

# Use of Virtual Simulation for Emergency Preparedness

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## ABSTRACT

Well-prepared people are at the core of emergency preparedness, professionals as well as the general public. Being well-prepared requires a combination of specialized and practical knowledge and experience that give a person the awareness and tools they need to be ready. Simulation offers a means to immerse a participant in realistic emergency situations that would be too costly, time-consuming, or dangerous to rehearse “for real”. Simulation can also make information more accessible, and lead to increased public interest through entertainment and social interaction. The technologies to support virtual simulations have continuously improved since work in the 1980’s at the Defense Advanced Projects Agency (DARPA) showed their effectiveness for training. Simulated virtual realities are being used today to train and prepare for emergency management in organizations such as the US Department of Homeland Security, the Los Angeles Police Department, and the New York City Office of Emergency Management. Emergency simulations are also being used throughout the world to inform and entertain the public. Recent advances in graphical processors, mobile computing, and social networking allow broader and more creative use of simulation. This paper illustrates with examples how simulation contributes to emergency preparedness in five key areas: specialized knowledge, experiential learning, psychological acclimation, team building, and complex planning. We also examine the operational, economic, and technical factors that drive effective use of virtual simulation in emergency management, and suggest how potential users might take better advantage of the technology, and how developers of simulation technology might make it more useful.

## THE WELL-PREPARED EMERGENCY RESPONDER

The primary goal of emergency preparedness in any country is for households, businesses, and government agencies to develop appropriate strategies for responding when disaster occurs (Lindell, Tierney, & Perry, 2001). A study of disaster preparedness in the Kingdom of Saudi Arabia (KSA) (Abosuliman, Kumar, & Alam, 2013) found that training of response teams, coordination of organizational responsibilities, and community awareness were among the among the top areas requiring future improvement in KSA, based on performance during 2009 and 2010 floods in Jeddah. In this paper we suggest how simulation technology might be used to better prepare households, businesses, and government agencies to deal with emergencies.

First, we discuss what preparedness means to two categories of individuals who must respond to emergencies: (1) professional responders, and (2) the general public. Effective emergency response requires both groups to take appropriate action, and the groups must also engage in effective collaboration.

### Readiness Needs of Professional Responders

Professional responders play specialized roles, and require specialized skills. They need to be knowledgeable about a wide range of emergencies, equipment, and protocols. They need to be able to perform their duties under stress, and be able to function effectively as part of a team. They need to be ready when needed, and they

must maintain health and fitness to satisfy the physical demands of their work.

Particular challenges professional responders face in attaining and maintaining readiness include learning critical information about various disasters, mastering special equipment and procedures, developing teamwork skills and learning complex coordination protocols, and gaining the experience to apply their skills and knowledge under the stress of a real emergency.

### Readiness Needs of the Public

Public readiness is as important as professional readiness; however readiness needs and issues are different for the public compared to professionals.

Members of the public must know what risks can occur in their area. For example, 7 out of the 10 major disasters in Saudi Arabia between 1900 and 2010 have been caused by floods (Abosuliman, Kumar, & Alam, 2013).

Emergency response is improved when the public knows the measures to be taken before, during, and after the various types of emergency. Extensive social research shows that when disaster strikes, the public is not generally overcome by panic, but instead individuals act to creatively cope and collaborate with each other to deal with the crisis (Dynes & Tierney, 1994). In fact, studies show that in many emergencies, the majority of people rescued are saved by non-professionals who are at the scene. For example 49 of 50 people saved from the rubble of the 1989 earthquake in Loma Prieta, California,

were rescued by a group of 8 Mexican construction workers who were at the scene (Glass, 2005). The public is better able to respond like this to emergencies, when they have access to knowledge and tools.

Beyond knowledge of potential emergencies and responses, the public can benefit greatly by creating response plans and disaster kits, by learning first-aid, and by practicing emergency response as a community.

Achieving a high level of public preparedness is often a challenge, because while professionals are thinking about emergencies every day, public consideration of emergencies is typically as rare as emergencies themselves. This leads to insufficient interest in and knowledge of emergencies, and unwillingness to make the effort to develop plans or prepare disaster kits or practice. Also, since the public rarely needs to deal with an emergency, they are more likely to be overwhelmed when an emergency occurs.

**Readiness Needs in the Interaction between Professional Responders and the Public**

An important part of emergency preparedness for both professionals and the public is awareness of what to expect when the two groups interact. For example, professionals need to account for special vulnerabilities to disaster in the population, due to factors such as age, poverty, infirmity, or culture (Peacock, 2005). This was illustrated in a 1995 Chicago heat wave that claimed more than 700 lives. Most victims were low-income elderly people who lived alone and were isolated from friends and family (Klinenberg, 2002).

It is also important for professionals to be prepared to take into account factors in the social system that influence public compliance with emergency plans or requests by authorities. For example, during the 1918 Spanish Flu epidemic (which killed about 500 million people worldwide), some Baltimore city residents objected to authorities’ curtailing of business hours. Their rationale was that because of lost wages they would not be able to afford extra heating fuel, which they regarded as larger threat to their families than influenza (Schoch-Spana, 2004).

Another important interaction factor that has become particularly relevant today is the need for “participatory governance” in emergency response (HEG Expert Group, 2011). This approach departs from centralized, insular decision-making and authority structures in favor of shared problem solving across sectors and social groups (Dynes, 1994). This is particularly important because of modern citizen’s need and capacity to choose for them-

selves, and the increasing role individual choice plays in health outcomes (Kickbusch, 2014).

Table 1 summarizes readiness needs particular to professionals and the public.

Professional	Public
Comprehensive and specialized emergency knowledge	Motivated to prepare for local risks
Can use special equipment, procedures	Have kits and plans
Prepared for stress of real emergencies	Prepared for stress of real emergencies
Can handle complex coordination and teamwork	Establish community collaboration
Adapt to special public situations	Know what to expect from/how to access professionals

**Table 1** *Emergency Readiness Needs of Emergency Professionals and the Public*

**SIMULATION TO SUPPORT EMERGENCY PREPAREDNESS**

Broadly speaking, a simulation is a representation of reality that allows limited aspects of a real-life situation to be experienced, without the need to incur the complexity, danger, or expense of the real-life situation. Simulations can take many forms; examples include scripted human exercises, sand tables or maps with model ships used for military planning, or computer-based simulations (Sokolowski & Banks, 2009).

Computers can simulate situations in several ways. Mathematical models can be programmed to work out the results of complex interactions in nature, structures, or society. Computer graphics can create realistic environments that allow users to practice driving or decision making, or even experience the stress of an emergency. Computer networks can create environments where teams can practice working together as complex situations unfold. *Virtual simulations* are computer based simulations that include a graphical representation of some aspects of the real world.

**Virtual Simulation to Support Professional Readiness**

Virtual simulation (VS) supports several types of learning particularly useful to professionals:

- *Automated book learning* – VS can provide efficient access to the kind of explicit knowledge that is typically written in books, for example automated equipment manuals
- *Experiential learning* – VS can help students learn from experience, for example to drive an emergency vehicle
- *Psychological acclimation* – a realistic VS can simulate danger and expose students to the stress of emergencies
- *Team building* – working together in a shared virtual environment, students can practice collaboration
- *Operating in complexity* – the many interacting elements of a facility, city, or scenario can be simulated, greatly extending the students' range of experience.

Use of VS offers a number of advantages in preparing professionals for emergencies:

- VS is less expensive and disruptive than real-life drills. It is easier to provide a much wider range of experiences
- Training can be fine-tuned using repeated exercises and controlled variation
- Students can be provided with instant feedback, and performance can be recorded and analyzed
- VS can be flexibly coordinated with a student's work schedule
- VS can be used to coordinate training across multiple locations
- Post-simulation analysis can be used to improve emergency procedures.

#### **EXAMPLES OF VIRTUAL SIMULATIONS USED BY PROFESSIONALS FOR DISASTER PREPAREDNESS**

The Virtual Terrorism Response Academy (VRTA) at Dartmouth University offers training in response to chemical, biological, radiological, nuclear, and explosive (CBRNE) threats (Henderson, 2005). This virtual environment provides automated workbooks to teach CBRNE science, virtual hazmat instruments, and simulations for practicing risk assessment and risk-based operational decision making.

The Fire and EMS Simulator Systems produced by Doron Precision Systems (DORON Precision Systems, Inc.) provides experiential training in driving an ambulance, including 150 road scenarios and driving hazards such as heavy traffic, road hazards, and treacherous weather.

A virtual reality training tool developed at Sandia Laboratories, BioSimMER immerses first responders and simulates the stress in a biological warfare situation

(German, 1999). A student treats a simulated patient seen through VR goggles. The simulated patient reacts to the treatment with changes in breathing and eye movement, and even death.

The Hydra Minerva simulation system was originally developed in London to support training in the command and teamwork aspects of police and fire activities (Alison, 2013). It has since been used around the world to support incident command training with a high level of realism to insure experiences gained with the system can be readily transferred to live incidents.

In New York City, the Office of Emergency Management drills its first responders and partner agencies in a 3-D virtual replica of the city (Pittman, 2010). The simulation uses artificial intelligence and physics-based modeling to reproduce the complexity and unpredictability of real-life situations.

The pervasive use of smart phones has created another opportunity - use of virtual simulation on these hand-held devices. An example is the Mass Triage Casualty APP (Mass Casualty Triage, 2013), which features real-world immersive scenarios depicting casualties that reflect data sourced from the Victim Base database of actual casualties (EMDM Academy).

#### **Virtual Simulation to Support Public Readiness**

Virtual simulation can be particularly effective in preparing the public for emergencies using immersive, realistic, and entertaining simulations that

- Increase public interest in emergencies by entertaining them and providing social interaction
- Increase public awareness by providing a memorable experience that makes the impacts of disasters more tangible
- Provide important information in an interactive, entertaining format
- Provide a game-like environment that motivates learning and practice.

#### **EXAMPLES OF VIRTUAL SIMULATIONS USED FOR PUBLIC DISASTER PREPAREDNESS**

Earthquake simulators have been used to raise public awareness of the real dangers associated with earthquake emergencies (Zollo, et al., 2014). The simulator at Zurich's Swiss Federal Institute of Technology simulates ground motion of real recorded earthquakes of up to magnitude 8, in a room that can seat up to 10 people, furnished with tables and other moveable objects.

The StormStruck exhibit at Walt Disney World's Epcot Center (Wake, 2008) provides an immersive audio-visual environment that simulates driving rain, high winds, lightning, and home damage associated with severe weather.

Video games are increasingly being used to make the public more aware of emergencies and preparedness requirements (Boehrer, 2014). Examples include the Stop Disaster! game from the United Nations International Strategy for Disaster Reduction (Leoni, 2007) and the Disaster Hero game funded by the US Federal Emergency Management Agency (FEMA) (Webster, 2010).

### CHALLENGES IN ADOPTING VIRTUAL SIMULATION

While virtual simulation has much to offer to help professionals become better prepared for emergencies, it can be difficult to introduce the technology into some operations. Organizations usually have tight budgets, and it can be difficult to quantify the cost-effectiveness of investing in and maintaining simulation technology. Also, use of simulation may require an organization to learn new technologies, which may disrupt operations or be beyond their capability. Finally, even the most effective virtual simulation can never fully replace live exercises.

### CONCLUSION

Virtual simulation offers the potential to greatly enhance emergency preparedness for both professionals and the public. Professionals can efficiently learn specialized skills and teamwork for a variety of emergency situations. The public can become more interested, engaged, knowledgeable, and practiced through physical and audio/visual simulations, and through online games.

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