Application of Existing Simulation Systems to Homeland Security Training

Roger Smith and Lou Ford
Titan Corporation
Orlando, Florida
rdsmith@titan.com, lford@titan.com

ABSTRACT

Following the events of September 11, 2001, many countries began new efforts targeted at improving the security of their nation. These have included additional security at border entry points, new procedures for screening materials entering the country, an increased focus on intelligence information gathered at home and abroad, and the preparation of emergency response personnel who must deal with terrorist incidents.

Each of these activities presents new problems, new tactics, and new ways of looking at familiar situations. Becoming proficient at any of these will require new forms of training that focus on issues unique to Homeland Security (HLS). Within the US Departments of Defense, Justice, and Health there are numerous efforts examining the best ways to create training scenarios, facilities, course materials, and simulations. Our team has identified a number of existing simulations that have the potential to address HLS issues. We have also defined some high-level requirements for new simulations in this domain.

The study of existing simulation categorized those systems as: leadership training, immersive systems, desktop trainers, analytic simulations, and simulation support tools. In this paper, we will introduce many of these systems and identify those that we believe are the most immediately applicable to different forms of HLS training. The large number of potentially applicable simulations indicates that HLS organizations should not engage in the development of a new simulation system before they have studied, experimented with, and applied several of the systems identified in these studies. Organizations can make more efficient use of their financial resources by applying them to the gaps that exist between available simulations, rather than paying to reinvent those capabilities. The study also indicates that existing simulation systems, usually from military or medical organizations, are targeted at the actions that should be taken in response to an emergency event. But, we were able to find very few simulations that focused on planning for an emergency, identifying threatening situations, or preventing an event from occurring. In these areas, it appears that new simulation systems will have to be constructed.

ABOUT THE AUTHORS

ROGER SMITH is a Vice President and Group CTO at Titan Corporation working on next-generation simulation applications and distributed computing technologies. His most current work has been creating techniques to model counter-terrorism, infrastructure protection, and information operations. He is the creator and instructor of a series of military simulation courses that have educated hundreds of simulation professionals. He also serves on several advisory and editorial boards involved in shaping the future of the simulation field.

LOU FORD is a Senior Software Engineer for the Titan Corporation working on modeling and simulation technologies that bridge the virtual, constructive, and live domains. He has worked on numerous simulation, space, and missile programs and is currently leading a team of software developers on the Intelligence and Electronic Warfare Tactical Proficiency Trainer (IEWTPT) and the Deployable Intelligence Simulation for Collaborative Operations (DISCO). Lou serves on SISO's IO-ISR Committee.

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HOMELAND SECURITY PREPARATION AND TRAINING

"We must prepare to minimize the damage and recover from any future terrorist attacks that may occur despite our best efforts at prevention. Past experience has shown that preparedness efforts are key to providing an effective response to major terrorist incidents and natural disasters. Therefore, we need a comprehensive national system to bring together and command all necessary response assets quickly and effectively. We must equip, train, and exercise many different response units to mobilize for any emergency without warning."

- National Strategy for Homeland Security, July 2002[1]

One part of preparing to act is rehearsal in an environment similar to that presented during a real emergency. All organizations engage in some form of training and many include simulation tools in that training. Military organizations are best known for simulation tools like flight simulators, command wargames, and executive seminar exercises. Many health organizations also use simulations that represent physical patients, crisis decision-making, and virtual surgery. There are also simulators to teach safe and efficient driving techniques to truckers and policemen; proper equipment operation for factory automation and nuclear power control; psychologically correct techniques for handling angry or disturbed people; and hundreds of other special applications.

The tools that have been developed for various purposes over the last several decades can be applied to different aspects of homeland security preparation and training. In some cases, the simulations can be applied directly, in others, it will be necessary to modify the simulation database or software. And in a few cases, there are no existing simulations capable of providing effective HLS related training.

SURVEYING EXISTING SIMULATION SYSTEMS

The National Homeland Security Training Center (NHLSTC) is constructing a facility and curriculum designed to better prepare emergency responders for threats from international and domestic terrorists who are willing to initiate mass destruction using conventional, nuclear, biological, or chemical weapons. The NHLSTC commissioned our team to identify effective ways to apply simulation tools as one part of their training center [2, 3]. We began with a survey of existing simulations that had applicability to HLS missions. In the short period allocated for the survey, we identified fifty-five different simulation systems and support tools that could be applied to HLS. Table 1 is a representative sampling of the systems listed in that study. The simulations were grouped into the categories shown in the table to better allocate them to different types of HLS training events.

Table 1. Representative List of Simulations with Potential Homeland Security Applications

Planning and Preparation
Hazard Prediction and Assessment Capability
Computer Aided Mgmt of Emergency Operations
Consequences Assessment Tool Set
Vapor Liquid and Solid Tracking
Virtual Cities
Cellular Automata Based Infiltration
Leadership Training
Civil Emergency Reaction and Responder Training Sys
Emergency Preparedness Incident Command Sim
Joint Combat Analysis and Tactical Simulation
Joint Semi-Automated Forces
VR Forces
Flexible Analysis and Mission Effectiveness System
Scenario Toolkit and Generation Environment
MAGTF Tactical Warfare Simulation
Cooperative Team
Regional Live Table-Top Exercises
Live Physical Events
Guard Force
Mass Casualty Operations Trainer
The Sims Online Conversion
Computer Aided Management of Emergency Ops
Individual Skills
BioSIMMER
MediSim
Emergency Room: Code Red
Combat Medic Special Ops
Virtual Emergency Management Training System

SWAT 3 Conversion
America's Army: Operations Conversion
National Counterdrug Center Simulation System

PLANNING AND PREPARATION

Simulations are used to plan and prepare for real and live training events. The U.S. Defense Threat Reduction Agency sponsors the development of a number of different tools that are used to study the effects of nuclear, biological, and chemical weapons. Models like the Hazard Prediction and Assessment Capability (HPAC) and Vapor Liquid and Solid Tracking (VLSTRACK) are well known for their abilities to estimate the dispersion of NBC materials following the detonation of a device containing these materials. These tools can be used in the HLS community to identify contaminated areas following a real or simulated attack. [4]

Most live HLS/EM training exercises are conducted without the assistance of computer simulations. However, these rely on the personal expertise of the controllers (i.e. referees or judges) to adjudicate events. For example, a human controller may be required to estimate the spread of a cloud of chlorine gas following an explosion. He or she would estimate the size and danger area of the cloud of gas and its dispersion rate over time. These estimates might be used to determine when a first responder is allowed to enter a contaminated area without protective clothing. Human estimates may be quick and easy to make, but they are not necessarily accurate. Therefore, the scenario that the first responders train in may severely underestimate or overestimate the lethal effects of a chemical or biological agent.

Models like CATS, HPAC, and VLSTRCK can be used to accurately represent the spread of agents and incorporate them into the exercise (Figure 1). These models may be run during the exercise, or they can be run prior to the exercise and plotted on time-phased maps to be used later.

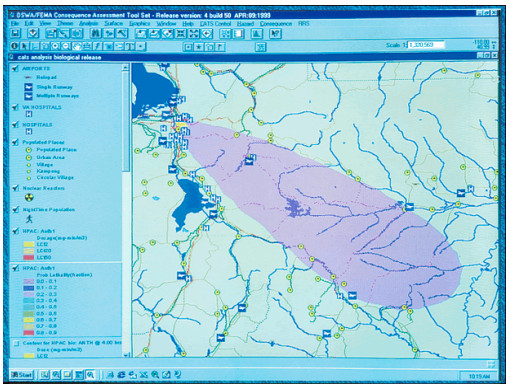

Figure 1. The Consequences Assessment Tool Set Predicts NBC Dispersion Patterns and Timelines

3D models created by the Virtual Cities project at the Institute for Defense Analysis can be used as interactive, three dimensional blueprints for studying the vulnerabilities of facilities and the occupants of them (Figure 2). These allow planners to examine a site from multiple angles and plan defense measures that would otherwise require travel to the site or mental visualization based on traditional blueprints.

Figure 2. IDA Virtual Cities Enables Emergency Planning in Geospecific Facilities

LEADERSHIP TRAINING

Leadership training focuses on developing the skills of a leader in managing and employing the assets at his or her disposal. Simulations used for this type of training present a complex situation to one or more people who have to assign assets to respond to the situation. In military environments, these simulations are often referred to as wargames and are used to train commanders of battalions of soldiers; naval battle groups; or a wing of aircraft.

In HLS and emergency management training, leadership training may focus on the ability of a fire chief to place and command his assets effectively. It may also teach a city management team to balance the

need to assign resources to one or more emergencies while still protecting the rest of the community. Traditional military wargames could be modified to represent the operational effectiveness of fire trucks, ambulances, and emergency workers rather than military equipment. Encounters with "the enemy" may also be modified to represent encounters with fire, caved in buildings, gas leaks, and the frightened populace.

These types of trainers usually provide a map display interface that shows the placement of assets and basic information about their status. The purpose is to exercise the decision-making skills of the leaders while presenting them with a broad picture of the situation. The Civil Emergency Reaction and Responder Training System (CERRTS) was derived from a military simulation and now represents emergency response organizations and disasters that might occur in a city (Figure 3).

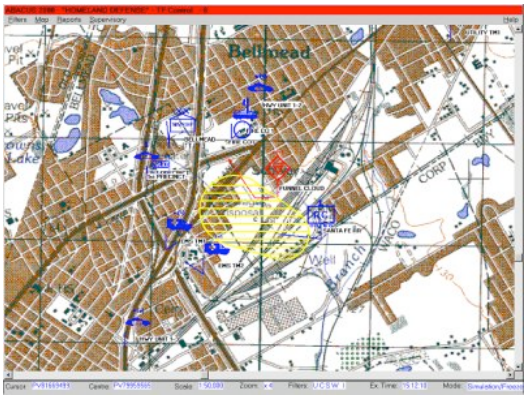

Figure 3. Civil Emergency Reaction and Responder Training System is a Military Wargame Converted to the HLS Mission

Several organizations are experimenting with conversions of leaderships training systems like the Joint Combat Analysis and Tactical Simulation (JCATS), JANUS, and Joint Semi-Automated Forces (Joint SAF) which may be able to present command situations to emergency managers as effectively as they have for military commanders (Figure 4).

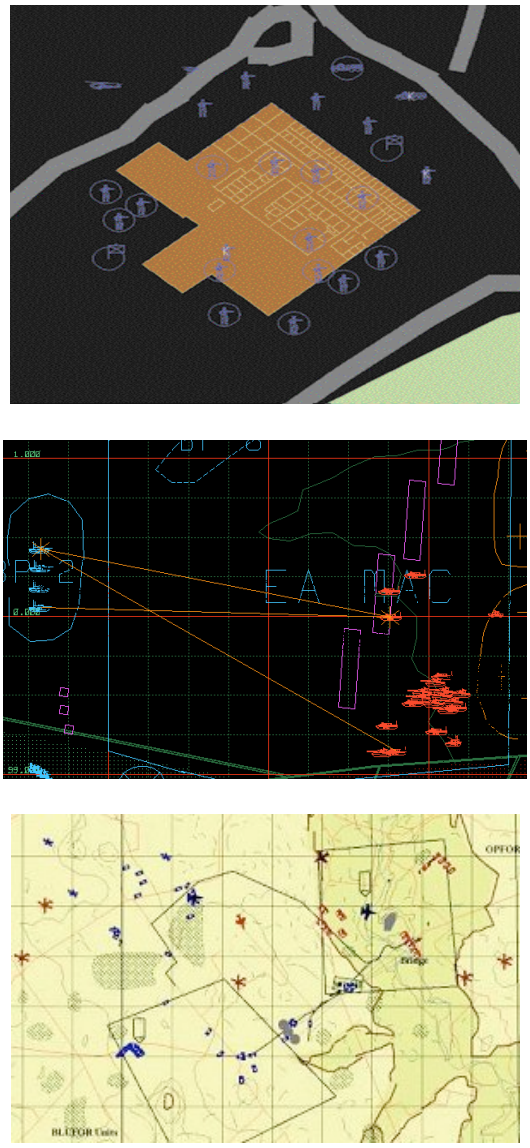

Figure 4. JCATS, JANUS, and Joint SAF are Potential Leadership Training Tools for HLS and Emergency Management

COOPERATIVE TEAM TRAINING

Training teams of people to work together has always been a challenge to any organization. This is usually done with either large live exercises, elaborate mock-ups of vehicles and facilities, or networked groups of computer terminals.

Live exercises allow people to practice team skills with their hands and to experience many of the limitations of communicating with each other, moving resources, and working with the equipment and assets available. These exercises are very good at giving people an opportunity to work with potential partners and to

determine the level of expertise that will be available during an emergency (Figure 5).

Figure 5. Live Exercises Allow Multiple Organizations to Work Together

Computerized mock-ups can cost as much as one million dollars each. But, they do provide an environment that can immerse one or more teams of people. Mock-ups of tanks, planes, and ships are most common within the military. During the survey we were not able to identify similar mock-ups that have been built to train for HLS missions.

Geographically dispersed organizations may create a team trainer by entering a networked virtual space in which avatars that represent each member interact instead of the actual people themselves.[5] Games like The Sims Online (Figure 6) and Everquest present distributed, shared environments for entertainment. Similar tools would be very useful as a learning environment for teams.

Figure 6. The Sims Online Provides Collaborative Entertainment in a Form That Is Adaptable for Collaborative Team Training

There are other training systems that provide an emergency management scenario for a single player and could be converted into team training systems. Guard Force is one new simulation, based on a traditional military simulation engine, which could be converted into a team trainer (Figure 7). This simulation provides a scenario in which national guardsmen respond to regional disasters and exercise their judgment is selecting the best ways to serve the people in danger.

Figure 7. Guard Force Provides Emergency Response Scenarios and has the Potential to Teach Teams to Work Together

INDIVIDUAL SKILLS TRAINING

Simulations are most widely recognized for their ability to teach specific skills to individuals. Flight simulators, tank simulators, and individual immersive trainers have all been used to teach people how to perform specific skills – and to do so in an environment where it is safe to make mistakes.

3D virtual worlds are usually created to provide an environment in which individuals can play autonomously and learn to do their jobs better. Pilots learn to fly aircraft in thunderstorms, wind shear, congested airspace, and through equipment failures. Each of these situations can be mastered in a simulation without endangering the life of the pilot, the value of the aircraft, or the well being of the local community.

HLS missions can use these types of 3D worlds and simulations to teach individual firemen to deal with collapsed buildings, unique fire conditions, and rescues of people from seemingly impossible situations. Emergency workers can confront life threatening injuries and complex combinations of problems in the computer (Figure 8). Software-based computer simulations also provide a more portable training environment than do medical manikins. They also

enable extensive scenario variations that cannot be conveyed through videotapes and CD-ROM programs.

Figure 8. Virtual Medical Training with Emergency Room: Code Red

RECOMMENDATION

The study that we conducted for the National Homeland Security Training Center recommended that an organization make the best use of the many simulations that already exist in this area or than can readily be adapted to it. We suggested going through four phases in equipping HLS organizations with training simulations.

1. *Apply Existing Simulations.* It is much less expensive to purchase any simulation system or tool than it is to build one from scratch. Many systems that exist are readily applicable to HLS missions.
2. *Customize Simulation Databases.* Many simulations are heavily database driven and configured. This means that the location, capabilities, asset identities, and missions described in the simulation can be changed with little or no modification to the simulation software.
3. *Modify Existing Simulation Software.* The NHLSTC study identified 55 systems and tools that can be used to support HLS training. Many of these provide a great software foundation that can be modified to represent emergency response assets and scenarios of interest to HLS organizations.
4. *Build New Simulation Systems.* After an organization has used existing simulations to the maximum extent possible, there will remain some deficiencies in representing HLS training scenarios. New simulation systems should be developed to fill these discovered gaps, but only after the economical application of existing systems.

LEVELS OF CONVERSION

Our research identified several very good candidates for conversion. As we studied dozens of systems we recognized a common pattern of options for these conversions. We organized these into four different levels as shown in Table 2.

Table 2. Multiple Levels of Conversion to Create HLS Simulation

Level 1: Scenario Customization
Develop scenarios of an HLS mission, but make no changes to the original simulation. *Example:* Combat in an urban environment. Defensive force lay-downs in domestic cities.
Level 2: Graphic Representation
Change the graphic appearance of objects, interactions, and menus. *Example:* Replacing tank icons with fire trucks, helicopters with tornadoes, and "Kill Rate" menus with "Rescue Rate".
Level 3: Algorithm Modification
Change combat algorithms to represent special capabilities of emergency equipment. *Example:* Modify movement rates and negotiable terrain limits of tanks to represent those of fire trucks and ambulances.
Level 4: Model Replacement
Completely remove combat models and replace them with newly created models of EM equipment and decision-making. *Example:* Create new models of the cooperative and supportive actions of firemen, policemen, EMT's, and members of the Red Cross.

At the most basic level is the use of the original simulation with a new HLS-specific scenario database. The user builds a scenario database that instantiates the same objects modeled in the military simulation, but as applied to a Homeland Security mission. This can be done by applying simulations like JCATS to urban combat with terrorists in apartment complexes, airports, and parking garages.

The second level is to change the graphics and menus of the simulation to provide the visual appearance of an HLS-specific simulation system. This was done in the 1990's by the Plowshares program. Under that program, the JANUS combat simulation was modified to represent hurricanes, fires, tornadoes, ambulances, police cars, and fire trucks. However, the only modifications that really occurred were the replacement of helicopter gunship icons with tornadoes and tank icons with a fire trucks – and many similar visual replacements. This same type of graphic

makeover has been used to create CERRTS in this decade.

The third level of conversion is to modify existing algorithms within the simulation to represent new objects and events. This would include changing the operational models of a tank to represent the capabilities of a fire truck. For example, a tank may be able to navigate extremely rough and uneven terrain, but a fire truck should be limited to roads and flat fields. A fire truck should not be able to shoot discrete rounds of ammunition at a fire, but rather deliver a stream of water at a determined volumetric rate. These types of changes would be made to algorithms for movement, detection, interaction, damage, and decision-making.

The fourth, and final, level is to completely replace the models of combat objects and the graphic interfaces with others made specifically for HLS missions. The new system would retain the underlying infrastructure of the original simulation. That infrastructure would include capabilities to load scenario files, store simulation results, communicate over the network, pause play of the game, capture checkpoint data, and initiate restarts. These and many other operations comprise a large portion of the functionality of a robust simulation system, and in most cases this functionality is independent of the objects and events that are being modeled. This level of conversion is a significant amount of work, but can be less effort than building a new system entirely from scratch.

CONCLUSION

The United States and other countries have invested heavily in training tools, educational materials, and simulations in the last several decades. These investments have resulted in many very good systems for teaching skills that are directly transferable to the Homeland Security domain. 9/11 was the not beginning of national-level interest in training for these types of events, but it did shift the focus and support of the nation to this area. Many of the existing tools should be adopted, modified, and fielded to national, regional, and local organizations that must prepare to deal with threats to the internal security of the nation. Following this adoption and experimentation with these tools, organizations will better understand the opportunities for developing new, HLS-specific simulation systems from scratch.

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