Someday Soon, Your COFT May Be Built Into Your Tank

Embedded Simulation For the Army After Next

by Claude W. Abate, Hubert A. Bahr, and John M. Brabbs

The power projection Army of the 21st century will require a flexible, go-to-war, on-board training capability. Individual, crew and unit training currently conducted in stand-alone simulators will not meet the needs of rapidly deploying forces and geographically dispersed Reserve Component units. Emerging technologies and miniaturization are advancing at such a rapid rate that a totally embedded training capability will be doable and affordable. Embedded training systems will replace the current suite of stand-alone external trainers, like the conduct of fire trainer (COFT), simulation network (SIMNET) and the close combat tactical trainer (CCTT). This fully embedded technology would provide an autonomous trainer that would literally allow soldiers to train as they would fight, using their combat systems.

Sustainment training can then be accomplished at home station, at combat training centers, at unit armories, or enroute to and while deployed in the combat theater. The embedded simulation technologies used to support training can also be exploited to support vehicle operational/warfighting systems. This technology can enhance the presentation of critical information needed by commanders and thereby avert an information overload situation. The Inter-Vehicle Embedded Simulation Technology (INVEST) is a technology exploration program with the goal of identifying those key technologies that have the highest pay-off. This paper outlines a program that will set the course for a totally embedded training (ET) and embedded simulation (ES) capability targeted for Army After Next (AAN) ground combat systems.

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 fully integrated simulation arena. ES will play a role in the combat vehicles of 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.

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 enhance the decision-making process and reduce information overload for our leaders through automated filtering tools. Digitization provides the raw data, and simulation enhances or presents 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.

It is becoming apparent that an onboard ES system will be useful 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. ES technology available to support both training and operations is referred to as "dual use."

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

ES, when integrated into the battlefield TOCs, 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 perform filtering of incoming data. The commander requests 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 three 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. This will heighten and improve the command coordination between elements of the 21st century force. The evolution of embedded simulation will enable the force to use a seamless multiuse simulation environment. ES will allow users to set up and diagnose com-

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munication nets, plan missions, and analyze logistical support requirements.

Mission Rehearsal. The use of modeling and simulation applications to facilitate mission execution.

Mission rehearsal is an inherent strength of ES as planning and rehearsing against an intelligent Computer Generated Force (CGF) adversary is always possible. Weaknesses in the plan or human performance levels required by the plan will be easy to determine with easy adjustment to the plan as equally possible. 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. 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 combat decision-making process.

An inherent advantage of the U.S. Army has always been the initiative and intellect of the ground commander. ES capabilities will allow leaders 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 filtering 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 and simulation comparison.

The ES technologies can be mated with expert systems to help analyze different courses of action. Quick-run simulations can determine possible results of the planned engagement or mission. The commander can make better decisions siince he will have 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. This linking will allow the rapid development and transmission of subordinate unit actions and orders via the 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 and tethered to combat systems, and look-alike crew stations, may be part of our training past if the same technologies can be reduced, embedded, and injected into the fire control and sensor systems. A simple method needs developing 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 occur on the combat vehicle. This on-board capability will place the training responsibility back under the unit cadre, vice separate instructor operators (IO) and observer controllers (OC), and support training in unit motor parks, training areas, and ranges. There will no longer be a need to centralize scheduling and time sharing on limited trainers/devices.

The primary tasks currently needed to attain and sustain combat proficiency include gunnery training, tactical training, and a secondary task of driver training. Current training for these tasks is on stand-alone gunnery and tactical trainers like COFT, SIMNET/CCTT and driver trainers. These simulators are in permanent facilities or shelters and require contractor support and centralized management. Embedded autonomous trainers may 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 occur by use of digital communications over the tactical internet or a supplemental wireless LAN. With an autonomous trainer, gunnery exercises are possible 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.

Commander

Tactical training similar to the tasks scheduled for 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 is a reality with ES. An automated ES system can be programmed to electronically capture data on key actions/events during the battle for playback and analysis. Recorded training and operational execution will help the OC during AAR preparation and execution to assess training effectiveness, record battle damage assessment (gun camera) and determine enemy tactics, techniques and procedures (TTP).

Training Transfer

There will be a direct training transfer associated from ES use because the crew will: (1) train on its combat system, (2) operate under real conditions and under the watchful eye of unit cadre, (3) gain increased availability of the system for training and (4) realize a synergistic benefit from the dual use autonomous training and an (their) operational system.

Today's training simulators present tactical information in a form intuitive to the trainee. He see it 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; this approach converts all controls to digital signals, which then activate the appropriate subsystems. These trends in vehicle architecture, digital displays, and electronic controls, have simplified the challenge to integrate embedded training/simulation.

In the past, ES technologies have had their greatest use in the domain of training, exercise, and mission operations (TEMO). ES technologies can also provide payoffs in the research, development and acquisition (RDA) and advanced concepts and requirements (ACR) domains. The evolution of a weapon's system or platform from ACR to RDA to TEMO presents unique challenges and requirements for embedded systems. 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 is useful in speeding up the vehicle development process. This process allows quciker integration and problem solving. 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. 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 for possible mass-production and distribution to units as a training library. Each vehicle will have a scenario reader and the appropriate computer technology to inject sensor and visual information into the vehicle's 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 possible by replacing the simulated terrain with actual training sites and integrating live and virtual forces into the scenarios.

Key technologies that need development 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. References one and two cover these topics in further detail. Areas that require enhancement include burst on/off target effects, determination of aim point, live to virtual image registration, and reduction of simulation communications overhead. The key challenges that need tackling will be integration and safety. The vehicle software design will need 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.

M1A2 System Enhancement Package (SEP)

The M1 Abrams main battle tank is the U.S. 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 C^4I 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 will be an optimized system for scout and cavalry units to conduct reconnaissance, surveillance and target acquisition on the Force XXI battlefield. This system will have improved survivability, mobility, lethality and deployability over existing platforms. To ensure 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 C^4I system.

The INVEST-STO evolution is explainable 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 PMs and the integration of ES into future and legacy systems. The fielding phase will occur sometime after transition with the intent of the first fully embedded fielded ES/ET system being operational on the Future Scout and Cavalry System (FSCS) (in FY 07).

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 computer hardware and software evolution.

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 readdressed to properly take advantage of computer hardware and software evolution. 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 industry delivers. We must structure our fielding plans to do the same.

An issue beyond embedded training which INVEST will address is reapidly reconfigurable force and equipment capability player models. This capability supports concept development and exploration. INVEST will provide repeatable results from scenarios executed for identical sets of inputs, for thier later use during operational testing. The program will explore simulations to prediction tools for 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 multiechelon training.

The ES/ET application provides a new look at an age-old dilemma of what TADSS are needed. For the combat ready deployable force, electrons have overtaken 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 decisionmaking, and course of action analysis. As the former CSA Sullivan said in his book, "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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Claude W. Abate is a Senior Military Analyst for Sherikon, Inc. and is currently supporting the Simulation Technology Division, Research and Engineering Directorate of STRICOM. He is a graduate of Florida Southern College and has a Masters of Science Degree from Florida State University. Prior to joining Sherikon, Mr. Abate was a career Army officer with a variety of command and staff assignments in the U.S. and overseas. As a retired Colonel, his experience includes a perspective as a training and doctrine developer and Training Brigade Commander at the U.S. Army Armor Center and School and as an opposing force commander at the National Training Center. He has two years experience working with PM CATT on training support materials for the Close Combat Tactical Trainer. His military schooling includes the Command and General Staff College and the Army War College.

Hubert A. Bahr is a Decorated Vietnam Veteran with 28 years of Federal Service. He received his BS degree in engineering from the University of Oklahoma in 1972 and his Masters Degree in computer engineering from the University of Central Florida in 1994. For the past 18 years, he has been involved with instrumented Force on Force Ranges. He is currently the lead engineer for the INVEST STO in the Research and Engineering Directorate of STRICOM. His research interests are in the areas of parallel processing, artificial intelligence, and computer architecture. He is also pursuing his Ph.D. at the University of Central Florida.

John M. Brabbs is a Senior Project Engineer at the U.S. Army's Tank-Automotive Research, Development and Engineering Center, where he has been employed since 1987. He is currently the Team Leader of the VETRONICS Simulation Facility (VSF) Team. His research interests are in distributed simulation, virtual reality, and software engineering. Mr. Brabbs holds a B.S.E degree in Computer Engineering and a Master's of Science in Computer Science both from Oakland University in Rochester, Michigan.