EMBEDDED SIMULATION FOR THE ARMY AFTER NEXT

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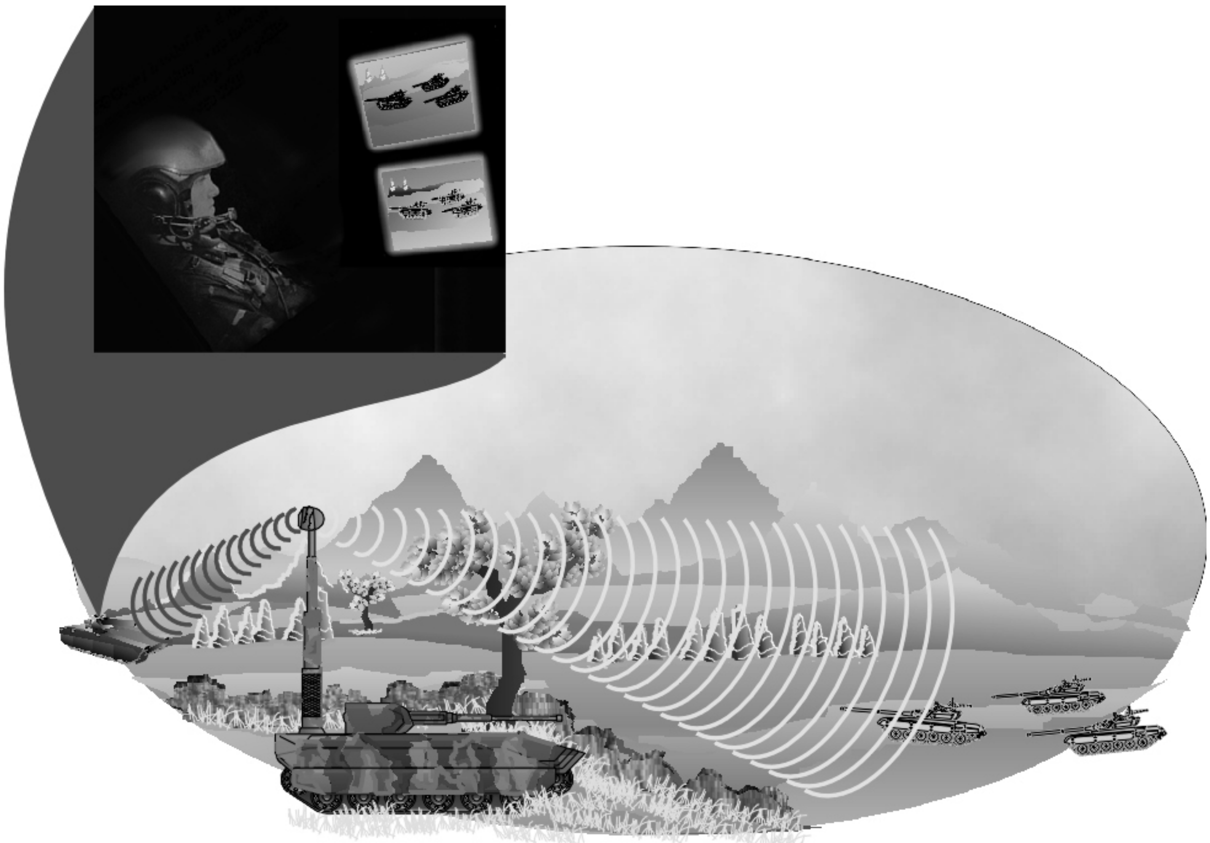
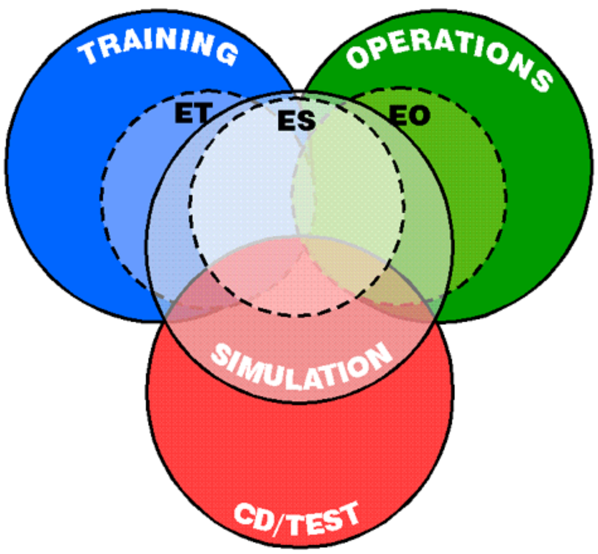


Embedded Simulation for Operations

The 21st century mounted soldier is going to have more information available to him than we even dreamed of a decade ago. This increased reliance on tactical information can be a two edged sword that may lead to information overload. The Simulation, Training and Instrumentation Command (STRICOM) and the Tank-Automotive Research, Development & Engineering Center (TARDEC) are exploring a concept based on using simulation technology developed for training to enhance operational/warfighting capabilities. Simulation technology can enhance the presentation of information in a rapid and easily assimilated fashion. The information would be presented on the combat vehicle operational displays and controlled in a manner similar to current vehicle operations. Another advantage with this fully embedded technology is that it would provide an autonomous trainer that allows the soldier to literally train as he would fight. This on-board technology would allow mission rehearsal and sustainment training to occur whether at home station or deployed to the combat theater. The balance of this article will discuss the potential operational and training benefits of the Embedded Simulation concept and finally present an overview of the Inter-Vehicle Embedded Simulation Technology (INVEST) program that should lead to a demonstration of this concept by the turn of the century.

Concept for Embedded Simulation (ES)

The ES relationship figure shows the relationships between the Training, Operations and Combat Development/Testing arenas. Simulation plays a central role in all three of these arenas. ES is the subset of the simulation arena that will be fully integrated into the combat vehicle. ES will play a role in Army XXI and Army After Next (AAN) by providing a capability to integrate training networks, training support automation systems and all battlefield operating systems. ET is all embedded training technology, including those not requiring simulation, and will be an integral part of the training arena. Embedded Operations (EO) which include the operational enhancement functions of situational awareness (SA), battlefield visualization (BV), mission rehearsal (MR), command coordination (CC), critical decision making (CDM) and course of action analysis (COAA) will be an integral part of combat operations. ES will permit commanders to seamlessly migrate from ET into EO and vice versa.



ES Relationship

To date the most prevalent target for (ES) has been to support embedded training. It allows the soldier to train, either individually or collectively, using the operational system. ES has other potential uses over the total system life cycle. For example, ES can support vehicle development from concept development through acceptance and operational testing. In the future it will be used to enhance the decision-making process and reduce information overload through automated filtering tools. Digitization provides the raw data, and simulation can be used to enhance or present that data as an information aid to the commander. Making simulation available for operational use adds to the information dominance capabilities needed for Army XXI and AAN.

Operational Enhancement

It is becoming apparent that an on-board ES system can be used to meet operational/mission support requirements such as: battlefield visualization, situational awareness, mission rehearsal/planning, critical decision making, course of action analysis and the development of artificial intelligence (AI) filtering tools. This ES technology available to support both training and operations is referred to as "dual use".

Battlefield Visualization

The process whereby the commander develops clear understanding of the current state with relation to the enemy and environment.

ES when integrated into the battlefield TOC's, will aid the company and battalion commanders' ability to plan, research and analyze alternative courses of actions and their resultant outcomes. Expert systems could eventually be built into the operational software to assist in route selection, deployment of forces, and use of assets. These systems could help determine the most effective uses of troops and their equipment, or the best sectors of fire given the terrain and force level.

Situational Awareness

Timely recognition of both enemy and friendly situation such that the warfighter can gain and sustain the initiative.

ES can be used to perform filtering of incoming data. The commander can request display of only certain high priority targets or essential elements of information. The resultant filtered output to the human decision-maker will permit faster and more accurate battlefield decisions.

Command Coordination

The ability to coordinate the 3 functions of command and control (plan, conduct and sustain operations) and the correlation, fusion and display of information needed by commanders at all levels.

The advent of Interface Design Specifications (IDS) for ES of various combatant vehicles will standardize informational interchange on tomorrow's battlefield. The command coordination between the various elements of the 21st Century force will be heightened and improved. The evolution of embedded simulation will enable the force to use a seamless multi-use simulation environment. ES will be used to set up and diagnose communication nets, plan missions, and analyze logistical support requirements.

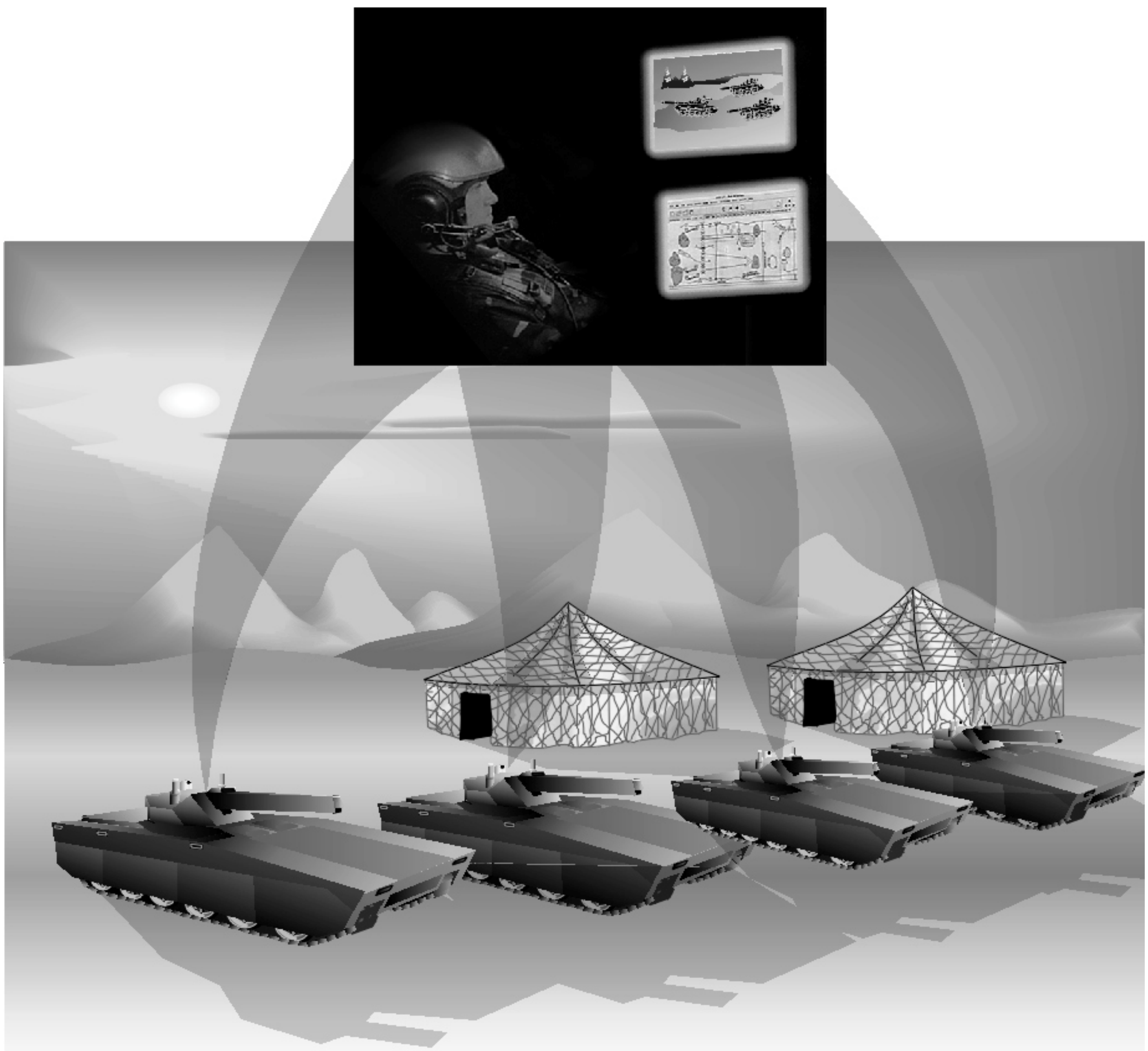
Mission Rehearsal

Mission rehearsal is the use of modeling and simulation applications to facilitate mission execution.

Mission Rehearsal is an inherent strength of ES. Missions can be planned and rehearsed against an intelligent Computer Generated Force (CGF) adversary. Weaknesses in the plan or human performance levels required by the plan can be determined. The plan can be adjusted to achieve best results. The mission rehearsal will increase unit awareness of mission requirements and difficulties and will allow the unit to maintain proficiency and practice against intended targets immediately preceding the actual mission.

Critical Decision Making

Critical Decision Making - The ability to identify the critical decisions that emerge within the combat decision making cycle and reduce information overload and the stresses associated with the



Mission Rehearsal

combat decision making process.

An inherent advantage of the US Army has always been the initiative and intellect of the ground commander. ES capabilities will allow the leader to make tactical decisions based upon a better understanding of the developing tactical situation. The pace of modern warfare dictates that commanders' need timely prioritized access to combat critical information. Extraneous information needs to be filtered out to prevent human overload and clutter on displays.

Course of Action Analysis

The ability to support the tactical/operational decision making process by selection of the best course of action based upon a rapid COA wargame modeling & simulation comparison.

The ES technologies can be mated with expert systems to help analyze different courses of action. Quick simulations can be run to determine possible results of the planned engagement or mission. The commander can make a decision based on a better understanding of the attendant risks and possible outcomes. The battle staff's mission presentation could be linked electronically to unit leaders at their TOC locations. Then details for subordinate unit actions and orders can be rapidly developed and transmitted via tactical internet. This planning would be via the on-board ES technologies. Electronic planning and stealth reconnaissance will maximize the use of planning time and minimize exposure to enemy observation and fire.

Training Enhancement

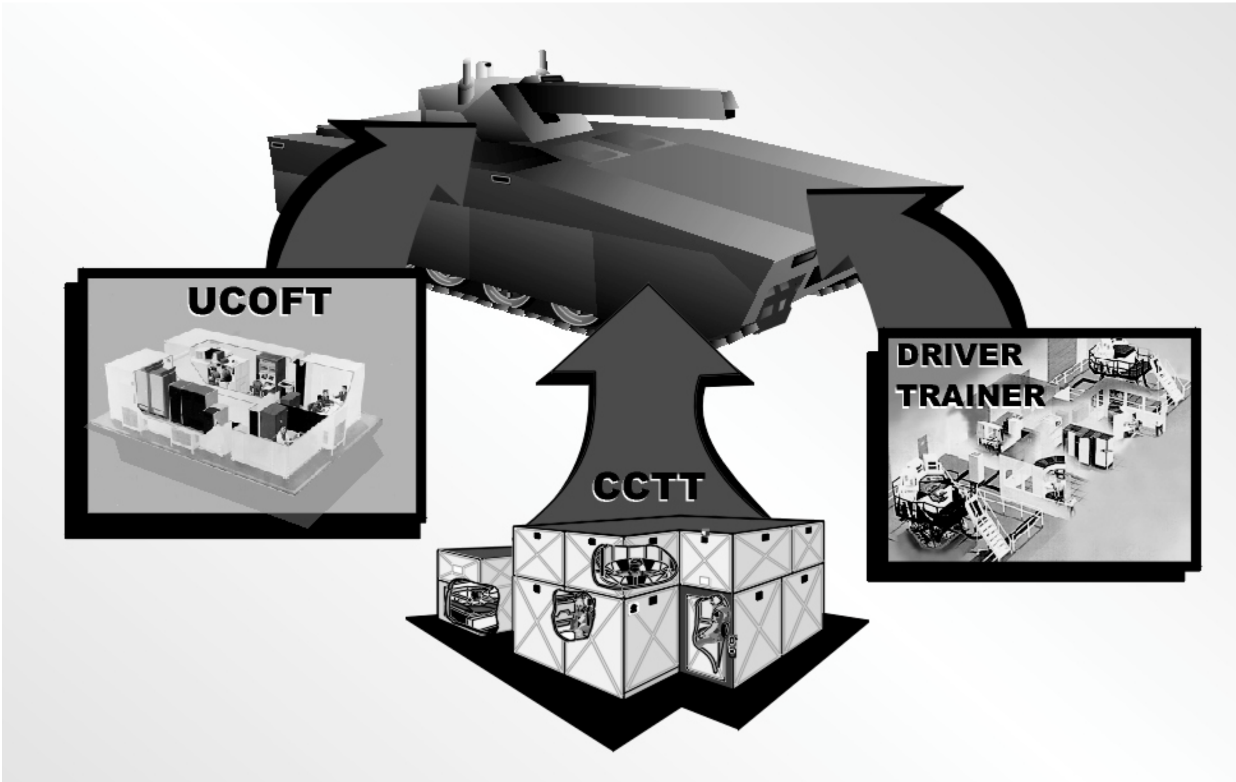
The ability to train and practice anytime and anywhere in the combat system affords a capability never before enjoyed by any modern fighting force. Training Aids Devices Simulators and Simulations (TADSS) previously strapped on, tethered to and look alike crew stations may no longer be needed if the same technologies can be reduced, embedded and injected into the fire control and sensor systems. A simple method needs to be developed to transition the crew from a combat mode to a training mode and vice-versa.

Those individual, crew, and collective training tasks currently conducted on part-task trainers and stand-alone simulators may in the near future be conducted on the combat vehicle. This on-board capability will place the training responsibility back under the unit cadre vice separate instructor operators (IO) & observer controllers (OC) and support training in unit motor parks, training areas, and ranges. The need for a centralized scheduling and time sharing on limited trainers/devices can be eliminated.

The primary tasks currently needed to attain and sustain combat proficiency include gunnery training, tactical training and a secondary task of driver training. These tasks are currently trained on stand-alone gunnery and tactical trainers like COFT, SIMNET/CCTT and driver trainers. These simulators are located in permanent facilities or shelters and require contractor support and centralized management. Embedded autonomous trainers could possibly stop or reduce any further tradeoff of OPTEMPO dollars and contractor support costs.

Gunner

Gunnery training currently conducted on stand-alone trainers will have similar capabilities built into the combat system. Multiple vehicle exercises may be accomplished by using digital communications over the tactical internet or a supplemental wireless LAN. With an autonomous trainer, gunnery exercises can be developed by the using unit with on-board semi-automated forces (SAF) or through exercises developed at battalion level and ported down electronically or sent by CD-ROM to the using unit.



Embedded Training

Commander

Tactical training similar to the tasks scheduled for the CCTT will be conducted using the combat vehicle. Again, on-board SAF and terrain/image generator (IG) provides the means. The tactical radio or wireless LAN will provide the inter-vehicle communications link and pairings required for force-on-force training. The use of synchronized player model technology will promote live vs. virtual vehicle interaction. This interaction and use of digitized terrain brings a combat training center (CTC) level virtual tactical engagement simulation (TES) capability to every home station. The migration of ES/ET to the command and control systems will round out the Bn/TF tactical training package.

Driver

Driver training will have a similar on-board capability less a motion platform when training in a stationary mode. In the stationary mode, the driver will have terrain graphics injected into his vision blocks or sensors to give the appearance of moving over the terrain database. Driver participation would be an advantage over the UCOFT where the IO plays the role of driver.

After Action Review (AAR)

The requirement for a standardized and automated AAR system can be realized with ES. An automated ES system can be programmed to electronically capture data on key actions/events during the battle for playback and analysis. The AAR can be used to determine deficiencies in unit performance and possibly pinpoint enemy weaknesses. Training and operational execution can be recorded and used to assess training effectiveness, record battle damage assessment (gun camera) and determine enemy tactics, techniques and procedures (TTP).

Training Transfer

The training transfer associated from the use of ES can be directly related to operational proficiency because the crew will: (1) train on their combat system, (2) operate under real conditions and under the watchful eye of unit cadre, (3) increased availability of the system for training and (4) the synergistic benefit gained from the dual use autonomous training and operational system.

OTHER USES OF EMBEDDED SIMULATION

Today's training simulators present tactical information in a form intuitive to the trainee. It is presented in the form of map displays similar to the paper maps using standard military symbology and scene displays that emulate the actual view seen by the combat crew. Advanced ground combat systems are taking advantage of electronic visual technology to provide better battlefield visualization from the "buttoned-up" vehicle. These same combat systems have moved to the vehicle electronics (VETRONICS) open-system architecture. An approach where all controls are converted to digital signals, which are then used to activate the appropriate subsystems. With these trends in vehicle architecture, digital displays and electronic controls, the challenge to integrate embedded training/simulation has been simplified.

ES technologies have historically been thought to have their greatest use in the Training, Exercise and Mission Operations (TEMO) domain. ES technologies can also provide payoffs in Research, Development and Acquisition (RDA) domain and the Advanced Concepts and Requirements (ACR) domain. The evolution of a weapon's system or platform from ACR to RDA to TEMO presents some unique challenges and requirements for embedded systems. The technology being developed under the INVEST Science & Technology Objective will allow Simulation Based Acquisition to become reality. ES will allow utilization of simulation for the entire acquisition process from concept to production and continued through training and maintenance of a vehicle. During ACR embedded simulation will provide the Army with the capability to migrate advanced concepts from the Battle Labs to the field units for testing. This will provide the leaders with a realistic view of future fighting capabilities for the next generation of combat vehicles.

During RDA, ES can be used to speed up the vehicle development process. This process allows integration and problem solving to be done sooner. The next step is to utilize ES technology to combine virtual and live vehicle testing. This combination will allow more realistic operational testing of the vehicle; it may also be the only way to test the Army's future vehicles with all the new technology being integrated. Embedded Simulation provides the capability to model, test, and model.

During TEMO, the training goal is to emphasize the correct doctrine and refine specific skills. Training and Doctrine Command will develop instructional scenarios/databases that could be mass-produced and distributed to units as a training library. Each vehicle will be equipped with a scenario reader and the appropriate computer technology to inject sensor and visual information into the vehicles sights displays, and targeting systems. Interconnecting the vehicles with local area networks using high level architecture (HLA) protocols would accommodate team and force level training. This would also allow the interaction with other units and systems. Mission specific preparation would be accommodated by providing, at the battalion headquarters, the tools to rapidly generate a scenario based on expected battle plans that would support mission rehearsal preparation. The ultimate level of training would be accommodated by replacing the simulated terrain with actual training sites and the integration of live and virtual forces into the scenarios.

EMBEDDED SIMULATION TECHNOLOGY & CHALLENGES

Key technologies that need to be developed for cost effective embedded simulation include low cost image generators, virtual target injection into sensor displays, live/virtual entity interaction, synchronized semi-automated player models, simulation information filtering tools, intelligent tutoring systems, scenario generation, and scenario players. The embedded training starts as an autonomous capability, where one vehicle and crew is all that's needed for effective training. The embedded simulation concept will also require synchronization techniques to keep all of the vehicles on the same scenario during collective training. These topics are covered in further detail in references 2 and 3. Areas that require enhancement include burst on/off target effects, determination of aim point, live to virtual image registration and reduce simulation communications overhead. The key challenges that need to be tackled will be integration and safety. The vehicle software will need to be designed in a way to allow easy integration of all the new ES features into the vehicle. Safety will be a major design requirement of the ES System, providing the necessary features to lock out firing the weapon during the embedded training mode and also provide a quick fail-safe way to return to combat mode.

TARGET VEHICLES FOR INVEST

M1A2 System Enhancement Package (SEP)

The M1 Abrams Main Battle Tank is the US Army's primary combat weapon for closing with and destroying the enemy. The M1A2 SEP has increased capability and capacity over the M1A2. These include electronic color digital terrain maps, Army Standard C4I architecture, under armor auxiliary power unit (APU), improved thermal imaging, improved vehicle intercom, improved position/navigation, and improved VETRONICS architecture.

Future Scout and Cavalry System (FSCS)

The FSCS is a system for scout and cavalry units that is optimized to conduct reconnaissance, surveillance and target acquisition on the Force XXI battlefield. This system will have improved survivability, mobility, lethality and deployability over existing scout platforms. In the area of tactical information dominance the FSCS will have a sensor package for rapid target acquisition, identification and destruction. It will also have a fully integrated and shared C4I system.

INVEST STO MILESTONES

The INVEST-STO evolution can be explained in terms of several distinct phases from inception to fielding an ES system on a future ground combat system. The phases of evolution span a six-year period from FY 97 to FY 02. The demonstration phase (FY99-00) starts with a hot bench or brass board and ends with vehicle prototyping at a Systems Integration Lab (SIL). The proof of concept phase (FY 01-02) will occur in three steps: (1) ES on stationary vehicle, (2) ES on a moving vehicle, (3) ES as an operational enhancement to the combat systems. The transition phase (FY 99-02) will involve transfer of technology to the vehicle PM's and the integration of ES into future and legacy systems. The fielding phase will occur some time after transition and hopefully the first fully embedded ES/ET system will be operational on the Future Scout and Cavalry System (FSCS) scheduled for fielding in FY 07.

SUMMARY

Today's technology allows us to demonstrate the initial capabilities of tomorrow's implementation. Over the past decade, we have seen in the commercial world the impact of the evolution of computer technology. In the business arena we have seen the acceptance of this ongoing evolution with planned replacement of the desktop computer every three years to incorporate new capabilities. The current practice of developing militarized equipment to last the service life of the vehicle, needs to be re-addressed to properly take advantage of the evolution of computer hardware and software. Ever increasing sizes of databases, driven by higher fidelity representation of terrain and targets, can be used by higher fidelity models, executed on faster processors and presented on higher resolution displays to give our warfighter a better picture of the battlefield. The commercial world is placing similar demands on computer technology, and takes advantage of the products the industry is delivering. We must structure our fielding plans to do the same.

Issues beyond embedded training that will be addressed by INVEST are the use of player models that allow the rapid reconfiguration of force and equipment capabilities. This capability supports concept development and exploration. INVEST will provide repeatable results from scenarios executed for identical sets of inputs, so they can also be used during operational testing. The program will explore the use of simulations to predict opponent strategy, thus enhancing the commanders' situational awareness.

The goal of the INVEST-STO is to develop/ demonstrate the technology that will lay the foundation for incorporating embedded simulation into future as well as legacy combat vehicles. This simulation capability will support training ranging from individual training, through crew training, to force-on-force training exercises. Along this continuum; however, there are many technological challenges. These range from the injection of artificial terrain into the driver's viewport for individualized training, to the intermixing of live and virtual images in the commander's and gunner's display for gunnery and tactical training. This includes all possible types of interaction, e.g., live on live, live on virtual, etc. Finally, there is the need to develop embedded simulation technology for command and control systems in order to provide complete and productive multi-echelon training.

CONCLUSION

The ES / ET application provides a new look at an age-old dilemma of what TADSS is needed. For the combat ready deployable force, electrons have over taken stand-alone TADSS. Just imagine embedding the likes of MILES, TWGSS, TSV, SAWE, and CCTT into the ground combat system plus the added benefit of embedded simulation to attain: information dominance, situational awareness, battlefield visualization, mission rehearsal, critical decision making and course of action analysis. As the former CSA Sullivan said in his book (ref 1), "Success is a journey not a destination". The road to a fully embedded training and simulation system will be a journey to attain training and operational superiority in the 21st Century.

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