

1-1-1989

Technology Integration Plan For Training Systems And Devices: A Technology Investment Strategy

J. Peter Kincaid

Find similar works at: <https://stars.library.ucf.edu/istlibrary>
University of Central Florida Libraries <http://library.ucf.edu>

This Research Report is brought to you for free and open access by the Digital Collections at STARS. It has been accepted for inclusion in Institute for Simulation and Training by an authorized administrator of STARS. For more information, please contact STARS@ucf.edu.

Recommended Citation

Kincaid, J. Peter, "Technology Integration Plan For Training Systems And Devices: A Technology Investment Strategy" (1989). *Institute for Simulation and Training*. 189.
<https://stars.library.ucf.edu/istlibrary/189>



TECHNOLOGY INTEGRATION PLAN FOR TRAINING SYSTEMS AND DEVICES

A Technology Investment Strategy

prepared for

Army Project Manager for Training Devices

written by

J. Peter Kincaid
Brian Goldiez
Thomas Clarke
Ronald C. Hofer

Institute for Simulation and Training
University of Central Florida

April 1989
UCF-IST-CR-89-01

DRAFT

TABLE OF CONTENTS

1. PURPOSE	1
2. ORGANIZATION	2
3. SCOPE	3
3.1 Advancing the State-of-the-Art	3
3.2 Enhancing Current Devices and Simulations	3
3.3 Risk Avoidance and Risk Reduction	4
4. TECHNOLOGY PROGRAM OVERVIEW	4
4.1 Programs Considered	5
4.2 Relationship to Fields of Endeavor	5
5. ANALYSIS OF TECHNOLOGY APPLICABILITY WITH RESPECT TO FIELDS OF ENDEAVOR	6
6. PROGRAMMATIC RECOMMENDATIONS	7
7. SPECIFIC PROGRAM RECOMMENDATIONS	8

APPENDIX -- FIELDS OF ENDEAVOR

1100 ENGAGEMENT SIMULATION AND INSTRUMENTATION	A-1
1110 Pairing Systems	A-3
1120 Range Instrumentation	A-5
1130 Targets	A-7
1140 Robotics	A-8
1200 REAL TIME MAN-IN-THE-LOOP SIMULATION TECHNOLOGY	A-10
1210 Simulation Networks	A-12
1220 Battlefield Simulations	A-14
1230 Modular Design Standards	A-16
1240 Standard, Reusable, Rapidly Reconfigurable Data Bases	A-18
2100 LOW COST/COMPLEXITY SIMULATION	A-19
2110 Novel Techniques for Low Fidelity Training Devices	A-21
2120 Test Bed for Cost/Training Effectiveness Evaluations	A-23
2130 Generic Reconfigurable Designs	A-25

2200	VISUAL SIMULATION TECHNOLOGY	A-27
2210	Visual Presentation Technologies	A-29
2220	Visual Performance	A-31
3100	TRAINING ACQUISITION TECHNOLOGY	A-33
3110	Total Training System Representation and Simulation	A-35
3120	Optimization of Training Device Cost and Effectiveness	A-37
3130	Embedded Training	A-39
3140	Training Cost Effectiveness Relationships and Data Bases	A-42
4200	AI AND INTERACTIVE INFORMATIONAL PROCESSES	A-44
4210	Automated Instructional Process	A-45
4220	Job Aiding	A-47
4230	Natural Language Interfaces	A-49
4240	Voice Technology	A-51

TECHNOLOGY RESEARCH INTEGRATION

1. PURPOSE

This report describes a technology investment strategy which can be used for two main purposes. The first purpose is to provide a means to organize current research programs which are applicable to training devices. The second purpose is to assess the long term technology needed to meet future requirements of training devices.

The construct of a "Field of Endeavor" provides the primary building block for developing this plan. Each Field of Endeavor establishes a domain of emerging or advancing technological opportunity with an assessment of trends and rate of advancement in the context of relevance to Army needs. The primary objective is to identify and promote the transfer of technology into fielded capabilities. Field of Endeavor descriptions provide the framework for communicating and coordinating technology initiatives with industry, academia and other government organizations.

The plan contains descriptions of key technology areas within these fields of endeavor. For example, "Real-time, Man-in-the-loop Simulation Technology" includes the areas of simulation networks, battlefield simulation, modular design standards, and standard rapidly reconfigurable data bases. As technology matures, objectives are met, or new opportunities emerge, Field of Endeavor descriptions will be modified to keep the plan current.

This report is a framework from which a data base is being developed to cross-reference research programs. Data base development is at an early stage of development. Once fully developed, however, the data base will serve multiple purposes. It will be used as a source of information to analysts and engineers seeking information on the state-of-the-art in training and simulation. This data base will also be used to identify the technology thrusts necessary to meet the training requirements of the future.

Consideration is being given to making as much of the data base as possible open to wide spread access while including industry sensitive information for use within the government only.

The information in the data base fuels the continuing assessment of technology trends and summarizes known technology activities. A relational structure will allow accessing information in the data base according to goals and objectives developed within the Fields of Endeavor.

Anticipated benefits of the total program (the plan and the data base) include:

. communicating and coordinating trends, goals and objectives of Army training and simulation technology

. an investment strategy which uses available Army funding to leverage the advancement of technology without duplication

. a source of current information for use by PM TRADE technical personnel for enhancing technology transfer into fielded applications.

A research investment strategy must incorporate advancements in allied fields, such as communications and computer technology, to maximize the return on investment. In addition, research programs must be created to fill those unique training areas where no parallel efforts can be found.

By comparing current training system capabilities and performance trends with future operational systems capabilities, a vigorous program of research can be formulated to ensure that cost and training effective systems are available to train tomorrow's soldier. The data base should serve to aid this process by identifying opportunities to "leverage" technology advanced in carefully targeted areas.

2. ORGANIZATION

The remainder of this report is organized around Fields of Endeavor, developed by the Army Project Manager for Training Devices (PM TRADE). The Fields of Endeavor include:

- . Engagement Simulation and Instrumentation Technology
- . Real time, Man-In-The-Loop Simulation Technology
- . Low Cost, Complexity Training Simulation Technology
- . Visual Simulation Technology
- . Training Acquisition Technology
- . Artificial Intelligence and Interactive Information Technology

Short descriptions of each Field of Endeavor are contained in the appendix. In addition, technologies associated with each Field of Endeavor are contained in the appendix.

Section 3 describes three types of research efforts and how these efforts apply to the Fields of Endeavor.

Section 4 describes current and conceptual technology programs.

Section 5 analyzes Fields of Endeavor according to research program products, schedules, and costs.

Section 6 provides recommendations relative to pursuits within a technology area as related to anticipated requirements. This section also assesses the amount of research being conducted in

different technology areas.

Section 7 specifies program recommendations based on the results obtained in Sections 5 and 6. Rationale for program development is presented for each research effort.

3. SCOPE

This section describes three types of research efforts and how they apply to the Fields of Endeavor. The objective of this section is to relate the Fields of Endeavor to create group information. All Fields of Endeavor will contain a category titled "Other" which will contain information on emerging technology, allowing each Field of Endeavor to be expanded as needed.

This approach is to categorize research efforts into the applied research domain as opposed to the basic research domain. Basic research is relevant to this effort, but only to the extent that discrete products can be identified as an ultimate result. Therefore, only research efforts which are directly relevant to training and simulation will be considered. Research efforts which have an indirect impact on training and simulation (e.g., the T-800 Engine Development Program for the LHX) will not be considered.

Research efforts fall into three, sometimes overlapping categories. These categories are:

3.1 Advancing the State-of-the-Art. These research efforts are oriented to providing technologies which will fill current and future requirements for training systems. This area is meant to characterize gaps between requirements and system capabilities. Advancement of the state-of-the-art for a particular Field of Endeavor can encompass areas such as the development of new technologies to meet future needs in visual technology for Mission Planning or the development of quantitative training effectiveness measures.

3.2 Enhancing Current Devices and Simulations. Often, the performance of existing training systems can be enhanced by applying existing or allied technologies and capabilities in unique ways. For example, the technology developed for processing satellite imagery might have application to rapid CIG data base development.

This merging of technology enhances existing systems by adapting existing technology in unique ways to either relieve identified deficiencies or enhance the characteristics of the fielded system. These types of research programs have a heavy concentration on dealing with integration issues.

3.3 Risk Avoidance and Risk Reduction. Often, the Procuring Agency uses a prototype development program specification to expand the state of the art. This experimentation is risky for both the procuring agency with respect to cost, schedule and technical performance. In addition, today's environment of fixed price contracts and cost control advances in the state-of-the-art can be risky for a contractor who is asked to bid fixed price development and follow-on units.

This area of research is often referred to as technology or feasibility demonstrations. A laboratory or set of laboratories can be organized into an "Underwriters Laboratory" concept for training and simulation equipment. These laboratories can serve to benchmark systems, validate performance, or test concepts prior to incorporation into a training system.

This report, along with the appendix, not only categorizes research efforts, but it also provides a road map for additional research or a concentration of resources to meet future needs. Current Fields of Endeavor and related technologies should be monitored for progress and problems. Future revisions of this report will make specific recommendations on the disposition of any problems. The dispositional recommendations will range from doing nothing to developing a specific program of research to meet a requirement.

4. TECHNOLOGY PROGRAM OVERVIEW

The programs considered in this Technology Research Integration Plan should cover efforts ongoing or contemplated in the government, academic, and industrial sectors. For this submission, available information has been limited to that furnished by PM TRADE regarding research efforts in some government sectors, and current research programs related to training and simulation at the University of Central Florida (UCF).

It is pertinent to mention at this point that UCF represents the only known broad based center of directly related research efforts in the training and simulation field. The research program at UCF is broad based, covering the engineering, computer science, psychology, and educational aspects of training and simulation. A survey commissioned by the Institute for Simulation and Training at UCF (summer of 1988) found no other academic institution in the nation covering the breadth of the training and simulation domain as that occurring at UCF.

This is not meant to imply that other universities and institutes are not engaged in research either peripherally or directly related to training and simulation. We have become aware of simulation related work at Georgia Tech Research Institute, University of Alabama, and the University of Dayton Research Institute. Specific research efforts, schedules, funding, etc. are not known at this time. Attempts will be made to gain a

broader insight into training and simulation related research activities at other universities.

Research activities in the industrial sector are difficult to determine and convey through a report such as this. Such information is considered proprietary by each company. Even if permission were granted to learn about specific research efforts, the ability to re-transmit that information is normally very limited.

In addition, many companies do not see any advantage to having a third party write or learn about internal research efforts. This realm of research investigation and reporting will continue to be looked at for meaningful input, since it represents a significant portion of training and simulation research effort.

4.1 Programs Considered. Programs considered fall into four realms:

- . government sponsored and industrial performed
- . government sponsored and government performed
- . government sponsored and academically performed
- . academically sponsored and academically performed.

As more programs are discovered, this data base grouping will evolve. New categories envisioned include industrially sponsored and academically performed, and government sponsored and academic/industrial performance as a team. The listing contained herein contains both ongoing programs and programs in the planning stage.

Planning programs are often expressed by the government using government developed planning documents. These planning documents are included in the enclosed list but are segregated from ongoing programs. Future revisions to this report can be used to identify how well program plans are being executed, and to gauge how priorities change or are extended with time. The stage of progression of the planning documents into actual research programs can be used as a barometer to gauge criticality of either the particular program being considered or ultimately the Field of Endeavor.

4.2 Relationship to Fields of Endeavor. Each of the six Fields of Endeavor is fully described in the appendix. Each description defines the domain of a Fields of Endeavor (including related technologies) and describes current trends and future directions. The descriptions also provide a time phased description of activities occurring in each Field of Endeavor.

Specific programs in either the planning or execution phase will be input into a computerized data base to be developed and maintained by IST. The data base, just being developed, is resident on the PM TRADE MIS computer system. This data base is Unix-based and accessible to any individual at PM TRADE or other agencies designated by PM TRADE. Each data base file contains

these fields: Title Field, Author, Textual Description, Schedule, Funding over time, Field of Endeavor (to include sub-Field of Endeavor code) or multiple Fields of Endeavor, and locator index. It is envisioned that contractors will be given the opportunity to make data base inputs which would contain proprietary data. Such data would have limited access as appropriate.

All documents will maintained in hard copy format at IST and PM TRADE, unless conditions warrant otherwise (e.g., classified documents need only be resident at one location). The format of ongoing programs or programs in the planning phase will be similar to the DD Form 1498. Bibliographical references will also be in the data base in an appropriate format.

5. ANALYSIS OF TECHNOLOGY APPLICABILITY WITH RESPECT TO FIELDS OF ENDEAVOR

It has become apparent in researching the Fields of Endeavor and their accompanying technology areas that two categories of maturity/need exist. The first category encompasses a need or expressed by the Army and/or DoD components, and specific programs that are planned or ongoing to fulfill the need. Research programs that fit this description ("Category 1") should receive priority in funding and focus, with respect to specific program definition in order to achieve results in minimal time.

The second category of maturity/need are those research programs which enhance the use of training devices ("Category 2").

With respect to financial commitments, Category 1 programs usually require larger financial commitments to achieve results than Category 2. (Category 1 programs normally require system development (hardware or software) to demonstrate concepts, while Category 2 programs normally produce reports.

All programs in the data base will be placed in either Category 1 or 2. Category 2 areas may remain as Category 2 or evolve to Category 1.

Included in Category 1 are:

- . 1110.0 Pairing Systems
- . 1210.0 Simulation Networks
- . 1240.0 Standard, Reusable, Rapidly Reconfigurable Data Bases
- . 3130.0 Embedded Training
- . 4210.0 Automated Instructional Processes

The sub-fields listed above represent well defined technical voids where requirements dictate solutions within five years or less.

The following areas should be monitored with minimal financial commitment in terms of research expenditures:

- . 1130.0 Targets
- . 1220.0 Battlefield Simulation
- . 2120.0 Test Bed for Cost/Training Effectiveness Evaluations
- . 4240.0 Voice Technology

All other areas should be classified as Category 2, requiring study efforts to focus research and programmatic objectives.

6. PROGRAMMATIC RECOMMENDATIONS

The previous section made recommendations regarding several technology areas which should be enhanced with respect to funding and/or programmatic focus. The rationale for each recommendation follows, along with programmatic efforts either underway or under consideration.

Regarding Pairing Systems, enhancements are necessary in Tactical Engagement Simulation technology on three fronts. First, improvements must be sought in Tactical Engagement Simulation technology to provide signal transmission of laser through smoke and obscurants. Second, accurate ballistics, weapons trajectory, and hit/kill determination are necessary in order to account for new munitions and target features. Third, Tactical Engagement Simulation must account for the "Smart Weapon" technology available today, which will undoubtedly increase in sophistication in the future. Such features as radar tracking, operator guided missiles and other systems require advances in the state-of-the-art in order to accommodate new advances.

Simulation Networking is a stated Army requirement, but the full capabilities of existing systems, interfacing requirements, and the impact of new communication technologies are not known. These programs are ongoing at a modest level at Ft. Knox, but require acceleration and expansion of scope to address critical areas.

The expanded program structure is currently being defined by IST under a new initiative sponsored by PM TRADE and DARPA. Long term thrusts should be focused on interoperability of simulator networks with operational platforms and components, the use of voice, and long haul approaches.

Standard, Reusable, Rapidly Reconfigurable Data Bases (RRDB) also require accelerated development. Industry and university (e.g., IST and UCF) are currently starting to ascertain RRDB problem areas and bottlenecks. New techniques which use Artificial Intelligence and other automated processes are necessary in order to reduce the labor intensive nature of data base development.

In the short term, methods to improve the efficiency of the man-machine interface between the data base modeler and the data base development system must be developed in order to create more cost and time efficient data bases. In addition, as the operational users become more dependent on sensor systems, the need for multi-spectral rapid data base generation will also increase.

Embedded Training (ET) is in a state similar to RRDB, except the engineering and behavioral requirements require definition. To date, modest efforts are ongoing to define training issues relative to ET. These efforts need to be accelerated. In addition, engineering development must commence in parallel in order to validate conceptual training approaches. These efforts should capitalize on new developments in operational system software and hardware developments (e.g., MIL-STD-1553B bus replacement).

The programs listed above require a concerted effort to define problems and find solutions in a timely manner (less than six months). PM TRADE must provide the impetus for this program definition phase.

Much effort is ongoing in Automated Instructional processes. Behavioral aspects have begun, but require expansion. Engineering implementation (with respect to software and hardware solutions) is lagging and requires emphasis.

Four technical areas in Section 5 were recommended for monitoring, but not funding. The rationale for those recommendations follows. Targets and Voice Technology represent mature technology. Demonstrable products are currently available and expanded capability appears to be low risk. Battlefield Simulation appears to lack focus and is being peripherally covered in other fields and sub-fields of endeavor. Test Bed for Cost Training Effectiveness requires additional definitive work in optimization for training device cost and effectiveness prior to data base development.

This analysis will change as research programs mature and requirements change.

7. SPECIFIC PROGRAM RECOMMENDATIONS

To be provided in future submittal.

1100 ENGAGEMENT SIMULATION AND INSTRUMENTATION TECHNOLOGY

Background

Training has traditionally been performed using both operational equipment and training devices. An important issue of the mix of using operational equipment and training devices is sophistication of the weapon system. Other issues affecting the mix include cost, availability of operational assets, safety, and student population. Although the mix between time on the weapon system and time on the simulator changes due to many factors, the key point is that for the vast majority of situations, training will occur on both.

Nothing can replace the value added to a soldier by training him on the actual equipment in the field. However, several issues limit this kind of training. Range space to conduct training exercises is limited. Limitations are also imposed for safety and cost reasons. Logistic concerns with massing large numbers of troops and instructors dictate maximizing the effectiveness of training time in the field. The problem has traditionally been to devise ways to maximize the value of field training.

Trends

As weapon systems have become more sophisticated, the number of areas where exercises can be conducted have diminished. This sophistication has also caused large increases in the amount of information necessary to monitor the training exercise. This data requires efficient means to reduce it to a useful form quickly. Data needs of other agencies also require conversion of large amounts of raw data to user specific information.

Weapon system sophistication has also had other impacts on field level training. On-board sensor systems require simulated targets to exhibit proper spectral characteristics and intelligence to respond to an operational system in a meaningful way. These requirements encompass such diverse areas as displaying targets with the proper thermal characteristics to simulated responses to IFF interrogations by the operational system being used in a training exercise.

Simulation has also had an impact on safety. Systems such as lasers and simulated weapon effects must be designed to prevent accidental injury to the untrained crew member.

The maturing of robotics technology has also had a positive influence on the effectiveness of on field training exercises. This technology is available to be used in situations where safety is questionable or in situations where surrogate vehicles or crew members are required.

Future Directions

Future directions of Engagement will be strongly influenced by necessary development work in multi-spectral target design, robotic system development, and high speed multipurpose data reduction techniques.

Range space will continue to be an increasingly important commodity. Weapon system sophistication will continue to grow. This sophistication will cause an increase in range data requirements and require targets to be presented in new spectral regions. Robotics will increasingly relieve operator workload, operate in hazardous environments, and serve in an opposing force mode.

As in other Fields of Endeavor, allied technology developments will also influence the Engagement Simulation Field of Endeavor. Some examples are the use of satellite based position locating systems for field exercises and the use of telemetry systems in training applications.

1110 Pairing Systems

Background

Pairing systems allow training devices and systems based on MILES (Multiple Integrated Laser Engagement System) to pair the shooter with the target hit-- i.e. to determine "who shoot whom."

The primary engineering issues in this technical area relate to Indirect Fire Simulation and Shooting through Obscuration (STOM). This second issue includes the topics of Obscurant Technology and Miles Enhancement/Through Obscurants.

The primary training issue relates to utilizing the value of the pairing capability in providing training feedback.

Present and planned Combat Training Centers (CTC) require means to realistically simulate paired force-on-force engagements. Present systems have evolved from umpired war games. The use of laser technology to simulate direct fire weapons has resulted in MILES that supports realistic force-on-force training.

While MILES uses modern electronics to achieve a substantial improvement over the old refereed training engagements, MILES lacks realism in many areas. These areas include the ability to shoot through obscuration, and the ability to simulate indirect fire.

Trends

One training system currently using pairing is the Precision Range Integrated Maneuver Exercise (PRIME) system as implemented at Ft. Hood, Texas. PRIME is the core of a MILES-based training system which is proving highly effective in force-on-force training. Data gathered from the PRIME system is paired to identify who shot whom, including identifying incidents of fratricide. The PRIME system identifies via its pairing capability the non-contributing crews, as well as the "killer" tanks and Bradleys, of the platoon.

Current production and research and development is targeted to enhance the realism of pairing systems. For the primary issue of Indirect Fire Simulation, this includes:

- . Simulated Wide Area Weapons Effects (SAWE) devices.
Several types of devices are planned for R&D:
 - . Mine Effects Simulator (MES) R&D begun in 1988
 - . Nuclear, Biological and Chemical I/II (NBC I-II),
R&D scheduled to begin mid-1989
 - . Radio Frequency (RF), R&D to begin 1990.

- . Air Ground Engagement System/Air Defense I, II (AGES/AD I-II) which is now in production.

Realistic inclusion of obscurants in force-on-force engagements to achieve the goal of STOM involves two areas:

- . Obscurant technology: Are existing smoke sources compatible with pairing systems?
- . Enhancements to the MILES systems to make it compatible with existing/new obscurant technologies.

Future Directions

The common thread that runs through all pairing systems is the ability of these systems to accurately assess casualties in real time. This provides opposing force commanders and their troops with real time determination of their individual and unit fighting skills.

In addition to the ongoing research areas noted above, the following are important directions for future research:

- . Weapons Effects Signatures
- . Military Operations in Urban Terrain (MOUT)
- . Future GEN engagement systems
- . Effective use of pairing data in After Action Reviews (AARs).

It is essential to improve the capabilities of pairing systems in order to effectively train for the confusion and chaos of the real battlefield.

1120 Range Instrumentation

Background

The range is an essential part of weapons training. From a simple paper target holder to the most sophisticated automated target, the goal is the same: to evaluate the performance of the weapon operator and to provide effective training feedback.

The major issues facing range instrumentation are: (1) Next Generation Training Instrumentation, (2) Automated Scoring Systems, (3) Manned Vehicle Technology, and (4) System Concept for OPFOR Augmentation.

Trends

A major trend in instrumentation development is the development of automated scoring systems that provide information not only on hit/miss, but also quantify the location of this miss. This additional information maximizes the effectiveness of range training time.

Planned R&D includes the Location of Miss and Hit (LOMAH). This is a device to provide downrange feedback of projectile location during marksmanship and gunnery training. Weapons usable with the LOMAH include the M16 rifle, the M60 machine gun, M240 machine gun, M231 firing port weapon, and M249 squad automatic weapon. The LOMAH will be designed to be compatible with present and planned marksmanship and gunnery ranges.

Another instrumentation system under development is the Armor Integrated Thermal Signature Target (AITST). In addition to the thermal target component, AITST consists of a scoring subsystem for use on live/laser fire ranges worldwide. This scoring subsystem provides adequate scoring of rounds fires from small arms through vehicle/aviation weapon systems. Scoring system will indicate target hit/miss, near misses, and round location/discrimination.

The Precision Range Integrated Maneuver Exercise (PRIME) system represents a major breakthrough in range instrumentation. It is proving highly effective in force-on-force training. The system consists of three subsystems-- target subsystem, vehicle subsystem, and computer subsystem for range control.

The PRIME computer subsystem includes the range command and control computer (CCC) which provides the operator with the interface to control and monitor the complete system. All commands are entered at the computer console and are automatically fed to the appropriate interface.

Data is transferred to and from the tower, and target and vehicle subsystems over a radio network. Targetry and vehicle PRIME transceivers have a duplex control and data link. Vehicles and targets operate on separate frequencies and each vehicle and

target is polled to collect event data. Although targets are generally line-of-sight to the control antenna, vehicles can continue to function in electronic dead spaces because each system records all data events and transmits this data when polled by the CCC.

Position location is determined using LORAN. The locations are used subsequently by the event driven scenario system to control presentation of targets as vehicles advance into the target presentation area. Bit maps have been made for each target that show points of intervisibility. Consequently, if a target and vehicle are not visible to each other, both engagements and shootback are blocked automatically. This event-driven target capability is one of the keys to PRIME's training effectiveness as it allows free play advance of vehicles.

The target subsystem is controlled through an interface to the lift mechanism. The LTID responds to the MILES codes from the vehicle firing system and initiates the MILES "Monte Carlo" routines to generate hit or kill signals. If a target is hit but not killed, the target remains upright -- duplicating real combat situations in which an enemy tank usually must receive multiple hits to be put out of action.

The PRIME LTID has an event recording capability that transfers data relating to the target to the CCC in the tower. Although the primary method of data transfer is over the various control networks, the LTID and Console record and store all events in on-board memory. In the event that a radio or the network fails, the exercise can continue using this backup capability. Thus scoring and analysis for evaluation of training performance can still be accomplished, just not as quickly.

Future Directions

Automated Opposing Forces (OPFOR) systems will be an important part of large scale maneuver simulation as well as more specialized training scenarios, such as command and control training. It is essential that future range instrumentation make provision for integration with automated OPFOR.

Range instrumentations need to be designed for compatibility with both live-fire and with simulated gunnery, such as MILES, to insure maximum training transfer. The PRIME system exemplifies this compatibility.

The use of the SIMNET system in training for the Canadian Armor Trophy (CAT) shows the potentially close connection between training on simulators and training on ranges. The training effectiveness of range exercises could be maximized by first training on a simulation of the range. Also, data recorded by instrument systems could be used as input to a simulator, so that the simulator becomes a display device for after action review (AAR).

1130 Targets

Background

Targets have been used as an aid for live ammunition training. As weapons and weapon systems have become more sophisticated, target sophistication has also increased. Target systems now move on railed systems, provide thermal imagery to selected sensors, and are left in natural environments for extended periods of time.

Trends

Advanced sensor systems and materials technologies have had the strongest influences on target technology. In the area of advanced sensor systems, continual improvements in infrared (IR) technology require that IR signatures accurately portray the target vehicle. Advances in materials technology have also benefited targets technology. Exposure to the natural elements has required durability in materials and electrical components. In addition, sustainment of electrical power in a field situation has been a trend that has continued to increase with time. These requirements have influenced the development of more durable and cost effective equipments.

Future Directions

Multi spectral and sensor fused sensors will affect the technology base in targets. These developments will require targets able to provide electromagnetic emissions over a broad spectral region. Current systems provide imagery over a single or limited spectral band. Robotic technology advances will also influence target systems. Advances in both the intelligence and cost per production unit of robotic systems will allow for their incorporation into target systems. These systems will provide for enhanced tactical movement and response to fire.

1140 Robotics

Background

The field of robotics is central to many different training technologies. Robotics is needed for implementation of drone targets, remote control targets, and realistic automated opposing forces (OPFOR) in field training.

The major categories of the robotics field are: Artificial Intelligence (AI)/Robotics, and Computer Simulation.

Within AI/Robotics, the major issues are Unmanned Vehicle Technology, Manned Vehicle Technology, and System Concept for OPFOR Augmentation.

Within Computer Simulation, the major issues are automated OPFOR, and role player assistant.

Trends

Robotic mechanisms are involved in several areas of training. General advances in robotics involving control algorithms, and actuator and mechanism design are not directly sponsored as part of training research.

The simulation analog of robotics appears in many training systems. Here no physical robot or automaton is involved, but is instead simulated with a computer. The simulated automaton then interacts with the trainee(s) through the simulated environment within the computer system. Problems of mechanism do not occur with simulations, but the problems of control algorithms remain. New problems related to articulation of animated objects arise.

Future Directions

For physical robots and automatons, most advances in the art and science of control algorithms, and actuators and mechanisms occur outside the simulation and training field. It is important to monitor these advances so that new technologies can be rapidly applied to simulation and training applications.

A few technologies are unique to simulation and training, and it is important that they be developed. For example, humanoid robots have applications in training devices such as Shoot Don't Shoot, but have little application in industry. Likewise, autonomous vehicles that are able to mimic Russian vehicle characteristics have little use outside of training.

Within the computer simulation field, many problems are shared with the video and film entertainment industries. Generating

realistic simulated figures and vehicles involves the problems of coordinating many moving and articulated parts. Developments in the computer animation area should be monitored.

Background

The areas dealing with designs to optimize a trainee's involvement and interaction with a simulated environment underlie this Field of Endeavor. Means to capitalize from separate development efforts need to become transportable and exportable to other systems. In addition, the ability to create systems with adequate fidelity within fixed time and cost as a constraint need to be developed.

The primary requirement that influences this Field of Endeavor is readiness of the soldier(s). Readiness is required at several levels. At the individual level readiness requires not only realistic training environments, but also the ability to develop, field, and upgrade training systems faster than current systems are developed, etc. The trend to have concurrency of the training system development with the weapon system development and modifications also influences this Field of Endeavor.

This technology is also influenced by readiness at higher than an individual level. Battles are fought and won by teams of individuals. Although the individual is the fundamental unit, coordination among individuals and between teams is critical to the success of any large effort to include war. The need to train large teams in inter-system/inter-crew tactics has long been recognized as necessary, but the technology to support large scale training device exercises is just beginning to emerge.

Trends

Modular and reusable designs are primary trends. In addition, the ability to look at allied technologies and their impact on training and simulation is becoming increasingly important. Several factors that influence these trends will be described, not necessarily in order of importance. The first factor influencing the trend to modular and reusable designs is cost. Cost is an increasingly important factor in both the government and private sectors. Reusable and modular design aids a contractor's competitive advantage. These same designs can also create additional cost efficiencies for the government if they can be extended across contractors and training devices.

The second factor influencing the trend toward modularity and reusability is maximizing the utility of training assets. This factor covers a very broad spectrum which can range from new more effective visual systems to new computerized algorithms for battle simulation.

The third factor influencing these trends is commonality. In order to achieve large scale simulations on a group level and

enhanced readiness on an individual level, designs must employ common units and standardized interfacing techniques. Changes must be implementable in a rapid fashion as operational equipment changes and as mission requirements change.

Future Directions

Work in this Field of Endeavor is focused on simulator bus technology, modular design standards, and visual simulation. In the area of simulator bus technology, standard simulator bus structures must be developed on two levels: intra-system and inter-system. At the intra-system level, continued research is required in order to develop standard bus structures to interconnect functional subsystems of training devices (both hardware and software as appropriate). Current work is centered in flight training, but needs to be extended to other training devices and subsystems where stimulated components are required. At the inter-system level, continued research is necessary in techniques to interconnect both large numbers of homogeneous devices and techniques to connect non-homogeneous devices.

Modular designs standards which permit development of components that can be exported to other devices and adapted to future systems require continued development. Visual Systems require continued development in all areas (i.e., data bases, image generators, and display technology). The primary thrust pertinent to this Field of Endeavor is continued research in visual technology in order to establish a mission rehearsal capability in the context of networked training devices.

1210 Simulation Networking

Background

The networking of simulation training systems departs from traditional use of a computer network whose purpose is to allow the sharing of computer resources among multiple computers. In the application of the networking of simulators, the network is used almost exclusively for communication of process states between vehicles engaged in the training exercise.

Simulation networks have made it possible for crews to train force-on-force in real-time simulated battle situations. In this free-play world, there is no instructor to set rules or generate scenarios. Although these networks provide enhanced training, the disadvantage arises when attempts are made to apply traditional techniques of performance evaluation. The complexities and dynamics of team performance present difficult problems in constructing appropriate instructional scenarios. These problems need systematic, validated and concerted design approaches.

There are many inherent limitations to using networks in this application. For example, as the number of simulators on the network and workload per simulator increases, there will be a deterioration in the throughput of the network and degradation of other performance measures. If throughput delays become significant, the effectiveness of real-time training simulation may be compromised due to response requirements which are time-critical in the simulation of true-to-life training scenarios. Depending on communication protocols, there may be an increase in the frequency of retransmissions and lost or distorted messages on the network. The magnitude of this problem is related to how well data is distributed throughout the networked simulation system, and the soundness of the network access and internal network protocols.

Trends

Mechanisms for providing feedback and performance evaluation/measurements for team training are now being developed. Much of this work centers on the behavior of teams as they become proficient in training together for electronic warfare. There are significant differences in the maturation of team behaviors between highly capable teams and teams which are merely competent. These demonstrated differences need to be taken into account in designing team training strategies.

Networking of different types of simulators is becoming an accomplished fact, requiring a standardization of simulation network interfaces and protocols. Currently, simulation networking standards do not exist. Of the networked simulation systems which do exist, standardization of these networks is being accomplished haphazardly.

Future Directions

The issue of crew turnover is one which is important for both Army and Navy training. Team training research of the future will need to take this into account by: (1) providing a surrogate missing team member using such technologies as expert systems and interactive voice, and (2) providing measures of performance and appropriate feedback to trainees.

Simulation networking and protocol standards will be further developed both on the intra-system and inter-system level. At the intra-system level, research is required to develop networking standards to interconnect functional subsystems of training devices. At the inter-system level, research is required to establish techniques for interconnecting large numbers of both similar and dissimilar training devices.

1220 Battlefield Simulations

Background

The modeling and simulation of the complexity of chaos of the battlefield environment is required for unit commanders and staff to maintain and enhance their knowledge and capability to perform their command-related functions. Various techniques have been used for battlefield simulation, and the two major issues involved in this field are force-on-force models and simulation models.

Force-on-force models are the traditional basis for battlefield modeling. Force-on-force training battle simulations are efficient and powerful vehicles for commanders to learn and practice the operational art and tactics of Air Land Battle (ALB) doctrine. These models are also useful for the staff (G-2, G-3 etc.) to learn and practice their respective functions, both individually and as an integrated team. Limitations in this approach occur due to the use of simple firepower scores to determine the result of engagements via historically based tables. These tables are minimally dependent on tactics or synchronization, and cannot objectively reflect the impact of new weapons systems.

Simulation models incorporate many more variables, often in the form of explicit role-players. Major issues are: (a) model optimization, (b) expert systems for controllers, (c) portability of software, and (d) networking of simulations.

Trends

There is currently a gap between the battle simulation models being developed for analysis purposes and those used in training. There is currently a trend toward updating the models used in programs such as First Battle, CAMMS and USAEUR McLintock Theater Model (MTM), which are used at WPC.

The Combined Arms Training Activity (CATA) is responsible for a near-term program to replace the following with First Battle: Battalion through Corps (B-C), ARTBASS, Battalion Automated Battle Simulation (BABAS), and Joint Exercise Support System (JESS). Improvements to the USAEUR MTM are also included in the near term program.

The CATA is also responsible for a long-term development program to replace the current and near-term generation models with Brigade Simulation (BDESIM), Division Simulation (DIVSIM), and Corps Simulation (CORSIM).

Future Directions

Battle simulation software is currently a cottage industry, with battle simulation software being developed independently for each

program or project. The development of software must be more disciplined, using modular structure, a common interface, a common language, and good documentations and management of the overall configuration.

The development of AI or expert based battle simulation components is very important. Maximum realism is obtained only through use of large number of human controllers; this limits the amount of battle simulation training practical. The use of AI and expert systems would reduce the manpower requirement, making more frequent training practical.

1230 Modular Design Standards

Background

Simulators continue to be required to replicate complex systems and events in order to achieve proper training. These complex simulations have caused training devices to become unwieldy due to the required hardware and software. For example, current full mission training devices are hosted on multiple processors and can have in excess of one million lines of higher order language lines of code. Traditional training system designs have suffered under such a requirements load.

Military standards (e.g., MIL-STD-2167) have forced some degree of modularity into software design. In addition, specialized training systems requirements have led to a limited degree of modularity (e.g., DRLMS and CIG systems). True modularity allows systems and subsystems to be developed, repaired, upgraded, and replaced without excessive downtime or catastrophic failure when a component is removed. This kind of modularity requires a systems level approach in order to allow proper treatment of both software and hardware. The development of modular designs for simulators requires a structured systems engineering approach in order to achieve satisfactory results.

Trends

Specialized requirements continue to force design modularity for selected training device subsystems. In addition, as small companies enter the training device market with specialized products, interfaces are developed enhancing modularity. However, modularity has proceeded in a sporadic and nonuniform manner. Standardization has occurred by market presence, not necessarily based on sound engineering principles.

Systems engineering principles of training device modularity have begun to be applied on specific classes of trainers for specific customers. Some examples of this are the Modular Simulator Program for the Air Force, and SIMNET, ultimately being developed for the Army.

Future Directions

Standardized bus structures are the key to future directions in modular design standards. The Air Force Modular Simulator Program is making progress in defining a standardized bus structure for flight trainers. Future research programs will seek to extend this technology to other types of training devices. This technology thrust will be strongly influenced by embedded training technology. Compatibility with operational systems and attendant bus structure(s) will be the primary influence. Modular designs will also occur within subsystems that are

extendable to other subsystems. Secondary influences include mainly hardware issues such as reusable board designs, power compatibility, and logistic considerations (such as common parts to reduce spares inventory).

Secondary influences from the operational world and cost will influence this area of modularity. These secondary influences must be considered early in the design process by the procuring agency in order to structure cost, reliability, maintainability, and logistic considerations prior to contracting.

1240 Standard, Reusable, Rapidly Reconfigurable Data Bases

Background

Data bases for visual systems have traditionally used many data sources, such as Defense Mapping Agency digital data, maps, and photographs for input data. These data bases have required a large amount of human intervention in order to arrive at satisfactory results. However, human intervention produces two adverse side effects: increased possibility for error, and increased development time when compared to the ability of the computer to perform the same task. The need is increasing for data bases that can be developed rapidly to aid in mission rehearsal requirements, and can be used by more than one visual system.

Trends

Project 2851 is attempting to develop common data base standards and a common structure which all CIG manufacturers can use as a source and repository for CIG data bases. This program has met with a certain amount of resistance from CIG manufacturers due to proprietary software each vendor has to use to convert terrain data into a usable CIG data base.

Mission rehearsal is an emerging requirement having an impact on data base development. The mission rehearsal requirement broadly requires a rapid turnaround in data base development and update with source data from a potentially large number of sources. This requirement is a significant addition to data base standardization efforts. This trend toward standardization has been emerging for a number of years, not only due to the mission rehearsal requirement, but due to basic issues stated in the Background section, above. Time and error rates are directly related to cost. Cost effectiveness can be enhanced if data base development times and error rates in data bases are reduced.

Future Directions

To be successful, standard CIG data bases will have to satisfy old systems and accommodate new technologies. This approach will allow old systems to be supported and enhanced, while allowing new approaches to take advantage of enhancements in data base generation methodology. In addition, the breadth of data sources will need to be continually expanded in order for data base development to become more cost effective. Rapidly Reconfigurable Data Bases (RRDBs) will need to gather additional substance regarding quantification of performance in order for engineering solutions to be developed. Research will provide the quantification and a further understanding into RRDB approaches and bottlenecks.

2100 LOW COTS/COMPLEXITY SIMULATION TECHNOLOGY

Background

Traditional approaches to simulation test beds for research have been to build full fidelity systems and then degrade system performance to look at lower cost and/or complexity components. An alternate approach has been to append low cost components onto full fidelity systems to evaluate performance and utility. While these approaches provide isolated cases of performance and utility, they often do not consider low cost and/or complexity simulations within the total training system concept or as alternatives to higher complexity solutions.

Trends

Increased component capabilities have enhanced the ability of simulation to provide more performance per unit cost and package that enhanced capability into smaller packages. In addition, the simulation community is now considering allied technology development in graphics systems, image processing, and computer hardware to develop more cost/effective training devices.

These new technological developments have for the most part used common hardware components with unique software application programs to increase the performance to cost ratio. The presentation of information to the trainee has been affected by these new components. Graphic displays now convey information to trainees instead of actual instruments. Modular designs allow reconfiguration of a trainee station from one vehicle type to another. Lower cost units are able to perform what was once only performed by high cost simulations. In addition, the impact of modular designs on operational equipment development and embedded training methods is just beginning to be exploited.

Future Directions

New products will continue to be developed that can be applied to simulation and training devices. As these products are developed, their applicability to specific training situations must be determined. Test beds are required to make these determinations.

It will be necessary for these test beds to be modular and reconfigurable in order to evaluate new technologies. While full fidelity test beds will always be necessary, low complexity test beds need to be developed to evaluate new products applicable to low cost/complexity training applications.

This is particularly necessary in the immediate future because a large amount of products are being developed for the low cost simulation market place. These low cost products require evaluation and development in a bottoms up fashion; this is typical of most product developments. Most products are developed and introduced into the market place with the goal of

growth in both capability and performance. Test beds must be developed to evaluate these products in a similar manner. In this way, a full range of evaluations can occur over a product's life cycle.

2110 Novel Techniques for Low Fidelity Training Devices

Background

Development of novel and low cost, low fidelity simulation techniques is of particular concern to the Department of Defense according to a report issued by the Defense Science Board in 1982. These devices take advantage of inexpensive microcomputers (including those which are portable) and relatively new technological developments such as interactive videodisc, CD ROM, and interactive voice technology. Timesharing of a single processor among several trainees is another approach particularly applicable to simulation which is predominantly information flow rather than equipment operation.

Another approach is the use of mixed-media simulations, such as interactive simulation presented via a combination of a microcomputer and a paper mockup of the equipment being simulated. This approach has been successfully tested for two applications: (1) training of procedures prior to using expensive simulators which are in great demand, and (2) as a stand alone training device for training maintenance and cognitive skills.

The approaches described above for improving simulation technology reflect a general desire to increase effectiveness while at the same time minimizing costs. The demonstrated effectiveness of some of these low fidelity simulation approaches for training raises questions about how much fidelity is required in various applications, and in what ways is it desirable to depart from physical fidelity to achieve the intended training purpose. Answers to these questions may come from a consideration of the behavioral aspects of simulation.

Trends

There is a trend toward low cost, portable devices made possible by new low-cost microcomputer technology, interactive videodisc, and paperless technical manuals. The more capable microcomputers can now host such applications as Artificial Intelligence-based training, which until recently required a mini- or mainframe computer.

The training value of inexpensive, portable microcomputers has been demonstrated for several applications. These include a number of innovative devices developed by the Army Research Institute including: the Personal Electronic Aid for Maintenance (PEAM), the Computerized Hand-held Instructional Prototype (CHIP), and the TopGun device, an arcade gunnery trainer developed by DARPA for the Army.

Interactive simulation, in which a trainee can interact with a computer or interactive videodisc, is showing considerable promise to replace more expensive training devices for the training of procedures.

Future Directions

These trends will be continued into the future. Continued development of technology in support of the Computer Aided Logistics Support (CALS) initiative, and particularly paperless technical manuals, is requiring R&D which will prove useful for low cost, low fidelity simulation and training applications.

Expert systems, in combination with powerful microcomputers, interactive videodisc and other delivery techniques, will increasingly be useful. Natural language and interactive voice interfaces should prove practical in the long term.

Mixed-media training, involving both paper-based and computer-delivered information, will continue to be developed.

Interactive simulation will become more common as authoring systems are developed which allow for less expensive production of courseware.

2120 Test Bed for Cost/Training Effectiveness Evaluations

Background

At a time when DoD budget cuts seem inevitable, and increased military readiness is the goal, cost/training effectiveness models are essential for decision makers and training developers. Proper use of these aids can help in controlling costs of training systems and devices and their use in programs of instruction.

The objective of a training and cost effectiveness test bed is to conduct research that produces data that identifies the technology and cost factors for every task/subtask. This data must be identified in order to develop a training technology data base that is meaningful for PM TRADE.

Examples of cost/benefit and economic analysis techniques which should be considered in the development of this test bed include: (1) the Optimization of Simulation-based Training Systems model (OSBATS); (2) Automated Simulator Test and Assessment Routine (ASTAR), (3) Training Effectiveness, Cost Effectiveness Program (TECEP), (4) the Orlansky and String model developed by the Institute for Defense Analysis, and (5) economic analysis tools used by various training development agencies in the DoD.

Baseline cost estimation of Army training systems tends to be fairly costly and time-consuming. Guidelines would be very helpful for both government and contractor personnel in preliminary costing of systems.

Measurement of training is necessary to provide: (1) feedback to trainers and training designers, (2) quantitative assessment of the value of training in contributing to unit readiness, and (3) "return on investment" information to senior Army managers to guide expenditure of Army training resources. If measurement techniques are to be effective, this requires specification of what to train, how to train, and what to measure.

Trends

IST under contract to PM TRADE is concentrating efforts in this technical area in the gunnery and armor training domains, working with such training devices as SIMNET, VIGS, TopGun and UCOFT and with ASTAR and OSBATS.

An initiative is underway to make ASTAR a standard for determining the training effectiveness of alternate training system configurations during concept formulation. While ASTAR doesn't produce detailed guidance to the training developer (which OSBATS does), it is well developed and doesn't require extensive data bases.

Several other trends exist:

- . Cost models and cost-effectiveness decision aids are used without standardization.
- . Available cost data are fragmentary, too highly aggregated and not always comparable.
- . No standardized methodology for the analysis of training costs has been developed, nor have cost data been acquired in accordance with a standard set of conditions.

The use of such decision aids as ASTAR and OSBATS should introduce standardization in training and cost-effectiveness analysis, and improve the concept formulation process.

Future Directions

As the training system acquisition process becomes shorter, automated aids for training system design, such as ASTAR and OSBATS, will be more frequently used.

To meet this goal, development of a test bed in support of the following should be pursued:

- . Development of a taxonomy of training device categories, categories, features, associated fidelity, costs and training effectiveness, tasks, etc. appropriate for organizing data bases.
- . Development of techniques to improve the gathering of data of the types listed above.
- . Assessment of the ease of use and acceptance by training system designers of automated design aids for the training system developer, such as OSBATS and ASTAR.
- . Empirical validation of such design aids as OSBATS and ASTAR.

2130.0 Generic Reconfigurable Designs

Background

The design of complex weapon systems has had the inherent problem that the validity of design concepts could not be assessed efficiently. Either the time required to evaluate design alternatives was too long to meet schedules or the resources to dynamically evaluate design solutions were not available until late in the design process. Identification of problems at this stage are costly to fix, resulting in make do fixes which compromise system performance. Furthermore, most complex systems undergo numerous updates and modifications during their life time, making assessment difficult.

The advent of recent technological advances in the area of computers, computer graphics, software, and hardware have begun to offer tools to address these design deficiencies. These rapid prototyping tools permit panels and equipment configurations to be simulated on high resolution displays utilizing touch panel overlays to simulate hardware switches. Advances in software programming for rapid prototyping permit simulated configurations to be rapidly developed or reconfigured. Rather than months to program displays and simulated panels, these rapid prototyping software tools require only days to develop total configurations of complex systems.

In addition, the time to reconfigure the design to reflect design alternatives or changes is reduced from weeks to days or even hours. Simple changes may be implemented in only minutes. Rapid prototyping tools have made the dynamic evaluation of design alternatives responsive to the overall design process, significantly reducing total system development cost and time. System performance is improved by identifying design deficiencies early in the design process while they can be corrected effectively.

Trends

As training systems become more complex and more integrated with the weapon system development process, it will be necessary to rapidly reflect system design changes in the training system design. Furthermore, future weapon systems are likely to have more mission tailored variations and individual tailoring as a result of the introduction of intelligent aiding systems. These trends will require training systems to be rapidly reconfigured.

Future Directions

Advanced rapid prototyping tools that have been developed to enhance the weapon system design process have the potential to significantly enhance the training system design as well. Rapid prototyping tools could be used to enhance training research

by providing a flexible test bed for evaluation of innovative ideas. Training system development would be enhanced through a quicker response to design changes and simulation within the system context. Training system maintenance would be improved through easier updates for design changes and tailoring for mission and individual variations.

In addition, rapid prototyping tools can improve the application of training work stations to multiple systems via their inherent rapid reconfigurability. The application and requirements for rapid prototyping tools have not been adequately assessed within the training environment.

Other trends in the area of generic reconfigurable designs that will become more refined in the future are:

1. The rapidly reconfigurable prototyping environment will be able to efficiently self-generate system compatible code eliminating the need to recode programs for actual applications. This will greatly enhance the development of embedded training materials.
2. The rapid prototyping tools will become more user friendly and more sophisticated, permitting ISD personnel to directly develop, test and refine designs on line. These tools will significantly reduce development time and cost, while providing a better evaluation environment.

2200 VISUAL SIMULATION TECHNOLOGY

Background

Visual simulation represents one of the largest cost drivers in operator simulation technology. Visual cues are critical in high fidelity operator oriented training systems. As tactical training requirements have increased, the need to accurately portray the ground for mission planning, concealment, etc. has become more stringent. In addition, multi-sensor/multi-spectral systems have required visual simulation systems to include radar and other electro-optical sensors to display correlated scenes. The need for improvements in scene content, display features (e.g., resolution), and field of view are increasing due to growing user requirements. Although training effectiveness is the stated goal, increased scene realism is the priority of most visual simulation system developments.

Trends

Photo based scene generation is one of the more recent trends in visual simulation technology. This technology originally sought to apply photographic quality texture to polygonal based image generators. This trend has continued and is now seeking to use actual photographs to create scenes the trainee can interact with which are not polygonal based.

Another trend is the use of standard data bases for visual simulation system developments. This trend is attempting to cross several spectral ranges. The multi-spectral aspects of standard data base developments represent an exciting area just emerging. The most significant trend in data base development is the continuing requirement for rapid data base development to support mission rehearsal. Data base contents should be sufficient to support tactical training.

Display technology continues to lag other visual simulation developments. Wide field of view requirements are still only met using domes; while domes provide adequate field of view, they have poor resolution, brightness, and contrast. Area of Interest Displays have alleviated some of these shortcomings at the expense of complex mechanical and optical systems.

Future Directions

One of the most significant directions in operational system development which will impact visual simulation technology is sensor system development. Although the need for out of the window scenes will be a necessity in the foreseeable future, closed crew stations and reliance on sensor signals are becoming increasingly important. This trend will drive enhancements in scene content within limited view fields. The view fields will be slewable. Slewable view fields will also drive technology in the area of interest display area for out of cockpit viewing.

Newer devices will be developed which will have higher speed than current systems and will exhibit ergonomical design features that are not implemented in current head and eye tracked display systems. Data base development will continue to warrant the expenditure of research effort. The major thrusts will be oriented to techniques for rapid data base generation for mission rehearsal, common data base generation techniques which are extendible to non-CIG technologies, and development of multi-spectral correlated data bases where a single data base structure can be used for multiple spectral ranges.

Image generation technology will continue to advance on two fronts: the low end system developments and high performance system developments. Extending graphic systems technology into the CIG arena will continue. Development in harnessing and controlling graphic engine performance and directing that power to CIG applications (e.g., fixed frame environments) will continue to be fertile research area. High performance visual system technology will continue to advance to advantage of microprocessor and VHSIC technology. In addition, non-traditional methods of image generation will be prototyped for evaluation.

2210 Visual Presentation Technologies

Background

The first flight simulators were purely instrument trainers; there were no out-the-window views. Visual simulation was added to later simulators through the use of model boards and a camera pick up whose path simulated the vehicle dynamics. The most recent generation of simulators has used specially developed Computer Image Generation (CIG) hardware to electronically generate the out-the-window view from a digital database. The approach permits a larger training flight area that can also be changed rapidly.

As CIG costs decrease, similar visual presentation technologies can be used to animate classroom presentations, such as simulated gaming boards and other visually oriented training activities.

The two major issues in the field of visual simulation technology are Computer Image Generator (CIG) architecture and visual display hardware.

Trends

Present CIG architectures were formulated when random access memory (RAM) was a scarce and expensive resource. As a result, the algorithms used by the CIG hardware for hidden surface removal were limited to techniques that require minimal memory, such as depth sorting. These algorithms impose additional computational load because the polygons in the data base must be pre-sorted before display. CIGs from Evans and Sutherland GE are examples.

The current trend is toward use of simpler algorithms such as the z-buffer technique, which trade additional memory for simpler computation. Modern memory technology makes the large memory arrays needed by these techniques practical. Examples are the BBN CIGs used in SIMNET, and the GI 10000 by Sogitec.

An additional trend is to include hardware for texture generation. Visual cues provided a shaded polygonal rendering of the data base are insufficient for low-level flight. The solution has been to provide special hardware to shade the polygons with a texture pattern. A current trend is to use texture patterns derived from photographic sources to provide maximum realism.

The development of work stations incorporating special purpose hardware for graphics is another trend. The performance of these work stations (exemplified by the Sun/TAAC combination, the Silicon Graphics and the Stellar machines) equals that of older special purpose CIGs. Much research is being devoted to evaluating the capability of these work stations as CIGs.

An additional trend is toward the use of systems that allow the perception of a hemispheric image, but do not require the CIG bandwidth of traditional multi channel solutions. Examples include the use of helmet mounted projectors together with eye trackers to location the pilot's fixation point. A single CIG channel can then display a hemispherical image whose resolution matches that of the eye across the field of view.

Display hardware requirements are now best met by light-valve projectors. CRTs and CRT-based projectors do not have the size or brightness required of a full fidelity simulator. Research is being funded by the Naval Training Systems Center (NTSC) to investigate the use of single crystal phosphors to produce high brightness CRTs that may offer lower cost alternatives to light valves.

Future Directions

As noted, the performance of general purpose graphics work stations is approaching that of special purpose CIGs. This trend is spearheaded by the emergence of the graphics super computer. As a result of the increased market for graphics hardware caused by the proliferation of graphics work stations, the price of high-speed graphics should fall dramatically. This will lead to improved performance/cost tradeoffs for simulators. Mass production offers the best chance of reducing costs while maintaining training capability.

Problems relating to use of work station type hardware as CIGs relate to the need for synchronization in a simulator. A new image must be produced for each frame. Work station-type graphics hardware does not generally support a synchronous update rate. Research should be done to identify possible hardware or software upgrades to work station hardware that would enable them to perform as effective low-cost CIGs in simulators.

High Definition Television (HDTV) is now being formulated for the consumer market. HDTV can be expected to result in large low cost CRTs and projection systems. An example is the liquid crystal light valve (LCLV) display recently developed by Kodak. Presently, this low cost LCLV system only supports standard National Television Standards Committee TV resolution, but as HDTV evolves, systems with resolutions useful in simulation can be expected. It is important to watch developments in the general computer and video marketplaces.

2220 Visual Performance

Background

Engineers, human factors scientists and other professionals who design training systems must consider how the physical and functional characteristics of visual imagery relate to cost and training effectiveness. The visual displays of most part-task and full mission simulators are the costliest and most critical component. When a training system designer is asked the question, "how good is a visual system?" it should provoke another question, "good for what training purpose?" The more we can limit and define training requirements and define the tasks to be trained, the more cost-effective the design of the visual system can be. The challenge is to identify the essential scene features and other visual information for a given function or task and determine the characteristics of the visual information that can be provided at the lowest cost.

The technology of visual simulation has advanced rapidly in the last 10 years. The availability of low cost computer image generators (CIGs) is rapidly increasing.

In addition to CIGs developed for the low cost visual market, the architectures for high end systems are moving in the direction of modularity, which will better permit the user to specify only capability needed for a particular training application.

From a requirements standpoint, the training system designer has to specify the level of capability that must be built into the visual system. Several aspects are included in representative requirements: what level of scene detail, what level of fidelity in the visual database, how many moving objects, what additional information can and should be presented to the human operator (augmented cues, target range information), etc.

Given new options, the training system designer must now consider the question, "how much is enough?" In the low end CIG domain, the behavioral question has a somewhat different emphasis, "how little is enough?"

Trends

Low cost visuals are being shown effective, both for fielded training devices, such as SIMNET and COFT and in research programs. For example, the consensus among instructors of the COFT device is that the relatively low fidelity visual system of the device is sufficient for most training applications.

One of the most prominent technical concerns is the improvement of visual scenes for military flight training. For certain applications, greater detail and realism of visual scenes is thought necessary to support such tasks as low-level, high speed

flight, and ground vehicle maneuvering. For low level high speed flight, performance tests have shown that current visual system technology is not sufficient to provide completely adequate distance and altitude cues. For both of these applications, it is thought that greater detail is required, such as ground vegetation and texture.

Another trend is the increasing use of intelligent and adaptive information processing. This is possible through the use of CIG which allows additional cues to be added to a visual display to add to the training effectiveness.

Human information processing capability is becoming a factor in visual presentation (e.g., advanced color coding, pictorial formats, information organization techniques, adaptive displays).

Future Directions

CIG will provide greater detail of natural environments and will allow artificial and augmented information to be added to scenes. Certain cues will be highlighted early in training and will be phased out as the trainee gains proficiency.

The emerging technologies of closed crew stations and reliance on sensor signals for advanced aircraft will cause examination of training techniques with reduced out of cockpit scene content and added artificial cues.

Advances in image generation technology for low end visual systems will cause new training applications, e.g., realistic 2-D interactive simulation for procedural training.

3100 TRAINING ACQUISITION TECHNOLOGY

Background

The question of economic benefit and training effectiveness underlies the acquisition of training devices and simulators. The question, "How much is a pound of training worth?" expresses the main thrust of the problem. This statement emphasizes the value of capital investments made expressly for training as providing more payoff per dollar spent than investments made for war reserve materiel. Also important is the need for meaningful ways of measuring soldier performance (warfighting capability) resulting from training received both at the individual and unit level.

Trends

With increasing sophistication of weapon systems, the cost of traditional methods of training continues to grow. Expensive, full mission, highest fidelity simulators continue to be unable to favorably compete for increasingly scarce investment dollars in weapon system accounts.

Interest in acquiring turn key training continues to grow. This approach shifts the burden for training equipment from investment accounts to operating accounts by requiring the private sector to price the capital investments as part of the service sold for training.

Likewise, growing interest in embedded training has many of the same drivers. The cost for training capability embedded in the weapon system becomes hidden in the weapon system cost. Accompanying this view is the belief that the increased sophistication of emerging weapon systems arising from increased investments in high technology makes embedding training capability a marginal added cost. These views generally do not include consideration of life cycle cost for sustaining training readiness levels, or how to treat elements of training which cannot effectively be accomplished using operational equipment.

Future Directions

Ways to examine the progressive measures of training effectiveness (beginning with individual skills and knowledge and continuing through unit performance measures) are needed. Possible mixes of separate training devices and simulators, operation of actual equipment on ranges and in field exercises (OPTEMPO), and the contributions of embedded training must be considered in each element of the training systems.

Other work in this field is concentrate in two areas. The first area of investigation relates to the exploration of ways to represent relationship of simulator features to cost and training effectiveness to determine how much simulation (fidelity) is enough. The second area relates to the capability to identity

the opportunities and methods for embedding training in weapon systems designs. Examination and development of ways to identify and track the primary functional characteristics of the soldier-system interface is needed.

Background

The primary issue in this technical area relates to the need to simulate large scale training environments such as team training and force-on-force engagements (e.g., with SIMNET). The challenge for training in the next decade is networking combat vehicle simulators to allow low-cost simulation of platoon, company and battalion-level exercises incorporating a representation of the total system -- including the tactical, logistics and communication elements critical to real field operations. Dramatic improvements of training via networked simulation are beginning to support realistic training of these real field operations.

The nature of training devices and simulators is changing as modern weapon systems, and indeed warfighting, are requiring more training for supervisory control functions and less training for psychomotor skills. Operator functions have become more managerial, consisting of monitoring system performance for conformance to plans, assessing situations, choosing among alternatives according to pre-established objectives, and evaluation of events as they occur.

Training devices and simulators have, typically, not been developed within the context of comprehensive training systems. Our devices are not adequately planned as part of a comprehensive training solution to assure cost-effective and responsive training. Many of the current problems being encountered within the Army training community can be traced to improper early requirements definition; within the more complex training requirements, problems can be traced to an inability to take into account true terminal training objectives -- higher order cognitive process skills.

Tools for the early estimation of training requirements are urgently needed. These tools, currently under development, will allow designers to assess the impact of the early training requirements on individual training in the institution and the unit, and collective training in the unit.

Trends

The shift in the function of the operator from a low level system operator and continuous controller to a system supervisor (whose primary functions are monitoring and decision making) will continue. The development of training devices and systems to accommodate this shift, and particularly performance assessment capabilities for networked simulation for training, will continue to receive high priority.

The consideration of training devices as part of the total training system will continue to be emphasized, partly as the result of the need to consider embedded training as a primary

training alternative. More emphasis will be placed on early definition of training requirements within the context of the total training system.

Future Directions

Development of effective performance measurement for team training, and simulation of force-on-force engagements, will improve particularly as it incorporates intelligent diagnostic capability for performance assessment and feedback.

Future developments for assessing workload will result in more efficient training devices, particularly full mission simulators. Some of these developments relate to: (1) operational measures and criteria of overall system effectiveness for representative tasks and operating environments, (2) intelligent diagnosis of performance, first for team training and later for large scale networked simulation for training, and (3) rapid and effective techniques for performance feedback.

Tools for early estimation of training requirements will result in training devices and systems better designed to meet training needs related to the development of warfighting capabilities.

Networking of simulation will become a dominant mode of training.

3120 Optimization of Training Device Cost and Effectiveness

Background

Training Device Cost and Effectiveness must be considered in the use of simulation and training technology. In some cases, the cost of training devices and simulators has exceeded, in some cases, the cost of the operational equipment that they simulate. On the other hand, the behavioral and analytic techniques needed to determine empirically how much simulation and training are enough is lacking. Also lacking is information on the most cost-effective use of training equipment within a course of instruction.

The training device and simulation community has achieved the technological power to simulate training systems with impressive realism. However, this technological strength is offset when the cost and training benefits of alternate approaches, and the training effectiveness of the fielded training systems are not considered. Ideally, design aids for training systems should have the capability for evaluating training alternatives with respect to: (1) desired effectiveness at a minimum cost, and (2) maximum effectiveness at a given cost.

Problems in the training system development process include the following:

1. Training devices and simulators have not been developed within the context of total training systems.
2. Training systems are typically over designed because the question "how much simulation is enough to properly train" is not properly addressed.
3. There has been a lack of proper emphasis on the affordability of training solutions, and the development of long term investment strategies for implementing these solutions.
4. We have generally been unable to conduct hard analyses of training alternatives because we have not properly measured the results of training; yet, despite the cost of training systems, no comprehensive assessment technology or performance assessment program is in place.
5. We have not fully accommodated the distinction between training to operate and training to fight.

Trends

The use of simulators will increase as a function of the economics of training and system design and the need to duplicate situations that are too risky or complex in actual practice.

Newer simulators will be more compact and reliable. Deliberate design decisions will be made to keep simulators current with the designs they represent.

As weapon systems become more sophisticated, the cost of training for their operation and maintenance also continues to grow. The MANPRINT initiative is requiring that manpower, personnel and training requirements of alternative weapon system design concepts be accurately estimated. Early determinations of training requirements and their associated resources are being made with the intent to optimize the design of the total training system. (This process has a long way to go.) As embedded training has taken on prominence as a training alternative, coordination between the training and weapon system development processes has become even more important.

The cost for embedded training can be hidden in the weapon system cost. As weapon systems become more technologically advanced, the cost of adding embedded training becomes a marginal added cost.

Future Directions

Work is required in two areas. First, models and decision aids must be further developed that will help in the process of efficiently examining the costs and effectiveness of training system alternatives early in the system acquisition cycle (e.g., OSBATS and ASTAR). Second, data bases that will allow the functioning of these models are required.

Models like ASTAR and OSBATS have not been fully utilized in the training system development process (in fact, hardly at all) and as a result, the training system design process is not highly automated, does not include sensitivity analyses of tradeoffs, and takes too long.

Future research to counter problems like these includes:

- . assessment of ease of use and acceptance of models (like OSBATS and ASTAR) by various types of training system developers (e.g., human factors specialists, engineers, training analysts).
- . assessment of requirements for application in the formal process of training system acquisition.
- . assessment of requirements for data to run the OSBATS model and the resources required to provide adequate databases.

A functions and task database is necessary to support the conduct of a training requirements analysis. These databases are intended to complement existing databases and are required for the proper functioning of the OSBATS model.

Background

In 1982, the Defense Science Board placed emphasis on embedded training by recognizing that emerging weapon systems with internal microprocessors and computers afford the opportunity for incorporating embedded training and performance measurement. They emphasized that embedded training capability should be considered early in system development and be coordinated with the overall training program for the weapon system.

Embedded training is defined in a 1986 DoD Directive as "training using operational equipment that involves simulating or stimulating equipment performance." This clearly ties the subject to the use of operational equipment. An Army embedded training policy letter issued in March 1987 refined the definition as "training that is provided by capabilities designed to be built into or added into operational systems to enhance and maintain the skill proficiency necessary to operate and maintain that equipment end item." Sustainment training will always be the major factor in determining the need for embedded training.

While the embedded training is often seen as the remedy for many training problems, embedded training adds new problems to weapon system development. Increasing dependence of training capability upon the use of operational equipment causes higher life cycle operating costs and more frequent replacement of equipment. Also, guidelines for adjusting RAM and weight requirements to accommodate embedded training requirements while continuing to meet combat mission requirements have yet to be established.

Successful implementation of embedded training will require two analysis: a top down, systems engineering approach to the definition of training systems at all levels beginning in the earliest concept phases, and the definition and continued tracking of man-machine interfaces as an integral part of the system design process.

There are many diverse objectives to be addressed as the Army and other services move toward implementation of the embedded training policy. The major objectives include: (1) identifying conditions under which embedded training should or should not be included in new or upgraded weapon systems; (2) identifying functions and tasks (by weapon system class) which best lend themselves to embedded training; (3) identifying critical design tradeoffs related to embedded training; (4) organizing current and existing information on embedded training in the form of a data base.

From the standpoint of economic benefit, some decision makers consider embedded training as a way to reduce or limit increasing weapon system costs. This line of reasoning includes

the ideas that the high tech and user friendly man-machine interfaces in new weapon systems can provide the necessary training capability at marginal cost. This would avoid a more expensive investment in stand alone training devices. Generally, the overall life cycle operating costs that might be brought about by such decisions have not been explored.

Trends

In accordance with the system engineering process, candidate embedded training requirements will be increasingly analyzed for implementation feasibility. The following factors will be considered:

- . operational interference
- . availability for training
- . RAM
- . cost-effectiveness
- . performance monitoring
- . graduated skill training (considering level of presentation to match the skill level of individual using embedded training information)
- . parent system changes (considering constraints and costs for upgrading embedded training hardware/software when parent system is upgraded).

As the use of simulation grows, contractors will be required to deliver interactive simulations of the man-machine interface in addition to (or perhaps in place of) paper documentation.

From the viewpoint of the unit commanders, embedded training capability should be a natural and normal element of the equipment and procedures the unit uses to maintain operational readiness to achieve its mission.

Future Directions

The increasing use of simulation in weapon system design will make possible the early functional definition and continued refinement of the man-machine interface using stand alone simulation of each interface. Such simulations will allow early evaluation and verification of functional allocations using projected performance parameters of weapons systems prior to building the first prototypes. Based on findings from these evaluations, functional allocations can be adjusted with resulting changes in the weapon system design parameters.

Likewise, real time man-in-the-loop simulations will play an increasing role in weapon system design, including embedded

training. As computer hardware and software processing capabilities grow, the distinction between non-real time engineering design simulations and real time man-in-the-loop training simulators will become blurred.

In many cases, these activities will converge into a full mission simulator prior to building first hard prototypes. Even when full mission simulators are not developed, the same early simulations will provide the foundation for the synchronous development of the weapon system, training system and embedded training capability

Technologies that will become increasingly important include:

- . authoring systems for inexpensive production of embedded training information
- . standard interface of embedded training software with that of the weapon systems platform
- . user-computer interface devices, techniques and protocols
- . computer display technologies
- . high capacity storage media for embedded training information, such as CD-ROM
- . performance measurement and assessment technologies for determining the need for sustainment training in the field using embedded training
- . training assistance technologies (automated intelligent target control, specialized feedback displays, adaptive learning techniques, and missing team member simulation).

3140 Training Cost Effectiveness Relationships Data Bases

Background

Cost and training effectiveness must be taken into account when considering the utility of simulation and training technology. Cost and training effectiveness measures need to be developed/modified and validated for use in this context, particularly as they relate to fidelity. The question, "how much is a pound of training worth?" deserves an empirical answer. Training and cost effectiveness data bases must contain such variables as: (1) the degree of simulator fidelity required to produce a corresponding degree of training effectiveness/transfer to the operational vehicle, (2) measures of performance, (3) cost measures which are easily used for cost estimation during concept formulation.

Although the Army has been training individuals and units to wage war for many years, recent requirements for deep maneuver and synchronization of activities across functional areas is requiring that units, commanders and staff perform with more stringent requirements on timing, accuracy, etc. The degree to which such performance is enhanced by training and the related readiness of units to conduct missions successfully must be measured and recorded in appropriate data bases.

Trends

Several trends are having a profound effect on Army training:

- . Tank training cost per round has risen dramatically particularly with the introduction of the 120mm round for the M1 Tank.
- . OPTEMPO costs have risen dramatically.
- . Constraints on maneuver and firing have been brought about by these and other factors.
- . Embedded training is emerging as a building block of the Army's training strategy of the future.
- . Combat Training Centers such as the National Training Center at Ft. Irwin, California are allowing a degree of realism heretofore unachievable in peacetime training.
- . MANPRINT is requiring that training be developed within a systems context taking into account personnel, human factors, safety requirements, etc. early on in the training system development cycle.

Future Directions

Issues which need resolution in selecting a method for training effectiveness assessment include: (1) whether to measure trainee proficiency or to evaluate the training system on some other basis, (2) whether to choose training time or performance quality as the basic measure of effectiveness, and (3) whether to measure training during or immediately after school or after some period of performance on the job.

The Crosswalk and Footprint data bases being developed by TPDC promise to be useful in aiding the process of training system concept formulation. MANPRINT is being demonstrated as a useful tool in speeding the process of concept formulation. In general, data bases for cost and training effectiveness will (or should) be developed, modified and validated for use in this context to examine such things as: (1) the degree of simulator fidelity required to produce a given amount of transfer to the operational equipment, and (2) appropriate measures of both cost and training effectiveness.

4200 ARTIFICIAL INTELLIGENCE AND INTERACTIVE INFORMATION TECHNOLOGY

Background

Machines continue to be the interface between instructor and trainee in simulators and training devices. The increasing role of computer technology has lead to advances in Computer Based Training (CBT) and Computer Aided Instructional (CAI) systems.

In addition, computers are being used to input large amounts of data necessary for screening trainees and remediation of training and instructional techniques. Traditional human/computer interfaces have required the user to adapt to the way the computer required information to be input and presented. Artificial Intelligence (AI) is beginning to reduce the interface problems. In addition, (AI techniques are relieving the human from mundane tasks, allowing increased efficiency in the level of human performance.

Trends

The machine role of the man-machine-man interface will continue to gain importance. Current trends are in two areas, reducing the interface between the individual and the machine and using AI to replace selected human tasks. Use of voice recognition and natural language processors ease the role of human interaction with the training system. These systems have reduced the knowledge an individual must have prior to interacting with the training system. In addition, the development of CAI and CBT have augmented or replaced the instructors role in the training environment. These trends will continue to have importance in training and simulation.

Future Directions

Machine capabilities will continue to augment and begin to replace the human in many training devices.. Machine capabilities will cover a broad range including on-board tutoring systems and surrogate crew member development. Common authoring languages conversion systems will be developed to enhance the value of AI. AI will also gain importance as a means to augment the training device development process and carry forward into the fielded training system.

4210 Automated Instructional Processes

Background

In the past ten years it has become apparent that training is not just practice, but requires: (1) structuring of exercises in the simulator in a coherent fashion, (2) providing methods for measuring performance, (3) diagnosing student difficulties in performance, and (4) providing feedback critical to the development of skills. These realizations have prompted the development of hardware and software interfaces so that instructors may select appropriate exercises for presentation to students, monitor student performance and provide feedback. These training assistance technologies have been applied to simulators but are not generally available in the classroom.

A variety of technology applications for training or learning devices are emerging which have the function of knowledge engineering. Systems employing these emerging technologies are called "Intelligent Tutoring Systems" or "Intelligent Computer-Aided Instruction" (ICAI).

Another significant development in this area is the development of paperless technical manuals (see 4220- Job Aiding) which are replacing paper technical manuals. In either form, the technical information aids soldiers in operating and maintaining equipment.

Paperless technical manuals have significant advantages in that they can provide only the information needed to perform a specific job. In addition, they can train as well as aid the performance of specific tasks.

Trends

Powerful microcomputers and advances in networking are providing the basis for significant advances in this technical area. Pertinent software advances include:

- . microcomputer-based artificial intelligence software
- . object-oriented programming languages, such as SMALLTALK, networking protocols for microcomputers.

Pertinent hardware advances include:

- . optical storage, such as CD ROM
- . low cost raster scanners which allow graphics in hard copy to be scanned into a digital data base
- . very rapid microcomputer processors
- . high resolution computer displays.

Training assistance technologies are being developed to customize exercise sequences, provide intelligent feedback, simulate scenarios and missing team members, and interact with the student to determine logic of the student's response.

Authoring techniques are being developed which facilitate the inexpensive production of electronically delivered job aids which: (1) are based on carefully developed presentation formats to aid the user in job performance, (2) adapt to the user's skill level, and (3) contain logic which facilitates troubleshooting.

Future Directions

Training assistance technology will come into more use in the classroom setting and training device applications, such as team training.

Portable, microcomputer-based job aids will continue to replace paper job aids (such as technical manuals) for maintenance and operation of equipment. They will benefit by the careful incorporation of human factors design guidelines.

Information for a variety of purposes, such as job aiding, classroom training, and embedded training will be authored as part of a common database serving diverse purposes.

4220 Job Aiding

Background

Microcomputer-based job aids (also known as paperless technical manuals) have significant advantages over paper-based documentation containing the same information. Unlike paper displays, electronic displays can be dynamic, information can be manipulated by users, and indexing and accessing can be automatic. For troubleshooting, electronic presentation can incorporate expert system technology. All of these capabilities of paperless technology result in faster job performance with fewer errors, as demonstrated in field tests conducted by all three military services.

Army policy, under auspices of the Computer Aided Logistics Support (CALS) office, is requiring the use of paperless technical manuals in support of all new weapon systems.

Interactive videodisc technology, particularly the Electronic Information Delivery System (EIDS), is bringing a new dimension to both job aiding and training of maintenance and operator skills.

Trends

Smart technology (i.e., expert systems and artificial intelligence) for operator and maintenance job aiding are making job aiding more effective by reducing both errors and task completion time.

The military has found that electronically presented job aids can easily incorporate training capability. Therefore the question of whether a job aid should also serve as a training aid is moot.

Future Directions

Continued development of technology in support of the CALS initiative, and particularly paperless technical manuals is requiring R&D which will prove useful for computer-based job aiding. There are several technological developments which will be useful in this sub-field of endeavor: techniques to display complex graphics, authoring techniques, storage technologies, and interface protocols for networking of training devices.

The technology of embedded training also has much in common with job aiding. For example, authoring systems for producing paperless technical manual information should also prove useful for producing embedded training information.

Expert systems will increasingly be useful in this sub-field of endeavor.

Electronically presented job aids will also be routinely used as training aids and will become a primary training media for both Army schoolhouse and job-site training.

4230 Natural Language Interfaces

Background

The natural language interface has been the goal of much research in computer science. Natural language interfaces would greatly enhance user friendliness of control computers in training systems. The computer could then interact more directly with the trainee, and reduce or eliminate the workload on the human trainer.

There are two major issues regarding Natural Language Interfaces: computer-to-human interface and man-to-computer interface.

The computer-to-human interface is well established. There are many techniques of having the computer generate natural language style output to the trainee. This output can even be audible. The remainder of this discussion will center on man-to-computer interface.

The man-to-computer interface is more problematic than the computer-to-human interface. However, advances in computing power and software algorithms are beginning to make natural language interfaces practical for incorporation into training systems. The use of natural language interfaces has been primarily limited to specialized applications where the vocabulary is limited and very precise.

Trends

Man-to-computer natural language interface is a basic research area. There are no specific training programs directed at improving the art.

There are, however, many programs and research projects funded by DARPA, AFWAL/FIGR and other agencies that investigate the problems and prospects of natural language interface.

A natural-language voice-recognition interface has been simulated in research on the pilot's associate (PA) program. This simulated interface performed well within the limits of the PA vocabulary. It is doubtful, however, that this approach taken can be generalized to much larger systems.

Future Directions

The incorporation of natural language interfaces will become more common as the technology improves. The chief stumbling block is the context-sensitive nature of natural language, which gives the same phrase or word different meanings depending on what has come before; even worse, the meaning sometimes depends on what comes later.

Nevertheless, demonstrations of the utility of natural language interface in the training environment can be accomplished using simulation techniques such as those used in the PA program.

The problem of speech recognition is intertwined with the problem of natural language interface. Speech recognition devices do fairly well on isolated words, but usually fail on connected speech. The missing link in connected speech recognition is probably the understanding of context that a natural language interface would provide.

4240 Voice Technology

Background

There are three pertinent technical areas related to voice technology, including: speech synthesis, speech recognition, and audio sound effect generation.

Speech synthesis is essentially a perfected technology. The size of vocabulary which may be practical is limited only by the dollars available.

Speech recognition, however, remains practical only for isolated speech and limited vocabularies. Reliable speech recognition systems are typically speaker dependent--each individual must enroll his or her own voice. In addition, many systems have a limited recognition vocabulary. Some systems utilizing powerful computers can now recognize thousands of words, more than enough for virtually any application with training devices. One serious drawback relates to problems in recognition when the speaker is under stress other adverse conditions. Nevertheless, the use of verbal commands for purposes of control is highly desirable in complex systems to permit the operator to control all necessary systems without overload.

Audio sound effects should be included in simulation. Noise is part of the confusion and chaos of battle, and can provide important cues to action. A mine explosion requires a different response than an artillery round, and can be differentiated by the aerodynamic noise of the incoming round.

Trends

In order to achieve more realism, simulation of audio stimuli must be improved. The SIMNET simulators use high-fidelity sound systems to simulate the machinery noise of the vehicle, and the sounds of direct and indirect fire.

Computer synthesized speech is used in many trainers. Examples include: (1) TopGun, to cue trainee actions, (2) the Joint Services Multi-Purpose Arcade Combat Simulator (JMACS), and (3) the Personal Computer Rifle Marksmanship Expert System (MET).

Use of synthesized speech in flight simulators include simulation of ATIS (Automatic Terminal Information Services) broadcasts, and GCA (Ground Controlled Approach) instructions.

Hands off control has become widely used in many applications, such as piloting an attack helicopter or gunnery in an M1 Tank. Many functions require reaching to a control panel. The use of voice control is a natural extension and allows the pilot to pay more attention to piloting the aircraft. If advanced systems are to make more use of voice control, then this aspect must also be considered in designing the training system.

Interactive voice for paperless technical manual application was successfully tested (in a proof-of-principle study) by the Army Research Institute for the Personal Electronic Aid for Maintenance (PEAM) device. Subjects in the experiment, soldiers who used a microcomputer with interactive voice to perform maintenance functions on the M1 tank, were favorably disposed toward both the synthetic voice (which read the instructions on the screen) and voice recognition, which allowed hands-off control of menu commands.

Future Directions

While significant strides have been made in the field of voice recognition, considerable advancement is still required. Needed advancements include: (1) total natural language tailored to the individual operator, (2) accuracy in adverse environments such as high noise levels and vibration, and (3) imperviousness to extraneous variables such as stress and "g" forces. Though not all of these desirable traits will be achieved in the near future, it is possible with today's technology to mimic many of these traits and provide a voice interface which gives the appearance of simulating an advanced voice system.

The use of voice technology to simulate missing team members is under consideration by a number of military labs including NTSC. When this technology matures, team training of crews that are often subject to personnel turbulence will be considerably enhanced.

As speech recognition matures, it may become practical to recognize and evaluate simple trainee vocal responses. As discussed under Natural Language Interface (4230), significant problems currently prevent an unrestricted natural language interface in training devices. However, good results can be obtained for limited vocabularies of disconnected words.

0000095