Embedded Simulation for Ground Vehicles

Hubert Bahr
HQ STRICOM AMSTI-ET
12350 Research Parkway
Orlando, Florida 32826
(407)-384-3874
fax (407)-384-3830
bahrh@stricom.army.mil

KEYWORDS
embedded simulation, embedded training

Abstract

In the past, embedded training has been dismissed as too hard and too expensive. Simulation, Training and Instrumentation Command (STRICOM) simulation technology division (AMSTI-ET) has an ongoing program to leverage current simulation technology into a form suitable for embedding into ground vehicles for training. This paper presents the concept and challenges driving this investigation. This concept embraces warfighter training from a stand alone single crew, to fully interactive vehicle on the move, and employing a combination of live and virtual forces.

The concept is based on low cost image generation, with pre-recorded databases providing a background to computer generated forces. This is expanded by providing a DIS/HLA type linkage for team interaction. Technology issues include image generation, live and virtual image registration, communications support for the simulations, and signal injection into appropriate platform subsystems. Efforts are underway to identify a common embedded simulation interface for future upgrades to Army combat vehicles.

INTRODUCTION

As of the beginning of Fiscal Year 97, the Inter-Vehicle Embedded Simulation Technology (INVEST) Science and Technology Objective (STO) was initiated. This effort, while aimed specifically at Embedded Simulation (ES) in Army ground combat vehicles, will address many of the technology issues raised in the ET Action Plan, reference 1. There are many benefits of embedded training, which include: (1) it will allow for mission rehearsal on site, on actual equipment, which will help fight the skills decay problem that occurs as time elapses from the last simulator session; (2) it provides the recognition that the battlefields of tomorrow will consist of diverse enemies in a wide variety of terrain; and (3) it provides the opportunity to plan and train for newly developed situations - on relatively short notice.

The Army has placed renewed emphasis on embedded training (ET) capability as a result of lessons learned during the Gulf War. Through the INVEST STO, the Simulation Training and Instrumentation Command (STRICOM) will address the technological issues associated with delivering embedded simulation capability to the force. The INVEST STO will concentrate on the technology, architecture and standards required for embedded simulation. Outside the scope of the INVEST STO, however, there are outstanding issues. The following are examples of issues not being directly addressed: The technology that will allow retrofitting of legacy vehicles, so they too can they interact on a training battlefield containing both live and virtual forces. Displays for operation other than “buttoned up” are not addressed. Parts of Embedded Training that do not include simulation.

Issues beyond embedded training that will be addressed by INVEST are as follows: Using parameterized models that will allow concept development/ exploration. Demand that results from scenarios be repeatable for identical sets of inputs, so they can also be used during operational testing. Explore the use of simulations to predict opponent strategy thus enhancing the vehicle 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 that ranges from individual training, crew training, up to and including 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 commanders and gunners display, on the battlefield. Of course, this includes all possible types of interaction, e.g., live-on-live, live-on-virtual, etc. Finally, there is the need to integrate command and control in order to provide complete and productive training.

A CONCEPT FOR EMBEDDED SIMULATION.

This document identifies technologies needed to support embedded simulation (ES) and the development timelines for achieving these technologies. This section presents a strawman concept that defines the program objectives and identifies technological requirements. This strawman establishes an approach for providing embedded simulation technology in Army tactical vehicles. This strawman was based on a compromise between the desire for the ultimate fidelity with the desire to eventually provide the capability within every combat vehicle. The current and future combat vehicle families represent a wide range of technology. Rather than diffuse the effort by trying to accommodate the total range, the INVEST STO focuses on a set of vehicles that are closely related in a technological sense. This target set is identified later in the document and will be refined as the investigation progresses. Using the target set as the baseline, plans can be developed to transition embedded simulation to the other combat vehicles. One primary characteristic of the target set, for the initial development, is that the primary commander’s and primary gunner’s displays are electronic rather than optical.

To date the most prevalent target for embedded simulation (ES) has been to support embedded training (ET) to enhance or maintain the soldier’s skill proficiency. It allows the soldier to train, either individually or collectively, using the operational system reference 1. ES has other potential uses over the total system life cycle. ES can support vehicle development from Concept Development through Acceptance and Operational testing. In the future it may be used to enhance situational awareness.

The training goal is to emphasize the correct doctrine or polish specific skills. With this as a given, Training and Doctrine Command (TRADOC), could develop instructional scenarios/ databases that could be mass produced and distributed to units as a training library. Each vehicle is equipped with a scenario reader and the appropriate computer technology to inject the sensor and visual information into the vehicle's sights, displays, and targeting systems. The crew would be required to use the actual vehicle controls to engage the opponent. Although this would not provide the versatility, and fidelity of the Close Combat Tactical Trainer (CCTT) class of trainer, it would certainly enhance the training available in the unit. Team and force level training would be accommodated by interconnecting the vehicles with local area networks using DIS/HLA communications. This would also allow the interaction with other units and systems. Mission specific preparation would be accommodated by providing at the appropriate headquarters the tools to rapidly generate a scenario based the next battle plan. 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.

To demonstrate the validity of the proposed concepts and technologies the INVEST project office plans to leverage existing simulators and prototypes from the target group of vehicles identified in later sections.

Embedded Simulation modes

TRADOC’S ET Action Plan defines four categories of ET[ref. 1]: (A) Individual/Operator, (B) Crew/Team, (C) Functional, and (D) Force Level/Combined Arms and Battle Staff. These categories are not appropriate for grouping ES technologies since they do not directly segregate the training technology. For example, gunnery training in the motor pool may be appropriate with stand-alone equipment, whereas on the firing range we may want to overlay physical targets with enhanced virtual targets with moving turrets and other signatures. Thus for the purpose of technology grouping the INVEST project office has identified four modes see Table 1. These are (1) Stand-alone, (2) Multi-element Stationary, (3) Mission Specific, and (4) Vehicle on the Move. A description of each mode follows:

Table 1. Training Category vis-á-vis Technology Mode				
	Individual/ Operator	Crew/ Team	Functional	Force Level/ Combined Arms
Stand-alone	√	√		
Multi-element Stationary		√	√	√
Mission Specific		√	√	√
Vehicle on the Move		√	√	√

Stand-alone

Simulation is used as a supplement to physical operation of a system by simulating everything but the actual crew activities. For example, the gunner still aligns the cross-hairs and pulls the trigger, but the simulation provides the target and shows the point of impact. The simulations are based on standard scenarios from a mass produced library. This mode could also include drills aimed specifically at individual operator or crew/team level. It includes full visual, sound and sensor stimulation.

Multi-element Stationary

This mode adds the technologies required for inter-vehicle action. It enables exercise of command and control as well as interactive force on force. It includes both wireless and wired communications to other players and the DIS/HLA network. This mode still relies primarily on the mass produced library for scenarios.

Mission Specific

This mode could be accomplished using physical mockups and conducted as vehicle on the move, but for the purposes of this category we are assuming that the majority of the environment will be virtual, and as a result requires preparation and playback of planned scenarios. These scenarios would need to be developed as the battle plans are developed and provided to the units as part of mission rehersal. It would expect a contribution from an automated battle planning system. Scenarios would be developed from automated data bases including terrain and intelligence information. This training is envisioned as in-place training with full command and control participation.

Vehicle on the Move

In this mode ES is used to supplement the physical forces and environment by introducing virtual forces, obstacles and other environmental factors. It will be designed to support the Combat Training Center (CTC) training in a Synthetic Theater of War type of joint exercise environment. It can also be used to enhance home station unit or force level training and could also be used at the crew level to enhance targets on the firing range. The key challenges in this area, are the communications, and live/virtual image registration requirements.

Embedded Simulation Technology

The following subsections list the technology required to support each of the above simulation modes. Since many of the components are common to all modes, the first subsection identifies the common components. Following this the additions required for the specific mode are listed. Definitions/descriptions for each are provided where first identified.

Common Technology Required

Low Cost Image Generator – An image generation system with video generation capabilities based on mass produced technology such as personal computers or video games.

Burst on/off target effects – The injection into audio, visual and sensor displays the appropriate sounds/images to simulate the effects of munitions' impact.

Aural stimulation – Sounds generated to simulate combat or vehicle sounds consistent with the actions of the crew and training scenario.

Virtual Target Injection into (1) Visual and (2) Range Finder paths – The virtual targets must register in all sight and sensor systems.

Stand-alone

Driver's Viewport Image Display – A display system either embedded or appended used to display the training scenario to the driver.

Scenario Player – The device used to load the training scenario.

Scenario Library – A set of professionally created scenario's prerecorded and mass published that are distributed to units for training. These are primarily aimed at developing common skills. They may include familiarization packages for potential locations of deployment.

Multi-element stationary

Team Communications – Wire or RF communications capability to interface as a DIS/HLA environment. The network whether RF/cable that allows the sharing of simulation data/results between team elements.

Synchronized ModSAF – A version of ModSAF that allows the concurrent execution of the same scenario on multiple platforms yet allows each platform to view the identical actions.

Drivers Viewport Image Display

Scenario Player

Scenario Library

Mission Specific

Camouflaged Communications – Team communications restricted to those means that would not generate a detectable emanation that could compromise the mission.

Synchronized ModSAF

Drivers Viewport Image Display

Scenario Player

Support of Scenario Generation Facility – A facility that would be deployed with the appropriate unit to rapidly create and generate copies of scenarios pertinent to the next mission.

- Mission Planning – Automated support to enable the commander to rapidly define the mission and the operations plan that would be used to generate the mission specific rehearsal scenario.
- Image Creation – The use of items such terrain data bases and structure models to create the images of the proposed mission scenario.

Vehicle on the Move

Live/Virtual Image registration – The remapping of Virtual images based on Terrain data bases onto the actual terrain seen through vision blocks and sights. This ensures no flying/burrowing above/below ground level. Also include proper masking of foreground/background effects.

Determination of Aim Point (pairing) -- Determining whether the live/virtual or live/live have been hit by an opponent.

Individually remotely directed Synchronized ModSAF – A version of Synchronized ModSAF that allows the individual elements to be reinitiated by remote commands. This is required to support the concurrent model approach [ref. 2].

Communications

- Alternative A: Appended Wide-band – A technique that depends on adding another communications element to facilitate this exchange with much higher bandwidth capabilities than is currently available on the vehicle or at the CTC's
- Alternative B: Reduced dData to share tactical system – The substitution of other techniques such local data storage and generation to facilitate reduced bandwidth and latency requirements. This would be the same order of magnitude in bandwidth and latency capabilities as currently available at NTC or with SINCGARS. An example approach is the Concurrent Model Approach see ref. 2.

GUIDING PHILOSOPHY

As a Science and Technology Objective it is not INVEST's goal to provide the full scale engineering of any product. As an R&D effort it will identify the "State of the Art" in embedded simulation for Army tracked vehicles. This will include investigations into certain classes of key technologies such as low cost image generators to determine what the capabilities are today with respect to current trainer practices. It will also build a rapid prototype embedded trainer to allow enhanced discussions with potential end users, and continued investigation of interface issues. Using the Spiral Development Approach repeatedly reestablishes the goals (requirements) for the next level of performance until the "State of the Art" is advanced to the point that the user community agrees it is time to transition a concept to Full Scale Engineering Development for inclusion in the next round of vehicle enhancements.

Products

The products to be developed by INVEST are proven demonstrated concepts with detailed technical reports on the demonstrated capabilities. In addition, specific byproducts of the investigations will be delivered. These include interface and architecture standards. Some of the benefit of using multiple organizations are interfaces will have to be documented, and the “good ideas” are not limited to those of just one R&D organization. Furthermore, requirements' documents will be developed and coordinated with TRADOC.

In addition to these above mentioned products all organizations involved in the INVEST STO are encouraged to submit technical papers to the simulation community workshops and conferences. It is anticipated that a sub-session on Embedded Simulation will be initiated at a future Simulation Interoperability Workshop.

Contract vehicles

The primary contract vehicle used by INVEST is the STRICOM Broad Agency Announcement (BAA)[ref. 3]. It allows anybody (full and open competition) to initiate a “good idea” white-paper which will be evaluated by STRICOM. “Good ideas” that are innovative and appear to be fundable can be refined between the potential contractor and STRICOM technical staff to the point that a proposal is requested. If the proposal is found acceptable a contract will be issued to pursue the “good idea”. A key benefit of the BAA approach is the white-paper refinement cycle. This allows the interaction between the proposer and our technical staff to reach a full understanding of the proposed “idea” and STRICOM’s potential use of that “idea” as well as resource requirements before the expense of formal proposal submission and evaluation. In addition the SBIR program is also being used to find “good ideas”[ref. 4]. All non-government efforts to date have been initiated through the BAA.

TARGET VEHICLES FOR INVEST

CRUSADER:

The Crusader is a Combat/Combat Support "system of systems" consisting of a self propelled howitzer and the resupply vehicle. The howitzer is the indirect fire support system providing direct and general support fires to the maneuver forces. The howitzer is a 155mm self-propelled model providing close, tactical, and operational fires during both offensive and defensive operations through the 21st century. It will displace the current M109A6 self-propelled howitzers and the resupply vehicle will displace the M992 resupply vehicle.

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, that includes: color digital terrain maps; Army Standard C4I architecture; Task Force XXI Command and Control Software; Under Armor APU; Thermal Management; Improved Thermal Imaging; Improved Vehicle Intercom; Improved Position/Navigation; Horizontal Technology Integration; improved VETRONICS Architecture.

M2/3 Bradley A3

The M2/3 Bradley Fight Vehicle (BFV) is a 30-ton armored vehicle which carries a basic crew of three. Depending on which version of the vehicle you are looking at (the M2 is the infantry carrier and the M3 is the cavalry/scout vehicle), the Bradley can carry a variety of payloads. The M2 carries a small (six-man) infantry squad, while the M3 carries a pair of scouts, with additional radios, ammunition, and TOW missile rounds. The A3 has a VETRONICS Architecture.

Future Scout and Cavalry System (FSCS) ATD

The FSCS ATD is a system for Scout and Cavalry units that is optimized to conduct reconnaissance, surveillance and target acquisition on the Force XXI battlefield.

INVEST STO MILESTONES

All of these milestones are for prototype or concept demonstrations. Each successive demonstration includes updates of the products of earlier demonstrations.

By End Of FY97

Demonstrate Crew Proficiency Application with XXXX trainer – The Crew Proficiency Application Demonstration includes: (1) the use of a prototype standard simulation scenario, (2) an image generator, (3) vehicle driver display, (4) virtual target injection, and (5) burst on/off target affects.

Develop and deliver a feasibility analysis study for Embedded Simulation – Reviews current simulation technology and evaluates the feasibility for inclusion for embedded simulation.

Assess which soldier tasks and skills are appropriate and affordable candidates for embedding and how this capability may augment the simulations systems in the existing training device simulation/simulator

(TADSS)(Training Aids, Devices, Simulators & Simulations) hierarchy. Convert training objectives into embedded simulation goals.

Initiate studies on all identified technologies.

By mid FY98

Demonstrate Unit Proficiency Application with Vehicle simulator. – Uses prototype ES modular hardware and software components. The key element is the addition of network capabilities, both RF and cable. This is the first demonstration of inter-vehicle activity.

Prototype a virtual-live interactive system (VICTOR).

By mid FY99

Demonstrate Mission Specific Application with Vehicle simulator. The key element is that this is the demonstration of a rapid scenario generation facility and the capability to generate mission specific training and then use it for a training demo within a prescribed time period. A primary challenge of this exercise is to come to an agreement on the availability of a mission planning facility and requirements for mission specific training.

By end of FY99

Demonstrate Vehicle-on-the-Move (VOM) Application with XXXX prototype vehicle. This demonstration may require both a field and laboratory demo.

Laboratory Phase

Simulator-on-Simulator Demonstration of Concurrent Model Approach. Verifies that the model approach provides the benefits of interactive training. Depending on success and expense of integration may be included in field phase.

Field Phase

Live/Virtual registration (VICTOR). Integration of VICTOR prototype on a prototype vehicle, demonstrating that live and virtual targets can be registered.

Determination of aim point – demonstrates that a live player can engage both virtual and real targets during the same scenario.

Demonstrate that can interact with remote entities while on the move. Uses wireless LAN and/or tactical radio (SPARTA) /(The Concurrent Model approach)

By FY00 – FY01

Deliver technology to vehicle PM's

Complete definition and demonstration of Inter-Vehicle Embedded Training capability. Develop a standard ES simulation architecture using common components, which will permit development of a consistent synthetic battlefield representation for use in all ES systems and improve interoperability and affordability among future systems.

Continue investigation of emerging technologies, unresolved issues, and situational enhancement techniques.

Organizations involved in development and roles.

All non-government entities are either vehicle prime contractors or have submitted white papers currently under consideration for contract as of the date of this paper submission.

STRICOM AMSTI-ET. – INVEST Project Office.

U.S. Army Tank-Automotive & Research Development and Engineering Center (TARDEC) – Responsible for development of vehicle to trainer interface standard, and architecture. Provides coordination assistance between INVEST office and vehicle PM's.

Sherikon, Inc. – Support contract, assists project office in overall project coordination.

Institute for Simulation and Training, University of Central Florida – Requirements collection, feasibility analysis, technology investigations.

Lockheed Martin – Trainer Prototype.

United Defense Limited Partnership – Prime for Bradley M2A3, and Crusader vehicles. Developing vehicle interface, provide access to vehicle simulators, and prototypes.

General Dynamics Land Systems Division – Prime for Abrams M1A2 (SEP) vehicle. Developing vehicle interface, provide access to vehicle simulators, and prototypes.

Sparta Inc. – Developers of wireless LAN potentially satisfying most of the appended communications requirements.

Science Applications International Corporation – Developing synchronous ModSAF.

Pathfinder – developers of "Virtual Image Combination Technology with Optical Recognition"

(VICTOR), a method for live/virtual target registration.

CONCLUSION

This an ongoing program so all data in this paper was as of the date of submittal which was 21 January 1997. Most of the identified roles are anticipated based on white paper submissions, still subject to proposal and contract actions. A concept for embedded simulation has been identified, but it is subject to revision as the "state of the art" becomes clearer and requirements become firm. Approaches were identified to pursue many of the objectives, but others remain unresolved. At this stage the door is open to new requirements, idea's and innovative approaches.

REFERENCES

1. Embedded Training (ET) Action Plan, Deputy Chief of Staff for Training, (DCST) (TRADOC ET Executive Agent), 3 June, 1996

2. "A Concurrent Model Approach to Scaleable Distributed Interactive Simulation," 15th DIS Workshop Proceedings, Institute for Simulation & Training, Orlando, Fl. September 1996

3. STRICOM & ARI Broad Agency Announcement (97-02), HQ STRICOM, AMSTI-EC, Orlando Florida, October 1996.

4. Small Business Innovative Research (SBIR), The Department of Defense FY97.2 SBIR Solicitation, Opening 1 May 1997 and Closes 16 July 1997.