DEFENSE AND FIRST-RESPONDERS LEVERAGE VIRTUAL TECHNOLOGY: TAKING IT TO THE EDGE

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ABSTRACT
Active-shooter incidents with multiple well-coordinated perpetrators are becoming more common worldwide. This concern inspired the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responder's Group (FRG) to build a partnership with the U.S. Army Research Laboratory - Human Research and Engineering Directorate, Simulation and Training Technology Center (ARL-HRED STTC) who has extensive experience making use of technology to improve training. First responders from Sacramento, California came together to establish the detailed requirements. This cross-organization partnership developed a virtual prototype for training first responders, which was successfully demonstrated in Sacramento in fiscal year 2014. This led the way for inter-departmental and cross-discipline groups to train together in advance of an attack to improve coordination and reduce response time and casualties. This paper illustrates how the organizations conducted a training exercise to support flexible training tactics and scenarios to maintain readiness despite limited resources.

Keywords: First Responders, Virtual Training Technology, Cross Collaboration, EDGE

1. INTRODUCTION

Consider your most recent stay in a hotel or visit to a mall. What would happen if you suddenly heard and felt an explosion, then gunfire, and in the ensuing chaos, you watched people all around you; men, women and children injured or killed by the blast, being taken hostage or being gunned down? In the distance, you hear other explosions and instinctively know this isn't an isolated incident and that help may arrive soon. You hear and see individuals speaking a foreign language with automatic weapons randomly shooting while you try to stay out of sight. One of the shooters begins setting fires along the exits to herd people toward the other shooters. You hear sirens, but with the fire and the active-shooters, you don't know what to expect; once the first responders coordinate their efforts and make their way into the building, will it be too late?

Now imagine you are the first Law Enforcement (LE) officer on the scene. There is carnage, fire, people screaming, and the sound of gunshots and shouting coming from multiple locations. This is clearly a "high complexity" event, meaning that it involves "teams of trained attackers simultaneously attacking multiple locations" (Blair, Nichols, Burns, & Curnutt, 2013). Based on historical data (Blair, Nichols, Burns, & Curnutt, 2013), if shooting is active at the time LE arrives, "there is a 14 percent chance that an officer will be shot when he or she makes a solo entry into an active-shooter attack site" (FBI Law Enforcement Bulletin, 2014), other sources show the statistic as closer to 15%, making response to an Active Shooter Event (ASE) one of the most dangerous activities in LE. The decision to proceed is a weighty one. The most critical task during an ASE is to "stop the killing" (Blair, Nichols, Burns, & Curnutt, 2013), so LE cannot sit idly while pondering the best course of action. The first LE officer on the scene has the command role and must coordinate the entire response until a higher authority takes over, meaning he or she holds responsibility for the scene. This means moving forward to stop the threat while coordinating with the fire department, immediately.

Fire and Emergency Medical Services (EMS) considers an event described above as an Active Shooter and Mass Casualty Incident (AS/MCI) (Federal Emergency Management Agency (FEMA) U.S. Fire Administration, 2013). The term describes active shooter incidents as those "involving one or more subjects that participate in a random or systematic shooting spree, demonstrating their intent to continuously harm others" (Federal Emergency Management Agency (FEMA) U.S. Fire Administration, 2013). The term is focused on fire/rescue and EMS agencies. AS/MCIs are primary LE events that require coordination between the LE on-scene lead and the fire/rescue/EMS on-scene lead. Unified Command (UC) is the vehicle for command and control of the event so a Unified Command Post (UCP) must be established as soon as possible. But in the meantime,

how might the LE on scene make use of the arriving fire fighters so that he or she can gain access to the building and engage the active-shooters? How will they render aid to the wounded and protect the firefighters? How will fire, LE and EMS coordinate to maximize responder safety while saving as many lives as possible? These are complex issues without clear-cut solutions.

Thankfully, the scenario described above, while similar to other events, is fictional. It describes a simulated experience developed as a means to better prepare first responders for AS/MCI events before they occur.

This paper documents the background of why such training is important, cross-organizational stakeholder goals, a description of how the exercise was conducted, outcomes, challenges and mitigation, and the way ahead for this effort.

2. BACKGROUND

In 2008, a terror attack in Mumbai, India (*Figure 1*) led to great loss of life, instability, and a series of lawsuits against the Indian government for failing to protect its people (Rand Corporation, 2009). This tragedy, in addition to a growing number of global terrorist events, exemplifies an increase in threat events (FBI Law Enforcement Bulletin, 2014) with the potential for increased complexity (Rand Corporation, 2009). DHS S&T FRG reached out to experts from the First Responder Resource Group (FRRG). The FRRG is a volunteer organization of individuals drawn from LE, Fire, EMS and emergency management across the

Figure 1 The Taj Mahal Hotel during the attack in Mumbai (Siddique, 2012)

United States. They identify capability gaps, set priorities and requirements and evaluate the newest responder tools (First Net, 2014). In 2011, the FRRG determined a virtual training capability was a high-priority cross-cutting training gap for response to attacks on the civilian population (DHS S&T FRG, 2013).

Historically, training for ASEs has focused on small groups and individual disciplines, i.e. LE trains on a strictly LE response, etc. Though live training is optimal, cost and complexity prevent full-scale live training events from occurring frequently, with only a fraction of responders receiving training when they do occur. However, virtual training cannot replace the interactions involved in live training, but there are opportunities to significantly reduce costs while increasing responder proficiency. Virtual training simulations allow a large number of responders to train repeatedly, both as individuals and in teams. This potentially increases the depth and breadth of trainee involvement since exercises can be repeated at a fraction of the cost of a live event and can be used to prepare trainees to make better use of live training time. More importantly virtual training provides an increased opportunity for cross-discipline training.

Both the FRRG and DHS S&T FRG look across the modeling and simulation community in the hopes of leveraging previous work to reduce cost without sacrificing performance. This led to a partnership with the Army Research Laboratory-Human Research and Engineering Directorate, Simulation and Training Technology Center (ARL-HRED STTC). The ARL-HRED STTC has demonstrated extensive experience making use of commercial technology to improve preparedness. Individuals from the commercial modeling and simulation industry, academia, ARL-HRED STTC, DHS S&T FRG, along with first responders from Sacramento's Fire (including paramedics), LE, dispatch and Incident Command came together to establish the detailed requirements. The result was a virtual training prototype which was used to conduct a demonstration and training exercise in Sacramento in Fiscal Year 2014.

3. STAKEHOLDER GOALS

The primary stakeholders for this effort included DHS S&T FRG along with the FRRG, ARL-HRED STTC and Sacramento City Fire and Police Departments. Each had their own purpose and goals that led to their involvement in the effort. Support in the development of this capability was provided by both academia - University of Central Florida, Institute for Simulation and Training (UCF, IST) and industry.

3.1. DHS S&T FRG and FRRG Goals

DHS S&T FRG and the FRRG have seen a considerable increase in the number of active-shooter, and complex coordinated attacks on civilian targets world-wide. The group established training gaps to confront this issue. Specifics on the goals and desired capabilities follow.

The training framework needs to allow training at the tribal, local, state or federal level, allowing varying authorities, and policies. The goal was to provide a capability that would better prepare first responders from Walla Walla, Washington to New York, New York.

The objective is to develop readily-accessible, high-fidelity simulation tools to support training and exercise in incident response and management. This allows large numbers of responders to train repeatedly, both as individuals and in teams, in a classroom or distributed. Responders from multiple agencies, disciplines, and jurisdictions would be able to train for a coordinated incident response and have the flexibility to integrate their own location's operational tactics and procedures. The tool would need to be intentionally agnostic regarding tactics, allowing for local responders to determine their own tactics and strategies.

The base capability allows for future growth and scalable numbers of participants. The architecture needs to allow for additional locations to be modeled as well as additional functionality as needed. As commercial technology advances the architecture will be expanded upon to maximize the government's investment. Using commercial game technology was expected to improve participant engagement (Dwyer, Griffith, & Maxwell, 2011).

The training solution must allow for varying levels of complexity. The virtual simulation would support training from individual tasks at a single site for individual mastery all the way through situation mitigation through synchronized (not just coordinated) efforts of all groups at once.

Communication would have to be realistic with local proximity noise and voice communication as well as radio communication across various tactical channels. During a real attack, LE and Fire have multiple channels at their disposal while dispatch has the ability to link and unlink channels across LE and Fire as necessary. The virtual environment needs to allow for the same functionality.

Separate individual roles must allow different capabilities. For example, dispatch needs to have the tools available that they would at their traditional station. Incident Command would need to be able to share information via a white-board at the command post alongside other jurisdictions or agencies. Protective gear such as Self-Contained Breathing Apparatus (SCBA) and protective clothing would be used in the environment by fire fighters to improve survivability from smoke and heat (*figure 2-green dots show air supply in SCBA gear)*. LE would have a realistic ammunition supply.

Trainers would need to be able to capitalize on teachable moments by being able to observe or coach individuals during and after the exercise. An After Action Report (AAR) would be needed to review tactics, techniques and procedures or standard operating procedures.

It would be important to avoid dependency on high-cost hardware. Due to the environment being immersive and graphically rich, a graphics card is necessary; however, quite often computers used for training can be dated by five years or more, so the environment must be compatible with older hardware.

Finally, the intent was not to develop a handful of scenarios, but to allow for a multitude of scenarios. This led to a "sandbox" approach meaning that the virtual environment could support any variation of possibilities from an individual shooter to multiple intelligent shooters with incendiary devices. Actions in the environment would be managed through exercise control managing the actions of humans role-playing the attackers (Department of Homeland Security Science and Technology, 2014).

3.2. ARL-HRED STTC Goals

To meet these needs DHS S&T FRG partnered with the ARL-HRED STTC to share resources and reduce funding challenges. ARL HRED STTC had been exploring the use of commercial game technology to train specific Army skills (Dwyer, Griffith, & Maxwell, 2011). Their goal was to develop functionality that could be leveraged across the US government to reduce development costs while making the end-product free for Government end-users.

One of the greater costs of training can be making the time for the students to attend a training event. Sometimes the instructor is brought to the students to reduce costs. One goal for the Army is to make training available at the point of need. Students do not need to be co-located with the instructor. The technology must allow for local or distributed exercises. The environment should be available 24 hours a day, seven days a week.

The way many individuals train can vary depending on the situation as well as the user interfaces, especially as technology advances. It was important to allow for flexible user interface strategies. The use of simulated weapons, game controllers, floor pads, head-mounted displays, and wearable technology must all be able to interface into the environment.

Interoperability with traditional simulations is important to the ARL-HRED STTC so that multiple echelons can train simultaneously. Middleware is used to pass position location and interaction data, while a terrain generation pipeline ensures that terrain is correlated.

Both DHS S&T FRG and ARL-HRED STTC felt a graphically-rich, high fidelity environment would make training more realistic and believable.

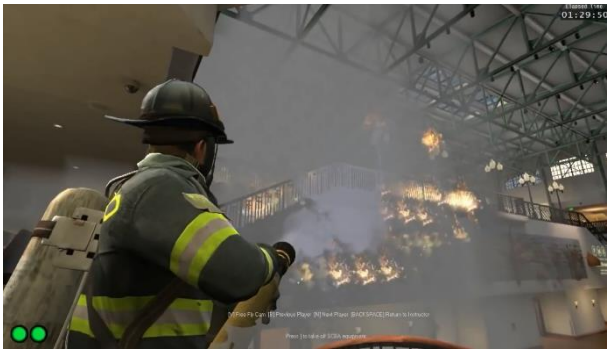

Figure 2: View from within the virtual environment (Nov 2013)

3.2.1. Enhanced Dynamic Geo-social Environment (EDGE)

The DHS virtual training prototype is the U.S. Government-owned Enhanced Dynamic Geosocial Environment (EDGE), which makes use of the commercial Unreal 3 Game Engine (Epic Games, 2015). ARL-HRED STTC began work on EDGE as a means toward leveraging high-fidelity training capability across the U.S. Federal Government. By developing capability that is shared across all Federal Agencies, a great deal of training capability can be established with small incremental investments being spread across different funding sources.

Having government rights to the source code of commercial technology experts can develop specific functionality and make it available to other government developers at no additional cost. For example, tactical

movement with a weapon is very similar across the Army and first responders. This capability doesn't need to be created new for each level within the environment. However, new functionality, such as the use of naturally propagating fire that has realistic damage effects on characters in the environment, can be developed once and reused by various agencies. The more people who use and develop the architecture, the greater it benefits the government overall.

3.3. Sacramento First Responders' Goals

Sacramento Fire and LE were eager to participate in the pilot exercise. They provided subject matter experts from dispatch, incident command, LE, fire and EMS throughout requirements definition and development cycle to set training conditions. It was important to bring all the responders together for requirements identification as each of their needs were significantly different, for example LE needed three-dimensional acoustic indications of where shots were coming from in order to move to stimulus while Fire needed access to a lock-box to gain access to all rooms and a fire alarm that reacted to smoke.

Realistic victims that react to gunfire and fire were needed in the environment. They were designed to be both playable characters, and artificial intelligent agents. The victims played by role players had to be able to provide information on the attackers and have indications of their health and the ability to be carried to casualty collection points for assessment if wounded.

In partnership with DHS S&T FRG, Sacramento first responders selected a popular hotel as the virtual environment, a 26-floor hotel near the state capital and the convention center. Every detail of the hotel is faithfully depicted in the virtual environment. Every room is modeled in every area, including employee-only rooms such as the kitchen, offices, and freight delivery areas. The actual location of exit signs, the lock-box, elevators and fire hydrants are accurately represented. Though the specificity would suggest training would be targeted to the location, this location could be generalized to any hotel around the world.

4. CONDUCTING THE EXERCISE

Putting on a large scale virtual training exercise takes coordination and cooperation from many different groups. The planning may be as detailed as a live training event; training goals and objectives have to be identified and the scenario needs to be tailored to that end with strict adherence by role players. While it is time consuming, the payoff and the number of individuals and roles that are able to train is significant.

4.1. Facility Layout

In preparation for the pilot event, a site survey was conducted of the training facility to determine where each participant group would sit during the exercise. In order to remain organized, each group of first responders were grouped by their specialization. This allowed for better communication and made it easier for any troubleshooting that was necessary. The opposing forces, or shooters, were located in a room across from exercise control and far from the responders. Another room was set up to support AARs and to conduct surveys after the event. Each participant room had training observers and technical support and radios were used to coordinate with technical support and exercise control.

4.2. Network and Hardware

Prior to the participants' arrival, the network was laid down, computers were set up, and each client was tested for connectivity and sound. There were ten LE officers, ten fire fighters (three engines, three trucks), a LE and a fire dispatcher, a medical manager, medic strike team and three medics in the environment. Unified command also contained a LE sergeant, a watch commander, a scribe, and two fire battalion chiefs. There were four suspects and two civilians and finally, there was an exercise control logon that could fly through the environment (invisibly) to watch what was taking place and step into various characters avatars to witness their actions. This brought the total number of participants to about 40 individuals. The exercise took place with no computational degradation or performance issues.

4.3. Preparation and Train-up

The entire participant group received a briefing on the intent of the pilot event and a description of how they would enter and navigate the virtual environment. The participants broke out into their designated groups and received a tutorial explaining how to use their specific capabilities within the environment. For example, representatives from the fire battalions learned how to connect to a hydrant and move a hose in the virtual environment. Everyone received a video describing their actions and a reminder card was provided at each station. Each individual participated in an in-game tutorial that allowed them to practice the tasks. After the tutorials, participants were invited to enter the environment and 'play.' They were encouraged to explore the hotel and practice using their weapons, tools and communications (*figure 3).*

4.4. Scenario Management

A Master Scenario Event List (MSEL) was established to direct events within the scenario. Initially the MSEL had timed events, such as: Start time + 30 seconds, 2 assailants enter third story lobby and engage hotel patrons, start time + 35 seconds first calls go out to dispatch of active-shooters in the hotel. The group ran through one practice scenario to gain familiarization during which it became clear that the scenario would need to be event driven rather than time driven since every action after the shots were fired was a reaction that would be conducted in real-time. From that point on, exercise control managed only exercise start, the movements of the opposing forces and exercise end.

The first time the exercise ran, the opposing force was asked to reduce their in-game aggressiveness. This

provided the participants an opportunity to gain confidence in using the training tool. As expected, the first AAR following the initial run through had a significant number of comments about the user interface, communication and overall familiarization issues. This provided an opportunity for the technical support team to respond to questions and ensure everyone was at about the same level of competence within the environment before ramping up the complexity of the threat. The first run through the exercise took about 45 minutes with the AAR taking about the same amount of time to complete each group.

The large environment including the 26 floors and having quite a few employee-only corridors and loading docks, allowed for a wide range of scenario possibilities. Active-shooters were able to use fire in higher floors to corral victims and cut off support from responders. The scenarios were able to take on a complexity that increased as those training learned from their mistakes.

Figure 3: Participants in the Pilot Exercise (Nov 2013)

5. OUTCOMES

The successful event proved that it was possible to host a cross-collaborative virtual training event that would provide the problem-solving skills that would be necessary to take on a complex coordinated attack (National Urban Security Technology Laboratory, 2014). The most significant outcome noted by exercise control was the exposure of policy gaps. For example, what is the protocol for a fire response to an occupied structure with an active-shooter? There were also more routine issues such as LE wanting to turn off the interior fire alarm so officers can hear better but fire responders' concern that turning off the alarm will allow the elevators to operate and may encourage occupants to try to evacuate via the elevators. These previously unknown conflicts were identified and resolved locally. Ultimately, when confronted with the dual threat of an active-shooter in an occupied building, the teams determined fire could enter the building with LE providing protection. They were then able to conduct analysis on how the change of tactics worked from within the environment.

A common challenge for Incident Command is to direct the response with imperfect knowledge of what is taking place in the hot zone. Lack of communication across first responder departments and organizations is a well-known and well-documented problem that continues to hamper a coordinated response. For technical and tactical reasons, command frequently has an imperfect understanding of the event on the ground and as a result, Incident Command may have a completely different idea of what is happening compared to the individuals on-scene; clearly this can lead to serious consequences. However, the AAR provided a great opportunity to see where communication breakdown or misinterpretation occurred and provided an opportunity to address the issues. By better understanding the issues they contending with, both groups were able to improve communication.

6. CHALLENGES AND MITIGATION

Experts in the area of ASE and AS/ACI events agree that first responders "jointly develop local protocols for responding to AS/MCIs and Fire/EMS and LE should plan and train together" (Federal Emergency Management Agency (FEMA) U.S. Fire Administration, 2013). Limitations to training across organizations can be associated with conflicting training schedules or with access to training sites and resources. By using virtual training technology, training can be conducted at the point of need. It is possible to prepare for an incident in New York's Times Square, even if you are in Sacramento, California. Using commercial game technology, an individual joins a team to accomplish a complex task. The team can be distributed anywhere around the world. Similar commercial game technology is applied to training exercises described in this paper.

Building a simulation that encourages first responders to train together while not being tied to any particular doctrine or standard operating procedure is critical. Consider one jurisdiction where the policy is that the first individual on the scene of an ASE must wait for backup before engaging shooters while another jurisdiction requires responders to move to stimulus immediately. The virtual environment must allow all possible response possibilities. In the case of the prototype used for this event, interactions are not scripted, and just like real-life - anything can happen. This means events in the environment can and will get very messy and complicated with miscommunication and chaos. The intent is mistakes or learning moments happen in the virtual environment rather than while actual lives are at stake.

Running an exercise as a training event is not the same as that of traditional course work. Sometimes, there is no "correct response." Sometimes, the correct response is purely defined by the outcome and can only be assessed retrospectively. Take for instance the decision by the Kenyan security forces to delay entering the Westgate Mall, while plainclothes civilian rescuers and plainclothes police rushed in to engage terrorist attackers (British Broadcasting Corporation (BBC), 2014). The decision by the impromptu group could have endangered existing response activity or it could have saved considerable lives. Retrospectively, given the lack of State response the civilian response was warranted.

In order for an exercise to become a learning event, it is critical that observers be present to make note of actions

at every level. For example, if the LE observer sees activities that violate doctrine, they are displayed and discussed during an AAR. Each component of the response team should receive a review of their individual performance during the exercise, and the larger team receives feedback on how each of the components worked as a team. Strengths and opportunities for improvements are highlighted and discussed. This is also a good time to discuss if protocols should be re-examined. After the exercise has been thoroughly reviewed, participants have the opportunity to apply the learning by running another exercise with varied details and make improvements.

Training for mass casualty events is often focused on one or two components of the event to simplify and focus training. For example, LE may focus on finding an active-shooter to stop the threat. However, they may not train on the events that follow, such as clearing the area and preserving evidence or providing timely care for wounded. With a virtual environment every activity associated with the response to an ASE can be accomplished. Details such as the control of traffic or the placement of the Incident Command Post (ICP) – that can bring about success or failure in an ASE (Los Angeles World Airports, 2014) – can be modeled and optimized in the virtual environment.

7. WAY AHEAD

DHS S&T FRG and ARL-HRED STTC are continuing to develop and evolve the virtual training model into a more robust and more widely accessible training tool to first responders throughout the nation. The STTC is using EDGE in their Visualization Test Bed (VTB) to explore strategies to improve realism, such as including a human-driven puppeteer into the environment. Larger terrain, strategies to control command and control robots and real-time tutoring are also capabilities being explored by the VTB.

Currently DHS S&T FRG is making virtual training available to training locations such as the California Fire and Rescue Training Authority, the Federal Law Enforcement Training Center (FLETC) and academic organizations such as the City University of New York School of Professional Studies in order to provide training to a large audience of first responders. Although development resources are limited, ongoing efforts are underway at DHS S&T and STTC to continue to not only improve the iterations of the current EDGE virtual training tool but also to expand the number and type of environments. As an example, a complex middle school has been modeled to allow for first responders to better prepare to respond to and mitigate such attacks. This environment also allows school officials to prepare their response protocols to prevent or minimize casualties.

Finally, international partners are receiving the benefit of the virtual training environment with the sharing of the EDGE virtual training tool to one ‘pilot’ country and discussions underway with others to follow.

8. CONCLUSION

Terrorism, unfortunately, is a part of our life for the foreseeable future. Asymmetric warfare or terrorism of the type favored by our current adversaries will continue to focus on nonmilitary civilian soft targets. It will benefit us all to prepare to the greatest extent possible to respond to AS/MCIs. Recent history has demonstrated the response to an AS/MCI must be pre-coordinated and preplanned with local agencies. An incident of this type will require a coordinated cross-discipline response and, currently, available training is inadequate to meet that need.

The training described in this paper (at no cost to responder agencies) by DHS and the U.S. Army is critical and will invariably save lives of not only responders, but also innocent civilians.

It is vital that responders have the opportunity to practice their ability to coordinate response tactics and strategy in a cross-discipline approach prior to responding to such an event in the real world. Virtual training provides the ability to prepare military troops as well as first responders in a realistic and cost effective manner.

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