Enhanced Dynamic Geo-Social Environment (EDGE) Evaluation and Transition Report

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Executive Summary

This document is the final report for the Enhanced Dynamic Geo-Social Environment (EDGE) Virtual Training and Transition project. The project was commissioned by the Department of Homeland Security Science and Technology Directorate Support to the Homeland Security Enterprise and First Responders Group following a series of projects focused on requirements gathering, EDGE software development in partnership with the U.S. Army and preliminary transition planning. The software effort produced a first responder "sandbox" for developing exercises for the virtual training of law enforcement, fire services, and emergency medical services personnel to respond to active shooter scenarios loosely based on the Mumbai hotel attacks of 2008.

This project consisted of three tasks. Task 1 used focus groups to elicit additional required training scenarios beyond the active shooter scenario and to provide additional input regarding training objectives well suited to the virtual training technology and additional desirable platform features. Task 2 used subject matter experts with an academic background in computer gaming systems and virtual training to evaluate the EDGE platform's capabilities and its likely effectiveness. Task 3 analyzed possibilities for transitioning EDGE to academic centers, commercial companies, and government training organizations and made recommendations for a specific transition plan.

At the outset, it must be stated that the project team based its analysis and evaluation on the EDGE software it was given in November 2013 at the time of a pilot conducted in Sacramento, California. Some of the deficiencies identified or some of the alterations and enhancements suggested may have been incorporated into subsequent versions of the software.

For Task 1, the focus groups were conducted via conference calls with three small groups of first responders (a total of 16) representing a variety of first responder disciplines and jurisdictions. A video describing and depicting EDGE capabilities was made available to the first responders before they participated in the focus group sessions. Responses to the first topic eliciting additional required training scenarios were diverse (very little overlap) and local (reflecting training needs specific to the participants' jurisdictions). Participants also provided additional suggestions, including alternative ways to collect requirements. The second topic asked the focus group what kinds of training objectives would a virtual training system like EDGE best support. Responses consistently mentioned coordination training (e.g., unified command, interoperability, multi-discipline coordination) and strategic decision making. One participant also mentioned scenario exploration for developing standard operating procedures, a suggestion made independently by one of the subject matter experts (SMEs) (see Task 2). Topic 3 elicited reactions to EDGE features. Responses primarily focused on the extremely detailed and accurate photo-realism of buildings and surfaces rendered with EDGE, and there was a debate over the usefulness of this high degree of photo-realism for training purposes. Topic 4 asked what additional features the participants would like to see incorporated into EDGE. A variety of features were suggested, including adding a capability to easily change weather and locations, automating some tasks to be performed by non-player characters (requiring artificial intelligence [AI]), adding more information sources (e.g., maps, charts, incident action plans), and improving time realism.

The final topic asked about desirable training system and data collection features. There was agreement that a capability to record actions for a subsequent after action review with a supervisor was essential.

The primary analysis by SMEs considered how the EDGE tool might be applied toward each of the five training purposes: physical skills training, individual decision training, coordination training, scenario exploration and discovery, and evaluation. The features of EDGE were compared to the requirements of each of these purposes. EDGE was evaluated as being potentially best suited to coordination training and scenario exploration and discovery. The SMEs also proposed a number of alterations to EDGE, perhaps the most important being the inclusion of a greater number of AI-coded non-player characters, which would greatly improve the efficiency of using EDGE for coordination training and scenario exploration and discovery. An analysis by another SME provided his running commentary as he explored the EDGE tutorial and learned about EDGE's functionality. The commentary was followed by reflections on his experience and recommended changes to EDGE. Among the recommended changes were adding AI to non-player characters—a recommendation consistent with the focus groups and other SMEs—and improving camera control.

The transition analysis began by identifying the desired criteria for any entity to which EDGE might be transitioned. These criteria include a strong training development and delivery capability, a strong technology capability, a way to reach first responder trainees, and a proven training business model. Three types of potential transition entities were examined: academic centers, commercial companies, and government training organizations. Leading examples within each category were compared against the criteria. The Texas A&M Engineering Extension Service was found to be the best fit to the criteria, with other government training organizations such as the Federal Law Enforcement Training Center and the National Emergency Training Center also appearing promising. A short-term transition plan for the current EDGE platform is proposed, as well as a longer term plan for the continued evolution of virtual training for the first responder community.

1. Background

1.1 Project Responder 3

The Enhanced Dynamic Geo-Social Environment (EDGE) Virtual Training and Transition project was preceded by a number of studies and related events. *Project Responder 3*[1] used a series of first responder focus groups and workshops to identify gaps between capabilities required to respond to a catastrophic event and current emergency response capabilities. Some 40 capabilities were identified and then prioritized using additional first responder input and analysis. The capability of highest importance that emerged from this process was "Readily accessible, high-fidelity simulation tools to support training and exercises in incident management and response." This capability was regarded as so important because of two factors—training and exercise mandates imposed on first responders by federal, state, and local agencies and a decrease in funding for training and exercises due to budget cuts. It was thought that a training system based on high-fidelity simulation could cut the cost of training. Moreover, training and exercise events are often limited in scope (e.g., a single scenario without alternate decision paths to explore) and do not easily provide opportunities for repetition. It was anticipated that high-fidelity simulation-based training would allow for variations in training scenarios and repetition by individuals and groups, increasing training effectiveness.

1.2 EDGE Interagency Agreement

The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) entered into an Interagency Agreement with the U.S. Army Simulation and Training Technology Center (STTC) to extend the development of a high-fidelity simulation gaming tool called EDGE. The Army had already invested millions of dollars to create an EDGE prototype that provided a virtual environment with a high degree of photo-realism utilizing the Unreal 3 Game Engine development framework for creating multiplayer online games. The agreement led to the creation of a first responder gaming environment that is loosely based on the Mumbai hotel attacks of November 2008 that left more than 160 dead and more than 300 wounded. Use of the EDGE platform by approximately 40 first responders, including law enforcement, fire services, emergency medical services (EMS), and dispatch, was piloted in Sacramento, California in November 2013.

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[1] Project Responder 3: Toward the First Responder of the Future, March 2012, Department of Homeland Security, Science and Technology Directorate.
http://www.firstresponder.gov/TechnologyDocuments/Project%20Responder%203%20Report.pdf

1.3 Naval Postgraduate School EDGE Transition Study

The Modeling Virtual Environment and Simulation Institute at the Naval Postgraduate School (NPS) issued a report in March 2013 titled *EDGE Virtual Training Program Transition Research & Plan*. Appendix B of the report describes an initial transition plan for EDGE. The plan consists of a methodology for assessing training requirements, objectives, and the kinds of human abilities and affordances required by the task; a plan for case studies (e.g., single trainee, team training); and an approach to creating a collaborative transition management team. The first two parts of this transition plan have not been carried out for EDGE and must be done as EDGE is transitioned to a training organization. The NPS report also focused only on a government transition path. This current report considers transition to academic centers and commercial entities. The transition analysis in Section 4 includes recommendations for transition entities and a transition management team.

1.4 Next-Generation Communications Interoperability Gaming and Virtual Training Workshop

The Next-Generation Communications Interoperability community at S&T convened a Gaming and Virtual Training Workshop on January 24, 2013, at the Command, Control, and Interoperability Center for Advanced Data Analysis at Rutgers University. Experts on serious gaming, virtual training, and simulation were brought together to discuss current trends in virtual gaming, training, and simulation that could inform the development of the EDGE platform. Robert Griffin, director of the S&T Support to the Homeland Security Enterprise and First Responders Group, gave a presentation on the EDGE project. He asked the experts assembled to think about how current technology and research could be applied to training first responders, how to use technology to mimic real-world environments, and how to tailor platforms at the community level.

1.5 Current Scope of Work

The purposes of this project are to:

- Identify future scenarios to be developed for the EDGE Virtual Training tool and the associated requirements and gaps;

- Evaluate the capabilities and likely effectiveness of the EDGE Virtual Training tool for developing future scenarios and meeting the associated requirements and gaps; and

- Identify the options for transitioning the EDGE Virtual Training tool to a commercial entity and to a number of government entities.

To accomplish these work items, three tasks were executed:

- Task 1: Focus groups were held to identify additional required training scenarios; results are presented in Section 2. The groups also addressed the following topics: the types of training objectives for which EDGE is suitable, reactions to EDGE's high degree of photo-realism, additional EDGE features desired, and desirable EDGE training system capabilities and student data.

- Task 2: EDGE was evaluated by computer gaming and training subject matter experts (SMEs). Section 3 presents the analysis of one professor based on reactions to EDGE games played by the professor's graduate and undergraduate students and postdoctoral fellows, a number of whom are expert gamers. This analysis is structured around the types of learning objectives for which EDGE is and is not well suited and also provides some suggestions for improvement. Evaluation by a second SME is given in Section 5.1 and is essentially a running commentary on using EDGE followed by an analysis and conclusions.

- Task 3: An analysis of potential EDGE transition entities is presented in Section 4. The analysis includes a description of transition criteria and the suitability of a number of entities that fall under three different organization types: academic centers, government agencies, and commercial entities. Short- and long-term transition plans are outlined in this section.

2. Task 1: Focus Groups to Identify Additional Required Scenarios

2.1 Hypotheses

Prior to conducting the focus groups, the project team developed informal hypotheses about the additional required training scenarios based on interviews with senior first responders. The interviews were conducted after the first responders were given a sense of the EDGE platform's capabilities. One first responder had participated in several iterations of an EDGE exercise; the second had been shown a video demonstrating EDGE capabilities; while the third had been given a verbal description of EDGE. The first responders were each asked what additional scenarios they would like to have developed using EDGE capabilities.

Here are the scenarios suggested by each of these senior first responders:

- *Senior Officer, Los Angeles Fire Department*: Los Angeles International Airport, Port of Los Angeles, earthquake, wildfire

- *Retired Deputy Chief, New York City Police Department*: explosive device, stadium stampede, domestic dispute, train derailment

- *Former Director, Illinois Fire Service Institute*: high-rise fire, auto wreck (with air bag "bombs" exploding), rural fire

Based on these interviews, the project team predicted that the additional required scenarios would be *diverse* and *local*. The expected diversity of scenarios is based on the fact that there was no overlap among the scenarios suggested by these senior first responders. The expected local nature of additional scenarios is based on how the scenarios described by the first responders reflect the local area in which these individuals are based. For example, earthquakes and wildfires are more likely to be relevant to first responders based close to Los Angeles but less relevant to those based in New York, whereas the opposite may be true of a train derailment.

2.2 Methodology

The focus groups were planned and carried out following the methodology described by Richard Krueger.[2] Logistics prevented holding face-to-face meetings, so the focus groups were conducted via conference calls following the modifications suggested by Krueger. Modifications included keeping focus group sizes small, limiting the number of questions, and limiting the length of the sessions to about 60 minutes. Three one-hour sessions covering five topics were conducted with group sizes of four, five, and seven people each.

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[2] *Focus Groups: A Practical Guide for Applied Research*. 3rd Edition. Richard A. Krueger with Mary Anne Casey. Sage Publishing, Thousand Oaks, CA, 2000.

Participants were predominantly first responders, most of whom had some affiliation with the InterAgency Board (IAB) Training and Education Committee, since their connection to the IAB facilitated the recruiting process.[3] Two participants had observed the EDGE pilot in Sacramento in November 2013. Some of the others knew about the EDGE project from news reports or by word of mouth, while some knew nothing about EDGE. In addition to 14 first responders, one participant was a Federal Emergency Management Agency (FEMA) manager with an extensive background in training first responders, and another was a professor who has researched training for first responders. All participants read and signed an informed consent statement that had been approved by the Rutgers University Institutional Review Board. Participants were not compensated for their time. Two additional first responders had been recruited for the study, but one had to cancel because he was responding to a fire, and another was involved in a training session that ran over the scheduled time.

Although the set of participants was neither random nor systematically stratified, it did represent some geographical and discipline diversity. Participants were drawn from 11 different states from the New England, Mid Atlantic, Midwest, Far West, and Northwest regions. Participants included representatives from law enforcement, fire services (including hazmat), EMS, and emergency management disciplines.

Prior to participating in the focus group, each participant viewed a 14-minute video that described and depicted the EDGE platform features and demonstrated EDGE in use by first responders for an active shooter/coordinated attack scenario. The video was made available for download over the Web in different formats for playing on machines with different operating systems and video players. All participants were able to view the video.

The focus group questions were structured around five topics. Topic 1 was the primary topic and it focused on soliciting additional training scenarios that could be delivered using technology with EDGE capabilities. Participants were asked to name one or two scenarios they would like to see developed beyond the active shooter/coordinated attack scenario demonstrated. Topic 2 sought to elicit the kinds of training objectives for which EDGE technology would be suitable. Topic 3 asked for an evaluation of certain EDGE features, specifically the high degree of photo-realism. Topic 4 sought to elicit additional desirable features beyond those in the EDGE platform. Topic 5 sought suggestions concerning the kind of training system capabilities a virtual reality simulation should have and what kind of training data it should collect.

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[3] We would like to thank Lt. Tracy Frazzano of the Montclair (New Jersey) Police Department and member of the IAB for her support in recruiting participants for the focus groups.

2.3 Findings

2.3.1 Topic 1: Additional Scenarios Required

The scenarios elicited in the focus group sessions are given in Table 1. The scenarios are diverse—among the 15 scenarios named, only one scenario was suggested in all three sessions, and one was suggested in two of the three sessions. The scenario elicited three times was an unspecified mass casualty incident requiring victim assessment, triage, and transportation. The scenario elicited twice was a radiological threat (RAD) that in one session was described as a "WMD [weapons of mass destruction] scenario" and in another session was described as a "hazmat scenario." No other scenario was brought up more than once across the three sessions.

Table 1: Additional Scenarios Elicited in Three Focus Group Sessions

Session	Scenario Description
1	- WMD scenario: RAD - WMD scenario: chemical - Improvised explosive device (IED), similar to the Boston Marathon Bombing - Mass casualty incident (regardless of cause), necessitating triage system and transportation
2	- Hazmat scenario: biological - Hazmat scenario: RAD - Secondary "sleeper" attack on first responders responding to primary attack - Mass casualty scenario, regardless of type, where victims may be assessed - Mass rescue and mass casualty, such as a jetliner crash into a body of water
3	- School active shooter scenario - Office complex active shooter scenario - Large passenger vessel scenario requiring U.S. Coast Guard integration - Water rescue or swift water rescue - Wildland fires - Mass casualty scenario that is prolonged, requiring additional integration beyond just fire, EMS, and law enforcement

What is not apparent from Table 1 is the support for our second informal hypothesis, namely that the elicited scenarios would be *local*. For example, the scenario involving a jetliner

crashing into a body of water was suggested by a member of the U.S. Coast Guard stationed on one of the Great Lakes. The wildland fires scenario was suggested by a firefighter in Southern California. The large passenger vessel scenario was suggested by a Boston-based medic. It makes sense that people will suggest scenarios that concern them in their daily jobs at their own location.

Besides giving specific scenarios to be developed, the discussion on Topic 1 included additional comments and suggestions about alternative ways to collect the required scenarios. The additional comments stressed that the scenario should involve multiple disciplines working together and should study how unified command impacts the response. One participant said that there is a critical need for developing a scenario that integrates multiple disciplines because multiagency integration and communication is a key training need. It also was noted that cross-agency communication generally fails during a response. A specific suggestion was to develop a scenario using multiagency entry teams that places EMS and fire personnel into "warm zones." (Note: This is a new and somewhat controversial idea at this point.) Other suggestions included scenarios in which a first responder may respond without knowing what he or she is getting into, and the need for scenarios to be local events, not just large-scale disasters. In contrast to the last suggestion, one participant suggested that the scenarios should focus on low-frequency, high-impact scenarios, since first responders are already prepared for smaller scenarios like a fire or auto accident.

One participant suggested additional ways to collect required training scenarios, beyond the focus groups used in this project. One was to base the scenarios on the Threat and Hazard Identification and Risk Assessments (THIRAs) that must be developed and submitted by all 56 state administrative agencies receiving funding under the Homeland Security Grant Program and all 31 urban areas receiving funding under the Urban Areas Security Initiative grant program. The THIRA is "a tool that allows a jurisdiction to understand its threats and hazards and how the impacts may vary according to time of occurrence, season, location, and other community factors."[4] A second suggestion was to conduct a systematic needs assessment. The results of the focus groups reported here could be seen as a first step in that process, which could be complemented by additional interviews and surveys to develop a set of required training scenarios.

2.3.2 Topic 2: Training Objectives Supportable by EDGE

The second discussion topic asked for the kinds of training objectives that can be supported by a system with EDGE capabilities. Responses are shown in Table 2.

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[4] THIRA Frequently Asked Questions FY 2012, FEMA (http://www.fema.gov/media-library/assets/documents/27775).

Table 2: Training Objectives that Can be Supported with EDGE

Session	Supportable Training Objectives
1	• Coordination and Unified Command of multiple disciplines. • Build more strategic capabilities into the virtual training environment (e.g., whether or not there are enough resources and the right resources; what are the tactical and strategic options; what are the National Incident Management System [NIMS] and Incident Command System [ICS] challenges as the disciplines interact).
2	• Train for incident management objectives. • Conduct team training and multi-disciplinary training. • Train field and boots-on-the-ground responders how to coordinate on scene. • Address strategic training objectives. • Train incident assessment: when coming on scene, being able to assess damage, sights, smells, etc. • Establish a program of walk-through scenarios for novice responders. Provide the correct decision making for the players for learning applications.
3	• Break the scenario down into a Unified Command training tool. • Train for command decision making: e.g., where to park vehicles; where to place triage. • Coordinate interoperability for multiple disciplines. • Develop a shadow program, allowing subordinates to train in place of their supervisors as continuity of operations or chain-of-command training. • Conduct scenario exploration: It may support standard operating procedure (SOP) development for scenarios such as a chemical release in a subway. If such a scenario is run multiple times, there may be changes to the SOP after each run. • Focus on whether to shoot or not to shoot rather than the action of actually shooting the subject. • After responding to initial incident, focus on the progression of next steps, such as public works or federal investigators, during a mass casualty event.

Perhaps the most common theme that emerged is that EDGE is well suited to training coordination among the different disciplines responding to an incident. Evidence for this theme comes from repeated instances of words like "coordination," "team training," "Unified

Command," and "interoperability." EDGE technology is viewed as highly suited to addressing coordination training.

A second theme that emerged is the focus on training strategic decision making. EDGE is viewed as well suited to training commanders on how to make decisions concerning the resources available, the strategic options, incident assessment, where to park vehicles, where to set up triage, etc.

It is worth noting that one participant suggested that EDGE would be very useful in scenario exploration—that is, a way to develop new SOPs for scenarios where none may already exist. In this case, EDGE would provide a safe environment for trying out different possibilities and analyzing what happens. Scenario exploration and coordination training were also identified as training objectives well suited to EDGE by the SMEs in their evaluation (see Section 3).

2.3.3 Topic 3: Reactions to EDGE Features

Participants' reactions to EDGE features centered on the high degree of photo-realism in the EDGE hotel setting, as well as other aspects of realism that might need improvement in EDGE. The photo-realism in EDGE provoked much discussion. Some participants felt that the high degree of photo-realism was important so that first responder trainees would not feel that the system was "dumbed down" compared to current gaming technology and that a "cartoonish" look would not be well received. One participant noted that a high degree of photo-realism could be of great benefit for rendering specific buildings hosting specific events (e.g., for training first responders for the Democratic or Republican National Conventions). Other participants felt that a more generic building would be sufficient to accomplish the training objectives, especially if the first responders were never going to be in the specific building rendered. Generic hotels or shopping centers may require less detail and could be better for general use. A middle ground opinion was that the photo-realism was good, so long as it did not take away from achieving the training objectives.

Additional discussion centered on how EDGE could be made more realistic. Examples included the following: (a) having varying weapons available for different officers, perhaps customizable to the local agency; (b) having the very precise building measurements interact appropriately with the weapons (e.g., in the real world, the hotel would have sharp corners and prevent the effective use of some larger weapons); (c) physiological aspects should be more realistic (e.g., EDGE currently gives only very crude victim health indicators); (d) chemical detectors with detailed readouts on hand-held devices should be available; (e) communication should be more realistic (e.g., by including technology failures such as random dropouts). Note that the last suggestion was also mentioned in the discussion of Topic 4.

2.3.4 Topic 4: Additional Desirable Features

Participants suggested a large number of features they would like to see added to the EDGE platform. Many of these features fall into the categories of options, additional information

sources, and realistic timing. Among the options desired were the capability to change the weather for scenarios (e.g., how a snowstorm might affect response); the capability to change the scenario environment and place buildings in rural, urban, or wooded areas; the capability to customize scenarios, for example by introducing chemical releases or IEDs; and the capability to have Unified Commanders direct characters to complete tasks and not necessarily to require people actively participating to complete the tasks. This latter suggestion would require adding some artificial intelligence (AI) to some of the characters, a suggestion also made in our SME analysis in Section 3.

Desirable additional information sources are simulations of various tools used in managing emergencies. These included maps showing the location of various kinds of equipment that could be assigned to the incident so that agencies relying on mutual aid would have an idea of what resources are available in the area. Another suggestion was to provide agency-specific documents with organizational charts for reference by users, particularly those in unified command. Other suggestions related to showing the ICS chart and how it can be grown to manage resources and showing the development of an incident action plan.

The issue of time realism was brought up in two of the focus group sessions. Specifically, it takes time to go up an elevator, to be dispatched and arrive on scene, and to remove a victim from a building. In the version of EDGE shown to the focus group participants, all these activities happen instantaneously so that users do not get an accurate sense of how long they will take. Another aspect of time realism has to do with the time to make decisions. Some participants suggested that adding time constraints and forcing timely decisions would add to the training.

2.3.5 Topic 5: Desirable Training Data and System Features

In all three focus group sessions, when discussing the type of training data and training system features required, participants made the point that the data collected and what is monitored or measured will depend on the training objectives established. That said, a fairly consistent theme emerged. The training system should record key decisions made by the users and then have a capability of returning to those decision points in an after action session led by an instructor. This may involve the instructor setting down a marker so that the recorded scenario can be easily restarted at the marker and replayed from there. Each of the focus groups raised the point that the instructor was necessary, since different agencies will have different SOPs. Therefore, a correct decision for one agency may not be correct for another.

2.4 Discussion

The primary goal for the focus groups was to elicit additional required training scenarios for which a virtual training system based on computer modeling and simulation would be appropriate. As hypothesized, the elicited scenarios were *diverse* and *local*. Most of the scenarios were mentioned only once across the three focus group sessions. While a mass casualty scenario with a prolonged aftermath including victim assessment, triage, and

transport was brought up in all three focus group sessions, its description was very generic. Specific mass casualty events (e.g., a large airplane crash, a stadium bombing, a subway bombing) can be very different and will not make sense for jurisdictions that do not include a large airport, stadium or subway—a point reinforced by the local nature of many of the other suggested scenarios.

Thus, it does not appear that a small set of scenarios will suffice to cover the training needs of a great number of first responders. Moreover, the terror threat is constantly evolving and includes new methods of attack where the structures attacked might be a hotel, a school, a shopping mall, a train, a stadium, etc. These evolving threats require training in new response strategies and new SOPs.

An ideal virtual training system would be easily customizable to allow for simulating local buildings and infrastructure, local first responder resources, and local SOPs in an efficient and cost-effective manner. At this point, it is not clear that such a system exists.

Participants in the focus groups felt that the current EDGE technology was best suited to training in multiagency coordination, especially unified command, and to training strategic decision making. As noted, one participant raised the idea of EDGE being useful for scenario exploration—a safe way to explore outcomes of different potential SOPs. This objective, along with coordination training, is also suggested by the SME report in Section 3.

The EDGE system's high degree of photo-realism in rendering buildings and surfaces was a point of debate by the participants. Some felt it was necessary to maintain the interest and engagement of trainees. Others felt a more generic form or "cookie cutter" rendering of a building such as a national hotel chain would be equally effective, especially for trainees who would never see the actual building that was rendered. Most participants questioned whether the exquisite rendering contributed significantly to attaining the training objectives. Since the cost of developing high photo-realism simulations is currently expensive, this debate is important to resolve and should be the focus of additional empirical research studies.

The discussion of additional features that could make EDGE more realistic and more useful should be valuable for any future EDGE roadmap or any successors to EDGE. A number of these features were also raised independently in the SME report in the following section.

The final discussion point concerning the issues raised in all the focus group sessions is the apparent disconnect between EDGE technology development and an analysis of those capabilities required to support various kinds of training objectives. This disconnect may reflect an inherent tension between development emphasizing game-like features and qualities (e.g., the high degree of photo-realism, the customization of avatars, the kinetic action) in contrast to development focused on the capability to support the delivery of specific kinds of training objectives (e.g., coordination training, scenario exploration, discovery). The game-like features may foster better trainee engagement, which could be very positive. However, it is not clear how EDGE features are designed to support the learning of various kinds of training objectives. Perhaps the most important recommendation from this project is that EDGE must be transitioned to a training organization that understands how EDGE current capabilities and any future enhancements can be used effectively to support training objectives.

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3. Task 2: EDGE Evaluation by SMEs

Our expert analysis of the EDGE tool focused on interrogation and testing of the existing developed scenario (a live shooter event) for effective training of first responders. It is important to note that, while the platform itself as a programming environment for a virtual world is quite versatile and could be altered, tailored, or expanded, our comments refer to the state of the tool as it was during our evaluation period (concluded in March 2014). Our recommendations are therefore specific to this implementation and case study and are not meant as a broader critique of the potential of all virtual training and simulation tools. Further, we include two additional sections:

- Appendix 5.1—a detailed running commentary and subsequent considered analysis of the user experience from one of our independent external expert evaluators as an example of one user trying to experiment and explore independently with the current tool; and

- References—a list of references to the scientific literature and conferences on which (in addition to direct expert opinion) our analyses are based.

3.1 Utility as an Effective Training Tool

While research communications and the published scientific literature discuss virtual training using a diverse set of goals and languages, it is widely agreed that there are five main, independent purposes that can be targeted or achieved using virtual simulation as a learning tool (for perspectives from a variety of fields see Chrichton & Flin, 2001; de Freitas et al., 2009; Kirkle et al., 2005; Marsh, 2011; Susi et al., 2007; and Jarvis & de Freitas, 2009). The five training purposes for virtual training are: (1) Physical Skills Training, (2) Individual Decision Training, (3) Coordination Training, (4) Scenario Exploration and Discovery, and (5) Evaluation. We therefore considered the EDGE tool as it might be applied towards each of these purposes.

1. Physical Skills Training – This category includes cases such as flight simulators, simulated surgeries using haptic feedback, and firearms targeting or shooting, among others. Success in this category relies on the realism of the relevant experiences related to developing and honing the skill in question. There must be approximations for each relevant sensory input (i.e., recognized cues from visual, auditory, olfactory, or tactile experience) that the user can learn and identify within the virtual environment in ways that either directly capture, or else provide natural transitions to the real-world experiences that surround how the skill being taught will be performed. There must also be an appropriate and approximate set of options for failure that mimic the impact of poor actions in the real-world and enable discovery of "what works and what doesn't." There must be the ability to practice the skill – physical skills frequently rely on recognition and reflex. An individual learning in a virtual environment must at least be able to hone

recognition of cases in which the skill being learned is useful and be able to rely on the training to trigger recall of the correct set of actions to take, ideally (though not necessarily) stimulating a reflex toward taking those actions. We know from many experiments on human learning of physical skills that practice and repetition are important for developing that response. Finally, there must be the ability to be given feedback on performance (related closely to options for failure), with the ability to repeat the same scenario until skills are developed to everyone's satisfaction.

In the case of the EDGE tool, we do not recommend that the tool be developed or deployed with this kind of training as a goal. We base this recommendation on the fact that many of the above points cited as necessary for success in this category are either impossible or significantly confounded in the EDGE environment. While the visual realism of the environment in EDGE is astounding, the realism of the experiences surrounding particular skills would be impossible to develop. For example, for police training, proprioception (or at least directional auditory cues) for moving into a space with a partner or in a team is of critical importance and there is no non-visual mechanism for locating your teammates. It is noted that you can hear footsteps in EDGE, but during our test runs, these were not directionally located; they were merely present or absent. This is not to say that such an input could not be incorporated for the user, but it would take considerable effort and time to do so. Again in law enforcement training, EDGE includes actions such as firing a weapon, but the mechanisms governing targeting and shooting within the environment are entirely decoupled from the types of physical skills or sensations associated with firearms in the real world. While it is important to train officers not to fire at civilians, it would require a cognitive process at the level required to translate the EDGE tool training to a physical skill in the field, and that is not a sufficient goal for physical skills training. Similarly for the emergency medical technician (EMT) role, it is unclear how effective EDGE can be for physical skills training since medical actions are frequently more delicate and require haptic feedback to develop appropriate reflex memory. We did find that the role of the dispatcher provided all of the needed cues and sensory interface options, but primarily because the real-world role of such a person is already strictly limited in its sensory scope.

In addition to these mentioned challenges in presenting types of sensory realism relevant to the skills being trained, it is also unclear how to incorporate meaningful errors for failed actions in ways that allow for repetition to gain better command of the skill. Successful virtual training for physical skills relies on a clear transition plan for moving from simulated practice to real-world practice that builds directly on the simulation experiences. For this reason, these types of training goals are accomplished best with skills that have only a small gap in the experience from the virtual- to the real-world training; this will clearly not be the case for the majority of roles and skills currently included in the EDGE environment.

Further, the collaborative nature of the environment means that "going back a step" is not an option, and the opportunity to train each skill happens on a moment-to-moment basis depending on how the scenario unfolds. While feedback may be offered on how to improve skills, this environment is not conducive to repeating physical skills training to the level required for learning. Perhaps most importantly, the multiplayer nature of EDGE requires the integration of multiple roles of participants, so training a skill (especially with the required repetition) for one role requires all other participants to re-enact the role-relevant scenarios,

which in very few cases will involve relevant skills training for those other participants. This potentially "wastes" time for at least two people (and potentially many more) in hopes of improving the training cost and efficiency for one person. This ratio scales for nearly all of the skills that could be targeted for training, with the exception of "search and clear" for law enforcement.

The Bottom Line – EDGE is not well suited to pursue this type of goal.

1. **Individual Decision Training** – This category includes communication training for helping returning veterans suffering from Post-traumatic Stress Disorder (PTSD), training analysts to identify possible threats, and other similar tasks. Success in this category relies on realism of the information presented rather than on the mechanism by which information is presented. In other words, for this goal, a text description of "what you see and smell" can be sufficient for successful training rather than needing to present a realistic visual and olfactory cue (as would be needed for physical skills training). Again, we find that this level of detail is currently absent from the EDGE tool for most of the roles and potential decision-making skills that would be naturally considered. (This is not to suggest that it could not be added, but doing so would require a great deal of effort, and it is not clear that a virtual simulation environment is any more effective than traditional, off-line mechanisms for delivery of such information.) As an example of this, firefighters rely on the visual quality, position, and direction of the smoke emanating from a fire to provide critical insight into the type of internal conditions they will encounter when entering a new area; firefighters make decisions about how to enter the area safely and combat the fire based on this information. The current visual presentation of smoke in the EDGE tool is accomplished by a single, uniform type of visual smoke that moves by expanding into existing neighborhood squares in the environment at a steady rate. Similarly, the decision skills required by EMTs rely on equally absent sensory signals, especially tactile information. While the EDGE tool has no interface for tactile information, a text interface presenting the EMT with a description of what is being felt could easily supply information; however, there is currently no mechanism for this, no set of actions an EMT can take that relate to medical care (other than checking if the patient is alive or dead), and no actions that an EMT could take based on having any information if they could perform any medical evaluation. All of those options would need to be developed before decision training could be made practical for that role.

Most importantly, decision training only requires the presence of multiple roles if the decisions themselves rely on the actions of others. The vast majority of decisions at the level of the average police office, firefighter, or EMT require (at most) information about the actions of others, but do not involve active collaboration or the need to influence each other actively in dynamic ways. Those types of decision making roles are in the hands of those in positions of command (see discussion of coordination training below).

The Bottom Line – EDGE is not well suited to pursue this type of goal.

1. **Coordination Training** – This category includes table-top games for command and control. Coordination training involves ensuring that tactical decisions are made by command for each role in a way that does not compromise the actions taken by the other roles (e.g., EMTs should not rush into an active exchange of gunfire in order to evacuate wounded civilians). We believe that this is one of the areas in which the EDGE tool could become very useful if refocused to a more command-centric user group. The EDGE tool is uniquely configured to allow incident commanders from the different disciplines of emergency response to practice establishing communications in real time, inventing working chains of coordination and command, deciding on whose team should take which actions and in what order, and balancing communications among commanders with communication with deployed teams under one's own command. These are critical skills that those in command must hone and for which there are very few existing venues available for collaborative training. By providing a training environment with scenario simulation, EDGE can help commanders move away from a "we figure this out in advance and go by the book when something happens" type of "playbook" training and increase the versatility and resilience of the system to be able to handle novel threats as they develop in real time at the scene of an emergency. Further, EDGE could provide hands-on, evidence-based reinforcement for how coordinated decisions work well while poorly coordinated decisions can lead to poor outcomes. By focusing on this command level, EDGE provides a valuable training platform for people in need of sophisticated training that is not currently readily accessible. In order to grow into this role, however, the current tool would need to be drastically refocused in its implementation (see section below on "Recommended Alterations").

The Bottom Line – EDGE could be well suited to pursue this type of goal after some major revisions.

2. **Scenario Exploration and Discovery** – This category includes traditional table-top games and "red teaming" efforts. Success in this category is achieved when the environment is malleable enough to allow users to push the boundaries of the system, inventing new ways to use the environment and interact with other users to create scenarios beyond those designed by the developers. In this context, the EDGE tool could allow incident commanders from each role to test proposed coordination responses to new scenarios. This provides a safe and efficient environment for trying new techniques internal to each role and new methods for communication and collaboration across roles to see if they compromise the capability or safety of other responders or civilians. This also allows a natural forum for "penetration testing" to determine gaps in support that prevent a seamless response, and automatically structures a collaborative conversation among the different participating types of responders about how such gaps could be most effectively filled. This focus increases the potential versatility and resilience of a set

of responders at the time of an actual emergency, especially if it could be structured to include modular sets of collaborating commanders (e.g., which first responders arrive at an active shooting scenario is likely different from those that arrive at a potential biological agent release; part of what can be explored within EDGE is real-time coordination when the set of players is not known in advance).

The Bottom Line – EDGE could be well suited to pursue this type of goal after some major revisions. (See section below on "Recommended Alterations.")

3. **Evaluation** – This category includes simulation-based testing of skills, decision making, and/or coordination of the user. To be successful in this category, a tool must have clear, pre-defined metrics for success for each role, individual, or team involved and the training goals must be linked to knowledge or experience objectives. For many scenarios of relevance to first responders within an EDGE environment, there will be many subjective "judgment call" actions available to each player, especially when the outcomes of their potential actions are affected by the choices of other players. In cases such as these, the best use of the tool is to provide a scaffolding for discussion with an evaluator about the nature of each choice made to determine whether or not it was actually appropriate given the conditions at the time. The tool allows for recording of all individual actions of all role players at all levels. This feature allows an evaluator to make objective assessments of the actions taken by those being trained and the trainees to observe behavior evaluated. This necessitates a human evaluator and does not allow for offline self-evaluation, but it can be very effective.

The Bottom Line – EDGE could be employed to pursue this type of goal, but there is no obvious need for a virtual tool to accomplish this on an individual responder level—it is far better suited for evaluating command decisions.

3.2 Other Concerns about the EDGE Tool

While the explained motivation for development of the EDGE tool involved many admirable goals, many of them are not supported or are indeed compromised by the current design of the system. We mention the ones that seemed the most compromised here, as there was no natural place for explicit discussion in the analysis above.

- One motivation for EDGE initially was to improve training efficiency, i.e., to allow large numbers of first responders to train repeatedly both in teams and individually.[5] However, training individually is problematic because, as currently implemented, the

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[5] See Nenneman, M. "Modeling and Simulation Virtual Training." Briefing to the Naval Postgraduate School Research and Education Summit, July 31, 2012.

EDGE tool requires a minimum of three people (an administrator, a suspect, and a first responder) to log in at the same time to do anything other than wander around the environment passively exploring. In this minimal case, two of the three participants are not experiencing training since they are in roles that do not involve learning goals. More importantly, this means that for an individual to engage in "relaxed, impulse-based play/training," EDGE requires at least two additional participants[6] who will not receive any training benefit.

- The realism of the visual environment is truly remarkable, but the interface allowing you to move around (e.g., run through a door) or manipulate objects (e.g., pick up a gun without crawling) is severely lacking relative to the high expectations set by the visual detail.

- Currently, the role for EMTs is not realistic. They can check whether wounded players and non-player characters are alive or dead, but the only action they can take is to transport the wounded person to a triage location outside. The EMT can place the person into a triage category (e.g., in need of minor care, in need of major care, dead) completely independently of whether or not their checking told them the person was, in fact, dead. Currently, they can take no medical actions to determine triage needs for or treat any wounded individuals. Most importantly for purposes of coordinated multi-role training, EMTs must move about the environment finding wounded individuals while avoiding getting in the way of police or firefighters, but once they discover a wounded person, they teleport to the triage region outside of the building, thereby removing the challenge of having the roles coordinate to work around each other.

3.3 Recommended Alterations

Based on this analysis, we propose particular recommended alterations to the basic structure of the EDGE environment.

- In its current form, **the EDGE tool focuses too much on the visual realism of the environment and too little on the realism of sensory elements relevant to physical skills, decision making, or coordination and command efforts** (e.g., in the current implementation responders can always hear clearly on their communication channels—this is critically untrue in many of the scenarios represented and can greatly hinder the ability of commanders to issue or update instructions to their deployed responders as the situation evolves). While the visual realism is appealing and may greatly enhance user engagement, being engaged is not the same as being effectively trained, and the aspects relevant for effective training must also be included. This issue was also raised in each of the focus group sessions.

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[6] It is conceivable that one person could handle both the role of the administrator and either of the other roles, so long as the computer they are using is able to run the virtual world simulation and the individual emulator, and so long as the person has the skill to perform both roles simultaneously.

- **Expanded AI presence is required. The EDGE tool requires too many players** with very limited roles or who are unable to learn from time spent in-game. In its current state, there are very few AI-coded non-player characters and the actions of those that do exist are severely limited in scope. The suspect and the majority of civilians required for a realistic population are roles that require human players in order for the simulation to work as intended as a populated training environment. However, in providing that realism for those being trained, the humans who are playing that suspect or those civilians are not being trained in any meaningful role. This essentially requires an altruistic donation of time with no tangible benefit by those players. Perhaps the intention is to rotate through so that everyone takes a turn at being "something useless" from a training perspective, but this is still a significant cost to achieve training for those playing roles that are actually relevant to their real-life positions.

- While the strongest role we see for EDGE is involved in coordination training and scenario exploration and discovery, those categories of purpose focus on a command level. As it is currently implemented, the EDGE tool is focused on deployed first responders, primarily at the most basic levels. These responders should not, on the whole, be trained to make coordinated command decisions unless they are being specifically selected for training in anticipation of greater leadership. Further, the command-level individuals who could best employ EDGE to its greatest utility should be able to take for granted being able to issue commands to a deployed set of responders. Inclusion of mistakes or failing to follow orders can be included, but exploring which commands are best to issue should not rely on teams of responders waiting around to test them out in simulation. We therefore strongly recommend that EDGE develop a much better AI driver for deployment-level non-player characters. In the language of game design, **we strongly recommend that EDGE be developed as a multiplayer real-time strategy game**.

4. Task 3: Transition Analysis and Recommendations

4.1 Assumptions

The EDGE transition project worked on a specific plan to identify the most appropriate entities that could successfully support the current active shooter EDGE-based game, provide a sustainable basis for supporting future games, and ideally provide funds for the maintenance and development of new games. The team did not want to, and was specifically instructed not to, take a blue-sky approach for EDGE evaluation and transition. For example, we did not consider other virtual training tools instead of EDGE and analyze how to make them available to first responders using a sustainable business model. The team believes that the needs and value of virtual training for first responders is well established[7] and did not consider validation of those needs in the scope of this effort. Further, there are several approaches to virtual training, including virtual games and computer simulation. Evaluating all types of virtual training and identifying organizations that are good at providing that training was not in the direct scope of this effort. Instead, we focused on transitioning current and future EDGE-based games to the most appropriate organizations that can offer support, train users, and potentially develop new games using the EDGE platform.

The EDGE transition analysis makes two sets of assumptions. First, it assumes that the EDGE license, which is free for federal government use, is extendable to free use by all first responders. EDGE can be freely used by the federal government because it was developed with federal government funds. We think that its use can be extended to first responders, even though the first responders to be trained using EDGE may be employed by state or local agencies. One way to accomplish this would be to transition EDGE to a federally funded organization that has a mission to train state and local first responders.

A second assumption is that the U.S. Army will be the recipient of EDGE updates and the Army's Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) will act as the Army transition partner and continue to collaborate with DHS after EDGE has been transitioned. PEO STRI will continue to support and fund the Army's roadmap for EDGE and has offered to serve as an integration hub for EDGE. This means that EDGE enhancements and bug fixes, whether made in the course of development funded by the Army or development funded by DHS, would be available to all EDGE users. Any DHS-specific requirements or modifications would be funded by DHS. The willingness of PEO STRI to continue this collaboration has been confirmed in conference calls and email exchanges.

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[7] Project Responder 3. Toward the First Responder of the Future, March 2012, Department of Homeland Security, Science and Technology Directorate.
http://www.firstresponder.gov/TechnologyDocuments/Project%20Responder%203%20Report.pdf

4.2 Transition Criteria

We established four criteria that any EDGE transition entity must meet. The entity must have:

- A strong training development and delivery capability;
- A strong technology capability;
- A capability to reach first responder trainees; and
- A proven business model for first responder training.

Having a strong training development and delivery capability encompasses several specific sets of expertise. First, the organization must have people who understand how to elicit training requirements and establish training objectives. This can be accomplished via periodic meetings with users and agency representatives where training requirements are gathered, discussed, and updated. Second, the organization must understand how simulation can be used to facilitate various types of learning objectives and how specific features of the simulation can be used to enhance training effectiveness. The discussion presented by our SMEs in Section 3 is an illustration of this expertise. Third, the organization must understand how to measure student progress toward training objectives and provide feedback to trainees. Finally, the organization must have the training staff to assist in organizing and running the EDGE events and facilitating After Action Review sessions.

A strong technology capability is required of the EDGE transition entity because EDGE is based on leading edge modeling and simulation software. The entity will need a suitable technology infrastructure for hosting EDGE events. Staff who can do some level of hardware and software troubleshooting, debugging and patching are required. Note that we are not suggesting that the transition entity must have a software development capability, but rather enough technical capability to handle activities like installing new software and hardware or installing patches and upgrades. The staff also should be able to communicate with software development engineers to describe deeper issues or recommend fixes. The staff also must be able to provide technical support (e.g., a help desk) for remote deployments.

While the capability to reach first responder trainees might seem like an obvious criterion, it differs depending on the type of entity being considered—academic center, government agency, or commercial company. For EDGE to be transitioned to a typical academic center, the center must have ongoing research projects involving training first responders. As shown in the following section, a number of such centers have researched and developed advanced training systems for specific first responder disciplines. For a potential government agency transition entity, this criterion means that the agency's mission includes training first responders. Since EDGE is meant to be multidisciplinary, the agency should have a mission to train more than a single discipline (e.g., not just law enforcement or fire service). For a commercial company, this criterion means that their customers include first responder trainees. In all these cases, the higher the throughput of first responder students, the greater the potential use of EDGE. Moreover, transition entities that offer an extensive set or catalog of first responder training courses may be able to make use of EDGE as an adjunct to those courses, perhaps as a kind of "lab" for practical exercises associated with the course, or for pre-course introduction or post-course practice. Finally, an important aspect of reaching first

responder trainees is the capability to "suitcase" courses and deliver the training directly within the jurisdiction where the first responders are employed. Suitcasing courses for delivery by Mobile Training Teams can reduce trainees' travel costs and time away from their jobs and may alleviate the necessity for an agency to have its own computer and networking infrastructure to support training.

Of the transition criteria we have identified, perhaps the most difficult to meet is having a proven business model for first responder training. This criterion is important to ensure the sustainability of an EDGE-based training effort. This criterion means that the transition entity should have an established customer base and a way to continually market to potential first responder trainees. It may mean that the entity has experience in working with agencies to secure training grants and the capability to work with an ecosystem of game developers who can provide assistance in getting development grants. Perhaps most important, and most difficult, is implementing a business model with the capability to fund additional development. An ideal transition entity would generate the margins and have mechanisms to fund more virtual training environments, improvements in game engines, enhanced "immersive" technology, and other features in the rapidly evolving gaming technology.

4.3 Transition Entities Examined

4.3.1 Academic Centers

The team evaluated several academic centers as part of the transition plan. The academic centers were examined for two reasons. First, we had an initial hypothesis that reaching the fragmented community of first responders was a significant barrier to transition. We wanted to explore whether a university center can establish a self-sustaining ecosystem of developers, users, and experts focused on first responders. The second reason was to understand lessons learned from similar previous efforts for transitioning federally funded technologies.

There are several university-affiliated centers that focus on researching and developing virtual environments for training. We narrowed our focus on university centers that were using virtual online gaming environments for training first responders because we wanted to learn lessons as specific to EDGE as possible. With this narrower focus in mind, the following centers were evaluated as part of this study:

1. National Emergency Medical Services Preparedness Initiative (NEMSPI) at the George Washington University (GWU)[8]

2. Center for Advanced Transportation Technology (CATT) at the University of Maryland[9]

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[8] http://inside.gwumc.edu/nemspi/index.htm

[9] http://www.cattlab.umd.edu/

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3. Institute for Creative Technologies (ICT) at the University of Southern California (USC)[10]

While the details on each specific center will follow, here is a quick summary of our findings:

1. University centers were very good at doing outreach and engaging users and stakeholders. The games developed by these centers were driven by user requirements and not simple proof-of-concept prototypes.

2. University centers are also very good for creating focused communities of interest or hubs, a necessary pre-cursor for creating self-sustaining ecosystems. NEMPSI created this community for EMS personnel and CATT focused on highway safety stakeholders. ICT is a particularly good exemplar of a vibrant and active hub for research and development (R&D) for virtual training at large. The ICT hub has successfully attracted a wide variety of commercial, educational, and academic stakeholders.

3. While university centers are good at bringing stakeholders together to create vibrant communities of interest, they do not have successful business models to make these hubs self-sustaining, and they continue to rely on additional (central) funding for ongoing operations.

4.3.2 National Emergency Medical Services Preparedness Initiative at the George Washington University

The George Washington University entered into a cooperative agreement with FEMA to develop research, education, and policy on EMS in America's largest cities. NEMSPI was established in 2005 as a result of this cooperative agreement.

NEMSPI is using game-based learning to create complex scenarios in a virtual environment to train responders. NEMSPI developed a game called Zero Hour: America's Medic using the Unreal 3 commercial gaming engine. NEMSPI's goal in developing the game was to provide a training environment in which responders were actively involved instead of learning via passive instructions. The game incorporated several National Planning Scenarios for training and focused on the following capabilities:

- Chemical, biological, radiological, nuclear and explosives detection;
- Triage and pre-hospital treatment;
- Information collection and threat recognition; and
- Information sharing and collaboration.

An important element of NEMSPI strategy was to use a commercial gaming engine and to employ commercial game developers. For this specific task, they worked with Virtual Heroes, an organization specializing in developing serious games for training using the Unreal 3 engine. Virtual Heroes has subsequently been acquired by Applied Research

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[10] http://ict.usc.edu/

Associates (ARA), a much larger diversified corporation. We discuss ARA in greater detail in the Commercial Entities section.
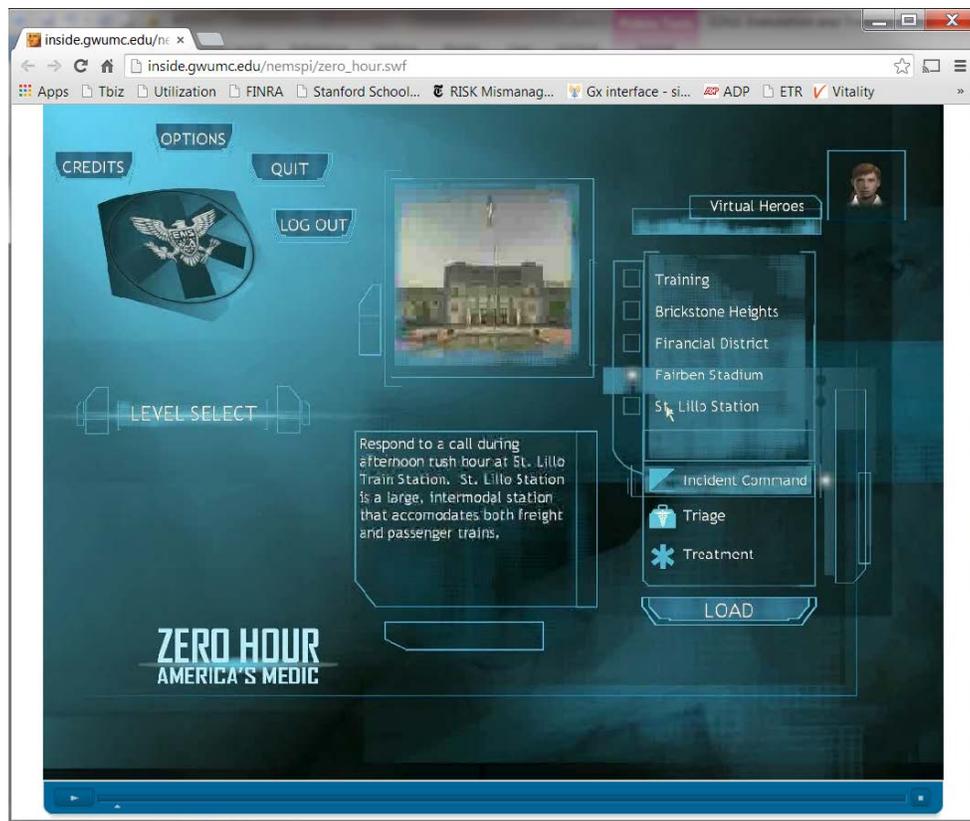

Figure 1: Zero Hour: America's Medic Virtual Training Game

NEMSPI conducted significant outreach within the EMS community before, during, and after the game development. They successfully got the Zero Hour game accredited with the AWR-149-W designation for the DHS awareness level training program. This enabled recipient organizations to apply for grant money for training.

There are some important lessons learned from the NEMSPI experience for EDGE transitioning. First, both EDGE and NEMSPI based their serious gaming on the Unreal 3 gaming engine so they could both leverage commercial off-the-shelf technologies. This speaks for the maturity and confidence in the Unreal 3 gaming engine and establishes its appropriateness for developing serious game-based training environments. Though we did not do a formal analysis of the Unreal 3 market share, we found the platform to be popular with a good developer base. As a popular platform, one should expect that it will keep pace with the overall technology trend.

The second lesson learned is that a majority of the training is grants-driven. NEMSPI initially targeted a more commercial business model; however, they had to reduce the licensing costs for the software. Currently, the software is available for download at $14.95 per license (with bulk purchase discounts) with online help resources. Even at these prices, grants-based funding has been critical for adoption of the game. Any sustainable approach

requires marketing of the games not only to the first responders, but also to the grant-making agencies and organizations.

Though anecdotal, the third lesson learned emerged from our discussions with a lead person for Virtual Heroes who was involved with the NEMSPI effort. The person reiterated that a licensing-based business model for first responders training is not sustainable. In fact, to penetrate the market and change the training mindset, the licensing costs for a set of initial games should be kept minimal or even be given at no charge (a loss leader). Of course, in the long run this has to be complemented with a more diversified business model by an organization that can market and offer complementing services once the channels are established. The transitioning team shares these views and will discuss them in greater detail later in this report when business models of various commercial entities are covered. However, it should be noted that for most of the academic centers, their current business models are not diversified along these lines.

4.3.3 Center for Advance Transportation Technology at the University of Maryland

The CATT Lab[11] is a user-focused R&D laboratory at the University of Maryland focused on a variety of fields, including computer science, computer engineering, geographic information systems, electrical engineering, civil engineering, telecommunication, digital entertainment and simulation, graphics, and systems engineering. Established in 2002, its mission is to support national, state, and local efforts to provide safe and efficient transportation systems through improvements to operations and management.

The lab was involved in developing a virtual online gaming system for training for the I-95 Corridor Coalition. The objectives for developing the system were similar to the DHS EDGE-based active shooter game. The following is from the CATT website:

> It is a low-cost high-impact alternative for training traffic management personnel and first-responders to better respond to incidents. The system was built to simulate a realistic, interactive, and collaborative training environment, with highly customizable training scenarios. Trainers could setup incident scenes, ranging from a simple fender bender to complex hazmat fatalities situations, in a matter of minutes.

> This system was built on top of a commercial gaming engine with heavy custom modification. It was tailored for a wide audience ranging from the avid gamer to the computer novice. Significant research and development has been directed toward usability, network optimization, and artificial intelligence, including dynamic traffic and fire simulations. The system is being used today as a low-cost high-

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[11] http://www.cattlab.umd.edu

> impact alternative to train select field officials in the I-95
> Corridor Coalition states.[12]

Another similarity is how the systems were originally funded using federal dollars. According to an interview with CATT Lab Director Michael Pack, the CATT Laboratory received $1.4 million dollars from the I-95 Corridor Coalition. At the time of development, all of the funding was pass-through grants funds from the U.S. Department of Transportation (DOT).

After the project development and rollout costs, which include the initial training of 750 individuals, were funded with DOT pass-through funds, the funding for continued training is now received through individual member states. As a result, Director Pack indicated that the I-95 Corridor Coalition decided that it does not want to pay for these training classes and changed its business model in terms of distribution of the training.

The CATT Lab is now providing support through maintenance of the system only. At the time of the interview, the lab was not in the process of developing any new features. Although some agencies have expressed interest in new functionality, none have officially offered any funding to do this. Currently, the coalition is now documenting best practices for providing computer-based training in virtual worlds, packaging the software, writing installation and user manuals, and other tasks. The coalition will provide "Train the Trainer" classes to any agency that wants to adopt the software and use it at their own pace with their own instructors. These limited classes are targeted to train regional trainers so they can deliver more classes without the coalition's support of training.

CATT offered local training and packaged the hardware and software for remote training. For local training, network connectivity back to CATT Lab servers was required. Costs to providing the training included: training moderator's time, lodging, travel, materials that were shipped to trainees ahead of time (e.g., checklists, scenario scripts), and technical support time to "manage" the game play and servers or to support the trainer. For remote training, laptops and portable servers were shipped to the trainee site. Each laptop either connects back to the CATT Lab server or a portable server is configured on a laptop with a small Wi-Fi access point for local networking when needed.

It should also be noted that users had pre-training materials that supported this program. There is an online core competencies course at http://i95vim.org. All students were required to take this course prior to attending the virtual worlds training. Also, there was a short pre-game online tool that trainees were asked to look over prior to showing up for a class. This online tool taught the students the very basics of how to manipulate an avatar, including how to communicate, pick up objects, and move. The hope was that this would allow the classroom-based training time to focus on teaching the mechanics of the game.

The lessons learned from CATT are remarkably similar to NEMSPI. Academic centers can manage good outreach but do not have viable business models to make the effort self-sustaining. Another lesson drawn is that these games are far from the goal of "self-training" tools as they require trainers, courses, and a structured curriculum for them to be useful. That

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[12] http://www.cattlab.umd.edu/?portfolio=virtual-incident-management-training

is, the instructive ability of these games relies quite heavily on a training curriculum, and the cost and means of delivering this training curriculum is as important as the game itself.

4.3.4 Institute for Creative Technologies at the University of Southern California (USC)

ICT is an academic research institute at USC that taps into the creative arts and movie elements of the regional economy. Its mission is to bring film and game industry artists together with computer and social scientists to study and develop immersive media for military training, health therapies, science education, and more. ICT merges skills from engineering, education, business, cinematic arts, communication, and medicine and focuses on virtual environments for improving decision making and other cognitive skills.

The center is an impressive institution with extensive ongoing R&D on immersive virtual training. While the business model of the center is still top-down and driven by U.S. Army and R&D grants, they have been very successful in creating a hub that brings together several external academic and commercial collaborators.

Figure 2: A Sample of ICT's Virtual Training Environments

Figure 2 depicts the scope of virtual training environment application development at ICT. Their website lists about 45 such applications, and while many are termed prototypes, several have been successfully deployed and are in use by actual users. For example, U.S. Army Full Spectrum Warrior (FSW) is a squad-based, tactical-action game for military operations in an urban terrain (MOUT). Game players assume the role of a squad leader for a squad of two fire teams of U.S. Army infantry soldiers. The players get training on tactical planning as the execution of the game plays out the MOUT battlefield scenarios. FSW was released for Xbox on June 1, 2004, and later ported for other platforms by other commercial partners.

ICT researchers were also involved in an effort for DHS to create a virtual training environment for disaster response training for incident command called Training, Exercise, and Lessons Learned (TELL). The DHS TELL program was designed to be a federated set of systems to facilitate the training and exercise of incident commanders based upon NIMS.

Various efforts and level of engagement of academic, government, and commercial partners clearly demonstrates the value of virtual environments for various types of training. ICT by

itself cannot be a transitioning organization for EDGE because the U.S. Army top-down business model is unlikely to work for the fragmented first responder markets. However, it is imperative for the organization that eventually manages the EDGE games for first responders to be engaged with the broader ICT ecosystem so that it can leverage other programs to bring about a truly immersive virtual training environment for first responders in the future. We believe this engagement with broader ICT efforts is strategically more important for the first responders than the current pooling of resources with the U.S. Army to maintain the EDGE platform for the short term.

4.4 Government Agencies

There are hundreds of federal, state, and regional agencies set up to train various disciplines of first responders. Many state and regional agencies train relatively small numbers of first responders annually, so they are not considered here as candidates for transitioning EDGE. We focus instead on government agencies that have a high throughput of trainees annually.

4.4.1 Federal Law Enforcement Training Centers (FLETC)

FLETC, a component of DHS that is headquartered in Glynco, Georgia, meets most of our transition criteria. It develops and delivers a variety of law enforcement training courses to 91 federal agencies and partner organizations as well as state, local, rural, tribal, territorial, and international law enforcement agencies. In fiscal year 2012, FLETC trained approximately 70,000 law enforcement officers. FLETC is a leader in using simulators for training and has a high-tech campus that includes computer labs and classrooms with infrastructure suitable for running EDGE. It has staff with the technical background that could support EDGE deployments, and its state and local programs deliver training on-site to jurisdictions. FLETC can reach law enforcement officers and has a program of meeting with law enforcement representatives to continually assess their needs for new training courses. It has recently developed an active shooter training course for law enforcement officers. FLETC has also evolved a business model that allows it to support the cost of maintaining and updating the high-tech simulators used in a number of core course offerings. It may be possible (but at this point is not certain) that this model could be extended to an EDGE-based training system.

One criterion that FLETC does not meet fully is the capability to reach first responder trainees of several disciplines. FLETC does not train fire service personnel, and its emergency medical training appears to be limited to "tactical medical training," i.e., medical training aimed at providing aid to law enforcement officers injured or wounded in the course of responding to an incident. With this one exception, FLETC appears close to an ideal transition entity for EDGE. An alternative would be to refocus EDGE solely on the law enforcement discipline (which is the most highly developed role in EDGE at this time), in which case the fit with FLETC would be quite good.

Several representatives of S&T, the U.S. Army Training and Doctrine Command, and the U.S. Army STTC who are working on the EDGE active shooter scenario for DHS toured

FLETC facilities, gave a presentation and demonstration of EDGE, and held discussions with senior FLETC staff in January 2014. FLETC staff could see a number of potential uses for EDGE, including use as pre- or post-course adjuncts to training courses already developed. At the time of the meeting, FLETC and S&T staff began discussion of establishing a memorandum of agreement between the two organizations.

4.4.2 National Emergency Training Center (NETC)

NETC includes the National Fire Academy (NFA), the Emergency Management Institute (EMI) and other components, all part of FEMA. It is located on a campus in Emmitsburg, Maryland, where courses are developed and residential training is delivered. Facilities include a Simulation and Exercise Lab and four computer laboratories.

The NFA "promotes the professional development of the fire and emergency response community and its allied professionals."[13] It delivers a catalog of 2-, 6-, and 10-day courses to residential students (typically more senior fire service leaders and representatives from allied disciplines) and off-campus students in state and local communities. The NFA also offers interactive online courses to students, including the general public. The NFA offers close to 70 courses structured into curricula, including fire/arson and explosion investigation, EMS, executive development, fire prevention (management, public education, and technical), hazardous materials, incident management, management science, planning and information management, responder health and safety, and training programs.

The EMI focuses on the development and delivery of training in emergency management to federal, state, local, and tribal government officials, including FEMA employees, as well as public and private sector employees. It offers resident and non-resident courses in areas such as natural hazards, technological hazards, professional development, exercise design and evaluation, and integrated emergency management. Approximately 5,500 people attend EMI residential courses each year, and approximately 100,000 attend non-resident programs sponsored by EMI and conducted by state emergency management agencies under cooperative agreements with FEMA.

The NETC appears to meet most of our transition criteria. It has a significant first responder training development and delivery capability. Its technology capability, while perhaps not as sophisticated as FLETC, may be sufficient. It can reach fire service, EMS, and emergency management trainees. It offers courses based on command coordination and integrated incident response, some of which might be able to use EDGE as an adjunct lab for practical exercises.

There are two areas where NETC may not meet our transition criteria. It does not focus on law enforcement officer training and in that sense is complementary to FLETC. Additionally, the NETC business model may not be robust enough to sustain continued development of new EDGE scenarios and advances in modeling and simulation technology.

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[13] See NFA 2014-2015 Course Catalog: https://www.usfa.fema.gov/downloads/pdf/nfa/1415_nfa_catalog.pdf

4.4.3 Potential State Transition Entities: POST Organizations

The Peace Officer Standards and Training (POST) organizations in each state are responsible for setting standards for state and local law enforcement officer training in the state. The POST organizations certify training courses that can be taught for credit at the police academies in the state. The POST organization may fund the development and delivery of training courses, which are then certified, or they may assess whether courses developed by commercial training vendors are worthy of state certification. For EDGE to be used for training in a police academy, the state POST organization would have to analyze the training objectives for the course and assess whether EDGE facilitates students mastering the course objectives.

While POST organizations play a central role in the development and delivery of training for state and local law enforcement officers, the capabilities and reach of POST organizations differ state by state. Our recommendation would be to consider, at least initially, the POST organizations in the most populous states, such as California, Texas, New York, and Florida. Each of these organizations likely has a significant depth of training staff and technology capabilities, and each serves more than two dozen regional police academies in their respective states, giving these organizations significant reach. Besides the difficulty of having to work with multiple state organizations for transition, the POST organizations address only law enforcement training.

4.5 Commercial Entities

Our review of the academic centers established that while the centers are very good in creating communities of interests or hubs focused on specific needs such as EMS or highway safety or virtual training in general, they lack the diversified business models needed to establish channels with the fragmented first responder community. Even in the case of NEMSPI, which involved the commercial organization Virtual Heroes for game development, a diversified business model could not be realized. In fact, the lessons learned from that experience underscores the importance of a diversified model because the training dollars are not sufficient to fund business models on their own.

An ideal outcome would be for the team to identify a commercially successful organization that can not only take over the support for the current games, but can also provide resources for the maintenance and development of additional games. There are some business impediments to realizing this ultimate outcome. EDGE is a middleware developed on top of the commercial Unreal 3 gaming engine to enable development of specific training functionality. EDGE middleware also provides programming abstractions that ease evolution of the core platform as the gaming engine evolves. The EDGE program is managed by the U.S. Army Research Laboratory's STTC. While there are benefits of the EDGE middleware, it creates licensing and other business impediments for a pure commercial transition. EDGE is open in the sense that the Unreal 3 licensing terms allow free deployment of EDGE-based games to federal customers, and other organizations can obtain the EDGE toolkit to develop their own games and scenarios for federal customers. However, any third-party development requires the developer to release their source code to the U.S. Army; additionally, five

percent of the overall project costs must be set aside for the U.S. Army to integrate the newly developed software into a centrally managed repository. This can severely limit the future competitiveness for any third-party organization and reduce new game development efforts to one-off responses to centrally funded requests for proposal (RFPs)—a far cry from a self-sustaining business model for new game development. The licensing model almost certainly rules out private or internal R&D investment by an organization, which is an essential element for realizing truly competitive product offerings.

The second detriment in realizing a transition to large and diversified commercial companies with a core business of training and simulation is that large organizations have their own platforms and they may face product roadmap management issues while working with an open effort like EDGE. Specifically, to reduce the training delivery costs for the fragmented first responder marketplace, these organizations may want the platform to evolve in a manner that may conflict with the top-down procurement and delivery model of the U.S. Army.

In spite of the licensing and roadmap issues, we believe that commercial organizations can be engaged in a hybrid model so that long-term game development costs can be reduced and these organizations can grow their business around a portfolio of virtual training technologies, including EDGE-based games. Further, we think that it is important to study the commercial entities independent of the EDGE lens so that we can synthesize elements that go into successful business strategies for sustaining first responder training.

The commercial entities we examined are listed below and a brief overview of each organization is provided in the following sections. Once again, we wanted specific lessons drawn so we focused on organizations with a) first responder focus and b) services and products for virtual-environment-based training and education. We analyzed the following organizations:

1. Environmental Tectonics Corporation (ETC);[14]
2. Applied Research Associate's' ARA's Virtual Heroes Division;[15]
3. Motion Reality Inc. (MRI);[16] and
4. A few small but relevant organizations.

One of the biggest lessons learned was the need for a diversified business model. Game-based virtual training is a new, but growing field; however, in the short-term, we did not find an entity that had a self-sustaining business model built around pure development of game-based virtual training products or services dedicated to the first responders. What we commonly found were organizations with a core focus on training and education that had a strong interest in growing their virtual training products and services business. We also discovered that most were focused on large enterprises such as the U.S. Army, but their product managers were demonstrating an increasing interest in addressing the first responder marketplace for incremental growth. Further, many product managers consider virtual-

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[14] http://www.etcusa.com/

[15] http://virtualheroes.com/

[16] http://www.motionreality.com/

environment-based training, which may not easily integrate into current curriculums, as a disruptive technology to their core business. However, due to growing interest they are increasingly seeking opportunities to build or acquire these new capabilities.

4.5.1 Environmental Tectonic Corporation (ETC)

ETC is an international corporation with offices that span the United States, Europe, Asia, and Africa. ETC specializes in simulated environments for training, testing, and R&D within niche markets. The simulated environment markets include aerospace aircrew training and the Advanced Disaster Management Simulator (ADMS), "an interactive, virtual-reality training platform for the emergency management, disaster preparedness, homeland security and defense markets, both international and domestic." The ADMS was first introduced in 1994 and is based out of the ETC offices in Orlando, Florida.

System Description

To get a better understanding of the system, the research team met with the Essex County Community College (ECCC) Police Academy, which had purchased the ADMS system. The ECCC Police Academy also houses the ECCC Fire Academy. After a demonstration, the research team was able to understand the users' experience in using the system during training.

It should be noted that the ECCC purchased a basic ADMS system with some limited capabilities. With enough funds, the ADMS system can include a number of enhanced and additional capabilities. In general, ADMS offers the following features: (a) directional sounds, (b) physics-based simulation, and (c) AI-based vehicles and participants.

Within the ECCC, ADMS is used primarily to evaluate students on their decision making within the context of the ICS. The ECCC does not attempt to use ADMS for lower-level first responder skill training. They repeatedly said that ADMS is "an advanced table top." It does not replace full-scale exercises. The ECCC staff felt strongly that ADMS is an improvement over PowerPoint and videos because it is interactive, i.e., the student can see the effects a decision has in the simulation. The student can make mistakes without the costly consequences an action could have in the real world.

4.5.2 Applied Research Associates' (ARA) Virtual Heroes Division

Our interest in Virtual Heroes was spurred by their strong presence in the development of interactive training games for training, simulation, and learning. The organization, founded in January 2004, grew rapidly and acquired extensive experience in developing interactive games based upon the Unreal 3 gaming engine. In fact, they played a key role in helping STTC (the U.S. Army R&D unit managing EDGE development) acquire the Unreal 3 licensing for federal use. They helped set up the software and conduct initial training of the EDGE team.

The early involvement for Virtual Heroes was with the America's Army project for which they developed games and interactive content. Over a period of time, they have assembled an impressive portfolio of training game products (refer to Figure 3).
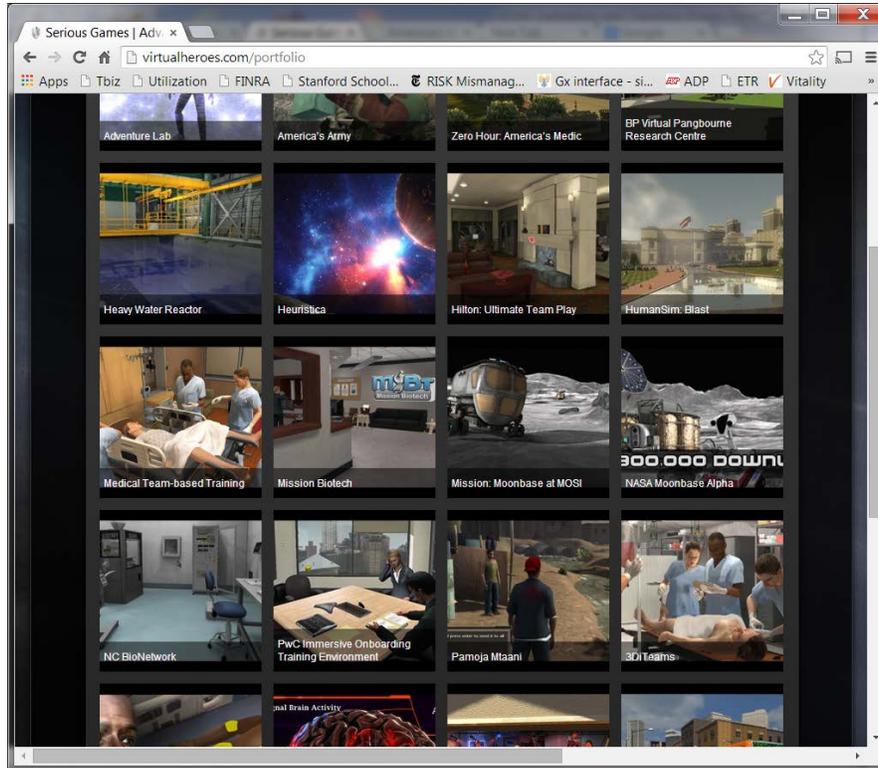

Figure 3: Virtual Heroes Portfolio Portal Screenshot

In April 2009, Virtual Heroes Inc. was acquired by ARA and became part of a larger organization with a more diversified business model and set of customers. ARA is more than 30 years old and started with a strong focus on the nuclear realm, such as doing blast effect modeling. ARA has approximately 1,100 employees and $200 million in revenue. It supports the Defense Threat Reduction Agency and other government agencies.

Virtual Heroes and its parent company are more than interactive game developers. Their marketing information claims to create courseware by combining educationally sound and scientifically validated approaches in a robust, proven production process. The following excerpt from their website, http://www.virtualheroes.com/about, outlines the training and learning formats they focus on:

1. Simulations for Learning: Representations of real life that accurately demonstrate a physical or simulated process or phenomenon.

2. Serious Games: Game technology used for other than purely entertainment purposes including education, training, strategic messaging, mission planning and rehearsal, marketing, scientific visualization etc.

3. Virtual Worlds: Computer-based, simulated 3D environments intended for many users to inhabit and interact with via avatars.

Virtual Heroes participated with several academic centers in developing interactive games for training. Their involvement with NEMSPI was covered earlier. They also collaborated with Duke University on a project now called the immersive learning environment for medical training. The project originated with a one-year $250,000 award from the U.S. Army's Telemedicine and Advanced Technology Research Center, followed by a two-year $290,000 award from the National Institutes of Health. The project has continued with a five-year $2.8 million award from The Duke Endowment with the goal of making the platform broadly available to the healthcare community. The project is managed under the Human Simulation and Patient Safety Center at Duke University.

ARA, the parent organization, has other synergistic divisions. Their Cognitive Solutions Division focuses on supporting how cognitive work can be better supported by understanding problem domains, worker's role and context; and developing a system to improve performance. Their Vertek Division provides fabrication facilities for full motion and stationary training simulators.

The transitioning team interviewed a business lead at Virtual Heroes to assess his views on EDGE's transition. Virtual Heroes has not entered the first responder training market, but has a strong interest in growing that part of the business. The business lead outlined several roles Virtual Heroes could play to support the transitioning efforts, including hosting servers and developing a visual interaction and conversation editor that would presumably ease the job of creating new scenarios by non-experts.

Considering the extensive experience Virtual Heroes provides, it would be beneficial for the long-term success of the program to involve them. In fact, Virtual Heroes has had a long-term relationship with EDGE. Their lack of current channels to reach the first responder market can be addressed by pairing them with an organization that has those channels and establishing a business model that works for both. We suggest such an arrangement as part of our long-term recommendations.

4.5.3 Motion Reality Inc.

MRI was founded in 1984 and has been providing motion-capture technology for use in military and law enforcement training, and also for use in improving performance at games such as golf. MRI created the VIRTSIM virtual simulation platform, an immersive environment that faithfully captures 3-D, real-time animation and human motion. The initial focus of VIRTSIM was for military users; VIRTSIM Military provides an untethered, 3-D, fully immersive environment with 360-degree awareness.

MRI has been a pioneer in 3-D, real-time engineering analysis and computer graphics animation of human motion, including its creation of the first accurate 3-D human motions for both video games and motion pictures. MRI's technology received a 2005 Academy Award for use in the motion pictures "Lord of the Rings," "King Kong," and others. MRI licenses the technology for others. Raytheon BBN partnered with MRI on several efforts, including the Intelligence Advanced Research Projects Activity's Sirius program that awarded $10.5 million to Raytheon BBN to develop serious, immersive games that result in

better decision making by teaching participants to recognize and mitigate their cognitive biases.
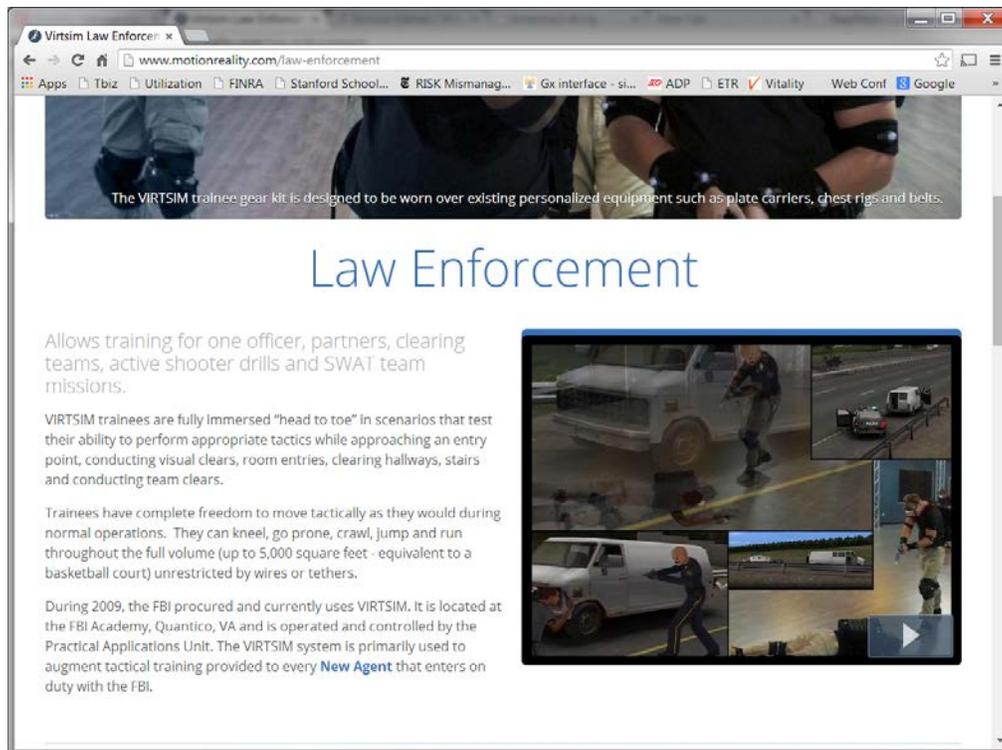

Figure 4: VIRTSIM for Law Enforcement Portal

MRI demonstrates a successful transitioning model for a platform that has evolved over a period of time using centrally funded dollars and is being actively marketed by a commercial entity to new partners and new customers. Case in point is their use of the same VIRTSIM platform for law enforcement. They have a VIRTSIM active shooter scenario-based learning environment that is currently being used by the FBI (refer to Figure 4 or their website for more details).

A key lesson learned is that a commercial force is needed to realize economies of scale for centrally funded platforms. The current EDGE program is missing that key element. Identification of an "MRI-like" outfit for EDGE is further complicated because of the mixed EDGE funding model. For example, the transitioning team is tasked to identify the best transition path for EDGE-based games, present and future, for first responders, but the scope of transition does not involve the complete EDGE platform (both military and first responder use). Given the constraints, the team strongly believes that a transition path involving a pure commercial entity is currently difficult to achieve. Our recommendations involve a hybrid approach that aims in the short term to identify a transition organization that can help support the current and near-future EDGE games, but in the long term provides a roadmap for the organization to create a governance model to sustain an ecosystem of commercial game development organizations.

4.5.4 Others

The EDGE transition team also reviewed other commercial entities but did not cover them in greater depth because either there were no new lessons to be learned or these entities did not have plans to offer virtual game-based training.

CRA Inc.: CRA offers training for the Homeland Security Exercise and Evaluation Program and NIMS. They have a national footprint and have a diversified business model because they also offer security training for the private industry. We were impressed with their national footprint and contacted the organization to see if they would like to include game-based training as part of their services offered. The organization did not have the technical know-how needed to host and support EDGE-type games and servers and believed that expanding in this space was beyond their established business model. Their business model heavily relies on traditional instructor-led training methods.

National Centre for Applied Learning Technologies (NCALT) **:** The United Kingdom's Hydra and Minerva are simulation systems developed by the NCALT at the Metropolitan Police Training School in Hendon, London, United Kingdom. The systems provide incident simulation and e-learning, but are not massively online. Both tactical and strategic incident command training can be accomplished using various scenarios. The Hydra system has had some success in the United States with deployments at the Los Angeles Police Department and FLETC. However, it appears that the system was developed using government grants. Though it appears to have had good adoption within the U.K., the business model is not based on pure commercial licensing. NCALT played a key role in Hydra's development and adoption in the U.K. NCALT was created to assist 43 Home Office police forces in England and Wales in adopting e-learning methodologies. A similar organization within the United States is hard to find; however, a national training center such as the Texas A&M Engineering Extension Service's (TEEX) National Emergency Response and Rescue Training Center (NERRTC)—an organization which we believe is an ideal transitioning partner—would be the most similar.

SAIC OLIVE 3.0: We did a preliminary study of SAIC[17] OLIVE (Online Interactive Virtual Environment) as this offered a unique transitioning exemplar. SAIC, a commercial organization, acquired this platform via the commercial acquisition of Fonterra Systems. The effort was initially funded by the U.S. Army and we believed that getting acquired by a large defense contractor (SAIC) was an interesting commercialization/transitioning strategy. However, our repeated effort to reach SAIC product managers for this product were not successful, and based upon the marketplace research, we believe that the system is not active or being actively marketed.

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[17] SAIC is now split into two organizations, Leidos and SAIC.

4.6   A Hybrid: Texas A&M Engineering Extension Service

Among the transition entities we studied, TEEX stands out as a hybrid, incorporating desirable features of academic, government, and commercial entities. As a training center affiliated with a university, TEEX benefits from the strong research and technical expertise at Texas A&M. This enables TEEX to create high-tech training and test innovative products for emergency response and homeland security. Home to the NERRTC, TEEX develops and delivers a catalog of training courses in support of the FEMA Homeland Security National Training program. Since 1998, the NERRTC has delivered training to more than 450,000 first responders in more than 10,000 jurisdictions in all 50 states. TEEX customers include law enforcement, fire services, EMS, emergency management, and others. TEEX, however, is run like a commercial entity with a strategic plan[18] and clear business and revenue goals with milestones and measures of success. It has approximately $80 million in annual revenue with 450 full-time and 700 part-time or adjunct employees.

A key facility at TEEX for the purpose of transitioning EDGE is the Emergency Operations Training Center (EOTC).[19] This center provides realistic, scenario-based training in incident management using high-tech simulation and a variety of computer-based training tools. Multi-discipline trainees respond to emergency scenarios taking on roles in an ICS structure. Coordination among teams of real or computer-based first responders is closely monitored by experienced instructors and supervisors; communications and command decisions are recorded for after action review. It seems likely that EDGE could play a role as an adjunct to courses based in the EOTC or perhaps even closely integrated with the courses. For example, the "Enhanced All-Hazards Incident Management/Unified Command" course is administered to up to 40 people per session, including multiple disciplines. The course currently is given 12 times per year with support from the FEMA Homeland Security National Training program, and another 10 to 15 times per year tailored to individual jurisdictions and agencies on a contract basis.

Our project team found that TEEX comes closest to "checking all the boxes" on our transition criteria. It has a great depth of expertise in training development and delivery, including conducting outreach sessions with first responder representatives to constantly assess training requirements. The TEEX technology capability is top notch and its technical support staff would have little difficulty supporting in-house or remote deployments. It can easily reach first responders of multiple disciplines and has an extensive track record of delivering courses to many jurisdictions. Perhaps most importantly, TEEX has made a business of training first responders and has a vision and business plan for maintaining and growing that business. The one question that remains is whether the business model can provide funds for continued investment in new virtual training scenarios and enhancements.

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[18] http://www.teex.org/TEEX/documents/TEEX%20Strategic%20Plan.pdf

[19] https://teexweb.tamu.edu/teex.cfm?pageid=USARprog&area=USAR&templateid=1858

4.7 Evaluation Matrix

The following matrix shows how the various transition entities described above either partially meet (+) or fully meet (++) the four sets of transition criteria.

	Training Development and Delivery	Technology Capability	Capability to Reach First Responders	Business Model Works
Academic Centers				
USC/ICT	+	++		
GWU/NEMSPI	+	++	+	
UMD/CATT	+	++	+	
Hybrid				
TEEX/NERRTC	++	++	++	+
Commercial Companies				
ETC/ADMS	+	++	++	+
ARA/Virtual Heroes	++	++	+	
Raytheon	++	++	+	
SAIC	++	++		
CRA	++		++	+
NCALT/Hydra	++	++	+	
Government Agencies				
DHS/FLETC	++	++	+	+
FEMA/NETC	++	+	+	+
State POST Organizations	+	+	+	+

4.8 Short-term Transitioning Option

One of the most important conclusions from our analysis is that the first responder training 'marketplace' is fragmented and grants-driven. It lacks the inherent economies of scale for any single organization to make a pure sales-based, self-sustaining business case for offering games-based virtual training solutions. For a transitioned entity to be successful, it would require significant existing channels into the various first responder organizations and an infrastructure to work at local, state, and federal levels to secure grants on behalf of the trained organizations. As the evaluation matrix identified, TEEX NERRTC has the most appropriate mix of needed characteristics and it should be engaged in a short-term pilot transitioning trial.

We strongly believe that the pilot short-term engagement should adhere to these specific recommendations:

1. S&T to engage NERRTC with the goal of transitioning the existing active shooter EDGE environment. The focus should be on the level already developed and on any short-term modifications needed to support the transitioning.

2. S&T to support NERRTC to incorporate the virtual training as an adjunct lab for practical exercises for their classroom-based training curriculum, and the instructors should be trained to manage specific training scenarios.

3. Three months to transfer the know-how and to create training materials and courses by NERRTC.

4. NERRTC operating staff be trained so that they are self-sufficient in hosting EDGE servers and in providing helpdesk operations.

5. Set a medium term (3 to 12 months) success gate of achieving firm training commitments from one to two large and two to four small first responder organizations.

6. After the initial training, it is likely that large organizations will require support to install and administer EDGE servers in their local networks. The transitioning team does not have a good understanding of the maturity of the current EDGE environment to support local deployment. We recommend that during the first year of transition, S&T and the U.S. Army STTC provide support to NERRTC to enable local installation for large organizations.

7. S&T and NERRTC should identify S&T's share of transitioning costs so that NERRTC can start outreach and pursue the leads generated by the DHS active shooter game roadshows. We believe that future funds should be targeted at making the transition to the active shooter level a success instead of developing new levels. This includes incorporating fixes and enhancements to support NERRTC staff in developing, delivering, and maintaining local and remote training courses.

4.9 Long-term Virtual Training Evolution

We believe that S&T, FEMA, and TEEX can all play a vital role in accelerating the adoption of virtual training techniques by first responders. However, the long-term vision needs to go beyond the EDGE-based training. In the absence of consolidation of demand, first responder organizations will continue to lag in adoption of new technologies. Virtual training and simulations have had wider success in other sectors, such as healthcare, aviation, and defense. New and immersive technologies will continue to emerge due to advances in these sectors, and if the fundamental fragmentation issue is not addressed, first responder organizations will continue to be late adopters. Thus, it is in the broader interest of the first responder community to have a specific organization emerge as a thought leader that can spur an open ecosystem of game suppliers, training organizations, and various first responder organizations.

We believe that TEEX NERRTC can be positioned to address the fragmentation and can become a key enabler for the long-term virtual training evolution for first responders. Achieving consolidation and still maintaining local independence of various first responder organizations requires a carefully drawn implementation strategy. The approach requires necessary federal involvement to act as a catalyst for the initial stages. We believe the following should guide a federated approach to address the long-term first responder virtual training needs:

- TEEX NERRTC should be encouraged, empowered, and incentivized to create an expanded ecosystem of virtual training technology suppliers, training organizations, and first responder organizations. The expanded ecosystem should include:

    a. Several commercial game development organizations;

    b. Other first responder training institutes, such as FLETC, NETC, and other state and local training centers such as state POST commissions; and

    c. First responder stakeholders, including current NERRTC customers.

- The federally funded RFP process should guide the expansion of the ecosystem. S&T and FEMA should ensure the openness of the ecosystem by creating a First Responder Virtual Training Governance Board.
- The expanded public-private consortium, through its governance board, should:

    a. Act as a requirements clearinghouse facility;

    b. Act as a virtual storefront for training resources at local, state, tribal, and national levels;

    c. Play a central role for open RFP processes by providing certification and transitioning requirements;

    d. Work closely with other Centers of Excellence, specifically, USC ICT, to create technology refresh roadmaps for first responder virtual training; and

    e. Work with the U.S. Army STTC to coordinate efforts across other EDGE users.

5. Appendices

5.1 Subject Matter Expert Comments and Suggestions[20]

This document contains my impressions about the Enhanced Dynamic Geo-Social Environment (EDGE) training environment. After reading the installation instructions, I installed the tutorial arena. I then installed the Local Area Network (LAN) version and explored it. Interspersed with exploring the environment using a variety of character classes, I read the html documentation. I will comment briefly on the documentation below; however, my main focus is on the game-play experience.

This document is organized in two main sections. The first section is a running commentary of my impressions as I explored the EDGE training environment. It is intended to be more raw to reflect my thought processes, although it does contains some interpretation. The second main section is a more thoughtful reflection of the experience, including some concrete suggestions for improvements and future directions. Lastly, in a third section at the end, I will briefly summarize my observations.

5.1.1 Notes During Exploration

This is a log of my impressions while playing the EDGE training game. It is also part a "reading of the game," where I've tried to intersperse interpretation, some commentary on training value, as well as my general observations.

5.1.2 Tutorial Arena

I really like the character customization. It engages a sense of ownership by players, which can improve engagement.

When I first entered the training arena, the camera was positioned inside my character. When going prone to get through the doorway, the character falls through the floor.

During the sprinting exercise, if I didn't release the sprint key combination before I was instructed to sprint to the target, it hung. I had to back away from the wall before it allowed me to move on to the next goal.

The camera control during driving the truck is atrociously bad. When you first enter the truck, the camera remains outside facing across the vehicle. When driving, the camera moves completely independently of the direction of the truck, making it extremely difficult to navigate.

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[20] See statement in Executive Summary regarding the version of the software the subject matter experts used, and note that some of the deficiencies identified and some of the alterations and enhancements suggested may have been incorporated in subsequent versions of the software.

During the shooting exercise, the orange panel was confusing. It wasn't immediately clear what that was referring to. More importantly, the scaffolding that was used to direct attention in previous exercises wasn't there.

One potential issue has to do with the instructions. If my attention is diverted, and I miss the instructions at the top of the screen, they don't come back and I get stuck. This happened to me in the part after the firing range. Annoying.

I pressed some random buttons, and ended up dropping the weapon. I thought I had made progress because I saw the icon indicating I could use 'F' to pick up the gun. That didn't help. When I repeated by pressing 'X' again, the option for 'F' didn't return. I had to press 'Z' to get prone before I could pick up the gun again.

Presumably, the task here is to shoot while zoomed in. This is a problem on a Mac (I'm running the software on Windows 8 inside a VMWare Fusion virtual machine). With only one mouse button, I can't simultaneously depress the right and left buttons. The mechanic of holding the right button while pressing the left may cause problems for some users.

I went back and did the training scenario over again. I now realize the scenario was complete and just stopped. I missed that the first time around.

5.1.3 LAN Arena

Uninstalled training scenario, now installing full scenario. This is extremely confusing for me.

When starting the server, I got four errors about loading or finding 'Class None.'

I selected firefighter. It's unclear if my character avatar changes my role in the game or not. I created my character, but wondered what can be done with the accessories. This is not covered in the tutorial.

When you enter the area, there are options for channels on the left. Initially, this was quite confusing. After playing through for a while, it became clearer that these are communication channels. I wonder how obvious this will be for first responders.

The large time that appears on the top right, what is this? It has been a number of different values each time I've joined the arena. The smaller time below it seems to be elapsed time since joining the arena.

I selected Channel 6, and pressed "GO."

Spawn points. Clearly these are user-selectable at this point. Will they always be? What purpose does that serve? It seems like giving the trainer the option to force spawn points is the right move.

I chose spawn point 1, which dropped me in an alley. I then entered through the doors on the left, which led me down into a large room full of useless characters. What purpose do they serve? I couldn't talk to any of them, even though the tutorial mode seemed to indicate non-player characters (NPCs) were talkative.

I exited the room to the left, and entered a back hallway of some sort. Found a few closets, more non-interactive NPCs, and then finally an exit.

After exiting the building, I walked down the street and came to a main intersection. I passed a few cars on the way, but ignored them for now. I found four colored areas, each labeled with a word. Presumably these are triage areas? Why so close together? Why such bright colors when everything else is styled more realistically (or am I just ignorant to how things are done in the real world)? Do they have something to do with the scenario?

A siren! Where is it coming from?

Running in a straight line seems to randomly stop after a while. I ran down to a line of orange cones and was stopped. I went back to the intersection and tried to enter the building caddy-corner to the grand hotel. The entrance seemed accessible, but when I approached my character stopped. A space that appeared to be wide open blocked my progress. Engagement broken.

Seems like there's nothing else to do at this point, so I'm trying out the menus. First, middle click menu. (Not clear everyone will know what a middle click is.)

I first clicked admin. Nothing.

Next I tried voice. This gave me two more options. I selected channel and was able to pick a new channel. Let's try channel 3. Apparently I joined channel 3, still quiet.

Next, I tried private voice. This brought up an empty scroll list. Attempting to get out of this list wasn't easy. Finally, I realized if I clicked on a different menu it would let me out. Frustrating.

Next, text chat. The private text chat menu had the same issue. If I don't want to select something from the menu, it's tough to get out. I try "area," which brings up a chat window. Here there's a graphic indicating the 'T' key is "PTT." I'm assuming everyone will know that PTT is Push To Talk? I press it, and it just prints a string of 't' characters to the chat window. I replace that string with the phrase "Hello." Now it won't let me type anything else; however, if I press the 'T' key now, I get a squelch sound effect and the volume indicator above the text chat changes to orange. I get it now, this is modal. Seems like there should be a keyboard shortcut to allow text entry, especially once the chat window is already visible.

One other thing I noticed trying to chat: The single quote key (used when typing words like "they're") in the chat seems to trigger some console for commands that aren't covered anywhere in the documentation.

Enter the grand hotel. I'm sensing a pattern here. No NPC is willing to interact with me. They are all static, slightly animated characters that add nothing to the scenario.

I go upstairs in the hotel and walk through the bar. I enter the back hallway. Here it becomes apparent how poor the camera control is. When colliding with a wall, the camera moves through the character and I lose perspective completely.

I walk through the kitchen, then pass through a sequence of doors that lead through an office and finally back into the bar.

I locate a map. Nice! Maybe this will tell me something interesting. Nope.

I moved through some more doors and find an exit sign, which led to some stairs, up we go. Level 4. Two things to note: 1) camera control is still awful when it comes to the character colliding with something; and, more importantly, 2) when doors open towards the character, they pass right through the character.

Down the hallway, into an office suite, and back to some stairs. Again, collision detection is awful here. I lose my character completely.

I now have three characters in the game environment simultaneously. I'm able to chat, etc. But there's still no "game" per se.

Lastly, playing around with instructor mode. I now realize the single quote key bug is part of the control console that gets you into instructor mode. The free-fly camera is nice, but the collision detection is pretty weird. There isn't much clear about why I can fly through some walls and not others. Further, the collision detection is very bad in certain areas (e.g., near the top level of the hotel).

The 'B' and 'N' keys spectate different character functions, but they didn't work for me.

I decided to mess around with the different commands that autocomplete in the control console. I tried a bunch with no clear effect, but finally found the suicide command. Interesting. I did get to verify the heartbeat visualization using an emergency medical services character to check on my firefighter who committed suicide.

Instructor mode also activates the admin submenu on the radial menu. If regular players don't get access to admin, why even bother including it? I got excited when I saw the option to start the exercise; I thought perhaps it would begin the artificial intelligence (AI) characters moving. I was wrong.

5.2 Impressions

Here I will provide a more thoughtful evaluation of the environment. In contrast to Section 1, this section is intended to incorporate more interpretation. It reflects my impressions after having played with the environment and then taken some time away to ponder my experiences. Generally speaking, my impressions are positive about what is contained in the current EDGE system. That being said, in an effort to be as constructive as possible I will emphasize some areas I see as potential problems moving forward or that already show a need for improvement.

5.2.1 Tutorial and Documentation

The documentation is a mixed bag in my opinion. The installation and software version description are not effectively written for the end user. This might be alright if the intended audience is information technology professionals who will be installing EDGE in firehouses, police stations, etc.; however, to be of great value, the networked game should be accessible to all first responders at the time and place they want to play it. A truly engaging training

simulation will excite players to play more, and you want them to be able to when they are home, with friends, etc. This seems relatively easy to address.

The html documentation is quite a bit better. It highlights a number of command options that aren't apparent in the tutorial (which I'll discuss below). The html documentation is where I learned about the different roles characters can be and the effects the choice of role has on the game interface. For example, selecting the incident commander restricts the spawn point to the parking garage where the mobile command vehicle is or the dispatcher never enters the arena, instead always remains in the transit screen. In fact, the html documentation is where I learned what the transit screen is.

> *In my view, one absolutely crucial task before this system becomes more broadly useful for training will be to provide an integrated tutorial mode that leads players step-by-step through the skills they will need in the arena.*

The separate tutorial mode covered basic movement and interface-level interaction; however, communication among characters was not explained at all, nor was the transit screen.

Lastly, the instructor mode was actually quite useful. I understand that few players will need instructor mode, but a tutorial for it will also be necessary.

5.2.2 Interface

I have very little to comment on regarding the interface. It is pretty standard with 'W,' 'A,' 'S,' and 'D' for movement and the mouse for camera position. That being said, I found the camera control to be atrociously bad. Any time a character collides with an object, the camera finds its way inside the character or even behind a wall.

> *The poor camera control alone was enough to break engagement for me and make me want to walk away. That will have to be vastly improved before this system is production ready.*

I also found the camera control during vehicle operation to be quite difficult. While many gamers might be accustomed to the paradigm where the vehicle operates differently than the character walking, I found it confusing. I suspect many first responders who aren't accomplished gamers will shy away from operating vehicles because of difficulty controlling the camera angle completely independently of steering. That being said, it certainly seems like the operation of vehicles isn't central to the desired gameplay.

While I found the radial menu a worthwhile thing, I do think there's some room for improvement there, too. The inclusion of the admin option when not in instructor mode is confusing. More serious is the issue of the text chat. I understand using the radial menu to bring up or shut down the text chat window; however, once it is up and the first message is sent, it is very frustrating to have to make four more mouse clicks to send another message. It would be far more expedient to have another key press active the text chat.

Lastly, the single quote character activating the console will need to be addressed. I'd even suggest disabling the tab key activation of the console and making instructor mode a startup option. You will have many confused players when this happens in the wild.

5.2.3 Assets/Level Design

The 3-D models and level design are the absolute shining star of the EDGE system to date. The avatar customization capability is a big plus. Customization leads to ownership and liking, which are known to increase engagement. The vehicles are probably the weakest models in the system; however, as they have the shortest perception window, that isn't a big concern in my opinion.

Presumably the focus of the experience is the interior of the hotel. There's no doubt in my mind the layout and textures of the hotel are the single biggest asset of the experience. The detail is impressive, both in public areas and behind the scenes. I'd imagine these behind-the-scenes areas are much more familiar to first responders than most hotel guests.

The placement of NPCs throughout the hotel's lobby seems very reasonable as a starting point.

> *I'm sure it's no surprise to hear that the lack of AI NPC interaction is a real problem.*

Seeing SoarTech as one of the credited developers, I expected to see at least some AI working in the system. I look forward to seeing another version of the game with working NPC AI.

5.2.4 Mechanics

The mechanics of interaction in the environment are also a bit of a mixed bag, but generally were on par with or exceeded my expectations. The standard movement and proximity-based object/NPC interaction makes sense, even if unimpressive. Although, I suppose there's no real reason to innovate on that level. The lack of animation on the elevator is a bit unsettling at first. When using the elevator to move between guest floors in the hotel, after pressing the desired destination button it's difficult to tell that anything has changed. When moving from the lobby to a guest floor, the change in the environment makes it clear that the action was successful. At the minimum, I'd suggest including a message indicating that the player has successfully moved to the new floor.

A close second to the design of the hotel is the sophistication of the communication system. Although I found it a bit confusing to select a channel during the transit screen (which, admittedly, at the time I first experienced it I hadn't seen in the documentation and therefore didn't know was the transit screen), I see how this gives what I would imagine is a very real feel to the experiencers that may someday use this environment.

> *The ease with which channels can be changed on the transit screen is in stark contrast to the four mouse clicks that are required to change channels once in the arena. This strikes me as a potential engagement breaker, as I'd imagine changing comms channels in the real world is trivial in comparison.*

The channel-based communication paradigm for voice seems to work well, as does the proximity-based default. I found the text implementation of communication paradigms to be

a bit more confusing. It wasn't clear to me how to do small group text messages, or if it's even possible.

> *In short, the opportunity for profoundly interesting game play exists with the communication paradigms that are implemented; however, some minor tweaks to the interface to make their use more efficient would be advisable.*

Lastly, I found the character roles to be quite compelling as well. More importantly I found the changes in affordances for the dispatcher and incident commander to be great.

> *One potential issue is the spawn of the incident commander being in a small area arbitrarily blocked off by cones. Being able to see outside but not go there was quite frustrating and was a huge blow to volition.*

Because volition is such a compelling aspect of successful games, I think it would make far more sense to provide a custom interface like the dispatcher's for the incident commander. As implemented, it feels like a hack.

5.3   Concluding Thoughts

My overall impressions are positive; however, I have a few reservations. I expected this environment to be in a more advanced state of development. Clearly a lot of effort went into the 3-D modeling and level design. The detail in the character avatars is impressive, the vehicles look pretty good, and the hotel is beautifully detailed. I especially like the back hallways where a wide array of storage areas contain realistically modeled objects like boxes of supplies, laundry carts, etc. Also, the variety of communication paradigms models what (I would imagine) is available in real-world first responder settings, albeit with some minor interface deficiencies that should be easily addressable.

> *Unfortunately, the details in the models, level design, and communication mechanics, while impressive, are also a bit of a liability.*

With high-fidelity models, players tend to expect high-fidelity game play. As I wasn't able to test game play yet, I can't comment on whether or not this environment will provide an engaging experience for players. I do know the potential is there; however, the visual appeal has set the bar for compelling game play pretty high.

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