Using Today’s Interconnected Technology to Better Prepare for Natural Disasters:

Research Proposal

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December 2018

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**Abstract**

The most concerning factor to a first responder is the unknown and nothing is worse than not knowing what mother nature is doing during a natural disaster. In todays interconnected world first responders have just started to integrate technology into their “best practices” during natural disasters but there is so much more they could do. Using a GIS, they could make drastic changes and improvements to their response to and mitigation of natural disasters.

**Introduction**

In today’s interconnected world we have more information at our fingertips than could ever be used in one lifetime. Although, this information is scattered throughout the internet and can be outdated by the time it is found. What if there was a live database of geographical data, overlaid with real-time changes, formatted for use by first responders around the world? Well there are databases of geographical data, some of which do have some real-time capabilities, these are called geographic information systems (GIS). None of which have ever been designed to specifically aid first responders in preparation for and during a natural disaster. In a small town a GIS could be used to predict the path of flood waters. Then during the storm, it could be used to monitor the water levels of the river in town and up stream. If the levels up stream reaches a point that could cause flooding downstream, residences could be evacuated from the area before the flooding begins. The problem with this is no system has been developed to do that specific task. My independent variables are the computer systems and technologies already in use today and my dependent variables are, response times, deaths, and monetary loss of property all related to natural disasters. I believe that if I go into some of the most natural disaster-prone areas of this country, I could understand what computer systems and technologies they already have in use in the field. To which I could come back and develop a GIS specifically designed for first responders. That would also be able to be used on the most common computer systems in the field. In the initial phase I intend on gathering as much related data as possible but then design a GIS for one specific disaster in one specific area to prove my theory.

**Literature Review**

**Introduction**

The question at hand is what technological resources are available in the Information Technology field that could be used for disaster management to help first responders better prepare for a foreseeable natural disaster. For the most part, anyone can foresee a natural disaster using the technology already in wide spread use today, which includes radio, television, telephone, mobile, SMS, and auto-alert systems. First responders make pre-plans for buildings in their district in the event of a catastrophic fire, they formulate a plan to help mitigate any potential problems, and they check fire protection systems such as sprinklers, fire alarms, and evacuation routes. Although, fires are not the only disasters that they respond to, it is also possible for a river to flood but most agencies never consider it until the flooding has started. Proposing that Information Systems be advanced upon and better utilized, in conjunction with “best practices” already in place. An example of one such system is the geographic information system (GIS). Educating first responders about these systems would increase positive outcomes and decrease human suffering.

**Current Disaster Management Standards**

Before being able to address areas of improvement in disaster management, an understanding of the current standard is required. The Incident Command System (ICS) was developed in the 1970s following a series of catastrophic fires in California's urban interface and was later adopted into the *National Incident Management System* (NIMS) (O’Neill, 2008). Then, in 2003, Homeland Security was tasked with creating a NIMS as a template for all domestic incidents.

**Incident Command System.**

ICS was created by a group of fire chiefs after an outbreak of wild fires in the 1970s. It outlined a standardized command structure to be utilized in emergency and nonemergency situations of all sizes. It can be used for everything from planned events (concerts) to natural disasters and man-made disasters. It became the standard across the country and was later adapted into NIMS.

**National Incident Management System.**

Homeland Security was tasked with creating a NIMS as a direct result of 9/11. President Bush (2003) felt that first responders needed to “enhance the ability of the United States to manage domestic incidents by establishing a single, comprehensive national incident management system.” (p. 280). NIMS built a standard framework for incident management that still allows for flexibility in preparation and during an incident. NIMS and ICS are both designed to work with all sizes of incidents and all levels of government. In the Supporting Technologies section of *National Incident Management System* (2017), the Federal Emergency Management Agency (FEMA) states “Ongoing development of science and technology is integral to the continual improvement and refinement of NIMS” (p. 71). FEMS allows for bringing in a science and technology team at all levels of the incident management team. Technical standards are also required for all information and communication systems that are utilized during an incident. An example is the command team using one radio frequency for communication, allowing for all members of that team to stay up to date on new and changing information.

**Currently Used Technology**

The use of technology in incident management is not a new concept, but it could use some updating. The National Research Council (2007) recommends “Disaster management organizations should take advantage of opportunities for adoption of existing technology or adjustment of policies and procedures that would allow significant short-term enhancement of disaster management.” (p 4). Various technologies already in widespread use are radio, television, telephone, mobile, short messaging system (SMS), and auto-alert systems (Mukhopadhyay, 2015).

**Radio / Television / Telephone / Mobile / SMS / Auto-alert systems.**

Some of the current forms of technology used in disaster situations include: radio, television, landlines, mobile phones, SMS, and auto-alert systems, to name a few. Radios and television have their emergency alert systems, which are already in widespread use. Landlines and mobile phones are used for gaining access to emergency services through the 911 system and now reverse 911, with which emergency services can call you to warn of an impending disaster. SMS is used in situations where congestion on phone lines is possible. Lastly, volunteer fire departments have audible auto-alert systems on their buildings to notify the residents and emergency personnel of a disaster or emergency. Another, much newer form of auto-alert system is the Wireless Emergency Alerts (WEA), an essential part of America's emergency preparedness (launched in 2012), all newer model smart phones (Gonzales, 2014). Although, these are not the only technologies available to first responders.

**New Technology**

All the previously listed technologies are already being used by first responders to help better preserve life and property but there are also newer ones that should also be considered. One example, a geographic information system (GIS), “is a computer application designed to perform a wide range of operations on geographic information” (Goodchild, 2009, p. 1231). A GIS takes various pieces of geographic information and overlays them for further analysis. Vyas and Desai (2007) explain that “The specific GIS application in the field of Risk Assessment are: - Hazard Mapping to show earthquake, landslides, floods or fire hazards” (p. 2). For instance, if soil composition and density were laid over a topographic map, the possibility of landslides during heavy rain could be predicted with reasonable accuracy. If you give this technology to first responders, they can be prepared for an incident prior to its occurrence, instead of reacting to its aftermath. According to Mukhopadhyay and Bhattacherjee (2015):

GIS can accurately support better response planning in areas such as determining evacuation routes or locating vulnerable infrastructures and vital lifelines, etc. [It] also supports logistical planning to be able to provide relief supplies by displaying previously available information on roads, bridges, airports, railways, etc. [Apart] from these activities such as evacuee camp planning can also be done by GIS. (p. 2)

GISs can also be used to predict a drought, monitor flood waters as they change in real-time, and for risk assessment in earthquake zones (Vyas & Desai, 2007). The problem is “The vast majority of first responders (such as police, fire, emergency medical personnel) [are] not that familiar with [GISs], nor are they likely to use these systems in the immediate response or rescue phase.” (Cutter, 2003, p. 442). Some GISs are so technical that first responders would require training just to understand how to use them, although it is possible to develop a simpler and more intuitive GIS designed specifically for first responders. Further research would need to be conducted on what computer systems are commonly used in the field today, to better understand what platforms it should be developed for.

**Conclusion**

In conclusion, the current disaster management system allows for the systematic integration of new technologies, if they follow technological standards. Some technologies that have been integrated into the current standards after the inception of ICS are radio, television, telephone, mobile, SMS, and auto-alert systems. Although there are others, GISs are a prime example of one new technology that was not developed for emergency services but could have lifesaving uses in the field.

**Methods**

**Introduction**

The idea at hand is to make emergency response better after a natural disaster. To do this I have to integrate new technologies into a well-developed system. Before I start the research, I will have to find a suitable location that is prone to natural disasters. After which I will head into the field to interview candidates, conduct surveys, and figure out what computer systems are already being used by first responders. Next, I will modify a GIS that meets their needs and is able to work on pre-existing systems. I will then return to the field in very select locations to implement the system, fix any bugs, conduct follow-up interview, and record new surveys. A final analysis of the surveys will be conducted to show the positive changes.

**Phases of Research**

**Step 1: Location Overview.**

To start my research, I would first have to locate an area with a high rate of natural disasters. An area with a higher than average rate of natural disasters would be ideal. This will allow for a more thorough and accurate data set during the testing period. Where applicable, I would also do a shortened study in areas with an impending natural disaster, to see the variations in response of the less experienced responders versus more experienced. Although, this data will give me further insight into current standards and practices. I will most likely be unable to study implemented changes in the shortened study areas due to the decreased likely hood of a recurring disaster in the timeframe of the study.

***Potential locations.***

Within the constraints of the study I intend of conducting most of my research in the United States. This also is one of the most ideal countries to conduct it in due to it having the second highest rate of natural disasters effecting population in the world. Within the United States: Texas, California, Oklahoma, and Washington are the top 4 states that are most prone to natural disasters. I intend on conducting the bulk of my research in California because it has one of the highest numbers of natural disasters. At any given time, there are approximately 14 million people in the state of California at risk of being affected by an earthquake. The state has endured wildfires, landslides, flooding, winter storms, sever freezes, and tsunami waves. Further focusing on areas such as Los Angeles county in California, with a population of 10.16 Million people. This makes it a prime study area and its sitting in the center of one of the most earthquake prone areas in the world.

When it is possible, I would also branch out into other parts of the country to gather more diverse information. Locations would include states on the east coast from Florida to North Carolina during hurricane season. Also, the states in the Midwest that fall in Tornado Alley including portions of Mississippi, Alabama, Arkansas, Missouri, Illinois, Indiana, Tennessee and Kentucky. Most of these areas don’t have a high enough frequency of disasters to move past the data collection phase of my research but some will be considered for the implementation and testing phases.

**Step 2: Data Collection Part 1.**

With the planning phase of the systems development life cycle (SDLC) completed in the Literature Review above, I will be able to begin the analysis phase after arriving in the designated areas. Data collection will begin with what computer systems and technologies (CSaT) do first responders have at their disposal. There will be two different types of candidates include in this part of the study; those who already have integrated appropriate CSaT into the planning for and response to natural disasters and those who have not. For the candidates who have not integrated CSaT; personal interviews and surveys will be conducted to uncover reasons why they are yet to integrate. For the candidates who fall into the other category different interviews and surveys will be conducted, along with a hands-on analysis of the CSaT will be done. The interviews will be aimed at answering:

* What the CSaT are already being used for?
* What are the skill levels of the users?
* What they dislike about their current systems?
* What they like about their current systems?
* What they believe would be useful data?
* What capabilities they would find

useful in a GIS?

The surveys are going to be used to collect as much factual data as possible, to show the positive changes after implementation. Some of the data collected will include: type of disaster, response times, damage done, persons effected, among anything else that can show a statistical change. During hands-on analysis I will be collecting data on mobile devices and personal computer including:

* What operating system is being used?
* What is the size of the memory?
* What is the available memory?
* What is the size of the RAM?
* What is the speed of the RAM?
* What is the type of processor?
* What is the speed of the processor?
* What is the type of GPU?
* What is the speed of the GPU?
* What type of network connections are available?
* What are the available network speeds?

This data will be taken into consideration during the design phase of the SDLC. The intent is to design a system that meets the needs of as many agencies as possible and have it able to be run on the most common systems already in use.

**Step 3: Analysis and Design.**

After returning from the field and completing the analysis of the data collected, I will select a target area and specific type of disaster. This narrowed design is meant to reduce design time and prove the positive outcomes. A likely location and disaster are the Los Angeles County and earthquakes, as stated above. After the research is completed more functionality can be added in. For the first step I will be researching currently available open source GIS’s, which I have chosen to do to reduce the cost and time required for development. I will allow me to modify an already working system, instead of creating one from scratch. I am unable to give further analysis of the design phase of the SDLC because I am unaware of what programming challenges, I will encounter till I begin to analyze and modify the code.

**Step 4: Implementation and Data Collection Part 2.**

After the design phase I will return to the target area to implement the system. Once the system is up and running, I will assist in the training and use of it, in a classroom setting and, in the field, where possible. I will also use this time to fix any bugs discovered, make any minor changes necessary, and note any major changes required for improvement. When the system has reached a stable state, I will begin the next part of data collection. This will include follow up interviews and surveys to show the initial impressions and immediate measurable changes.

***Data collection part 3.***

If funding and time would allow, I would also like to return to the field and do a final data collection. I would again conduct interviews and surveys with the intent of noting the long-term impressions and long-term measurable changes. Once all the data has been collected, I am going to do a final analysis to show how people’s impressions and the statistical data has changed.

**Methodology**

To accomplish goals as outlined above I will need a place to stay with transportation while I am in the field. I will also require a space, appropriate computers, and software to do my analysis and software development. The only major barrier to my research is the unpredictable nature of natural disasters but I have attempted to overcome this by conducting my research in areas with a high frequency of natural disasters. Another potential barrier could be finding first responder agencies that will allow me to conduct my research. The final intention of my work is to educate and distribute this system to first responders to increase positive outcomes and decrease human suffering.

**Results**

**Introduction**

Although I have not conducted my research yet, I will outline the results I intend on finding throughout my research. I will cover the three data collection points, the first time including the interviews, surveys, and hands-on analysis. The two subsequent data collection points are only going to show the notable changes. I will also outline what the expected outcomes and significance of the completed data analysis.

**Data Collection Part 1**

For my first set of data I will be in the field collecting data from as many first responder agencies. This data will be separated into three parts; the in-person interview, the survey, and hands-on analysis.

**Interview.**

I will start with the cases where I will be interviewing people from agencies who do not have the appropriate CSaT already in place. I expect to find two recurring answers is this data subset; they are unwilling to spend the money for fear of it costing more than they have and they believe that what they already do works and does not need to be changed. I don’t expect to be able to change their stance on this till I have concluded my and proven that it’s less expensive than they expected and that they can benefit from this change.

The second case is where they already have the appropriate CSaT in place. I expect to find wide spread mobile phone use, and vehicle mounted or portable windows computers in the field. They will be used for retrieving dispatch information and response route guidance or no more than a simple GPS. The skill levels are sure to be all over the board and a major complaint is always down time, but they will love it when it works properly. The users will value any kind of real-time data they can get their hands on. One potential functionality is; the first responding personal notes in the system a road is impassable after an earthquake, which causes all other systems to automatically avoid that area when mapping response.

**Survey.**

The initial surveys are not going to show us anything that we aren’t already aware of on a national level, such as average response times. They will however give us a subset of that data specific to the area being studied for comparison to later. One simple example is the national average for response time is nine minutes, Oneida County the average is four minutes, and rural area have averages of thirty minutes or more.

**Hands-on analysis.**

As with the survey, the hands-on analysis is not going to show us anything we aren’t already aware of. Everyone is going to have either an Android or Apple mobile device. Most of the computers used in the field are going to be windows based and next to none of them are going to have a standalone graphics processing unit.

**Data Collection Part 2**

For this data collection it is only going to include the agencies in the trial phase. The most significant changes from the first part to now will be people will have complaints regarding the new system. This is to be expected to occur till people are off that learning curve and fully understand the new system. The surveys may show some changes in the early days but there will not be enough data for a proper analysis.

**Data Collection Part 3**

For this collection I will be returning to the field after the system has been live for some time. I expect to find that the overall opinion of the system will have changed from people generally disliking it to how much they love having the system. The data it provides at their fingertips will have proven invaluable in the field. Although, the surveys are going to be the key factor here showing the changes in response times, loss of life, and loss of property; among others.

**Outcomes and Significance**

When all the data has been analyzed and modeled it’s going to paint a clear picture. First responders are going to find the system to be a necessary tool in the tool box. The surveys are going to show minor changes in minor incidents and drastic changes in major incidents, both of which are going to be a decrease from the initial results. Response times are going to be decreased across the board, loss of life is going to be down, and costs related to loss of property will have decreased. All of this means that they will be able to work more efficiently, from the amount of time spent in response, placement of suppression crews during wild fires, better and more targeted evacuations, to having no loss of life related to a major disaster.

**Discussion**

**Impact**

The results of my research will have the greatest impact on the communities that are protected by the responders who adapt this system. Although, it is designed for and meant to be used by first responders, the effects of it are meant to be felt by the people, if they feel it at all. To the family’s homes that are still standing after a California wild fire, they may never know that they would have lost anything because a commanding officer was able see the wind speed and direction had just changed. The real-time data could also allow for responders to do evacuations as an active disaster changes unexpectedly, instead of doing rescues in the aftermath.

**Value**

In the world of dollars and cents, how do you put a price on what could be prevented? Is it even possible to access damage not done or put a price on a life not lost? If the system does what its intended to do then, homes will be saved, life’s will not had been lost. The monetary value could never truly be measured.

**Solutions**

The biggest issue with natural disasters is not being able to see changes quickly enough. This system solves this by reducing the time it takes to gather and evaluate that everchanging information. With this system in place first responders will have access to more preexisting data than ever before and will be able to see real-time changes laid over it faster than ever.

**Limitations**

Although, this system will make the responders aware of impending disasters faster or be able to monitor changes real-time, it will not tell them what to do with the data. I used an example of changing wind conditions earlier, if that commanding officer did not see that change or know what that information meant he, could have misread it or ignored it completely.

**Moving Forward**

This research is nowhere near complete, I intend on implementing a design that’s used for one disaster in one geographical area. Extensive research will need to be conducted to include more geographic regions and more types of disasters. So much research needs to be conducted that it would take many years and many teams to complete. Just imagine, someday there could be a first responder-oriented GIS that could be used anywhere in the world with any kind of natural disaster.

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