	PNCOC	043-15E20/30
14.	TACFIRE Operations Specialist	TOSC	250-13C10
*15.	Field Artillery Firefinder Operator	FAFIROC	221-13R10
*16.	Field Artillery Firefinder Organizational Maintenance	FAFOMC	221-AS1X5
17.	Lance Operations/Fire Direction Assistant	LOFDAC	250-15J10
*18.	Field Artillery Radar Crewmember	FARCMC	221-17B10
*19.	Field Artillery Radar Crewmember (AN/TPS-58)	FARCMC	221-17BIT
*20.	Field Artillery Target Acquisition Specialist	FATASC	412-17C10
*21.	Weapons Support Radar Repairer	WSRRC	104-26B10
*22.	Weapons Support Radar	WSRC	104-26BIT
*23.	Firefinder Radar Repairer	FRRC	104-AS1K1
24.	FADAC Mechanic	FADACMC	101-AS1F7
25.	Tactical Communications Chief NCO Advanced	TCCAC	101-31V40
*26.	Field Artillery Meteorological Crewman	FAMCC	420-93F10
27.	Meteorological Equipment Repairer	MERC	420-AS1H1
28.	Field Artillery Cannon NCO Advanced	FACA	0-13-C42
29.	Field Artillery Missiles NCO Advanced	FAMA	0-15-C42

30.	Combat Surveillance and Target Acquisition NCO Advanced	CSTAA	2-17-C42
31.	Target Acquisition Radar Technician	TARTC	4C-211A
32.	Cannon Fire Direction Specialist	CFDSC	250-13E10
33.	Field Artillery Fire Support Specialist	FAFSSC	250-13F10
34.	Field Artillery Surveyor	FASC	412-82C10
35.	BTC (Not Developed)		
36.	RPV (Not Developed)		

DISCUSSION

1. General

To see the results of the study and conclusion of the report a detailed discussion of the technique and technology is essential.

a. Integrated Visual Active Design (IVAD)

Integrated Visual Active Design (IVAD) is a synergistic combination of design concept and instructional methods currently used by the CFD, the USAFAS, the U.S. Army Training and Doctrine Command (TRADOC) and other Department of Defense (DOD) components, commands, schools and units. It is totally consistent and compatible with the "Systems Approach to Training" (SAT) directed by TRADOC and currently applied at the USAFAS and in the CFD. However, IVAD emphasizes the words in its title--"Integrated," "Visual," "Active," and "Design" as well as the systems engineering methods and behavior learning assumptions in the SAT.

"Integrated" means that all material, examples, exercises, examinations, etc., are integrated in such a way that the behavioral objectives are related, and relate to the "integrating view" of the system of which the job and/or device being employed, operated or maintained is a component. It is also related to and reinforces the actions and consequences in other systems. It involves an extension and an additional dimension to the task cluster concept currently used in the SAT.

The unique advantage of integration is the added dimension of "systems appreciation" or an appreciation and comprehension of the "big picture" which is currently included in the traditional classroom method of instruction, and "textbook media," but has been "engineered" out of other instructional methods and media.

The requirement for integration, especially in soft skills such as planning, leadership employment and analysis is the reason the classroom and textbooks remain the dominant methodology and technology for training. However, "seeing" integration as an objective, even though the concept cannot be measured directly, allows the "big picture" to be included in other methodologies and technologies.

When integration is complete, the rationale and accuracy of the "school solution" is both obvious and appreciated.

"Visual" means that all material, examples, exercises and examinations are based on what the soldier "sees" rather than what he or she reads (or hears about what he or she sees). Instead of explaining a procedure and action as a consequence, a soldier sees the procedure, action or consequence. Instead of describing the job, the soldier sees the job and sees its interrelation to the "big picture."

The unique advantage of the visual approach is the capability for direct communication with those who are wholly or partially illiterate. According to the interviews conducted with CFD instructors, over 90% of the students of the CFD and over 80% of the officers and enlisted men in the U.S. Army have below average reading skills. The decline of reading skills in high school graduates is well documented.

Using visual rather than a verbal presentation would increase the efficiency of current textbooks and individualized instructional materials by 30% or more. This has been documented in numerous studies of audiovisual materials.

The requirement for a visual rather than a verbal presentation accelerates as reading skills decline. As with integration the requirement is also more necessary in the soft skill areas.

When visualization is complete, the student sees the job as an expert would see it and can "mentally project or see" visual images of the consequences of actions.

"Active" means that the student participates or performs the required tasks and the required Level of Challenge (LOC) or level of difficulty required for competence or effectiveness. All materials, examples, exercises and examinations require action or performance rather than reading and repeating. The LOC is raised in increments that individuals and groups can handle competently and additional practice is built in, required and rewarded.

The unique advantage of action or practice is so well accepted in military training that it doesn't need further justification. However, practical exercises within a training environment are severely limited in time and technique.

By designing active participation into a training program, the student can progress by doing, rather than by "passing." In addition, increases in effectiveness could be achieved by using the time saved. The average increase in the POI's in the CFD would be 500%. This is based on the assumption that as a student participates and practices more times at higher levels of challenge, he or she achieves a higher level of qualification. Thus, "experience" is obtained in training.

The IVAD methodology evolved from design methods for development of training programs and materials for use with complex computer technical objectives in the mid-1960's. Various elements of the design concept are used in other military training design and are also used by companies which sell training programs as packages. It has been proven in profits. Those companies which compete in the training material and training program marketplace in adult training have made more money when they use the IVAD approach.

The product of IVAD is commonly called a "package." A package usually contains one or more of the following components:

1. Leader's Guide. A list of the step-by-step methods and materials, for leading a learner through the information, examples, exercises and examinations contained in the "course." The leader's guide can be used by an "instructor," a "coach," a "supervisor," or the learner. It can be in print, on a computer or on some other media form. It should contain all the instructions, answers and directions for leading a learner through a series of objectives.

2. Visual Content Carrier. A combination of software and hardware which presents the material to the learner in a visual sequence using visual logic. In the U.S. Army's TEC program this would be a filmstrip on a projection device. However, due to the limitations of this medium, most civilian organizations use videotape. In fact, most of the TEC material is not visual, but text-based.

3. Visual Job Guide. An integrating visual presentation of the primary steps, procedures, decision points, consequences and interrelations of the actions of a job and/or a major task within a job. It provides a portable, readily available visual summary of the job. It is similar to what the SAT calls a job performance aid. However, it is considered an essential component of a training package, not a substitute for training.

4. Learner's Manual. A sequenced and integrated assembly of all the materials, instructions, guidelines, questions, etc., required by a learner or student in a particular training exercise. It provides the learner what he or she needs to allow optimization of learning and to reduce administrative time.

5. Simulation Exercises. A series of exercises on paper, on simulators, or on the actual equipment which allows the active participation and practice of the tasks required in the job.

6. Criterion Tests. A series of graded tests--on the simulators or actual equipment when possible--which provides both practice and progress reinforcement.

b. Alternative Media/Delivery Systems

The full value of the Integrated Visual Active Design (IVAD), has been limited by the media through which the training materials are delivered and the training exercises actively conducted.

The most complete and flexible medium for the past few millenia has been and remains the instructor in the classroom and the field. This medium still dominates TRADOC and FORSCOM training. Over 90% of resident instruction of officers still uses this age old method.

The limitations of the medium are well recognized and numerous alternatives have been proposed, tried and rejected. Teaching machines, programmed texts, videotape, slide-audio, computer and many other media have been tried and found wanting.

The limitations of these media have been and remain their lack of flexibility to meet individual needs, changing objectives and changing conditions. They also lack the capability for providing systems views and practice.

To overcome the limitations of the classroom and the limitations of currently available media, the U.S. Army is looking to a number of computer-based systems. These range from the basic Computerized Training System (CTS) which manages and presents training up to realistic full-scale simulators (FCS) which can replicate most equipment functions and displays and provide realistic feedback. The CTS is limited by hardware and applications. Since its primary output is word-based written (or perhaps verbal) information and instructions the potential of visual power is limited. However, it does provide a direction and a model for programming VEDM. In fact, CTS would be included as a subsystem of VEDM.

Simulator costs are counted in the millions of dollars and the lead time for obtaining and modifying them are numbered in years and months rather than days and hours. Analysis shows that simulator systems generally cost about $1 million per major task cluster or lesson to be trained. Development and purchase of such devices to provide for training in the task cluster and lessons in the CFD would be unreasonable, regardless of the potential training trade-off.

In the long run, FCS will produce increases in effectiveness and efficiency comparable to those listed previously for Visual-Electronic-Digital Media (VEDM). However, the price will be much higher.

To overcome the costs and delays the Army is turning to Part-Task Trainers (PTT). These devices are mock-ups of equipment and provide partial displays and feedback on a flat or 2-D device. These can be produced in less time and at less cost. However, since most of them are one-of-a-kind there are limits to full flexibility and feedback.

So, the alternatives besides the classroom with which VEDM should be compared are CTS, FCS, and PTT. If designed correctly VEDM will actually include the visually relevant features of all three.

c. Visual Electronic Digital Media (VEDM)

VEDM is a synergistic combination of a number of separate devices or media. Actual VEDM devices exist only in the prototype stage today. No commercial models are available. However, none of the components of a VEDM system are experimental. All have been proven as separate systems.

A VEDM system for training will consist of five integrated subsystems or components.

1. An electronic visual display. The display can be one of many current display devices--cathode ray tubes, liquid light valves, charge couple devices, and enlarging video projectors. The devices can be standard designs such as standard television-type CRT's or standard EVP's, or they can be specially modified for higher resolutions, longer retention, image shaping, lighter weight lower power, etc. However, they must be electronic. Film, film strips, slides and other chemical and mechanical devices won't provide the flexibility and capability required.

2. An electronic visual storage. The storage can be one of many current visual storage devices--videotape, videodisc, or charge-couple device. The storage device must have the capability for recording and playback. However, the recording device may be a separate system. Each unit does not have to have a recording capability, but the recording capability must not be a limitation to modification of the software stored on the system.

3. A digital signal processing system. The signal must be recorded, retrieved and processed as a digital signal rather than as a standard analog signal. This is the primary departure from the videodisc systems, which are currently available. Digital signal processing has started in some television applications, and will soon obsolete all current analog video equipment. Digital processing and storage will provide numerous advantages including: lower power requirements, increased playback condition tolerance, higher resolution, ability to modify the image without creating a new display. This latter capability will be required for many CFD applications including those for the Firefinder Radar System, The Remotely Piloted Vehicle (RPV), and map reading.

4. A digital control system. The signal control system can be any of a number of standard 16-bit mini or micro computers. The exact signal processing system and the exact computer system will depend on the application and the cost. Currently the Digital Equipment Corporations PDP-11 series appears to have the greatest flexibility at the lowest cost. However, other equally capable systems are in the prototype pipeline. The standard home computer such as the Apple II and the TRS-80 do not have the capacity and flexibility required for the more advanced applications. However, as the capabilities of 16-bit home systems expand this may not be a factor in the future. The system must have the capability of controlling and modifying the image on the screen as well as the image retrieved and reproduced. Today this requires a business-level 16-bit computer with a relatively large on-board memory.

5. Adaptable digital control points. The control panels through which a learner interfaces with the VEDM system must be capable of simulating the actual device control panel. For example, the control panel for a VEDM to train Firefinder radar operators must look exactly like the controls on the panel of the radar unit itself and the input switches, dials, and display dials must have the same "feel." If an operator turns a dial it must have the same range and produce the actual item of hardware. In many cases the display does not have to be three-dimensional, but can be a two-dimensional picture on a screen. The interaction can be through light pens or other devices. Generally if a PTT would suffice a Cathode-Ray Tube or flat screen display will suffice. Also, the 2-D devices could be used to train tasks in preparation for work on the 3-D VEDM.

These five integrated subsystems operate together to provide a complete VEDM system. The system can be configured for a single individualized application or a large collective trainer where many crew members are doing their jobs and the actions of one affect the other. The display can be modified to be a small screen for individualized work, or a very large screen for collective work, reconstruction, etc.

Analysis of currently available components reveals that the components are all available, economical and reliable. What's missing is:

- Digital Signal Processing
- An overall design concept to allow extension of systems from one application to another.

A brief design concept for CFD applications is described in the following section, but a computer design for TRADOC applications will require much more detailed technical analysis.

d. Using a VEDM System

To see in a general way how a VEDM system would be used by an individual--and a group--and how it could improve effectiveness and efficiency, a description of use with the three areas of detailed analysis can provide a glimpse.

The most obvious application is for training the crew members of an RPV. A VEDM system for each of the primary stations for operations--mission commander, mission payload and air vehicle--could be designed using a console similar to the actual console. It would contain a minicomputer which would allow control of a dual or perhaps quadruple videodisc system to provide the display on a screen similar to the console screen.

The system would be designed to provide cues, feedback, conditions and consequences as close to those in the actual tasks as could be simulated. A learner would sit down at the console and based on the specific task he or she needs to practice, the system would provide an introductory-conceptual explanation and then a series of questions to see what the learner wants to do or needs to do next.

The learner's interaction with the system would be through instruments exactly like those on the real console. If a keyboard isn't required, the learner wouldn't like a keyboard. If it is, he or she would, but the important aspect is to begin to practice using the same input devices that would be used on the actual hardware.

If the objective of a specific exercise is to provide individual training, the learner could start and fly a complete mission without depending on what others were doing at other consoles. Specific aspects of the mission would be preprogrammed so that specific objectives and specific standards would be achieved.

If the objective requires developing the teamwork skills between the learner-operator and others in the crew, this could be programmed in, or three or more consoles could be linked with an instructor's console.

The same units could be adapted to specific environments and sent to major installations where an RPV unit is stationed. Smaller versions could be sent to individual units. The system could also be adapted to replay or work through the actual consoles in the field. In addition, the system could be set up to record actual missions flown by the unit and the same flight could be repeated for other operators and to a certain extent could be modified.

The impacts in equipment extension, employee extension, exercise extension, experience extension, entry extension, environmental extension, excellence extension and expendible extension add up to savings of millions of dollars per year.

In addition, the limitations of flight of the RPV due to FAA and other restrictions would allow a training availability increase of almost inestimable dimensions.

With a VEDM system a learner could sit at a console and work through mapping problems and exercises that relate to time, distance, elevation and direction. Analysis reveals that tasks which need to be performed in the field could be replicated on a VEDM. Again the extensions and savings in time and money run into the millions. (A system like this could also save millions of dollars annually in fire adjustment experience for forward observers). An officer could leave school with hundreds of statistically simulated missions instead of 4 or 5 actual missions fired on a number of costly exercises in which the learner was inactive a major portion of the time.

There are those who will contend that distance cannot be interpreted from a flat screen display. They are correct for distance up to a few hundred feet, but after that, the ocular separation of the two eyes does not contribute to depth perception. In the artillery most distance estimates are well over a few hundred feet. Other cues dominate. With a high resolution display system the cues for distance could be replicated and an image for a shell burst could be superimposed on an image in such a way that the old "puff board" principle could be used to have an observer's connection appear where they "fall" rather than at some pre-programmed point.

In the targeting area a learner could operate a console similar to the ones that will be introduced with TACFIRE. Not only could the learner practice the tasks and skills identified earlier, all the introductory material could be presented in an individualized, self-paced, visual sequence.

An improvement in effectiveness exceeding any rational estimate would be possible. The instructor who is currently teaching the targeting portions of the advanced courses agrees that not only could time be saved, but the increases would actually reveal major questions about current targeting doctrine. Targeting is a "soft subject" requiring rational judgement based on conditions that cannot be created in a classroom or even on a CPX or FEX.

Though the application is not as obvious as it would be for RPV operations, nor as easy to define as it would be for targeting, the VEDM would produce the greatest increase in effectiveness in the mapping instruction.

Mapping is simple when approached visually instead of verbally. In its simplest form it can be described as comparing a picture on paper with a picture on the ground. The problem with a verbal approach, ("map reading", as opposed to a visual approach "map seeing"), is the translation of visual concepts into words. One can't describe a vision. Also, an instructor can't show a learner a specific view. He can only point to it. There is also a relationship between the two pictures--ground and map--and the physical percept of the individual. To a certain extent, especially in pacing, the person "feels" the distance. The time of day, season of the year and other factors affect the picture on the ground.

A VEDM programmed to provide a gradually expanding picture comparison that the learner could interact with would solve the host of mapping problems in the Army today. Those who have been in combat will recall that many tragedies were caused by the lack of skill of experienced officers in map reading.

At this point, many readers will be saying, "but describe how I'd use a visual approach with a VEDM". See! This is the challenge. The process can't be described in words. It can only be hinted at in still pictures. The power of this will remain a mystery to all except a few who have worked with military map problems and computer graphics until a device is built. It will be so powerful that 20-year veterans will learn how to "see" a map for the first time.

Yet, the hardware to achieve these improvements will cost less than $2,000 per learning station.

2. <u>Conduct of the Study</u>

a. <u>Information Sources</u>

Three information sources provided the input data for evaluation. These are:

(1) Interviews and discussions with experienced CFD staff and faculty.

(2) Reports and evaluations, including validations, of CFD POI's.

(3) Professional literature and relevant research data.

b. <u>Interviews and Discussions</u>

Discussions were held about the impact of the factors, the dimensions and the variables on CFD POI's with over 40 staff and faculty members of the CFD plus five staff members of the USAFAS. The discussion, whether in groups or with one person were structured to specific aspects, but the question relating to them were asked in a general way.

Detailed, directed discussions and interviews were held with 14 staff and faculty members of the CFD and four staff members of the USAFAS.

c. Reports and Evaluations

Over 200 separate reports and documents were considered. The data determined and partially used is shown in Table 1. This chart lists the Instructor Contact Hours (ICH), the standard TRADOC factor which enumerates the number of hours a class--not an individual student--is supervised by one or more instructors.

A strange result appears when the instructor contact hours are correlated to the contact with an individual learner per period of time. This factor is called Instructor Availability and is shown in the third column in Table 1.

The analysis also uses a factor called Equipment Contact Hours (ECH)--the number of hours a class is actually using major items of equipment. The Equipment Availability is determined by calculating the total time per unit an individual student is on the equipment. A factor called Task Availability can be determined by dividing the equipment availability by the number of tasks. In other words, if during crew drill of seven hours there were 49 tasks to be produced, the task availability would be .143.

The Media Contact Hours were analyzed since instructional media application was the major objective of the analysis. The media contact hours--the time spent using media other than books--is obviously low, but no lower than most other military or civilian training. However, it is much lower than civilian training in technical tasks similar to those in CFD.

Since simulators are a new and growing part of the training, an attempt was made to determine the Simulator Contact Hours. Considering the number and amount of simulators purchased for the course, it is extremely low.

The Self-Paced Contact Hours is a factor to try to determine in the self-paced POI's how much time is spent in reading the written materials and working verbal exercises.

A complete analysis was performed on parts of three POI's. These are:

1. Mapping - The major concepts, tasks and results of using a map to find and compare locations on the ground. Mapping is a critical part of many USAFAS and many CFD courses, but emphasis is on the following: FACA, FAMA, CSTAA, TCCAC, FAOBC, PNCOC, MASOC, LOFDAC, TFOSC.

TABLE 1

COURSE	LENGTH WK	LENGTH DY	TOTAL ICH	INSTRUCTOR AVAILABILITY	EQUIPMENT AVAILABILITY	MCH	SCH	SPCH
FATASOC 13D	9	1	1208.7	4.4	4.6	.2TV	1	
FAFIROC 13R	6	2	1396.1	12.1	24.4	4.7TV		4
FAFOMC AS1X5	14	4	865.6	14.6	15.8			26
FARCMC 17B	7		360.6	12.9	28.6	6.7TV 2.8AV	44	120
FARCMC 17B1T	1	4	61.6	11.4	34.4			31
FATASC 17C	6		422.6	7.4	25	1.6TV 3.5AV		63
WSRRC 26B	23	3	992.6	20.9	27.8	20TV 15AV		311
WSRC 26B1T	3	2	103.4	15.2	26.5			30
FRRC AS1K1	23	4	1448.5	15.2	15.8			7
FAMCC 93F	9	3	742.2	12.9	21.5	8TV		110
MERC AS1H1	9	3	380.3	39.2	35.7			127
TARTC 211A	17	4	1438.3	5.4	17.8	8.4TV		
FASC 82C	11		1097.8	4.0	17	63AV		

2. Targeting - The major concepts, tasks and results in achieving the major mission of the counterfire or target *acquisition elements* of the field artillery to include target identification, target location, target attack and damage assessment. Targeting is a critical part of the following courses: Field Artillery Officer Advanced, Field Artillery Target Acquisition and Survey Officers Course, Combat Surveillance and Target Acquisition Advanced (NCO), Field Artillery *Cannon* Advanced (NCO).

3. Remotely Piloted Vehicle - The concepts, tasks and results of using a new unmanned airborne surveillance and assessment system. The courses for this system are not developed either for primary MOS training or for information and familiarization in other POI's.

d. Professional Literature and Studies

Over 500 relevant publications and reports were surveyed for information relevant to IVAD and VEDM.

3. Findings

a. General

Based on the analysis of the input data, the following findings were developed. A well planned, informed creative appreciation of IVAD and VEDM *could result in:*

- A 500% increase in effectiveness
- A 50% increase in efficiency
- Or, some linear combination of increases in both effectiveness and efficiency.

b. 500% Effectiveness Increase

Effectiveness is considered to be a measure of the skill or ability to achieve an objective accurately and consistently. It is a measure of how well an individual or group performs a task.

Effectiveness is based on practice and directed feedback.

c. 50% Efficiency Increase

Efficiency is considered to be a measure of the time and cost of performing an individual or collective task.

By using IVAD and VEDM the efficiency of training in the CFD could be increased 50%. This 50% increase would come from improvements in the following dimensions and variables:

- Entry Extension

- Equipment Extension
- Employee Extension
- Expendibles Extension

The design for the courseware and training support system could result in improvement in the following variables:

- Training Time
- Training Cost
- Training Availability

d. Increase in both Efficiency and Effectiveness

The percentage increases in effectiveness and efficiency are related in an approximate 10 to 1 ratio. In other words, a 10% increase in effectiveness could be traded for a 1% measure in efficiency.

The training manager can decide *after initiating an IVAD/VEDM system* wherever they want a maximum increase in effectiveness, a maximum increase in efficiency or some combination of the two.

e. Theoretical Increase Projection

The projected increases in effectiveness and efficiency for each of the 36 POI's was determined by assigning potential values to each of the eight dimensions and the eight critical variables. Numerical values were estimated, but the interaction among the dimensions and variables was also considered. This report does not contain the detailed calculation because many of the numbers were weighted on the basis of judgement and experience. Straight mathematical calculations won't work.

Some general information will provide an example. IVAD/VEDM combines a number of techniques and technologies. Research has shown these techniques and technologies will produce certain improvements. For example:

- Programmed Instruction can improve the efficiency of some types of instruction by 60%;
- Computer Assisted Instruction produces an average 30% increase in efficiency;
- Video-Assisted Instruction produces an average 30% increase and efficiency.

Since IVAD/VEDM combine all three of the above, straight mathematical addition would *yield a 120% increase*. However, some of the improvements in computer assisted instruction come as a result of using programmed instruction techniques.

f. Eight Dimension Analysis

Analysis of the eight dimensions with the POI's of the CFD was based on the following rationale.

Exercise Extension

Given the same time for exercises, for example 27 hours (FEX's + Exams) in the FAOBC and approximately 675 hours in the WSRRC, how many additional repetitions of a task could be performed using a VEDM instead of the current systems? For example, if a lieutenant in the mapping exercise could locate 10 points on the map and on the ground in a one hour field exercise and could locate 100 points in a one hour VEDM exercise, there is a 900% increase. If an operator can troubleshoot 2 conditions in a one hour repair exercise and can troubleshoot 6 on a VEDM guided exercise, there is a 300% increase. A number of elements were considered in the evaluation.

- Travel Time
- Briefing Time
- Equipment Check Out Time
- Equipment Turn In Time
- Other Student Delay Time
- Station Limitations
- Terrain Limitations
- Range Limitations

For example, a person who is to practice operating a radar set will spend approximately 50% of the time on a field exercise in non-training activities and if there are eight people each serving as a crew member, the person can only perform a single task or function one-eighth of the time. This means that on a specific task the best possible training time is 30 minutes on an eight hour exercise. (1/2 x 1/8 x 8)

Experience Extension

The additional repetitions a person could perform in the same time would provide more experience. Here experience is assumed to be additional practice in doing the same job, but in a controlled way to insure that the challenge is increased gradually to maintain interest.

Excellence Extension

The additional repetitions a person could perform in the same exercise time or in additional study time if increased in difficulty to the highest level of qualification would increase the skill level of the person.

Environmental Extension

Since any environment-terrain, time of year, etc., can be used the increase in this dimension is infinite. However, the limitations of learning a new environment should be considered. An assumption was made that exercises would be conducted on Ft. Sill terrain and four other terrain types in four seasons of the year for a 500% increase in all exercises.

Entry Extension

The only limitation on entry location is the availability of hardware and power. For simpler tasks it was assumed that the hardware would be available in any location and for complex tasks at any division school for an overall 2000% improvement.

Equipment Extension

Three aspects were considered in equipment extension. First, the amount of equipment and its associated maintenance and support that would be required to allow the same level of training that could be achieved with VEDM. In most instances this would be about six to eight times the total equipment and equipment support cost now paid. Second, the amount of equipment that could be reduced from inventory, and the cost of the associated maintenance and support that could be reduced. As a general rule the reduction could be about 50% in equipment inventory and associated costs. Third, the capability of conducting training before the equipment is fully deployed, fully modified, etc.

Employee Extension

The largest number of employees are in the equipment maintenance courses. With VEDM these could be reduced to a fraction of the current level. However, programming and updating a VEDM would actually require more people than currently on staff. With VEDM the time these employees now spend in working with individual students could be spent in developing models, software and courseware which could be used by hundreds of students. The efforts of the current staff would be extended in space and time by a factor so large it can't even be estimated.

Expendible Extension

The expendibles required for instruction could also be reduced to 10% of their current cost.

Actual Increases

The actual increase for any of the 36 POI's or any portion can be calculated by assigning reasonable values to each of the eight dimensions and the eight variables and calculating the increases.

A standard set of values would be difficult to develop due to the differences among POI's and portions of POI's. Some sessions are highly subjective and the value of the equipment extension dimension would be zero. However others use million dollar equipment systems and would have an extremely high value.

The best way to calculate the actual increases would be through a pilot program.

g. Observations

The following observations can be made about the situation and conditions within the CFD.

- The military and civilian instructional staff within the CFD have a high dedication and motivation to accomplishing their mission of providing qualified personnel to the field units.

- They have been and still are with the leaders in adopting TRADOC directed methods and technology.

- They have developed, delivered and improved instruction with almost no formal training in training technology.

- They have reached the limits of the current methods and on-hand technology.

- They are aware of these limits and are beginning to seek progressive methods to obtain the flexibility, motivation and security missing from current methods.

- What those in contact with the students in the CFD courses and classes perceive as a lack of motivation is caused by six verifiable factors:

  1. Limitations in Design. The design of current self-paced courses and materials--mostly publications but including some slide-audio and videotape is based on classroom methods and materials, and on technical manuals and materials from previous instructor classroom-based courses. In short, the design is rooted in older methods and materials, not in self-paced techniques.

  2. Limitations in Literacy. The current students in the CFD courses have a lower than average reading ability. Based on data on entry tests the reading level of the average CFD enlisted student is between the 6th and 7th grade. The average 7th grader reads two hours per week in school and the average high school senior reads less than nine hours. The average self-paced course requires a student to read 27 hours per week at an advanced high school level or basic college level.

  3. Limitations in Practice. The current design still requires close supervision and the participation of other students in practical exercises. Self-pacing can only go so far on crew served systems and highly dangerous jobs, and the time of practical exercises is restricted by the self-paced techniques.

  4. Limitations in Reward. The current system does not provide rewards for rapid progress and in many cases provides a punishment. Students who finish early are often assigned to work details.

5. Limitations in Mathematical Reasoning and Skill. Most courses in the CFD require an above average capability in mathematical reasoning and computational skill. The older manual methods require less computational skill because forms were developed and validated years ago to provide a job performance aid to compensate for the missing abilities. The newer computerized methods require advanced reasoning. Most students are unable to determine when a computer solution is obviously wrong or inaccurate. To compensate, the older methods are still taught and more time is allowed for problem solving.

6. Limitations in Mapping Reason and Skill. All courses in the CFD require an above average capability in using a map to "see" terrain and in plotting on a map. The newer computerized methods require even more reasoning ability, again for checking computer solutions.

In summary, the observations add up to:

- The military and civilian leaders in the CFD want to do a top quality job, and have led the way in adopting newer, more effective and efficient technology.
- They have hit the limits of the training technology imposed by design limitations, support limitations and technical limitations.
- Currently available training methodology and technology would not increase the effectiveness or efficiency of the current POI's without a major redesign and redevelopment effort.
- The CFD staff does not have the capabilities or resources for designing, developing, implementing and controlling a new training methodology or technology, but would "try" if given the mission.
- The design procedures and techniques included in the IVAD approach would be to provide the guidance and feedback necessary to improve the design of materials used in the CFD.
- The integration of Visual Electronic Digital Media (VEDM) would provide the means to include the systems approach, the extensions and the visual presentation in the CFD Training.

h. Related Considerations

In addition to the dimensions, variables and observations made up to this point, a number of other critical considerations bear on the study. These are phrased below in the form of questions.

- Why, despite its limitations, does the self-paced instructional methodology provide superior validation results when compared to the instructor or group-paced classroom method?

- Why, when the reading level of the average enlisted student is so low, is so much reading at such a high level required?

- Why, on the other side, when the average reading level of a basic or advanced commissioned officer is so much higher, is so little reading required?

- Why, when the military has emphasized the use of visuals and media in all its policy, guidance, literature and instructional courses, is so little media used?

- Why is the contact between individual students in self-paced POI's higher than in instructor-paced POI's?

- Why is the contact with equipment in equipment and operation courses so low?

- Why is there little or no comparison between the eight extension variables and the training methodology?

When one begins to compare the answers to these questions with educational research, the answers seem to develop a pattern. A summary of the answers are contained in the following paragraphs.

First, analysis shows a number of reasons for the generally higher validation of self-paced methodology. Probably the most common reason is the selection of courses for self-pacing. In general the course selected will be those for which the tasks are easier to define. For example, it's easier to analyze the job of a radar operator than that of a battery commander. However, there are a number of other reasons. Among them are:

- Mastering before progress. A learner does not progress to the next step or objective until he or she has qualified and/or feels confident with the previous level.

- Individual attention. The learners can work with an instructor on a one-to-one basis rather than "sharing" the instructor with 20 to 30 other students.

There are some disadvantages to self-paced instruction as it's currently designed. Among these are:

- Difficulty of presenting and obtaining feedback on concepts (the "big picture") as opposed to specifics (individual parts of the "big picture").

- Difficulty of presenting interpersonal and team skills.

- Difficulty of reading the material.

Analysis of external validations and critique of the self-paced POI's in the CFD can be interpreted to arrive at exactly the conclusions listed above. This analysis was performed and verified by discussions with designers, faculty and students.

Second, the instructional design currently requires too much reading probably because of resource constraints on instructional designers at the USAFAS. It is probably impacted greatly by the frequent turnover of military instructional designers.

Visual media could make a significant contribution to the introduction of concepts, to the modeling of interpersonal skills and to reducing the reading requirement. However, in spite of the obvious advantages, media is not used in this way in the CFD or anywhere else in the USAFAS or in the entire TRADOC system.

Third, if a lot of reading were required in the advanced courses for officers, the attrition rate might exceed TRADOC standards. If the reading-based, self-paced approach to officer training were adopted, the lack of immediate feedback might cause the washout rate to exceed 20%.

Fourth, the other factor, Equipment Availability, should dismay everyone. Since the tasks in most CFD POI's are equipment oriented, the more time on the equipment, the better. However, the actual time on equipment in either operation or maintenance is a major limitation, due to the cost and availability of equipment versus the time of training and number of personnel to be trained. Equipment unavailability will be a major factor as newer and more technical, more computerized weapons are developed. Equipment unavailability is a prime decision factor for adopting a VEDM system.

The analysis on the final question asked as a related consideration deals with comparison of the eight extension variables identified earlier and the training methodology.

In short, the analysis is completed, but there is no current model, method or procedure for converting the analysis into realistic training using the SAT design approach. What is occurring is a good analysis and then a "retreat" to the older "classroom-subject" design and development concept.

Based on the analysis, the conventional design and development concept will not work for VEDM. If an attempt is made to take a verbal approach, rather than a visual approach, the material will be long, boring and almost unrelated, and the programming will never be finished unless the design is done on a VEDM System. However, the feedback a designer receives from developing material using the VEDM technology will force him or her back to the tasks, cues, feedback, conditions and to a certain extent consequences.

SUMMARY

By adopting, implementing and managing an Integrated Visual Active Design (IVAD) methodology and a Visual Electronic Digital Media (VEDM) technology, the Counterfire Department (CFD) of the U.S. Army Field Artillery School (USAFAS) can:

- Increase the efficiency of current and future resident instruction by 50% or more.
- Increase the effectiveness of current and future resident instruction by 500% or more.
- Increase both the efficiency and effectiveness of current and future resident instruction by some combination within the two ranges above.
- Increase the efficiency and effectiveness of related non-resident training in active, reserve and national guard units by similar or even greater percentages.

By increasing the efficiency by 50% the CFD could reduce the "training time" or "training costs" by 50%, or reduce both the "training time" and "training costs" each by some percentage as long as the total increase is approximately 50%.

By increasing the effectiveness by 500% the CFD could provide graduates to the field who are 5 times better qualified than the current graduates.

Both the efficiency and the effectiveness could be increased by some percentage by offsetting increases in one with increases in another. For example, efficiency could be increased by 25% and effectiveness by 250%.

These same increases, or combinations of increases, could be extended beyond resident instruction into active, reserve or national guard units.

The increases would apply to both individualized and collective training in areas involving management skills, operational skills, technical skills or maintenance skills. The design and delivery of programs for each of these skills would be different, but the results would be approximately the same.

The above estimates are based on analysis of the 36 POI's currently used or planned for use in the CFD and on projections of the results of applications of technologies in other military, government and civilian organizations. Since both the methodology and technology are combinations of current methods and media, the research projections are indirect, but seem to be both logical and relevant.

To relate the analysis and research and skills for which the CFD is the proponent to the subjects and skills trained in other departments of the USAFAS, in other U.S. Army and military units and in other government and civilian organizations, a view of Integrated Visual Active Design (IVAD) and Visual Electronic Digital Media (VEDM) is required.

CONCLUSION

Based on the challenges, needs, task-types, reading levels, prior education and future requirements of the CFD, only four alternative media delivery systems seem favorable. These four, along with relevant conclusions, are summarized below.

1. Traditional Classroom. This method provides the system overview, and the low reading requirements essential to current and future CFD requirements. However, it does not provide the opportunity for systems operations required. The method is well-known and fits easily into the current school model. IVAD could increase efficiency by 25% to 35%, but effectiveness would be only 50% to 100% greater. The extension to field units would be as limited or more limited than it is now.

2. Individualized Instruction. This method provides neither the system overview nor the low reading requirements needed to meet CFD requirements. It theoretically enhances practical exercises, but this is not significantly higher than the previous traditional classroom mode. The system overview is provided by tutoring. The only reason the current individualized instruction is working as well as it is in the CFD is the individual efforts of instructors. The addition of IVAD would enhance the efficiency and effectiveness of the current instruction, but if incorporated, the need for a VEDM would become obvious. Analysis will show that VEDM combines all current individualized efforts in the CFD.

3. Equipment Simulator. Equipment simulators like those used in the Firefinder training and those planned for other CFD training provide excellent practice in hardware-related skills, but at an extremely high cost when compared to VEDM. The current simulators do not provide total training, and therefore, do not provide systems overviews nor low reading requirements. These cannot be extended to field units because of the cost and maintenance requirements.

4. VEDM. With some minor exceptions VEDM can combine all the above delivery systems and provide the capabilities, flexibilities and increases in efficiency and effectiveness described in this report.

The logical, economical and practical conclusion is that VEDM is superior to all alternative media for CFD applications.

However, TRADOC has not specified or purchased a VEDM system and only two individuals in the CFD have any familiarity with the IVAD method. The logical conclusion is to go to a contractor. However, the CFD have an advantage over most potential contractors. They can "see" the subject. Many of the instructors and senior officers at the CFD have been working with the subjects taught for years. They have had to develop "visual analogies" for describing their systems and actions to students. This could eliminate years of "trial and validation."

To allow continued progress toward cashing in on the benefits of IVAD and VEDM, a phased approach seems to be the most feasible, though the best and most effective approach would be a rapid and massive conversion to the new methodology and media. The technical and technocratical barriers should be advanced slowly. A specific application area, technology and design team should be selected for a pilot project. Since over 2000 alternatives exist, the most practical approach based on the analysis is contained in the following section on recommendations.

The specific task clusters within the CFD which would provide the largest increase in efficiency and effectiveness is the area of targeting which is taught to the Field Artillery Officer Advanced Course and other advanced employment courses. The percentage increase will be even larger when the targeting system is integrated into the TACFIRE system sometime within the next 2 to 5 years. However, this is also a reason for passing this area up in a recommendation. The approach will all change within a short time and the residual value of the development effort will be obsolete.

The next task cluster which would provide almost immeasurable increases is in the Remotely Piloted Vehicle (RPV) POI. This new system, if employed effectively, will almost require VEDM. The traditional classroom or book-based instruction will provide less than 2% of the skills needed to fully exploit this new system. However, the system is still in the prototype stage and the training development, while two to five years away, would be a massive effort for a first VEDM project.

The final area, while not as glamorous and while not as potentially effective as the other two areas is one that offers almost every aspect of artillery and military operations--map reading. As described earlier, map reading and land navigation are almost purely visual subjects. This application would not only provide improvements in efficiency and effectiveness within the CFD, but would have bonus benefits throughout the entire USAFAS and in FORSCOM.

RECOMMENDATIONS

Despite the solid research and conclusions reached from the analysis of the 36 POI's in the CFD, there will be those who will want more proof. Since IVAD has been tested in only a few applications other than the 1980 Census Data Processing training and other technical skills areas, and since VEDM has only been evaluated in limited, non-complete, system applications, proof will have to come from a carefully defined and evaluated pilot project.

The pilot project recommended is one based on mapping. Based on estimates of approximately $100,000 per lesson or major task cluster for developing a VEDM module, three task clusters with differing skill requirements will provide the necessary proof.

An evaluation of the current mapping task clusters currently trained in a number of POI's by the CFD reveals a number of task clusters. However, the three most common and most needed are:

1. Map orientations and direction, distance and elevation.
2. Target location.
3. Land navigation.

These three modules should be developed by a joint contractor-CFD team. The contractors should provide the technical guidance, the design guidance and the programming necessary to allow the system to replicate actual field situations, and provide the interactivity and individualized practice needed. The CFD staff should provide the experience required to describe how the students acquire the skill to "see" mapping.

Despite the potential problems of a joint effort between a government group and a contractor group, experience with the 1980 Census program shows this is the only feasible way.

The equipment required for using a VEDM system includes:

1. Input devices.

- Digitizing X-Y coordinate board large enough to accomodate a standard 1:50,000 contour map.
- Location sensitive digital input devices.
- A compass type input device.
- A light or torch sensitive screen to allow direct location of points.
- A keyboard to allow numerical and alphanumeric input.

2. Display devices.

- Two high definition cathode ray tubes to provide higher resolution than standard television.
- A video projector when required for group presentations and demonstrations.

3. Storage devices.

- A dual floppy disc system for storing computer and alphanumeric instructions.
- Two videodisc systems capable of playing back digitally encoded visuals. (Digital picture information is required.)

4. Control systems.

- A device to control the display to allow changes in perspective without changes in image.
- A minicomputer with a relatively large internal memory. (How large? Depends on the program, but it must be larger than an Apple or a TRS-80.)

The system proposed for a mapping pilot program could also be used for targeting or other applications within the CFD. It differs from some of the commercial prototype models in four ways.

1. Two displays instead of one. This allows one display for the image on the map and another for the image on the ground.
2. Two videodisc storage units. Two are needed to allow smooth transitions from one scene to another based on actions by the student and to allow display of dual images.
3. Digital signal recording and playback.
4. Larger than microcomputer memory capacity. The exact memory capacity will depend on the software and further analysis.

To produce the courseware and software, either the contractor or the government will need to provide:

- Two high quality color television cameras, and digital recorders.
- A computerized editing system capable of linking four digital videotape recorders.
- A larger computer for programming work.
- Two prototype playback units.

When the modules are ready for evaluation, at least 10 prototype VEDM units should be available to allow testing of a representative sample of students from a number of POI's.

Since the design concept, the media and the software program are all new adaptations, a taskforce should be established to complete the pilot project and to document decisions and alternatives for later evaluation. The taskforce should consist of:

- A taskforce leader skilled in mapping, IVAD, VEDM and management.
- A course developer/designer skilled in IVAD and SAT.
- A subject matter expert skilled in mapping instruction.
- A design artist skilled in technical illustration.
- A computer programmer skilled in interactive algorithms.
- A computer systems designer skilled in digital signal processing and visual displays.
- A television cinematographer skilled in lens effects and lighting techniques.
- A television editor skilled in computerized editing.

A total of 40 manmonths is estimated for system assembly, software development, program production and program duplication. A total of 9 man will be required for evaluation and report preparation.

The cost of the prototype VEDM system is almost impossible to project. In mass production, the simpler units could be $4,000 or less. The more complex could be $10,000 or less. A budget of $10,000 per unit should be set for the prototype playback VEDM's and about $100,000 for the developmental system. Much of the equipment could be obtained by lease.

The CFD should be responsible for the project due to their previous interest, their experience with technology and the combination of instructional and technical skills required.

As part of this contract, the contractor was to provide data for making valid value judgements on the recommendations and alternative applications. The time and cost estimates above are based on estimates from the videodisc project at the Massachusetts Institute of Technology and the University of Illinois. They estimate $100,000 per lesson. However, none of their work has been on a specific subject like mapping and none has been evaluated. Also, the systems they are using are less complex and they use graduate students so their cost and time estimates are biased.

The value judgements which led to the mapping recommendation were:

1. Need - mapping is needed in many CFD POI's.
2. Payoff - the payoff would be in the millions of dollars.
3. Simplicity - mapping is relatively simple once one "sees" it.
4. Visuality - mapping is almost totally visual.
5. Interest - the interest of everyone in the subject is high.
6. Validation - results of training can be validated easily.
7. Sources - sources of materials, scenes and examples are readily available.

Since the success of the project depends on a joint CFD/contractor team, a special and complex statement of work should be prepared. A joint project between a contractor and the CFD should be considered to prepare a statement of work. This should begin immediately while the data and considerations from *this study* are still fresh in everyone's mind.

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