IMMERSIVE TECHNOLOGY CONVERGING LIVE FIRE AND SIMULATED TRAINING EXERCISES

John Steadman
AMRDEC ATI Directorate
AMSRD-AMR-AT-SE
Bldg 7804 Patton Rd Rm 106
Redstone Arsenal, Al 35898

James Meehan & Greg Dawson
Computer Sciences Corporation
4090 South Memorial Parkway
P.O. Box 400002
Huntsville, AL 35802

Karl King
Kottmann, Inc.
513 Sparkman Drive
Huntsville, AL 35816

ABSTRACT

The Aviation and Missile Research, Development, Engineering Center (AMRDEC) provides support for the development and acquisition of training range targetry programs for the Army. These efforts currently focus on design and development of the New Generation Army Targetry System (NGATS) supporting the Army's Combined Arms Training Strategy (CATS) to train and sustain the total force to standard at the individual, crew / team, unit, and leader skills levels. NGATS will provide the Army's standard targetry system that supports the full scope of live training from skills qualification to collective exercises, including seamless integration with training simulation capabilities.

Live fire exercises have long been the staple of Army training. Though during recent times, more simulated military training tools have become available to train troops for combat. With the implementation of NGATS there is an opportunity to meld these two training paradigms together into one seamless combat readiness training tool. Using NGATS, along with the software concepts that have been generated within the scope of the system's development, and linking this with the implementation of the Test and Training Enabling Architecture (TENA), a new level of performance and benefit can be attained from combat training exercises. The actual realism of live fire, coupled with the synthetic environment of simulated combat tools, will allow tomorrow's soldier to attain a level of military training unprecedented in today's mission rehearsal applications.

TENA is a product of the Foundation Initiative 2010 project and is designed to facilitate the interoperability of resources used on test and training ranges. To provide this interoperability, TENA uses the concept of a Logical Range. A Logical Range is simply a set of software applications that share a common object model and run together in support of specific test or training event. TENA provides a standard way to define the range object model and a common software mechanism for communicating these objects between ranges and range assets. By implementing within this architecture, NGATS is able to provide a standard way of exchanging data with non-NGATS application and bridge into simulation-based architectures such as Distributed Interactive Simulation (DIS) and High-Level Architecture (HLA).

Building on the TENA concept of a Logical Range, the NGATS software development team developed the concept of Logical Targets to describe and contain the attributes and behaviors

Report Documentation Page	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
00 DEC 2004	**N/A**	**-**

4. TITLE AND SUBTITLE	
Immersive Technology Converging Live Fire And Simulated Training Exercises	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **AMRDEC ATI Directorate AMSRD-AMR-AT-SE Bldg 7804 Patton Rd Rm 106 Redstone Arsenal, Al 35898; Computer Sciences Corporation 4090 South Memorial Parkway P.O. Box 400002 Huntsville, AL 35802**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2005 in Orlando, Florida. , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**6**	

of a target. This new concept will significantly impact the future of Army combat training systems. It is what makes a pop-up target face become a realistic battlefield threat. By assigning to a Logical Target a series of attributes and behaviors indicative of a threat vehicle or enemy combatant, existing range resources can be coupled together to best imitate the desired threat. For instance, a Logical Target of a tank could incorporate a series of stationary and moving armor targets working together to simulate an approaching armor vehicle. Linking these different targets together, along with associated battlefield effects devices and hit detection sensors, this Logical Target would appear to approach the firing position in different stages of exposure while the battlefield effects would be exercised as needed in an event-driven manner from hit detection feedback. This complex interaction of target presentation devices, representation devices, battlefield effects devices, and weapons effect measurement devices lend to a more realistic training exercise. These Logical Targets will be constructed by scenario developers at the ranges using the NGATS Graphical User Interface by simply clicking on specific targets, dragging and dropping resources to them as necessary, and further refining the Logical Target by assigning Logical Behaviors indicative of the desired threat. By building these behavior patterns within the Logical Target definition, a level of abstraction is achieved between actual battlefield cause and effect relationships, and the software command sequence necessary to manipulate a target face.

Since realistic training is the end goal of all combat readiness activities, it is easy to see why live fire range scenario executions would greatly benefit from a direct link with the cost effectiveness of simulated battlefield training exercises. Implementing TENA to bridge between the simulation and live fire resources involved in real-time training exercises, an armor battalion could train together while only deploying a fraction of the crews onto available range firing positions. The remaining tank crews could participate in unison with the live fire armor, further enabling a master gunner to be able to face a more realistic threat than that presented in a training manual.

It is the mission of the NGATS Block 1 development team to develop a deployable software system capable of broadening the scope of tomorrow's Army training range capabilities. Further along, in Block 2 development efforts, even greater strides will be made upon the broad shoulders of this robust targetry system, incorporating advances in technology and resource utilization only contemplated before. The continued advancement in targetry management efforts within the Army can only lead to a more comprehensively trained soldier, with combat readiness unparalleled worldwide. It is this vision and inspired current development activities that make NGATS a critical element in the dossier of Future Combat Systems.

1. INTRODUCTION

The New Generation Army Targetry System (NGATS) will provide the Army's standard targetry system that supports the full scope of live training from skills qualification to collective exercises, including seamless integration with training simulation capabilities. NGATS will provide the Army a capability for converging live-fire and simulation to support training, testing and stressing today and tomorrow's soldiers and weapon systems. It will overcome the shortfalls found in currently fielded systems and be employed by the unit commander and staff to support training of worldwide based U.S. Army forces and close air support forces during Live-Fire Exercises (LFX) and Field Training Exercises (FTX) at home stations, maneuver Combat Training Centers (CTCs), and in Outside the Continental United States (OCONUS) theaters of operations. The capabilities and enhancements founded in NGATS will allow the Army to support current training and be responsive to enhancements in weapon system performance through live fire training coupled with simulated training exercises.

The currently deployed Remoted Targetry System (RETS) that is used on most Army live fire training ranges capability is very limited when compared to the capabilities of the NGATS. The new system will be deployed in all new range developments and as a RETS replacement on all existing RETS equipped ranges, and will thus usher in a new era of targetry management for live fire training exercises.

Along with this new era will also come the advent of simulation training OPFOR exercises running concurrent with live fire exercises. The new TENA middleware is capable of facilitating highly effective communication between the two independent software systems, providing value added feedback in a timely manner. TENA is a controlling software interface, providing a common communications link between uncoupled software systems, and is one of three new elements which will facilitate and shape the direction of Army live fire training systems. While simple in concept, TENA is also elegant in design and has robust heavily patterned implementation.

2 THREE KEY ELEMENTS

As the preceding section stated, TENA is a new key element in the NGATS system which can be used as the middleware interface between various fielded targetry control systems. It is being implemented in the current development of NGATS, which will be the first to incorporate TENA onto an embedded processor to facilitate a communication link between a pit-located target processor and a targetry control workstation located at the range operations control center. The decision to use this particular middleware for NGATS is due to the tried and proven architecture already fielded throughout various armed service branches. To date, it has been utilized mainly for testing applications, but NGATS will have the distinct honor to prove the effective use of the middleware for training purposes.

TENA serves as a strong backbone of communication between physical elements of a fielded NGATS system. This is only the first of three key elements outlined in this document which help define the strengths and innovation of the NGATS development and implementation efforts. The other two are the conceptual object models of Logical Behaviors and Logical Targets. While originating as conceptual ideas, their current implementation has already proven them indispensable in the NGATS architecture object model. Both the Logical Behaviors and Logical Targets concepts apply to the actions, reactions, and coupling of physical targetry devices, such as a presentation device or a weapons effect measurement device.

2.1 TENA

One of the main tenets of TENA's design is the use of a Stateful Distributed Object (SDO). This is a combination of two paradigms: a "distributed object paradigm" and a "publish & subscribe" paradigm. An SDO will provide an application the ability for one-to-one communication with another application through the use of remotely-invocated methods defined in the interface. The middleware will also provide the mechanism for publishing information to many subscribers of that information. Subscribers will be able to read the published data as if it were local data. By combining these two powerful programming paradigms, the SDO provides an interface to an object's methods as well as the advantages of publication state.

As the middleware interface for NGATS software components, TENA supplies communications links between the Master Targetry Control Workstation (TCW) located at the Range Control Tower, Operator TCW, and Remote TCW located in the field. TENA also facilitates all communications between the Target Processor (TPROC) located directly in the target pit, and the various TCWs. The small memory footprint of TENA will enable the TPROC to operate the middleware within an embedded system. This will be a first for TENA middleware deployed on an Army training and qualification range.

2.2 LOGICAL TARGET

The Logical Target is a repository for behaviors and targetry interactions that will mimic an enemy threat vehicle or enemy combatant. Whether mobile or stationary, a threat will exhibit certain traits, behaviors, and reactions which can be modeled into physical characteristics and mimicked by various targetry devices.

While a Logical Target can consist of a single targetry device, it can also be comprised of multiple devices. This feature is what makes a Logical Target such a powerful element in the architectural design of NGATS. When multiple targetry devices are coupled together, the overall behavior of a threat vehicle or combatant can be more closely realized. Motion can be imitated using multiple stationary targets, and infantry targets can be linked together to give the training soldier a very real ambush experience. These are just two examples of how a scenario developer might recreate the battlefield for his combat readiness exercises.

To facilitate the interactions of multiple targetry devices included together into one Logical Target, TENA is used extensively to facilitate communications between these various physical components that are connected to different target processors. Although communication between targetry devices that are connected to the same target processor does not utilize TENA, those devices within the definition of a particular Logical Target that do not share a common target processor will rely on the middleware for effective communication.

The combination of targetry components into Logical Targets is only limited by physical resources and the imagination of the scenario developer. With the coupling effect of added simulation applications, the scope of combinations and their implementation within a training scenario broadens yet again.

2.3 LOGICAL BEHAVIORS

Incorporated into the concept of a Logical Target is the Logical Target Behavior. This is a non-trivial aspect of a Logical Target, and is the essence of its functionality. By building these behavior patterns within the Logical Target definition, a level of abstraction is achieved between actual battlefield cause and effect relationships, and the software command sequence necessary to manipulate the required targetry devices.

To better understand the significance and meaning of a Logical Behavior, the tactical nature of targetry must be addressed. The base tactical definition of Logical Target Behavior is the actions necessary to imitate how a representation device creates the impression of being an actual target on the battlefield. The base definition of Target Reaction (still a type of behavior) is the actions necessary to imitate the response of a representation device to interaction with weapons fired projectiles or the element being trained.

The tactical representation of personnel targetry replicates the sudden appearance of threat personnel within the target engagement area (down-range). The tactical representation of threat vehicle targets replicates the techniques used by vehicles in tactical situations. Dismounted soldiers use techniques known as cover and concealment to protect themselves while engaging enemy soldiers with direct fire. Vehicles have similar techniques, with terminology more indicative of the crew-served weapons platform.

Target representation devices replicate the same tactical postures that the firing vehicle practices during gunnery exercises. And to facilitate this, a scenario developer needs to be able to build a behavior pattern for a targetry device that is consistent with the tactical representation required by the training event. To this end, a scenario developer could define a Logical Target Behavior that unexposes a target face after three hits are detected. Associated battlefield effects could then be triggered to further simulate a successful kill. All of these behavior patterns would lend to a more realistic training exercise.

Logical behaviors can also be used to duplicate evasive maneuvers by threat vehicles. Evasive movement by targets is defined in training doctrine as targetry representation devices that move at varying speeds, conduct short halts of no longer than 5 seconds, or change direction. These evasive actions are similar to the jerky movement, uneven speed, and change of direction actual vehicles do when moving across unimproved terrain. By developing a Logical Behavior of uneven speeds and sudden stops for a Moving Armor Target (MAT), a Logical Target is further able to mimic the actual battlefield behavior of a threat vehicle.

A final tactical replication that Logical Behaviors make possible is dynamic movement across terrain. Unfortunately, most terrain being traversed by tactical vehicles is anything but flat. Therefore, tactical vehicles will usually dip and dodge in, over, and around terrain features as they move across the landscape. Existing range capabilities, to an extent, replicate this tactical movement action during events such as Tank Table XII, with depleting bands of targets. However these capabilities must be carefully planned and the system is unable to dynamically create, change, or control the outcome of such an event. But Logical Behaviors within Logical Targets make this situation possible. Grouping multiple Moving Infantry Target (MIT) and MAT representations together, and building their Logical Behaviors to mimic a tank appearing and disappearing across undulating terrain is easily accomplished within the scope of NGATS using Logical Behaviors within Logical Targets.

By defining the logical targets with logical behaviors, scenario developers can take existing range assets and use them in manners that were not possible before. A series of stationary targets at decreasing range distance locations, by exposing and unexposing in sequence, can mimic the actions of an approaching enemy tank coming in and out of view. The multiple physical target lifters and associated battlefield effects have coordinated actions and reactions built into the behaviors of a single logical target. With the ability to orchestrate threat vehicle interactions using any combination of range assets desired, the scenario developer is no longer limited by the utility of a single device or pit location.

These logical behaviors and logical target definitions are constructed by the user of NGATS software prior to developing scenarios, and stored in a database for repeated use. The database is populated with different and varying combinations of range assets and their desired behaviors, coupled to best mimic actual battlefield conditions, threat vehicles, and enemy combatants.

The reuse of logical behaviors and logical targets makes the NGATS system very efficient to operate. A scenario developer only needs to build one advancing T72 tank with three stationary pits in a firing lane to use it in multiple scenarios. Behaviors and reactions of threat vehicles (MAT & SAT) and enemy ground troops (MIT & SIT) are defined once in the database for a particular logical target, and thus the logical target and its associated logical behaviors are captured for reuse in any future scenario for any training event.

3 SIMULATION

While NGATS is being developed for live fire training and qualification testing of troops and tank crews, there is also a design consideration for future interface with simulation applications. Currently, there are no fielded sim-world apps which would readily be useable on an Army training and qualification range, but future developments will easily couple with NGATS to provide a powerful training tool for combat readiness.

A simulated training exercise would have a scenario built with the NGATS software, just as a scenario developer would do for a live-fire exercise. The simulated training would use the same database of logical targets with the same encapsulated logical behaviors. But instead of deploying all of the combatants onto the training battlefield, many could take part in remote locations within various types of battle simulators.

The feedback garnered from the simulated battle exercises could be fed to the live-fire training exercises in session to achieve coordinated target kill success between real and simulated combatants.

OPFOR training could utilize the interface between live-fire and simulated exercises by registering enemy combatants as simulated entities. In this manner, a live-fire exercise could be executed upon an opposing enemy that had been developed by a scenario developer using NGATS software. While tank crews battled on the range with live training munitions, opposing forces represented by troops or crews in simulators could present an OPFOR challenge with real-time feedback.

The coupling of the sim-world and live-fire training is made possible by the ease and speed of communication between the various applications driving the training event. This is facilitated by the TENA interface and would incorporate all the advantages outlined in previous sections of this document.

By incorporating the benefits of TENA and reutilizing the Logical Target and Logical Behavior elements within the NGATS software, simulation can be readily coupled with the live-fire training capabilities of the Army, as well as joint force training exercises. The user interface being developed now for NGATS will easily adapt for inclusion in simulation applications making a common user experience possible throughout all training and qualification range applications.

CONCLUSION

In addition to harboring all of the design features described within this paper, the NGATS Architecture also is modular and reconfigurable in order to meet the broad spectrum of Army training missions. These training missions range from individual and crew-served weapon skill qualifications along with sustainment for current and future weapon systems to multi-echelon force-on-target and force-on-force, including real-time live, virtual, and constructive exercises. The NGATS architecture provides the capability to support all combinations of training events as described above.

NGATS architecture, incorporated with new technologies, methods, and processes, creates a system that is designed to revolutionize the acquisition of targetry and training range resources by the Army. This includes the introduction of government and industry standards within the range and targetry inventories for future ranges in the areas of interfaces, cables, power distribution and communications. Also, NGATS will include a government standard and government owned command and control software system that will interface with a family of compliant devices from multiple manufactures. All current target control systems are primarily unique or proprietary and do not support other vendors equipment.

With such a robust and modular targetry system, it is not difficult to project a future for NGATS that will seamlessly integrate simulation applications for battlefield threat mitigation training. There is no substitute for realistic and readily accessible training. With NGATS, all branches of the armed service will be able to afford the highest possible training experiences for their combat troops.

The savings incurred by reusable software components throughout a suite of live-fire and simulation applications will help to disseminate the NGATS architecture over a broad range of training environments. It is because of the modularity of the system, as well as the common communications capabilities afforded by TENA middleware, coupled with the ability to build a database of Logical Targets and Logical Behaviors, that will make the NGATS architecture and the ensuing software components the chosen platform for deploying superior combat readiness training systems upon the live-fire ranges of today and tomorrow.