

BOOZ ALLEN HAMILTON INTERNAL



Virtual Emergency Scenario Training

SUMMER GAMES 2018

Team: William Calaman, Thomas Courtney, Matthew Honecker, Coehl Gleckner, Kaitlyn Neitz

*Prepared exclusively for **Organization Name***

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1 EXECUTIVE SUMMARY

The purpose of this report is to demonstrate how virtual reality technology can be beneficial in emergency preparation training. In our society, people are unprepared for emergencies. The cause of this unpreparedness is not due to a lack of practice drills for emergency situations, but because of the ineffectiveness of these drills. Individuals lack preparedness when an emergency arises because drills are not taken seriously, and people do not participate which makes the typical drill ineffective. Our team sees vast opportunities for virtual reality technology to be used in training, specifically emergency procedures.

The Digital Solutions Summer Games Team is creating a proof of concept emergency training simulation called Virtual Emergency Scenario Training (V.E.S.T.). The purpose of V.E.S.T. is to create a more realistic training environment for situations that are difficult and costly to re-enact in real life such as a fire, earthquake, or active shooter incident. Our simulation will immerse users in an emergency scenario where they must escape a fire using the proper safety techniques. As users go through the simulation, their senses such as sight and sound are altered to mimic what a person would see and hear during a fire. Additionally, the simulation will collect data while users are in the simulation and provide feedback on their level of emergency preparedness. The data collected in the simulation will also be used for A/B and Multivariate testing to help determine the placement of escape route signs, fire extinguishers, and location of safety equipment during an emergency.

2 BACKGROUND

EMERGENCY PREPAREDNESS

U.S. fire departments responded to an average of 358,500 home fires per year between 2011 and 2015.¹ The responses eventually lead to 12,300 civilian injuries and over 2,500 civilian deaths.² In other building structures, there were 95,000 apartment fires in 2016³ and an average of 3,304 fires per year in offices⁴ and 4,980 in educational buildings between 2011 and 2015.⁵

According to the National Fire Protection Association, 71% of Americans have an escape plan, and yet only 47% of them have practiced their escape plan.⁶ Without practice, individuals are not prepared for an escape in the event of an emergency. Within this 47%, are many individuals who do not take emergency drills seriously that they are "practicing." Individuals often do not take emergency exercises seriously, because they are a drill.

¹ Fast facts about fire. (n.d.). Retrieved July 25, 2018, from <https://www.nfpa.org/Public-Education/Campaigns/Fire-Prevention-Week/Fast-facts-about-fire>

² Ibid

³ Apartment structure fires. (n.d.). Retrieved July 25, 2018, from <https://www.nfpa.org/News-and-Research/Fire-statistics-and-reports/Fire-statistics/Fires-by-property-type/Residential/Apartment-structure-fires>

⁴ U.S. Structure Fires in Office Properties. (n.d.). Retrieved July 25, 2018, from <https://www.nfpa.org/News-and-Research/Fire-statistics-and-reports/Fire-statistics/Fires-by-property-type/Business-and-mercantile/US-Structure-in-Office-Properties>

⁵ School fire safety. (n.d.). Retrieved July 25, 2018, from <https://www.nfpa.org/Public-Education/By-topic/Property-type-and-vehicles/School-fires>

⁶ Fast facts about fire. (n.d.). Retrieved July 25, 2018, from <https://www.nfpa.org/Public-Education/Campaigns/Fire-Prevention-Week/Fast-facts-about-fire>

2.1 The Scope of the Problem

UTILIZING VIRTUAL REALITY FOR EMERGENCY PREPAREDNESS

2.1.1 CURRENT STATE OF EMERGENCY PREPAREDNESS

Across the United States, the number of emergency drills required are rising. In 2003-2004 school year, 46.5% of American schools practiced an active shooter drill.⁷ The percentage rose to 94.6% of schools during the 2015-2016 school year.⁸ An article from FEMA states that an effective plan must encompass planning and variability.⁹ Considering the recent shooting in Parkland, Florida, individuals had a plan, but were not prepared for the variability of a school shooter eventually leading to one of the deadliest school shootings in American history.

2.1.1.1 Futile Tragedies

1. Stoneman Douglas Highschool

On February 14th, 2018 in Parkland Florida seventeen individuals were found dead at Stoneman Douglas High School.¹⁰ Cruz (the gunman) walked into the school, where he then fired an AR-15 for twelve minutes on three different floors of the building. Following that day, parents around the world questioned if their children were safe going to school.

A 2016 Government Accountability report states, “40 states, including Florida, require individual schools to perform exercises or drills to test their emergency plans.”¹¹ Students and teachers alike are practicing in case of an emergency. Students at Parkland High School ended up not being prepared, even though they practiced specific emergency drills. The current procedures are not helpful in prepping students for the variability of an emergency.

One of the issues questioned by politicians, school administrators, and parents is how to prepare their state, students and sons and daughters to act in a time of crisis. Michael Dorn, the executive director of Safe Havens, a non-profit whose aim is to assist schools on safety issues has an answer. Dorn believes students should be taught using “scenario-based training” to prepare for emergencies in and out of school.¹² Forty states require schools to perform exercises or drills, but the drills performed are not realistic.¹³ Dorn also states in his article that active simulations can result in injuries for the trainers and trainees.¹⁴ In the article, Jerry D. Loghry discusses that EMC insurance paid out over one million in medical bills to school employees by one program in a twenty-two-month period.¹⁵ Few options are both effective preparation techniques and safe for the public.

⁷ Diliberti, M., Jackson, M., & Kemp, J. (n.d.). Crime, Violence, Discipline, and Safety in U.S. Public Schools. Retrieved July 25, 2018, from <https://nces.ed.gov/pubs2017/2017122.pdf>

⁸ Ibid

⁹ Preparedness For Emergency Response. (n.d.). Retrieved July 25, 2018, from [https://training.fema.gov/hiedu/docs/fem/chapter 9 - preparedness for emergency response.doc](https://training.fema.gov/hiedu/docs/fem/chapter%209-%20preparedness%20for%20emergency%20response.doc)

¹⁰ Summary and Timeline Related to Parkland Shooting Investigation. (2018, March 20). Retrieved from <https://www.fbi.gov/news/testimony/summary-and-timeline-related-to-parkland-shooting-investigation>

¹¹ Nowick, J. (n.d.). Emergency Management: Improved Federal Coordination Could Better Assist K-12 Schools Prepare for Emergencies. Retrieved from <https://www.gao.gov/assets/680/675737.pdf>

¹² Dorn, M. (n.d.). Security Management. Retrieved July 25, 2018, from [https://sm.asisonline.org/ASIS Issue PDFs/January 2018.pdf](https://sm.asisonline.org/ASIS%20Issue%20PDFs/January%202018.pdf)

¹³ Nowick, J. (n.d.). Emergency Management: Improved Federal Coordination Could Better Assist K-12 Schools Prepare for Emergencies. Retrieved from <https://www.gao.gov/assets/680/675737.pdf>

¹⁴ Dorn, M. (n.d.). Security Management. Retrieved July 25, 2018, from [https://sm.asisonline.org/ASIS Issue PDFs/January 2018.pdf](https://sm.asisonline.org/ASIS%20Issue%20PDFs/January%202018.pdf)

¹⁵ Ibid

2. Bronx Apartment Fire¹⁶

On December 28th, 2017, twelve people passed away in a Bronx apartment building fire. The tragic event was the city's deadliest fire since 1990. The fire began at 6:51 p.m. at 2363 Prospect Ave. Among the twelve individuals who passed, two victims were a one-year-old and her mother. Residents did not know the proper procedure on how to evacuate the building and became trapped by the fire. Many residents did not know what to do in case of a building fire. The residents quickly realized the fire was spreading up the main stairwell. With the typical path blocked off, everyone had to adapt and think of another way to get out of the building. Some individuals were successful in finding another exit route, but others were not as lucky. The unexpected blockage is what caused people to panic. If the residents had a better understanding of what to do in the event of an emergency, there might have been a different outcome.

3. California's 2014 Earthquake

On August 24, 2014, in Napa, California, two-hundred and eighty people were injured, and one person was killed in an earthquake with a magnitude of 6.0.¹⁷ The quake resulted in power outages, fires, as well as some building and road damage. According to a survey taken by the California Department of Public Health, "23% of households reported: one or more of their family members were injured during or after the quake."¹⁸ The study also states, "48% of injuries occurred during the cleanup after the earthquake".¹⁹ The different injuries occurred because people lacked knowledge of what equipment is needed for cleanup, and how to approach damaged buildings and roads. Virtual reality training would be helpful in this situation because people could see how things can fall during an earthquake and practice safety techniques without the risk of injury in virtual reality to prepare. Additionally, virtual reality could show what conditions would look like after a quake and teach people how to approach roads, buildings, and other structures as well as teach best practices for cleaning up after the incident.

2.1.1.2 Legalities

General- Regulations for VA Schools

- a. Virginia law requires every school to develop a written "school crisis, emergency management, and medical emergency response plan." Specifically, § 22.1-279.8., *Code of Virginia*, sets forth the following:
- b. **Definition of Plan**
"School crisis, emergency management, and medical emergency response plan" means the essential procedures, operations, and assignments required to prevent, manage, and respond to a critical event or emergency, including natural disasters involving fire, flood, tornadoes, or other severe weather; loss or disruption of power, water, communications or shelter; bus or other accidents; medical emergencies, including cardiac arrest and other life-threatening medical emergencies; student or staff member deaths; explosions; bomb threats; gun, knife or other weapons threats; spills or exposures to hazardous substances; the presence of unauthorized persons or trespassers; the loss, disappearance or kidnapping

¹⁶ Twelve people killed in a 5th alarm fire in the Bronx. (2017, December 29). Retrieved from <https://www1.nyc.gov/site/fdny/news/fa7217/twelve-people-killed-5th-alarm-fire-the-bronx#/0>

¹⁷ *Community assessment for public health emergency response* (Rep.). (2015, January 22). Retrieved [https://www.cdph.ca.gov/Programs/CCDC/DEOD/CDPH Document Library/Napa CASPER report.pdf](https://www.cdph.ca.gov/Programs/CCDC/DEOD/CDPH%20Document%20Library/Napa%20CASPER%20report.pdf)

¹⁸ Ibid

¹⁹ Ibid

of a student; hostage situations; violence on school property or at school activities; incidents involving acts of terrorism; and other incidents posing a serious threat of harm to students, personnel, or facilities. (§ 22.1-279.8.A, *Code of Virginia*)

- c. The code of Virginia section 22.1-137 states: “In every public school there shall be a fire drill at least twice during the first 20 school days of each school session, in order that pupils may be thoroughly practiced in such drills. Every public school shall hold at least two additional fire drills during the remainder of the school session.”

(Note: “school session” means school year)

Building Codes

- a. Virginia Fire Safety Regulation. Section 402. Number of Exitways
- b. Every story shall have at least one Exitway, and every story exceeding 4,000 square feet in area shall have at least two separate Exitways.

2.1.2 HISTORY OF VIRTUAL REALITY

Virtual reality began in 1838 with Charles Wheatstone’s research. According to the Virtual Reality Society, Charles determined “the brain processes the different two- dimensional images from each eye into a single object with three dimensions.” Wheatstone’s viewing process gives depth to the image. His process was later patented and used to create low-cost virtual reality headsets such as Google Cardboard.

One hundred years later, Edward Link created the “Link Trainer” as a safer alternative for training pilots. The system, controlled by motors, gave pilots a similar experience to flying. Link’s device was later purchased by the military, and over 500,000 pilots used it to train and improve their skills during World War Two.

The following decade, virtual reality stepped into the entertainment market. Stanley Weinbaum is a science fiction writer who created the world’s first four-dimensional movie. To experience the movie, viewers had to put on goggles. The viewer experienced the alternative universe through multiple senses including sight, smell, and touch. The film catalyzed the development of virtual reality technology.

Later, Morton Heilig came out with the first virtual reality headset in 1960. The headset was not interactive and did not include motion traction. However, the set did provide low levels of three-dimensional work and provided stereo sound for the user. The Philco corporation followed developing the Headsight. The Headsight allowed for immersive remote viewing of dangerous situations in the military.

Ivan Sutherland laid the groundwork for the next fifty years of virtual reality. His essay titled "Ultimate Display" discussed a theory where a computer could control the existence of matter, and the line of what is real and what is fake is blurred. The history and growth of virtual reality technology lay the groundwork for future innovations in the market. Our team plans to utilize the history of virtual reality to enhance education and training.

2.1.3 CURRENT STATE OF VIRTUAL REALITY

There are four top virtual reality headsets on the market, the Oculus Rift, HTC Vive, Samsung Gear VR, and the Google Cardboard. Virtual reality headsets range in functionality and price to accommodate their target market. The most expensive headset available today is the Oculus Rift. The Oculus Rift is designed for gaming and creating immersive experiences for the user. Next, the HTC Vive, sets itself apart by utilizing the headset and controller combination. The HTC Vive also distinguishes

itself apart from its competitors by incorporating the use of room scale to create an immersive environment. Less expensive headsets are the Samsung Gear VR and the Google Cardboard. Both require smartphones rather than computers to use.

The question surrounding Virtual reality is: How can someone feel they are in another universe, while still sitting in their living room? Virtual reality technology is now at the point where people can put on a headset and experience an artificial environment that replicates the real world.²⁰ Major companies such as Lockheed Martin, Leidos, and Northrop Grumman are using head-mounted display's (HMD's) like the Oculus Rift and the HTC Vive to create immersive environments. Virtual reality headsets use a combination of liquid crystal displays, lenses, movement tracking technology, and sound effects to place users in a realistic virtual world.

2.1.3.1 VR Industry Potential

The virtual reality market is rising. From 2014 through 2016 the virtual reality market tripled in the United States alone.²¹ In figure one below the market share of virtual reality is broken down to show the increase in market share for virtual reality in the technology market. Virtual Reality technology grossed 62.1 million dollars in revenue in 2014 and rose to 220 million dollars in 2016.²² The market share for virtual reality continues to grow on a global scale, and in 2017 totaled 3.7 billion dollars.²³ By 2022, the virtual reality market as a whole will reach a net of 39.4 billion dollars, growing around 60.5% each year from 2017-2022.²⁴

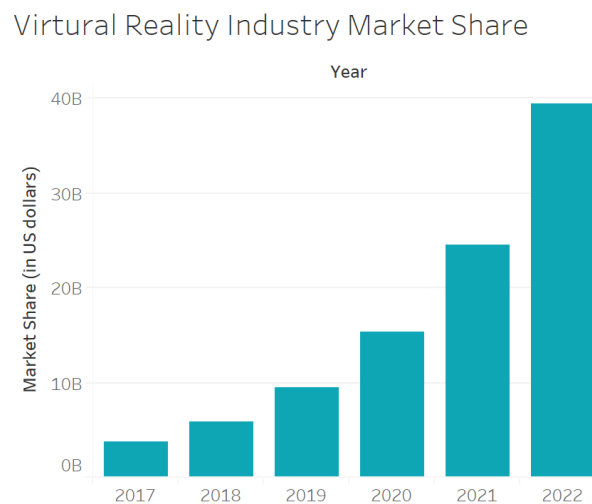


Figure 1: Increasing Market Share of Virtual Reality

Referring to (Figure 2) below, the education segment of the virtual reality market grossed 116.7 million dollars, taking a 3% market share in 2017.²⁵ The gaming segment totaled 2.1 billion in 2017, taking in 57% of market share.²⁶ Although education holds a tiny percentage of market share, the

²⁰ Immersive Experience. (n.d.). Retrieved from <https://www.boozallen.com/expertise/analytics/immersive-experience.html>

²¹ Market Research. (2018). Retrieved from <https://www.reportlinker.com/p05308313/Virtual-Reality-Technologies-Global-Market-to.html>

²² Ibid

²³ Virtual Reality Market Size Growth & Analysis | VR Industry Report 2025. (2017). Retrieved from <https://www.grandviewresearch.com/industry-analysis/virtual-reality-vr-market>

²⁴ Ibid

²⁵ Market Research. (2018). Retrieved from <https://www.reportlinker.com/p05308313/Virtual-Reality-Technologies-Global-Market-to.html>

²⁶ Ibid

educational segment is expected to grow at a rate of 76.6% over the next five years, while gaming is estimated to have stagnant growth at a rate of 50.9%.

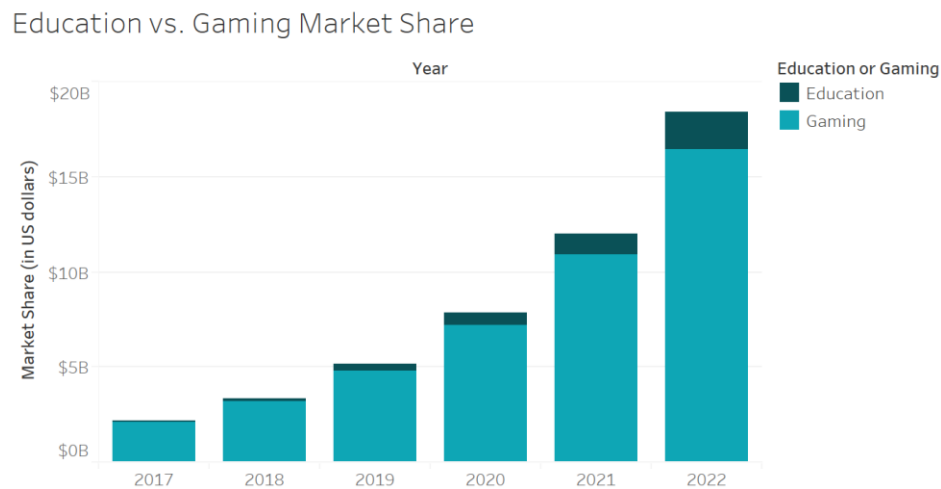


Figure 2: Virtual Reality Market Share by Segment

Based off the data above, virtual reality technology will grow away from gaming and into many areas with the opportunity for training including military, medical, and the public sector.

3 CONCEPT

3.1 Proposed Product

Virtual Emergency Scenario Training (V.E.S.T.) is an emergency response training tool where the user must either evacuate the office or save someone in the burning office. This proof of concept will lead to other emergency incidents including earthquakes, military emergencies, and active shooter drills involving residential buildings, armed services, and schools. The simulator prepares people for unexpected situations that are difficult and costly to emulate in the real world. In addition, the simulator will be able to collect data and create a progress report to display how quickly the user escaped and what decisions he or she made for each obstacle.

3.1.1 PRODUCT FEATURES

Our project has two main features: sensory alteration and data collection. Sensory alteration is currently not in any of our competitor's attributes (refer to figure five). Sensory alteration is used in multiple ways throughout the simulation. Virtual reality manipulates the user's sight and ability to hear. For example, the individual in the virtual reality headset will start to lose vision while walking through a cloud of smoke. To create a realistic experience, the user would hear the fire alarm or people screaming. Additional layers of immersion make the training simulator more intense than the typical fire drill.

The second distinguishing feature of the product is the use of data collection. The simulator will allow the user to see their performance report after they escape the building. The system will be able to record data which is relevant to helping the individual improve evacuation techniques. This technology will assist building managers in finding the optimal location of key items during an emergency. The individual will be able to see how quickly they escaped the building and if there was a different route they should have taken if the user did not escape. They will see what they could have done better to

help others or to prevent the fire from spreading. For example, the simulator can show the user how they should check for heat in the next room by touching the handle of the door with the back of their hand. The user will also be informed to close the door behind them after leaving a room with a fire to prevent more oxygen reaching the flames. Data collection can also be useful for implementing A/B and multivariate testing.

3.1.1.1 A/B and Multivariate Testing

Data collection can also be useful for implementing A/B and multivariate testing. A/B testing is a way to compare different versions of a single variable. With A/B testing the experimenter typically tests a user's response to variant A versus variant B. Once the test is completed the experimenter can use data collected to determine which of the two variants is more effective. The process of conducting an A/B test is shown below in (Figure 3).



Figure 3: A/B Testing Process²⁷

The A/B testing process begins with identifying goals and ends with measuring results. Utilizing A/B testing in the simulation will help determine the optimal position of key items in the building. Items include but are not limited to fire extinguishers, fire alarms, exit signs, and evacuation instructions. Understanding the optimal location of safety items will assist building managers in where to place helpful items.

Another method of testing is called multivariate testing. In multivariate testing the experimenter can test a hypothesis with multiple variables modified and the goal is to determine which combination of variations performs the best. To determine the total number of variations to experiment with in a multivariate test there is an equation:

$$[\# \text{ of Variations on Variable A}] \times [\# \text{ of Variations on Variable B}] = [\text{Total \# of Variations}]^{28}$$

The multivariate testing process is like the A/B testing process shown in (figure 3) above, accept in multivariate testing the experimenter can test more than two variables in an experiment. In (figure 4)

²⁷ A/B Testing. (n.d.). Retrieved from <https://www.optimizely.com/optimization-glossary/ab-testing/>

²⁸ Multivariate Testing. (n.d.). Retrieved from <https://www.optimizely.com/optimization-glossary/multivariate-testing/>

below the levels of multivariate testing are illustrated in chart form. The variables can be altered and tested with other variables listed in the chart to find the best combination of variants.

















Multivariate Testing Levels				
Variations	Variable 1	Variable 2	Variable 3	Variable 4
	 Lights 1	 Alarm 1	 Fire 1	 Smoke 1
	 Lights 2	 Alarm 2	 Fire 2	 Smoke 2
	 Lights 3	 Alarm 3	 Fire 3	 Smoke 3
	 Lights 4	 Alarm 4	 Fire 4	 Smoke 4

Figure 4: Levels of Multivariate Testing

Utilizing multivariate testing in the simulation will help determine the best combination of variants. One combination to test would be whether a user responds quicker to fire alarms with faster blinking lights and a high pitch alarm or slower blinking lights with a low pitch alarm. Understanding which combination of lights and sound make a person respond to alarms quicker will aid in making evacuations quicker and more efficient.

3.1.1.2 User Base

The Federal Emergency Management Agency (FEMA) is a potential client for V.E.S.T.. FEMA's mission is "helping people, before, during and after disasters."²⁹ V.E.S.T. will give FEMA a new and innovative way to prepare the American public for disasters. FEMA's role to train people how to respond in different emergency situations is just as important as their role to assist after disasters. Utilizing V.E.S.T. will ensure that people know what to do in the case of an emergency. Booz Allen Hamilton would be able to contract out employees to assist with implementing this technology for buildings or

²⁹ Federal Emergency Management Agency (2018). About the Agency: Mission Statement. Retrieved from ://www.fema.gov/about-agency

organizations that FEMA would train (refer to ROI on pg.15). We have estimated that one person would take 12 minutes to go through the simulator and receive feedback. In an eight-hour work day with one headset, the building or organization would be able to train 160 individuals without disrupting everyone's schedule.

The United States Fire Administration (USFA) is the specific entity of FEMA that would be able to utilize V.E.S.T.. The USFA budget shows \$43.5million allocated to education, training and exercises in the Federal Assistance account.³⁰ The objective of USFA is to "significantly reduce the nation's loss of life from fire."³¹ Currently, USFA offers 3,833 courses, reaching only 102,773 students.³² V.E.S.T. can train four times the number of students with only 4 headsets. Not only would V.E.S.T. be able to train more individuals, but it would be more immersive than taking a course.

Individual students would fall into three distinct categories. The first category would be emergency personnel. Emergency personnel includes firefighters, EMS, and police officers and can practice costly training daily. The second group is using the technology for A/B testing, such as engineering firms, construction companies, and safety officers. They can determine the correct placement of stairwells, doors and fire extinguishers. Lastly, individuals in offices, residential buildings, and schools can learn their own buildings safety code and evacuation procedures.

3.1.2 PRODUCT FUNCTIONALITY

The simulator requires a user in the headset and a Challenge Master, who creates the virtual reality space using pre-made rooms and hallways that will snap together using a computer. The Challenge Master would be able to either create a new space every time or download a saved maze they created before. Before the user enters the headset, they will be required to fill out a form about their medical history and sign a waiver to show that they understand any potential risk that virtual reality could have. At the start of the simulation, the user will be put in a tutorial room where they can get use to the feel of virtual reality. Once they exit the tutorial room the timer will start, and they will have to escape the burning building. Data will be collected on the different decisions the user makes and be displayed on a report at the end of the simulation. The user will be able to review their mistakes and understand what they could have done better.

3.1.3 FURTHER APPLICATION

In 2017, the United States Navy had one of the deadliest ship collisions in recent decades. The USS John S. McCain collided with a merchant ship around 06:24, creating significant damage and flooding to the ship's compartments such as berthing, machinery and communication rooms.³³ The accident left five sailors injured and ten missing.³⁴ The sailors went through training on what to do in the events of a flood to stop the flow of water.³⁵ DC1 Andrew Augusta, one of the Wet Trainers for the Navy, states, "simulations [of these events] are absolutely critical."³⁶

³⁰ K, Lennard. (2018). United States Fire Administration: An Overview. *Congressional Research Service*. Retrieved from <https://fas.org/sgp/crs/homesec/RS20071.pdf>

³¹ Federal Emergency Management Agency (2018). FY 2019 Budget in Brief. Retrieved from <https://www.dhs.gov/publication/fy-2019-budget-brief>

³² Federal Emergency Management Agency (2018). FY 2019 Budget in Brief. Retrieved from <https://www.dhs.gov/publication/fy-2019-budget-brief>

³³ USS John McCain Collides with Merchant Ship. (2017). *America's Navy*. Retrieved from http://www.navy.mil/submit/display.asp?story_id=102034

³⁴ Ibid

³⁵ Augusta, A. (Interviewee) & Ruby, C. (Interviewee). (2017). US Navy Damage Control. Retrieved from <https://www.youtube.com/watch?v=97XDakVK0Ro>

³⁶ Ibid

Ultimately, negligence and attention to detail lead to the ship crashing. Carelessness and attention to detail cannot be fixed using virtual reality. With virtual reality technology, users can explore a person's reactions to negligent acts, which not currently on the market. In our team's example, we have a fire. The proof of concept will move in multiple different directions, including school shootings, earthquakes, and ship flooding in no particular order. Sailors can practice their skills while aboard the ship, and even practice specific scenarios using GIS mapping.

The Department of Defense is now using virtual reality for flight simulations, medical emergencies, and battle scenarios. Reining in the skills save time, money and lives. Considering flight and battle simulations, soldiers can practice various situations before the actual event. In the medical field, surgeons and emergency response individuals can practice different medical exercises. A major component to consider when building a training simulator is human error. In the future, V.E.S.T. can assist the United States Navy and the Department of Defense in the event of an emergency regarding negligence.

4 BEYOND BOOZ ALLEN HAMILTON

4.1 Market Analysis

The future of our Virtual Emergency Scenario Training (V.E.S.T.), combines one of the world's most significant problems, the technology of the future, and individuals who care about their and other's safety and well-being. One of Booz Allen Hamilton's current clients, under Federal Emergency Management Agency (FEMA) is the United States Fire Administration (USFA) which has a budget of forty three million for training and education of individuals.

4.1.1 MARKET VALUE

4.1.1.1 Return on Investment

The V.E.S.T. return on investment for the software development is calculated by estimating the total cost and return generated from a twenty-week project (refer to ROI on pg.15). To complete the project in twenty weeks a team would consist of: one 3D Modeler, one Senior Project Manager, three developers, one tester and two requirements analyst. The total labor cost for a twenty-week period is estimated to be \$643,200 based on salaries generated by Glassdoor. The non-labor costs with fees (10%) for the project totals to \$17,930. The estimate includes all the equipment needed to develop the simulator: unity software license, unity assets, HTC Vive Pro, Computers, and the Go Pro Fusion. Based on these estimates, the total cost to Booz Allen to develop the simulator is \$788,140. The burden labor rate we would charge FEMA is \$1,415,040, which is how much we would charge FEMA on the development side. As a result, Booz Allen would receive a 44% return on investment from the sale of the simulator.

4.1.1.2 Value Added

A financial calculation is not the only area where value is added to an organization. Instead, the safety increase is the value for students in public schools. The simulator can add value in two ways: increasing preparedness and enhancing the way the user learns. The user preparedness is two-fold. First, the simulator could require certification of the teachers yearly. If the teachers know what to do when different scenarios arise, they will also be able to instruct the students. The second application is in the classroom. Schools will be able to monitor how each of their students respond to emergencies and the students can even turn it into a competition. The second use is enhancing the user experience.

4.1.2 IMPLEMENTATION STRATEGY

V.E.S.T can be implemented across schools, office buildings, and residential complexes. Through partnering with USFA and FEMA, in its testing year V.E.S.T. can be made available to almost half a million individuals. To maximize a consistent ROI for Booz Allen Hamilton, Booz Allen will work with a sub-contracting agency. The sub-contractor would run the game, putting individuals through the waiver, pre-questions, tutorial, simulation and post-questions. Here at Booz Allen, project managers will acquire clients such as offices, schools and residential buildings and organize the sub-contractors, all under FEMA's name.

To maximize Booz Allen's ROI, we broke the country into nine areas based off the US census breakdown. Within these nine areas, there would be three teams in each to keep travel costs low. The cost of one hundred and eight subcontracted employees, one subcontractor administrator, four project managers, a program manager and two maintenance developers would cost FEMA just under seven million dollars. Considering variable travel expenses for the employees and depreciation on the materials, total cost for the implementation of V.E.S.T would be just over eight billion for FEMA, while giving us a consistent ROI at 84.2%. This calculation assumes that each team would work twenty-five hours a week, thus cost and ROI would rise with continual growth of the service.

Overall, considering the cost of both the product and one year of service serving 2,808 environments would be \$3,278,574 to Booz Allen. With the multiplier on both ends, the profit would be \$5,233,077, or a 59.6% return on the investment in the initial year. This number would continually rise after the development of V.E.S.T. is completed and only maintenance fees on the technology are required.

4.1.3 COMPETITION ANALYSIS

Booz Allen Hamilton faces several competitors when it comes to virtual reality. Our team is focusing on the following competitors; Lockheed Martin, Leidos, Northrop Grumman, and Alion Science and Technology.

4.1.3.1 Lockheed Martin

Lockheed Martin developed a training simulator called PREPAR3D (pronounced "prepared"). PREPAR3D is a virtual reality simulation which allows for scenario creation across aviation, maritime, and ground domains. The product includes a variety of scenarios for both private and commercial uses.

Advantages/Unique Features:

- Simulation is multi-player
- Simulation collects operational data to use for review
- Simulation offers the ability to adjust scenarios

4.1.3.2 Leidos

Leidos has developed multiple Synthetic Training Environment's to use across many platforms including, computer simulations, virtual reality, and real-world training exercises. The training environments were built for the U.S. army and can integrate live, virtual, and constructive game training.

Advantages/Unique Features:

- Users can manage simulation life-cycle
- Users can adjust the difficulty of the simulation

- Users can develop their own scenarios
- Users can review their actions

4.1.3.3 Northrop Grumman

Northrop Grumman has developed various simulators which utilize live, virtual and constructive (LVC) training. The firm's products can be used with various technologies including virtual reality headsets.

Advantages/Unique Features:

- Prime contractor for U.S Air Force's Distributed Mission Operations Network (DMON)
- Virtual training for battle scenarios
- Focus more on simulation through OCs than VR (makes it more affordable)
- Simplifies scenario creation
- Ability to connect with other models and data sources

4.1.3.4 Alion Science and Technology

Alion Science and Technology has developed various live, virtual, and constructive (LVC) training simulations. The firm is a partner on the Navy's enterprise tactical training solution and they help create simulations to help the Navy train for real situations.

Advantages/Unique Features:

- Users can experience virtual and augmented reality
- Users can train in the field with the help of globally integrated networks
- Advanced modeling and simulation makes training more realistic
- Utilizes game-based training to help DoD meet readiness requirements

4.1.3.5 Feature Comparison





Company	Booz Allen Hamilton*				
Criteria	Booz Allen Hamilton	Lockheed Martin	Leidos	Northrop Grumman	Alion Science & Technology
Variability	✓	✓	✓	✓	✓
Data Collection	✓	✓			✓
A/B Testing	✓				
Customization	✓	✓	✓		✓
Sensory Alteration	✓				
Cross Platform	✓	✓	✓	✓	
User Feedback	✓				
After Action Review	✓		✓		
Uses 360 Video	✓				

Figure 5: Competition Feature Comparison

Return on Investment					
Functional Prototype (20 weeks)					
Team LCATs	DS Role Count	Hourly Rat	Labor Cost	Hours for Project	Labor Category
3D Modeler (3 weeks=1 school)	1	60	\$ 7,200	800	PM,Dev, Tester,RA
Project Manager- Sr	1	150	\$ 120,000	120	3D Designer
User Interface Developer-Sr	3	140	\$ 112,000		
Developer-Sr		135	\$ 108,000		
Developer-Mid		95	\$ 76,000		
Tester-Mid	1	80	\$ 64,000		
Requirements Analyst-Sr	2	130	\$ 104,000		
Requirements Analyst-Jr		65	\$ 52,000		
Booz Allen Cost			\$ 643,200		
Overhead (facilities, 401(K), PTO, etc.)			\$ 128,640		
Labor Cost to FEMA			\$ 1,415,040		
Equipment	Quantity	Cost Per			
Unity Software License	2	\$ 1,500	\$ 3,000		
Unity Assets	1	\$ 200	\$ 200		
HTC Vive Pro	1	\$ 1,400	\$ 1,400		
Computer	2	\$ 5,500	\$ 11,000		
Go Pro Fusion	1	\$ 700	\$ 700		
Other Direct Costs (ODCs)			\$ 16,300		
ODCs with Fee		10%	\$ 17,930		
Total Cost to Booz Allen	\$ 788,140				
Profit	\$ 644,830				
ROI	44%				

ROI of Service					
One Fiscal Year					
Team LCATs	FTE Count	Hourly Rate	Total Labor Cost	Yearly FTE Hours Per Contractor	
Total Sub Contractor Labor- Low (25 hours a week)	108	\$35.00	\$5,824,224.00		1440
Sub Contractor Administrator (SCA)- Mid (20 hours a week)	1	\$106.59	\$102,326.40		960
Project Manager- Mid (20 hours a week)	4	\$253.00	\$971,520.00		960
Program Manager- Sr (20 hours a week)	1	\$330.00	\$316,800.00		960
User Interface Developer-Sr (maintenance) (10 hours a week)	1	\$140.00	\$67,200.00		480
Developer-Sr (maintenance) (10 hours a week)	1	\$135.00	\$64,800.00		480
Booz Allen Labor			\$1,522,646.40		
Total Labor Cost to FEMA			\$8,044,823.09		
Variable Expenses	Quantity	Cost Per Employee/Product	Estimated Variable Expenses	Rav-4 Rental from Enterprise	
Travel Expenses					
Rental Car Rate	4212	\$93	\$391,716.00		
Perdiem Rate	16848	\$62	\$1,044,576.00		
Computer- Depreciation	108	\$20.00	\$2,160.00		
Vive- Depreciation	108	\$50.00	\$5,400.00		
Fusion- Depreciation	108	\$25.00	\$2,700.00		
			\$1,446,552.00		
Variable Expenses with Fee		10%	\$1,591,207.20		
Estimated Number of Environments					
Total Cost to Booz Allen for one year of service	4,212			20 individuals can fill out our waiver, take our pre- scenario survey, run through the scenario, and fill out post scenario questions in 4 hours using 1 headset. In an 8 hour day, using 4 headsets, 160 people can be trained in 1 environment	
Profit for one year of service	\$2,969,198				
ROI for one year of service	\$5,220,280				
	75.8%				
Total Cost to Booz Allen for product and one year of service	\$3,757,338			"Environment" is a location where you offer the service for a day. This could be done at an office, school or residential building. With 2,808 environments, each team would have 104 appointments, or 2 environments a week.	
Total Profit to Booz Allen for product and one year of service	\$ 5,865,110				
ROI for product and one year of service	56.1%				

20 individuals can fill out our waiver, take our pre- scenario survey, run through the scenario, and fill out post scenario questions in 4 hours using 1 headset. In an 8 hour day, using 4 headsets, 160 people can be trained in 1 environment

"Environment" is a location where you offer the service for a day. This could be done at an office, school or residential building. With 2,808 environments, each team would have 104 appointments, or 2 environments a week.

About Booz Allen

For more than 100 years, business, government, and military leaders have turned to Booz Allen Hamilton to solve their most complex problems. They trust us to bring together the right minds: those who devote themselves to the challenge at hand, who speak with relentless candor, and who act with courage and character. They expect original solutions where there are no roadmaps. They rely on us because they know that—together—we will find the answers and change the world. To learn more, visit BoozAllen.com.